HEALTH, SAFETY
& ENVIRONMENT.
WE'RE ALL RESPONSIBLE.

NO SHORT CUTS. NO EXCEPTIONS. NO INCIDENTS.

SEA LION PHASE 1 DEVELOPMENT

ENVIRONMENTAL IMPACT STATEMENT

PremierOil

HEALTH, SAFETY
& ENVIRONMENT.
WE'RE ALL RESPONSIBLE.

NO SHORT CUTS. NO EXCEPTIONS. NO INCIDENTS.

REVISION HISTORY

Rev	Reason for Issue	Author	Date	Checker	Date	Approver	Date
B04	Issued for Consultation	SAERI	02/01/20	PMO	02/01/20	PMO	02/01/20
B03	Issued post-Consultation	SAERI	24/05/19	PMO	24/05/19	PMO	24/05/19
B02	Issued for Review	SAERI	03/04/19	PMO	03/04/19	PMO	03/04/19
B01	Issued for Consultation	SAERI	19/01/18	PMO	19/01/18	PMO	19/01/18

	Document Number	Rev
This document contains proprietary information belonging to Premier Oil and must not be wholly or partially reproduced nor disclosed without prior written permission from Premier Oil. The master copy of this document is held electronically within Premier's Document Management System. If you are using a paper copy or a digital issue of this document, it is your responsibility to ensure it is the latest version.	FK-SL-PMO-EV-REP-0008	B04

PremierOil

Table of Contents

List of Figures

List of Tables

1 NON-TECHNICAL SUMMARY

Table of Contents

1.1 Introduction

Premier Oil Exploration and Production Ltd (Premier) is proposing to develop the Sea Lion Field in the North Falkland Basin (NFB) with a view to the long-term production and export of oil. The first phase of this field development is referred to as 'Phase 1'.

Premier will conduct all operations in compliance with its Health, Safety, Environmental and Security (HSES) Policy, which requires that Premier do all that is reasonably practicable to prevent major accidents and minimise environmental impacts.

In line with Falkland Islands legislation and its HSES Policy and Management System (MS), Premier has conducted a full Environmental Impact Assessment (EIA) of the Phase 1 Development.

The EIA was carried out in line with:

- Falkland Islands Government (FIG) Environmental Planning Department (EPD) Hydrocarbons Environmental Impact Assessment Guidance Note (FIG, 2015m).
- Corporate Premier Standard: Environmental and Social Impact Assessment (CP-BA-PMO-HS-SE-ST-0001).

The detailed outcomes of the EIA process are reported in the Environmental Impact Statement (EIS) and the key outcomes are précised in this Non-Technical Summary (NTS). Following submission to FIG (who have determined that the EIS is compliant with legislation), a copy of the full EIS is available on request from the Premier office in Stanley (sealion.enviro@premier-oil.com).

This version of the Sea Lion Environmental Impact Statement (EIS) reflects the Sea Lion Phase 1 Project at the end of the design stage and details a number of changes and optimisations from the project EIS that was submitted and consulted on in 2018 (see Section 1.4).

1.1.1 Purpose of the EIA

The main purpose of the EIA is to answer the following six questions:

1) What is the context within which the proposed Development is being carried out?
   - What do the regulations and the Premier HSES-MS require?
2) What does the Phase 1 Development involve?
   - What activities are involved in the proposed Development? In other words, what is the '**Phase 1 Development Description**'?
   - Are any mitigation measures built-in to the Development design to minimise interactions with the environment and the human population? In other words, what are the '**Base-Case Mitigations'**?
3) What do the stakeholders think about the proposed Development?
   - What do the Falkland Islands Government (FIG) and its consultees think? What do the Falkland Islands public think? The answers to these questions were invited during '**Scoping Consultations**' and the purpose of this '**Formal Consultation**' is to elicit further comment.

4) What are the existing environmental and social attributes and sensitivities in the area?

– What is known about the local environment and the local human population? For example, what species of marine mammals or seabirds, are found in the area? When are they there? What are they doing there? How important is the population that could be impacted upon? Do they have international or local protected status? This is called the '**Environmental and Social Baseline**'.

5) What are the environmental and social impacts and risks associated with the project activities?

– How might the Development interact with the environment and / or the human population? In other words, what are the associated '**Environmental and Social Aspects**'?

– How are the impacts and risks assessed? In other words, what is the '**Impact and Risk Assessment Methodology'**?

– What are the environmental and social impacts of these interactions? What impacts and risks are associated with the planned activities and accidental or unplanned events? Are the potential impacts and risks significant? What are the '**Key Findings of the EIA'**?

6) What is Premier doing to reduce the potential impacts and risks?

– What if an impact or risk is considered to be significant despite compliance with legislation, the use of industry-standard practice and the 'base case' mitigation measures? Will additional actions be taken to remove, minimise or monitor the impact or risk?

– All mitigations and monitoring commitments will be summarised in the '**Project-Specific Environmental Monitoring and Management Plan**' which will remain 'live' (be continually reviewed and updated) for the life of the field.

Numerous steps are involved in conducting an EIA and in answering the questions above. This NTS briefly outlines the planned Development and describes the key outcomes of the EIA.

1.2 The Sea Lion Field

The Sea Lion Field is an oil field, oil and gas are trapped in underground sandstone rocks approximately 2.5 km below the seabed, in water depths of approximately 450 m. It is likely that there is a gas accumulation (or 'gas cap') overlying some of the oil. The existence of the gas cap will be determined during development drilling operations. The field is located approximately 220 km to the north of the Falkland Islands in Block 14 / 10. Premier propose the development of the Sea Lion Field in accordance with the Production Licence areas PL032 and PL004b granted by the Falkland Islands Government (Figure 2.1).

The Sea Lion Field is the first potentially commercially viable hydrocarbon discovery in the NFB and was discovered by Rockhopper Exploration plc in 2010. With regard to oil production, a field life of 20 years has been projected and it is estimated that the Phase 1 Development can recover approximately 250 million stock tank barrels of oil in this time.

The crude oil discovered in the Sea Lion Field has a high wax content such that it needs to be kept at an elevated temperature throughout the production and export process to ensure that it can flow.

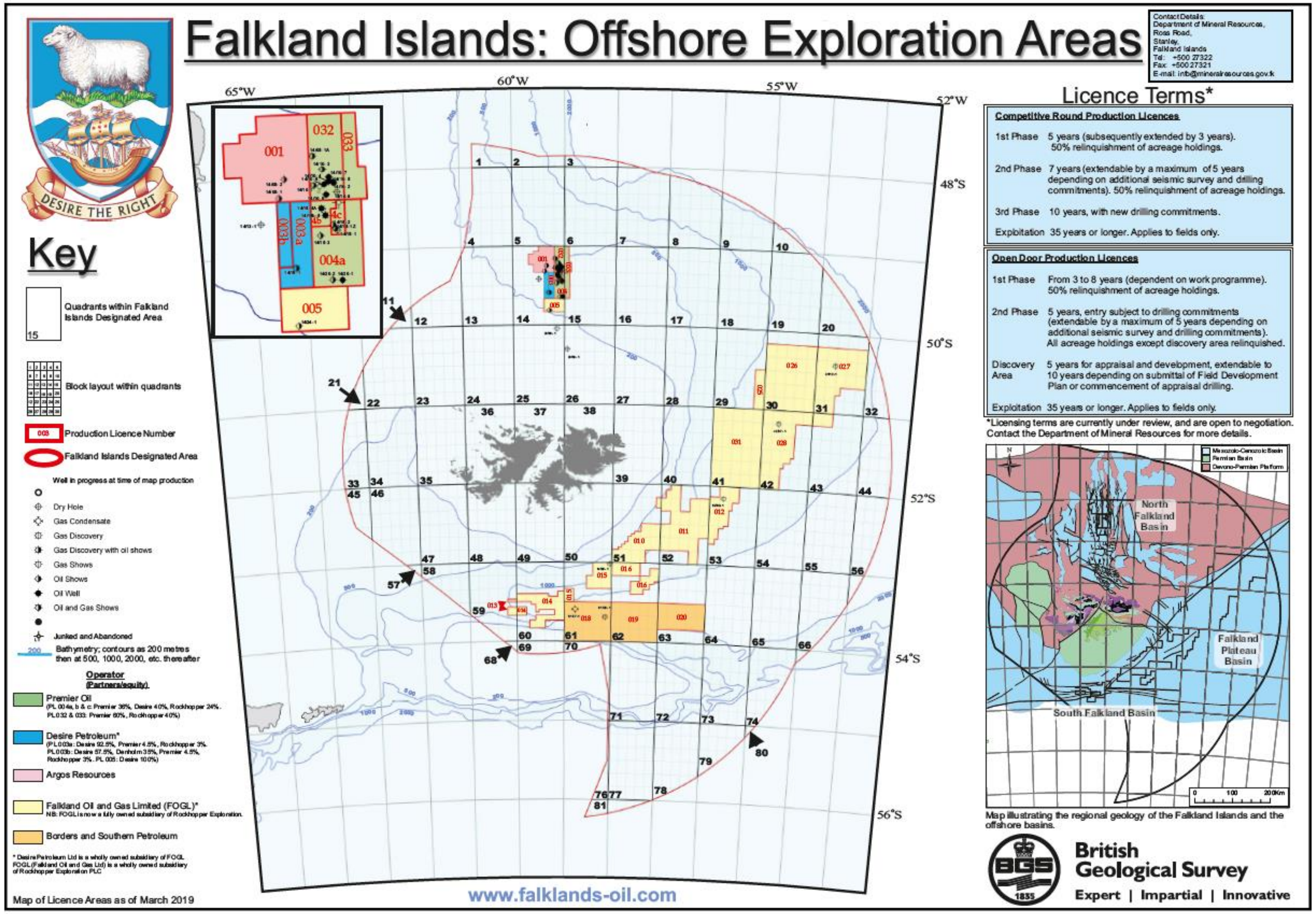


Figure 1.1: Sea Lion Field and Licence Block Locations

1.3 EIA Context

To answer 'Question 1' above, the following information summarises FIG's regulatory requirements, and those of the Premier HSES-MS, both of which define the context within which the EIA was carried out. Full details on both is provided in Chapter 3 of the EIS.

1.3.1 Regulatory overview

The Falkland Islands is one of 14 UK Overseas Territories (UKOT) as defined under the British Overseas Territories Act 2002.

The Environmental Charter is a joint agreement between FIG and the UK Government that was signed in 2001. The Charter lists ten guiding principles and 11 commitments. All commitments are intended to ensure effective environmental management within the Islands.

Environmental legislation that applies to Oil and Gas (O&G) activities within the Falkland Islands is based upon the regulatory requirements for the United Kingdom Continental Shelf (UKCS). In early 2018, updated legislation in the form of the Maritime Ordinance (2017) and Harbours and Ports Ordinance (2017) came into effect. The Maritime Ordinance, which was amended in 2019, in particular contains new legislation relating to offshore oil pollution.

Legal compliance and the preparation of required consents will be based on current FIG legislation (where it exists) with reference to UK legislation and guidance. In the event that FIG legislation is enacted in the future, this will supersede UK legislation.

Existing Falkland Islands legislation relevant to the O&G industry is as follows:

- Offshore Minerals Ordinance 1994 (1997 and 2011 Amendments).
- Offshore Petroleum (Licensing) Regulations 1995 (2000, 2004 and 2009 Amendments).
- Petroleum Survey Licences (Model Clauses) Regulations 1992.
- Marine Environment (Protection) Ordinance 1995.
- Environmental Protection (Overseas Territories) (Amendment) Order 1997.
- Maritime Ordinance 2017 (as amended (2019).
- Maritime (Oil Pollution Preparedness, Response and Co-operation Convention) Regulations 2019.
- Deposits in the Sea (Exemptions) Order 1995.
- Marine Mammals Ordinance 1992.
- Conservation of Wildlife and Nature Ordinance 1999.
- Fisheries (Conservation and Management) Ordinance 2005.
- Endangered Species Ordinance 2003.
- Planning Ordinance 1991.
- Planning (Environmental Impact Assessment) Regulations 2015.
- Falklands Interim Port And Storage System (FIPASS) Ordinance 1989.

- Harbours and Ports Ordinance 2017.
- Maritime (Registration of Ships) Regulations 2019.
- Merchant Shipping (Confirmation of Legislation)(Falkland Islands) Order 2018.
- Offshore Installations (Prevention of Fire, Explosion and Emergecny Response) Order 2008
- Offshore Installations (Safety Case) Order 2008.
- Oil in Territorial Waters Ordinance (1960).

Specific guidance on the Falkland Islands EIA process and the development of the EIS is provided in:

- FIG Environmental Planning Department (EPD) Hydrocarbons Environmental Impact Assessment Guidance Note (FIG, 2015m).

1.3.2 Premier Health, Safety and Environmental and Security Management System

As in all of its oil & gas activities, Premier will, as a minimum, adhere to its own corporate HSES Policy and HSES-MS Framework throughout the Phase 1 Development to ensure environmental management is considered at every stage.

In summary, and as a minimum, the Premier HSES-MS requires:

- Ongoing review of the environmental impacts and risks throughout the 'Define' (the detailed engineering phase) and 'Execute' (awarding contracts to start the work) project development processes to ensure that they have been reduced to, and remain, 'As Low As is Reasonably Practicable' (ALARP);
- Development of 'Specific, Measurable, Attainable, Relevant and Time-measured' (SMART) environmental objectives and targets to ensure continual improvement in the management of aspects and impacts where possible;
- Development and implementation of project-specific management plans where necessary;
- Development of operation controls based on a safe system of work;
- Training and competency of relevant personnel;
- Monitoring and measuring e.g. of emissions, discharges to sea, waste etc.;
- Internal and external environmental performance reporting;
- Internal, external and third party auditing during contractor selection and pre-mobilisation processes and throughout field life;
- Contractor selection strategy and management;
- Incident reporting and investigation;
- Emergency response; and
- Annual management reviews.

The HSES-MS will apply through all subsequent Phases of the development. Full details on the Premier HSES-MS are provided in section 3.2 of the EIS.

1.4 Phase 1 Development description

To answer 'Question 2' above, the following sections provide a summary of:

- The activities that will be required during the proposed Phase 1 Development to enable the production of oil from the Sea Lion Field; and
- The base case mitigations that are built-in to the basis of design.

The full Phase 1 Development Description is provided in Chapter 5 of the EIS.

1.4.1 Activities associated with the Development

1.4.1.1 Drilling and installation of subsea infrastructure

The proposed Phase 1 Development is expected to consist of 28 clustered oil production and Water Injection (WI) wells drilled across three Drill Centres (DC, the Main, Eastern and Southern DCs), and a remote Gas Production / Injection (GPI) well. If the remote GPI well has insufficient gas flow an additional remote GPI well will be drilled in the south west flank of the field. In this case the development will comprise 30 wells in total. All wells will be drilled by a Mobile Offshore Drilling Unit (MODU). Whilst the base case comprises up to 30 wells, the final number of wells that will be drilled will depend upon the characteristics of each well that is drilled and could be less than 30. The MODU will be anchored to the seabed and surrounded by a 500 m exclusion zone, supported by up to two Multi-Role Support Vessels (MRSVs) and a Platform Support Vessel (PSV), which will also act as supply vessels and an Emergency Response and Rescue Vessel (ERRV).

Figure 1.2 shows the layout of the Sea Lion Field with both the MODU and Floating Production, Storage and Offloading vessel (FPSO) present. An FPSO will be used to produce the fluids from the wells. The FPSO will be anchored to the seabed, surrounded by a 500 m exclusion zone. The FPSO will be located approximately 2.1 km from the main Drill Centre (DC), 3.0 km from the Southern DC, 1.6 km from the Eastern DC and approximately 6.0 km and 5.8 km from the remote GPI well(s) locations, respectively.

The GPI well(s), which access a different part of the underground reservoir, will be set apart as remote well(s). The first GPI well will be about 6.0 km to the southwest of the FPSO and the second, if required, will be located approximately 5.8 km further to the southwest (Figure 1.2).

The maximum well count (30 wells) will comprise:

- Twenty oil production wells;
- Eight Water Injection (WI) wells; and
- Up to two remote Gas Production / Injection (GPI) wells.

Up to four of these wells will be cleaned up, i.e. removal of debris from the well bore, by the MODU. These hydrocarbons would then be flared offshore for approximately one day for each well. If the first four well clean ups demonstrate that the wells initially return volumes and/or types of debris that could damage the swivel system on the FPSO, then, as a worst case scenario, all oil and gas production wells would be cleaned up by flaring via the MODU – i.e. 22 in total. The decision to clean up the remaining eighteen wells would be performed in consultation with FIG and will require FIG approval. It is anticipated that a separate submission will be made to FIG detailing the objectives of the clean-up(s) and the arrangements and control measures on the MODU, in line with UK practice.

To support the Development, six subsea manifolds and an array of subsea pipelines, 'umbilicals' and 'risers' will be installed to connect the wells at the seabed with the FPSO at the surface. The six manifolds will comprise three WI manifolds and three production manifolds.

While drilling of the wells is underway, installation of the subsea production facilities will be undertaken by dedicated installation vessels.

It is anticipated that up to four Large Transport Vessels (LTVs) will be anchored in an inshore sheltered location, expected to be Berkeley Sound, for a combined period of c. 12 months. However, a maximum of two LTVs will be present at any one time. These LTVs will act as 'floating storage barges' from which equipment will be collected and taken out to Sea Lion for installation.

It is anticipated that drilling will start approximately 21 months after project sanction. When drilling starts, only the MODU, the supporting MRSVs and the installation vessels will be in the Field.

1.4.1.2 Hook up and commissioning of the Floating Production, Storage and Offloading (FPSO) vessel and first oil

Oil production and processing will be carried out from the FPSO ship-shaped vessel which will be anchored to the seabed and surrounded by a 1,275 m radius exclusion zone, which is effectively 500 m beyond the installation extremities (including the hose and tanker during crude oil offload). The term 'Hook Up and Commissioning' (HUC) refers to the process by which the FPSO is connected to the subsea wells, via the manifolds and the pipelines, umbilicals and risers (Figure 1.2).

Following HUC, it is expected that 'First Oil' will occur approximately 42 months after project sanction.

1.4.1.3 Simultaneous operations

After 'First Oil' there will follow a period of Simultaneous Operations (SIMOPS) with the MODU continuing to drill the remaining wells while the FPSO produces from the wells which have already been drilled, see Figure 1.2 below. During SIMOPS, both the MODU and the FPSO will be supported by two MRSVs.

Once all the wells have been drilled, the MODU will leave the Sea Lion Field and only the FPSO and its support vessels (two MRSVs, with one acting as an ERRV) will remain.

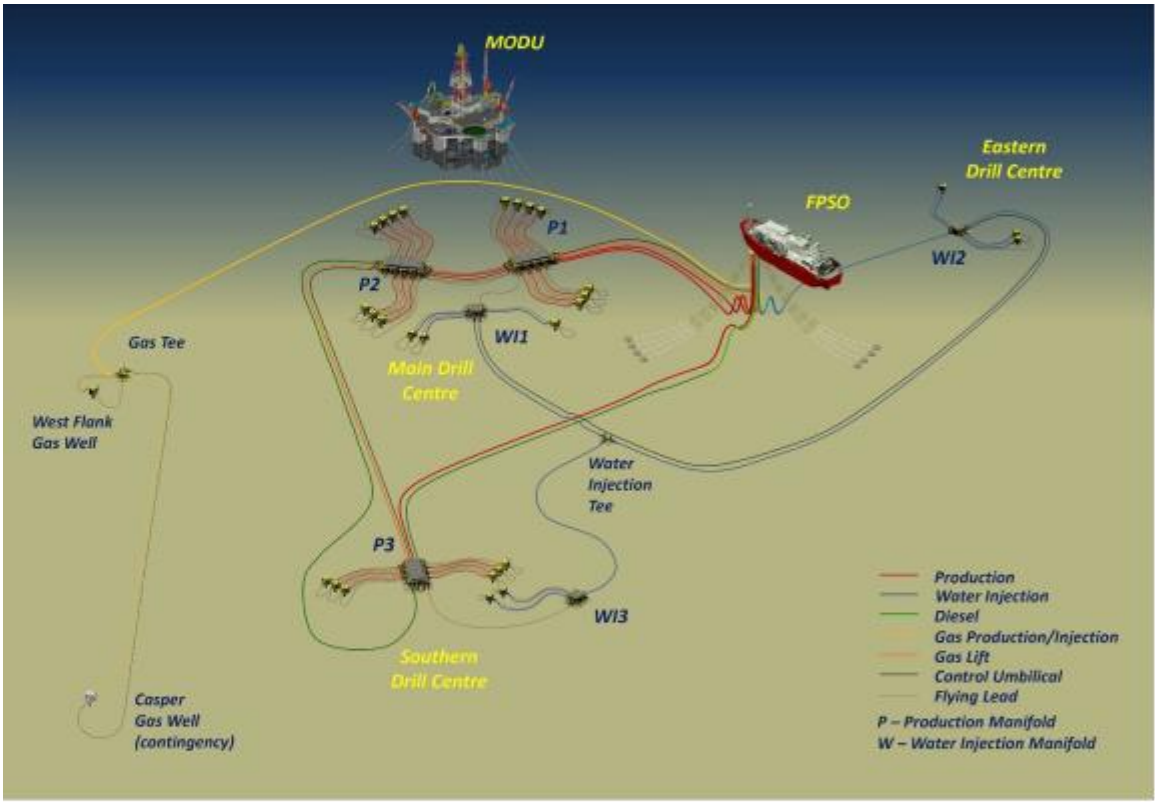


Figure 1.2: Graphic showing the Sea Lion Field in Simultaneous Operations with both MODU and FPSO present

1.4.1.4 Production

The oil production wells will produce reservoir fluids to the FPSO. The total produced fluids will consist of:

- Crude oil (the desired product);
- Associated hydrocarbon gas (arising from the gas cap in the reservoir, (if present) and gas dissolved in the oil which is liberated as the oil flows to surface i.e. the gas is 'associated' with the oil production); and
- Water (a by-product of the oil production which is referred to as 'produced water').

These three products will be separated and treated on the FPSO:

- The oil will be stabilised (i.e. made ready for export) and transferred to storage tanks within the FPSO hull for subsequent offloading and export (section 1.4.1.5);
- The associated gas from the production wells will be used:
  - As fuel to heat and power the FPSO; and
  - For 'gas lift' in the oil production wells, which reduces the density of the oil enabling it to flow at higher production rates.
    Note: During normal operations any excess associated gas will be re-injected back into the reservoir via the remote GPI well(s). In the event of a deficit in associated gas, the required gas volumes will be supplemented with gas produced from the designated GPI well(s); and

- The produced water will be cleaned to remove dispersed oil and any solids (e.g. sand, if present). During normal operations, produced water will be re-injected via the WI wells (in combination with treated seawater) to maintain pressure in the reservoir, thereby optimising oil recovery.

1.4.1.5 Oil export

Crude Oil export. will be via Direct Offtake i.e the crude will be directly offloaded from the FPSO to a purchaser's CTT at the Sea Lion location and from there the crude will be exported to market. To ensure that the offloading operating conditions are maintained within strict limits, Direct Offtake will require an Offshore Support Vessel (OSV, i.e. a pull back tug) to attend the CTT offshore, in addition to the presence of the ERRV, which is always on standby.

Previous versions of the development EIS included descriptions of a potential inshore transfer option for the export of crude oil however, this option has been rejected and as a consequence, the only planned Sea Lion operations in Berkeley Sound relate to logistics support for the subsea installation campaign(s). The Environmental and Social aspects of Berkeley Sound are therefore still described in Section 7 in order to allow assessment of the remaining (short-term) LTV activities in Berkeley Sound in support of the Phase 1 Subsea construction campaign.

1.4.1.6 Logistical support

The logistics and infrastructure support required by the Sea Lion Phase 1 project includes:

- **Port facilities and onshore supply base:** including the Temporary Dock Facility (TDF) already established in Stanley Harbour together with onshore laydown yards, storage bases and offices in the Gordon Lines area of East Stanley;
- **Use of vessels:** for the movement of materials and equipment, installation of the infrastructure and support;
- **Personnel transportation facilities:** including for fixed-wing flights, helicopters and land transportation; and
- **Use of resources:** e.g. accommodation, freshwater, electricity, fuel, roads and waste management / disposal facilities.

1.4.1.7 Decommissioning

At the end of field life, expected to be 20 years after commencement of production, the FPSO and all associated subsea infrastructure and pipelines, will be decommissioned and removed from the NFB in accordance with regulatory requirements in place at that time. Decommissioning will be subject to a separate EIA, submitted at a time to be agreed with FIG (most commonly a few years prior to the cessation of production).

1.4.2 Base-case mitigations

FIG legislation, Premier's corporate standards and industry standard practices will be followed to reduce the potential impacts associated with the above planned activities, and to minimise the likelihood and / or consequences of unplanned events or accidents. The legislation and industry standard practices relevant to each activity are detailed in the impact and risk assessment chapters of the EIS (Chapters 10, 11 and 12).

It is important to note that, where possible, a number of best-practice mitigations are built-in to the design of the facilities. These serve to minimise the impacts of the Development by reducing the outputs or activities that might lead to impacts in the first place (e.g. technologies to reduce the amount of gaseous emissions, measures to minimise anchoring of vessels). These are referred to as the base case mitigations and are summarised in Table 1.1.

Table 1.1: Summary of the mitigations built-in to the Phase 1 Development basis of design

Project activity	Mitigations built-in to the Phase 1 basis of design
General	• All materials, fittings and system contents contained in the FPSO hull will be non-toxic, non-smoke emitting, fire retardant or 'low flame spread'.
Drilling and production	**The following will reduce the amount of atmospheric emissions:** • The main fuel supply for the FPSO will be produced associated gas; • Waste heat will be recovered for use to reduce fuel consumption / CO_2 emissions from generating heat; • No planned flaring during normal production (notwithstanding the flare pilot light); • Use of a Flare Recovery Package during normal operations; • No venting from the FPSO during normal production; • Use of Vapour Recovery Package during normal operations; • Back-up inert gas generator for use as cargo tank 'gas blanket' in the event that the Vapour Recovery Package malfunctions to prevent venting of hydrocarbon gas; • Use of Fluorinated-Gases with the lowest Global Warming Potential; • Use of Marine Gas Oil instead of Intermediate Fuel Oil (i.e. a lighter fuel) when operating inshore; and • Application of Best Available Technique to the incineration process, if required, to ensure appropriate flue gas treatment that minimises emissions of pollutants to levels as low as reasonably practicable and that achieves the relevant standards of air quality. **The following will reduce the volumes of drilling discharges:** • Use of seawater sweeps, bentonite and water based mud for tophole drilling; and • Batch drilling to optimise drilling mud use. **The following will reduce the volumes of, or negate the need for, discharges of oil and chemicals to sea:** • Produced Water Reinjection (PWRI) to alleviate the need to discharge produced water to sea during normal production operations; • Diversion of produced water to dedicated 'off-spec' temporary storage tanks for later retreatment in the event that PWRI is unavailable and the water is not compliant with discharge specifications; • Subsea and topside technical flow assurance measures, e.g. insulation and heating, will minimise the use of 'flow assurance' chemicals; and

Project activity	Mitigations built-in to the Phase 1 basis of design
	• Oil in ballast tank detection on the FPSO. **The following will reduce the volume of oily waste returned to shore:** • Use of a Thermomechanical Cuttings Cleaner during drilling which will clean-up drill cuttings on the rig so they may be discharged to sea, reducing the amount of oily waste sent to shore for treatment. **The following will reduce the volume of waste being returned to the UK for disposal:** • Use of the planned FIG Waste Management Facility to treat and dispose of project wastes, as available; or • In the event that the FIG Waste Management Facility is unavailable to project wastes, Premier may install a portable incinerator at the supply base for the burning of suitable waste streams. The resultant ash from the incineration process will be returned to the UK for disposal if a suitable disposal route cannot be established on the Falklands. **The following will reduce the competition for resources:** • Use of buffer storage water tanks at the TDF, the mud plant and potentially the at-shore bulk supply base to ensure management of peak water use requirements.
Oil spill *prevention* measures	Note that many industry standard spill prevention measures must be built-in to the basis of design. Therefore, there are very few ‘extra’ base case mitigation options available as they are all required as standard. However, for the sake of completeness, it is important to describe these measures here. **Spill prevention measures built into the FPSO include:** • The cargo and forward diesel tanks will be double-skinned; • Bunding of all liquid containing equipment and chemicals; • Hazardous and non-hazardous open drains to route any deck spills to a dedicated slop tank; • High level tank filling alarms and emergency shutdown of the process; • FPSO offloading quick-break hose connectors to prevent spills on unplanned disconnection; and • Automatic Identification Systems (AIS) and Marine procedures to prevent collisions. **Spill prevention measures built into the well design include:** • Development of the appropriate, and peer reviewed, well design; • Use of appropriately weighted drilling muds; • The use of appropriate mud additives to ensure over-balanced drilling; and • Use of Blow-Out Preventers (BOP) and production X-mas trees. **Preventative measures built into the CTT nomination and selection include:** • Cargo tanks, and potentially the fuel tanks, of the vessel will be double-skinned; • Vetting and auditing prior to acceptance of the nominated vessel; • Premier personnel (including loading master and Pilot) on-board the CTT to manage the mooring and cargo transfer process; • Cargo tank high level and high-high level alarms to prevent overfilling;

Project activity	Mitigations built-in to the Phase 1 basis of design
	• Bunding of all liquid containing equipment and chemicals; and • Open deck drains to catch and collect spills to a dedicated slop tank. Further detail on the industry standard preventative mitigations are described in section 12.1.5 of the main EIS.

1.5 Scoping consultation

To answer 'Question 3' above, the following section describes the scoping consultation processes, which were carried out to identify any concerns that the stakeholders (including the Falkland Islands public and consultees) had regarding the Phase 1 Development. The consultations were carried out in line with the FIG EPD EIA Guidance (2015m) and were intended to:

- Inform the stakeholders about the proposed Development;
- Identify stakeholder concerns; and
- Ensure that the EIA adequately addresses stakeholder concerns.

As advised by the FIG EPD EIA Guidance (2015m), the stakeholders consulted by Premier included:

- Local authorities;
- Conservation groups;
- Naturalists;
- Special interest groups;
- Other users of the sea; and
- The general public.

Scoping consultations for the proposed Phase 1 Development were carried out between 2014 and 2016, prior to formal submission of the EIS, and at various stages in the planning process. Details on the pre-submission scoping consultations and their outcomes, are provided in Chapter 6 of the EIS.

During scoping consultations, numerous questions were asked, and issues raised by the stakeholders. All representations were taken into account during the EIA process, and are recorded in the EIS. The issues that were identified as key areas of concern for stakeholders were:

- Control of vessels and general management in Berkeley Sound;
- Oil spill mitigations and clean-up;
- Onshore infrastructure;
- Environmental Offsetting;
- Decommissioning;
- The impact of this particular type of crude on the marine environment;

- Jobs, employment and numbers of people; and
- Standards and governance.

Note: following formal submission, this EIS will undergo a formal 42-day consultation process. The outcomes of this formal consultation, and Premier's responses to any representations, will be recorded in Chapter 17 of the final EIS.

Note: a previous version of this EIS (Premier, 2018) has already been through this process.

1.6 Environmental and social baseline description

To answer 'Question 4' above, the following sections aim to summarise the current environmental and social baseline information. It is necessary to describe the baseline in sufficient detail to:

- Understand what is currently present, the 'baseline'. For example, what benthic (seabed) communities, fish, birds, marine mammals are in the area, what is the current condition of the seabed, what resources are available in the Falkland Islands, the local human populations and who else uses the offshore and inshore locations?;
- Understand the sensitivity of the receptors. For example, what are the population sizes of the species present, what are they doing there, are they vulnerable, are they protected, are they commercially important or important for other users, are stakeholders concerned?;
- Determine whether there are data gaps and if, or how, these could affect confidence in the impact assessment; and
- Provide a reference point of comparison for future monitoring that will be carried out by Premier to determine whether or not the Phase 1 Development has had any discernible environmental or social impacts and to validate the results of the EIA.

1.6.1 Key environmental sensitivities

Understanding the attributes of the NFB, the Sea Lion Field and Berkeley Sound area was informed by:

- Extensive literature reviews;
- Historical environmental surveys conducted in the area by various parties since the mid-1990's; and,
- Further surveys carried out by Rockhopper and Premier between 2012 and 2019.
  - Note: The Premier survey reports can be requested from sealion.enviro@premier-oil.com.

The Patagonian Shelf, on which the Falkland Islands archipelago is located, is one of the most biologically productive areas in the South Atlantic. Two marine ecosystems, the sub-Antarctic ecosystem and the southern temperate ecosystem, are separated by a transition zone, which runs through the Falkland Islands. Further, the area is dominated by two different oceanic currents.

The resulting mixing of water masses produces areas of high biological productivity, including one on the edge of the Continental Shelf to the south of the Sea Lion Field. This productivity supports high biomass of plankton in the NFB, which forms the basis of marine ecosystem food chains, on which many species of larger animals such as fish, seabirds and cetaceans depend.

The inshore area of Berkeley Sound is important given its regular use by the fishing and tourism industries, as well as wildlife. The Sound is used by a variety of protected marine mammals and protected birds. Moreover, the entrance to Berkeley Sound is flanked by two National Nature Reserves (Volunteer Point and Cow Bay, and the Kidney Island Group), which are also classified as Important Bird Areas (IBAs).

Potentially sensitive habitats identified within Berkeley Sound that are equivalent to those of conservation significance in the UK, as defined by the Offshore Marine Conservation of Habitats Regulations (which implement the EC Habitats Directive), include biogenic reefs (reefs created by living organisms), geogenic reefs (created by geological processes) and kelp forests.

The key biological sensitivities of the Falkland Islands offshore environment and Berkeley Sound are summarised in Table 1.2 and Table 1.3 , respectively. In order to provide an overview of the environmental sensitivities, the tables indicate the relative importance of each month, regardless of the particular species, fishery or site that is driving the sensitivity.

Table 1.2: Summary of key environmental sensitivities in the Sea Lion Phase 1 Development area

Environmental baseline and sensitivity at Sea Lion											
Low[a]				Medium[a]				High [a]			
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Plankton: Plankton comprises of small to microscopic plants (phytoplankton) and animals (zooplankton) that drift in the surface layers of the sea. Phytoplankton require sunlight, like all other plants, to survive, and zooplankton graze upon the phytoplankton or prey on other zooplankton. The oceanic fronts around the Falkland Islands result in nutrient rich waters which create an area of very high phytoplankton productivity immediately to the north of the Islands (and approx. 60 km to the south of the Sea Lion Field). This phytoplankton productivity is seasonal and in turn supports complex communities of zooplankton, which then support complex pelagic (in the water column) and demersal (near the seabed) ecosystems.											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Marine flora: Not applicable to offshore location.											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Benthic fauna: Benthic fauna are those animals which live on, or below, the seabed. Overall, benthic fauna around the Sea Lion area is very uniform, with polychaetes (i.e. marine worms) and crustaceans (e.g. crabs) being the two most abundant groups present, followed by molluscs (e.g. clams).											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fish and shellfish: The convergence of the temperate and sub-Antarctic regions in the Falkland Islands archipelago results in the presence of species belonging to both. The six sub-Antarctic, and seven temperate, fish and squid species found in abundance in Falkland Islands' waters primarily utilise the NFB as feeding grounds, migrating in and out of the area as food availability changes and to follow seasonal spawning migrations. Other species feed in the area as juveniles and move to deeper waters as they mature and become adults. This results in seasonal changes in the fish assemblages across the ecosystem.											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Seabirds: Over 70 % of the global population of black-browed albatross breed on the Falkland Islands with a significant proportion of the global populations of gentoo and rockhopper penguins doing the same. The waters surrounding the Falklands also support numerous species that breed elsewhere. Of the species recorded in the Sea Lion area, the Atlantic petrel, grey-headed albatross, and northern royal albatross are all listed as 'Endangered' on the IUCN Red List, and the southern rockhopper penguin, white-chinned petrel, southern royal albatross and the wandering albatross are listed as 'Vulnerable'.											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Marine mammals: Confirmed records indicate that 25 species of cetacean (whales, dolphins and porpoises) occur within Falkland Islands waters and three species of pinniped (seals) breed on the Islands. Many of the cetacean species are rare and inconspicuous and some are only known from stranded animals. Of these 25 cetacean species, two species are listed as 'Endangered' on the IUCN Red List, namely the sei whale, and one species, the sperm whale, are listed as 'Vulnerable'.											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Conservation sites: There are no designated marine protected areas in Falkland Islands waters. However, work is ongoing to identify marine areas that support important aggregations of seabirds and other fauna. On land, a number of Important Bird Areas (IBAs) have been designated and the influence of these extends 15 miles into the surrounding marine environment. Additionally, a network of National Nature Reserves (NNR) and Important Plant Areas (IPAs) protect many of the most important seabird breeding sites and areas supporting native flora respectively.											

[a] Note that the terms Low, Medium and High in this context provide a guide only as to the general sensitivity / abundance as it is relevant to each receptor. Specific sensitivities of each receptor to each environmental impact are explored in full within the EIS.

Table 1.3: Summary of key environmental sensitivities in Berkeley Sound

Environmental baseline and sensitivity in Berkeley Sound											
Low[a]				Medium[a]				High [a]			
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Plankton: Plankton comprises small to microscopic plants (phytoplankton) and animals (zooplankton) that drift in the surface layers of the sea. The most conspicuous component of the inshore zooplankton community is lobster krill, which is an important prey species for higher predators (such as penguins and whales).											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Marine flora: Marine plants are the major primary producers in the marine environment. The most common species of seaweed within the Falklands are the giant kelp and the tree kelp, which are found around the entire Falklands coastline. Kelp is a habitat forming species and is a very important part of the inshore ecology.											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Benthic Fauna: Benthic fauna are those animals which live on, or below, the seabed. Berkeley Sound supports a wide range of benthic habitats (including biogenic and geogenic reefs), each supporting a characteristic range of species. Although none of the species found is rare or protected under any Falkland Islands legislation. Work is ongoing to identify important marine areas, and as such work develops, new designations can be incorporated in the ongoing management of the project via the EMMP and the 5-yearly review of the EIS.											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fish and shellfish: The most conspicuous species found inshore off the east coast is loligo squid, which play a key role in the inshore ecology as predator and prey. In addition, loligo support the second largest fishery in the Falklands. Loligo are known to migrate inshore to spawn, although the key spawning sites remain unknown. Periods of 'high sensitivity' reflect the spawning periods of the two loligo cohorts. There are several species of shellfish found within Berkeley Sound that are commercially exploited elsewhere but not currently in the Falklands.											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Seabirds: Berkeley Sound encompasses significant breeding populations (>1% of the national population) of gentoo and rockhopper penguins and a far higher proportion of the national populations of king penguins, sooty shearwaters and white-chinned petrels. In addition to king and gentoo penguins, there are large resident populations of imperial and rock shags and Falklands steamer ducks, which are present year-round. Of the species breeding in Berkeley Sound the white-chinned petrel, southern rockhopper penguin and Cobb's wren are listed as 'Vulnerable' on the IUCN Red List.											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Marine mammals: Berkeley Sound supports small breeding populations of South American sea lions (Diamond Cove), South American fur seals (Volunteer Rocks) and is likely to have breeding populations of Commerson's and Peale's dolphins. Conspicuous seasonal visitors include sei whales, which are most numerous in the late summer and autumn. Several other species of large whale have been recorded within Berkeley Sound including southern right and Antarctic minke whales. An unprecedented influx of southern right whales was recorded during the winter of 2017.											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Conservation sites: The entrance to Berkeley Sound is flanked by two National Nature Reserves (Volunteer Point and Cow Bay, and the Kidney Island Group), which are also classed as Important Bird Areas.											

[a] Note that the terms Low, Medium and High in this context provide a guide only as to the general sensitivity / abundance as it is relevant to each receptor. Specific sensitivities of each receptor to each environmental impact are explored in full within the EIS.

1.6.1.1 Data gaps

1.6.1.1.1 The Gap Analyses Programme

The Falkland Islands Offshore Hydrocarbons Environmental Forum (FIOHEF) was established in 2011 to facilitate discussion of environmental issues relating to current and future hydrocarbon activities in the Falkland Islands. FIOHEF established a subcommittee, the Gap Analyses Group, to examine the data gaps that needed to be filled in order to better inform and monitor the potential environmental impacts from offshore hydrocarbon activities in the Falkland Islands.

Data gaps of most relevance to the development were identified and prioritised according to the urgency with which it was perceived that the data was required:

- Offshore benthic ecosystems with regard to collation of data, infauna sampling, sedimentology and chemistry;
- Oceanography in relation to oil spill modelling with regard to hydrographic dynamics, temporal and water column dynamics;
- Seabirds with regard to priority species and temporal movements; and
- Marine mammal (pinnipeds and cetaceans) with regard to populations and breeding activity, spatial and temporal distributions (described further in section 7.2.4.2).

Much of the data will take a number of years to collect and assimilate, and this is ongoing. There has however, been significant progress in many areas, e.g. oceanography, offshore benthos and marine mammal distribution. In this EIS, best available data has been used for the assessments including outputs from the Gap Analyses Programme (GAP) Project and parallel studies related to its recommendations.

1.6.1.1.2 Key data gaps relevant to the Sea Lion EIA

The GAP project is complete with most results available and it is considered necessary to acknowledge the outstanding and project-specific data gaps that have been identified during the Sea Lion EIA process.

The key data gaps of relevance to the Sea Lion EIA are:

- General:
  - Impact of sea lion crude on fur;
  - Predicting the likelihood of introducing invasive species;
  - Auditory sensitivity of penguins and marine mammals;
  - Quantifying the impact of bird strikes;
  - Impact of long-term noise and actual noise outputs from the operations;
  - Adhesion of Sea Lion crude oil on fur;
- Offshore environment (NFB and Sea Lion Field):
  - Inter-annual distribution and abundance of marine mammals in the NFB;
  - Seabird distributions;
  - Benthic habitats and fauna at the Sea Lion drill centre and flowline locations specifically;

- Inshore environment (Berkeley Sound):
  - Location(s) of loligo spawning grounds; and
  - Inter-annual distribution and abundance of marine mammals.

1.6.1.1.3 Management of data gaps within the Sea Lion EIA

Data gaps identified during the EIA process (those based on a total absence of data and those where the results from the GAP project are pending) are specified in the respective impact and risk assessment chapters in the EIS (Chapters 10, 11 and 12). While a precautionary approach was taken during all the impact and risk assessments, it is important to note that the identification of data gaps was pivotal in determining the level of confidence in the assessment, as is described in the EIA Methodology (Chapter 8 of the EIS).

Where data gaps had the potential to undermine assessments of the 'Sensitivity of Receptor' or the potential 'Severity of Effect' associated with an activity, the confidence in the assessment was indicated to be either 'Probable' or 'Uncertain' (as opposed to 'Certain'). In turn, the level of confidence in the assessment was used to inform the monitoring requirements for each potential impact / risk (see again the EIA Methodology in Chapter 8 of the EIS).

To enable identification and agreement on reasonably practicable monitoring options, a workshop to consider the contents of an Environmental Monitoring and Management Plan (EMMP) to accompany the Sea Lion oil field Environmental Impact Statement (EIS) was held in Stanley, Falkland Islands on 23-25 April 2019. It was attended by 25 interested stakeholders, comprising FIG, PMO, industry bodies and NGOs. Consideration was given to eleven environmental impacts from the Sea Lion development where there was potentially a need for further certainty as to the actual impact. The Summary EMMP tables are provided below (section 1.8; Chapter 15 in the full EIS). International researchers will continue to be engaged in the EMMP process through workshops and collaborative peer review so the work has international standing and transparency.

1.6.2 Key social sensitivities

As of the 2016 census, the permanent population of the Islands stands at 3,200. The majority of the population reside in the capital, Stanley, which is the main town on the Islands and is situated on East Falkland. The key social sensitivities of the Falkland Islands are summarised in Table 1.4.

Table 1.4: Summary of key social sensitivities in the Sea Lion Phase 1 Development area

Social baseline and sensitivity											
Low[a]				Medium[a]				High[a]			
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Commercial fisheries: The two most important fisheries within the Falklands Economic Exclusion Zone (EEZ) are the jig fishery for Argentine shortfin squid and the trawl fishery for Patagonian long-finned squid, which accounted for 54% and 20% of the 2012 – 2018 catch by weight respectively. There is also a fleet of trawlers that operate over the Falklands continental shelf that target a range of finfish species. Currently, the only other fishery in the Falklands EEZ is the longline fishery for Patagonian toothfish, which operates in deeper waters (≥ 600 m).											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tangible property and resources: There is a range of onshore infrastructure on the Falkland Islands that will be utilised during the Phase 1 Development, which could lead to competition for resources with other users of these facilities. The main areas of potential impact include the use of: port facilities, supply routes, airports and airlinks, the road network, accommodation, freshwater and electricity supply. During the austral summer period, accommodation, flight availability and freshwater may all be less available.											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tourism: The majority of tourists visiting the Falkland Islands arrive on cruise ships. Many cruise ships visit locations in the west of the Islands to see wildlife and most vessels visit Stanley. Within Stanley, there are a number of businesses and individuals that support tourist excursions to locations within driving distance of the town. Many of these sites are important for the wildlife that they support; however, they are also important recreational sites for residents.											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Marine archaeology: The UK Hydrographic Office Wreck site database indicates that there are 177 wrecks recorded within Falkland Islands waters, with records dating from the 1800's to present day. There are six recorded wrecks within 100 nautical miles of the proposed drilling sites; the closest of these wrecks is located approximately 50 nautical miles from the nearest well site. Two wrecks were identified within the Berkeley Sound survey area: the trawler *Ocean 8* to the northwest, and the *Blakeney* to the southeast.											

[a] Note that the terms Low, Medium and High in this context provide a guide only as to the general sensitivity as it is relevant to each receptor. Specific sensitivities of each receptor to each social impact are explored in full within the EIS.

1.7 Environmental and social impact and risk assessment

To answer 'Question 5' above, the following section provides:

- A description of how the activities associated with the proposed Phase 1 Development may interact with the environment e.g. the environmental and social aspects, impacts and risks;
- A brief summary of the EIA methodology;
- Key findings of the EIA including:
  - An overview of the overall EIA findings with regard to the initial and residual assessments; and
  - Narratives on the residual impacts (planned activities) and risks (unplanned / accidental activities) which remain of '**Moderate**' significance or above.
- A summary of *all* residual impacts and risks from *all* activities.

1.7.1 Environmental and social aspects, impacts and risks

All of the activities that will be carried out in the proposed Development have the potential to interact with the environment and the human population. The ways in which the Development activities may interact, and the potential impacts and risks associated with these interactions, were identified during an ENVironmental Impact IDentification (ENVIID) workshop (see Chapter 9).

In summary, the ways in which the planned Phase 1 activities and unplanned / accidental activities may interact with the environment and the human population are as follows:

- Environmental aspects:
  - Artificial light;
  - Disturbance to wildlife from use of helicopters;
  - Disturbance to the seabed / placement and removal of objects on the seabed;
  - Underwater noise offshore;
  - Underwater noise inshore;
  - Drill cuttings and mud discharges to sea;
  - Operational discharges to sea;
  - Thermal discharges;
  - Atmospheric emissions;
  - Waste;
  - Collisions between vessels and marine mammals;
  - Introduction marine non-native species; and / or
  - Introduction of terrestrial non-native species.
- Social aspects:
  - Disturbance to other users of the sea offshore;
  - Disturbance to other users of the sea inshore;
  - Competition for resources:
    - Accommodation;
    - Freshwater;
    - Electricity;
    - Air-links; and
    - Use of roads network.
  - Disturbance to the human population through:
    - Light; and
    - Helicopters and noise.

Note: The EPD EIA Guidance notes that some socio-economic impacts, such as tax revenues, wages, land values, are unlikely to be relevant within the scope of an EIA, though the above impacts were considered to be 'in scope'.

- Accidental events offshore, inshore and at-shore:
  - Loss of control leading to oil / chemical spill;
  - Small spills contributing to chronic oil pollution; and / or

– Fuel spill either from bunkering operations or from an accidental event.

Each activity carried out during the Development may lead to one or more of the aspects above and one or more associated impact or risk. For example, the use of vessels will result in the presence of artificial light, underwater noise, impacts to other users of the sea and atmospheric emissions whilst also carrying the risk of collisions. Therefore, the project activities, their associated environmental aspects and the environmental receptors on which they may impact upon are presented in Figure 1.3.

PremierOil

Identification of Environmental Aspects

Development activities	Environmental Aspects															
	Artificial light	Helicopter disturbance	Seabed disturbance	Underwater noise	Drill cuttings and mud discharge	Operational discharges	Thermal discharges	Atmospheric emissions	Waste	Collision with marine mammals	Marine species introduction	Terrestrial species introduction	Disturbance to others sea users	Competition for onshore	Nuisance factors [a]	Oil spill
Drilling operations	✓		✓	✓	✓			✓	✓				✓	✓		✓
Subsea works [b]	✓		✓			✓		✓	✓				✓	✓		✓
FPSO HUC [c]	✓					✓		✓	✓				✓	✓		✓
SIMOPS [d]	✓		✓	✓	✓	✓	✓	✓	✓				✓	✓		✓
Production	✓			✓		✓	✓	✓	✓				✓	✓		✓
Offloading from FPSO to CTT	✓			✓				✓	✓				✓	✓	✓	
Use of the onshore supply base	✓							✓	✓					✓		
Use of the TDF	✓							✓	✓				✓	✓		
Use of resources [e]																
Fixed-wing flights								✓				✓		✓		
Helicopter use	✓	✓		✓				✓						✓		
Vessel use	✓			✓		✓		✓	✓	✓	✓	✓	✓	✓		✓
Decommissioning																

[a] Onshore light, noise, odours and visual disturbance
[b] Installation of subsea infrastructure
[c] Hook-up and Commissioning
[d] Simultaneous drilling and production operations
[e] Accommodation, freshwater, airlinks, electricity, roads network

Identification of Environmental Impacts

Environmental aspects	Environmental receptors which may be impacted upon during planned activities and unplanned and accidental events:																	
	Physical				Biological								Social					
	Seabed (including	Water quality	Regional air quality	Global atmosphere	Marine flora	Plankton	Benthos	Fish / squid	Seabirds	Marine mammals	Designated sites	Biosecurity	Landscape / seascape	Human population	Other users of the sea	Tangible property / resources	Archaeology	Stakeholder concern?
Artificial light						✓		✓	✓	✓			✓	✓				✓
Helicopter use			✓	✓					✓	✓				✓		✓		✓
Seabed disturbance	✓	✓			✓		✓	✓										
Underwater noise						✓		✓	✓	✓								✓
Drill cuttings and mud	✓	✓			✓	✓	✓	✓	✓	✓		✓						✓
Operational discharges	✓	✓			✓	✓	✓	✓	✓	✓								✓
Thermal discharges	✓	✓				✓	✓	✓										✓
Atmospheric emissions	✓	✓	✓	✓		✓	✓		✓					✓				✓
Waste				✓					✓	✓	✓	✓	✓			✓		✓
Marine mammal collision										✓								
Marine invasive species					✓	✓	✓	✓				✓						✓
Terrestrial invasive species											✓	✓	✓	✓		✓		✓
Disturbance to other sea users			✓	✓						✓		✓	✓	✓	✓	✓		✓
Competition for onshore resource														✓		✓		✓
Nuisance factors														✓				
Oil spill	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓

Figure 1.3: Project activities and the identification of environmental aspects and the receptors, upon which they may impact

1.7.2 Impact and risk assessment methodology

To understand the impact and risk assessment process and the summary results presented below, it is necessary to appreciate that:

- *Impacts* to the environmental and human population may result from planned activities; and
- Each activity carries the *risk* of impacts occurring during unplanned and / or accidental events.

As shown in Figure 1.4, the *impact* is assessed by considering the 'Sensitivity of the Receptor' *and* the 'Severity of Effect' on that receptor. This then leads to an overall impact significance rating ranging from '**Very Low**' to '**High**'. Impacts of unplanned or accidental events are assessed in the same way while the *Risks* associated with these events take account of the 'Likelihood' of the event occurring. Taking account of the impact and the 'Likelihood of Occurrence' the significance of risk is then rated, again ranging from '**Very Low**' to '**High**'.

Impact	=	Sensitivity of the Receptor	x	Severity of the Effect
Risk	=	Impact	x	The likelihood that an unplanned or accidental event will occur

Figure 1.4: Illustration of the impact assessment for planned events and the risk assessment for unplanned and accidental events

When carrying out the EIA, the impact and risk assessments are each conducted twice:

- The *first* assessment takes account of the legal requirements and industry standard practices as well as the mitigations which are built into the base case (see section 1.4.2 above). The latter are included as these are already in place and are often included to minimise outputs e.g. emissions, discharges etc. This assessment describes the significance of the *initial* impact or risk (i.e. 'Very Low' to 'High').
- The *second* assessment takes account of any additional project-specific mitigations which are considered reasonably practical to further reduce the initial impacts and risks which were considered to be significant (i.e. 'Moderate' or above). Project-specific mitigations are those which are used in addition to any mitigations required by legislation either in the Falklands or the UK and / or are currently considered to be standard industry practice in the Falklands. This second assessment describes the significance of the *residual* impacts and risks.

All residual impacts and risks will be reduced to a level that is 'As Low As is Reasonably Practicable' (ALARP) throughout the EIA process and throughout the life of the Development.

The mitigation measures and commitments are listed in the Environmental Monitoring and Management Plan (EMMP) described in Section 1.8.1 below.

1.7.3 Offsetting

The Offshore Minerals Ordinance states that 'EISs must contain a description of offsetting.' Exco paper 124/16 (FIG, 2016d) details FIG's recommendations for developing offsetting guidance. This in turn has led to the development of Appendix 2 to the Hydrocarbons Environmental Impact Assessment Guidance Note (EPD, 2015).

The Exco paper states that 'hydrocarbon development should seek meaningful offsetting of any impacts which cannot be avoided or mitigated, specifically in relation to greenhouse gas emissions and biodiversity' (FIG, 2016d). The options for offsetting of these impacts include:

- Direct offsetting, i.e. the operator develops local projects to offset, like-for-like, the impacts arising from the development that cannot be avoided or mitigated; or
- An environmental fund whereby the operator contributes to a fund with a non-governmental panel to direct, manage and oversee various offsetting projects.

Following elimination and / or reduction of all the impacts and risks identified for the Sea Lion Field, Premier conclude that only tangible significant impacts / risks (impacts / risks assessed as 'Moderate' or above) may be offset.

Premier has reviewed the significant residual impacts and risks associated with the Development activities, and explored practicable, effective and locally beneficial direct offsetting measures in relation to these. In all instances, it has not been possible to identify appropriate direct offsetting projects that will benefit the local environment, and that are practicable for Premier to implement. Consequently, Premier will not pursue direct, like-for-like, offsetting for the significant residual impacts / risks associated with the Sea Lion Development.

Premier has also reviewed indirect offsetting. Indirect offsetting refers to implementing measures that do not directly compensate for the impacts / risks identified above but may provide opportunities to achieve environmental benefits in the Falklands in the longer-term. Such measures do not attempt to attain carbon neutrality nor seek to provide net gains in biodiversity.

Premier is not best placed to identify and endorse suitable indirect offsetting projects. The Exco paper acknowledges that operators "do not always have the knowledge, resources, or inclination to take such projects on" (FIG, 2016d). As such, Premier will not pursue indirect offsetting for the significant residual impacts / risks associated with the Sea Lion Development.

A third option available is to make a contribution to an environmental fund. FIG Policy allows for operators to contribute to an Environment Fund to achieve carbon and biodiversity offsetting and environmental legacy benefits. The fund would promote enhanced stewardship of the environment and aim to build wider eco-system resilience and knowledge to create a lasting Falkland Islands environmental legacy. The fund would be managed and governed by a trustee board including environmental stakeholders and industry to award grants and oversee general administration (FIG, 2016d).

Premier considered the significant residual impacts predicted to arise from the Sea Lion project in order to explore the opportunity for a formula or methodology to calculate a financial payment commensurate with the predicted impacts. However, given the difficulties in developing such a methodology, Premier proposed a level of contribution to the Fund following review / consideration of:

- Premier's support for environmental legacy projects in other areas in which it operates;
- The scale of costs of environmental projects past and present in the Falklands, which are similar to those it is envisaged the fund will support;
- Other operators' environmental legacy projects around the world; and
- Economic context, both in terms of the project itself and the wider Falklands economy.

This analysis enabled a proposed annual contribution to be agreed with FIG. Contributions to the fund will commence from Stage 1 (production drilling) and will continue for all following stages of the project. However, Premier will review this approach and level of contribution every five years, in line with the EIS review, to ensure it remains the most effective way to achieve offsetting.

1.7.4 Key findings of the EIA

1.7.4.1 Overview of EIA findings with regard to the initial and residual assessments

During the initial assessment:

- 69 % of the impacts and risks assessed were considered to be **Very Low** or **Low**. While no additional, project-specific, mitigations were considered necessary for these impacts and risks, all will be subject to ongoing reviews to ensure that they remain ALARP;
- 25 % of the impacts and risks were considered to be of **Moderate** significance;
- 3 % were **Upper Moderate**;
- 1 % were **High**; and
- 1 % were considered **Beneficial**.

Where initial impacts and risks were considered to be **Moderate** or above, project-specific mitigations were identified and those that were considered to be 'reasonably practicable' were factored into the *residual* assessment to reduce all the impacts / risks to ALARP. This resulted in an overall reduction in the number of **Moderate, Upper Moderate** and **High** impacts and risks.

Based on the residual assessment:

- The number of **Very Low** and **Low** impacts / risks increased to 75 %,
- The number of **Moderate** impact / risks was reduced to 21 %;
- The number of **Upper Moderate** impacts / risks remained the same at 3 %;
- None of the residual impacts or risks were deemed to be **High**; and
- 1 % were considered **Beneficial.**

A summary of the impacts and risks that were **Moderate** or above during the initial assessment and were reduced to **Low** or **Very Low** in the residual assessment due to the project-specific mitigation commitments is provided in Table 1.5. A summary table showing *all* the *residual* impacts and risks to all the receptors is provided in Section 1.7.5 (Table 1.7).

The impacts and risks, which *remained* significant despite the use of industry standard mitigations and the commitment to reasonably practical project-specific mitigations, are described further below.

Table 1.5: A summary of the impacts and risks that were initially identified as being of Moderate significance or above and which were reduced following commitment to reasonably practical project-specific mitigations

Impact / risk	Initial assessment [a]	Key project-specific mitigation summary	Residual assessment [b]
Risk of injury to marine mammals via collisions with vessels *en route* between Stanley and the Sea Lion Field	**Moderate**	Increased awareness and vigilance of vessel's crew and voluntary speed limit while transiting inshore waters	**Low**
Competition with domestic energy needs during the night	**Moderate**	Use of vessel generators to prevent need for shore-power hook-up by vessels (and monitoring of generator noise levels)	**Low**
Disturbance to the human population from operations noise at the TDF and supply base	**Moderate**	Activity restrictions and minimising noise at night	**Very Low**
Risk of impacts of inshore MGO fuel oil spills (10-3,700 tonnes) to fishing grounds, seabirds and marine mammals	**Moderate**	Vetting of vessels, Vessel Traffic Management System, use of exclusion zones, and onsite oil spill response capability	**Low**
Risk of impacts of a 1,526 tonne Intermediate Fuel Oil (IFO) spill inshore on benthos, fishing grounds, seabirds and marine mammals and coastal habitats	**Moderate**		**Moderate**
Risk of day-to-day small leaks and spills at-shore	**Moderate**	On site oil spill response equipment	**Low**

[a] Taking account of regulatory requirements, industry standard practices and base case mitigations

[b] Taking account of reasonably practicable project-specific mitigations

1.7.4.2 Significant residual impacts and risks

The significant *residual* impacts and risks are summarised in Table 1.6. The full EIS describes the initial *and* residual assessment outcomes for *all* the environmental and social aspects (Chapters 10, 11 and 12). The sections below summarise only the *residual* impacts and risks that remained significant following project-specific mitigation.

Significant residual impacts and risks are those that have been reduced to ALARP but are still considered to be '**Moderate**' or '**Upper Moderate**', primarily because of:

- The limited options for effective and reasonably practicable project-specific mitigations; and / or
- The use of a precautionary approach during the assessment when faced with data gaps, which leads to higher levels of uncertainty.

In each summary below, only the highest impact or risk is presented. For example, where underwater noise may affect diving seabirds and marine mammals, only the impact to marine mammals is described in the sections below as this was assessed as the greatest potential impact.

Table 1.6: A summary of the residual impacts and risks that, while considered to be ALARP, remain significant

Impact / risk	Residual assessment [a]
Impacts and risks associated with planned activities	
Risk of bird-strikes due to artificial light	**Moderate**
Impact on and behavioural disturbance to marine mammals from underwater noise offshore	**Moderate**
Impacts of drill cuttings discharge on benthos including burial of benthic fauna, modification of habitat, toxicity and oxygen depletion	**Moderate**
Impacts from atmospheric emissions	**Moderate**
Impact of waste disposal to the UK	**Moderate**
Risk of injury to marine mammals via collision in Berkeley Sound	**Moderate**
Risk of introducing marine invasive species in Premier managed vessels	**Moderate**
Risk of introducing marine invasive species from Premier chartered coaster vessels and LTVs in Berkeley Sound	**Moderate**
Risk of introducing marine non-native species from third party vessels (i.e. vessels not directly managed by Premier) which are associated with Premier activities	**Upper Moderate**
Risk associated with non-native species arriving on air freight	**Upper Moderate**
Competition for freshwater resources	**Upper Moderate**
Competition with domestic electricity needs during the day	**Upper Moderate**
Competition for use of road network	**Moderate**
Disturbance to the human population from light inshore and onshore	**Moderate**
Risks associated with accidental events	
Accidental releases of oil or diesel to sea offshore	**Moderate**
Accidental release of Intermediate Fuel Oil (IFO) inshore	**Moderate**

[a] Taking account of industry standard mitigation and reasonably practicable project-specific mitigations

1.7.4.2.1 Artificial lights offshore and inshore

Throughout the Phase 1 Development, installations and vessels will add to the existing levels of artificial light both offshore and inshore, and this was raised as a concern by stakeholders during consultations in 2014, 2015 and 2016 (see EIS Chapter 6). Further, while flaring is not expected to occur during normal operations, a pilot light will be permanently lit, and flaring may be necessary during planned or unplanned equipment outages. Flaring during well tests and well clean up may also be required for all production wells.

During the hours of darkness, artificial light will attract plankton, fish and squid but the impact upon seabirds is considered to be of greatest concern. Lights will attract and / or disorientate seabirds (small petrels) and there is the potential for these birds to collide with the lights or vessel superstructures. This phenomenon is known as ‘bird-strike’.

Bird-strikes may result in mortality through direct collision. Birds may suffer injuries or hypothermia, should feathers become contaminated with residues on the deck of a vessel. The occurrence of seabird collisions will depend upon a combination of factors including the species and abundance of birds in the area at the time, and local weather conditions. Small nocturnally active petrels are most susceptible during periods of poor visibility.

Taking account of the sensitivity of bird species which may be susceptible, the potential severity of effect of multiple bird-strikes, the fact that artificial lighting on vessels and installations cannot be reduced or altered without compromising safety, and adopting a precautionary approach, the residual risk of bird-strikes is considered to be '**Moderate**' (see EIS section 10.1).

1.7.4.2.2 Underwater noise offshore

Underwater noise will be generated by the use of vessels throughout the Phase 1 Development and will be continuous throughout the life of the project. Noise pollution and its effects on sensitive receptors was raised as a concern by stakeholders during consultations in 2014 and 2015 (see EIS Chapter 6). While underwater vessel noise may impact upon fish, squid and diving birds, it is most likely to have a consequential impact upon marine mammals, through disturbance and / or changes in behaviour.

When assessing the impact of sound on any animal, it is necessary to compare the sounds being made with the thresholds above which the animal may exhibit behavioural reactions to disturbance or experience hearing loss / injury. It is also necessary to consider how close the animal needs to be to the source of the noise for it to experience the sound at levels above the disturbance and injury thresholds.

Modelling was carried out to assess the impact of different sound sources on the different receptors e.g. fish, seabirds, marine mammals, at different distances. Based on the modelling results and available information, the worst case impact of underwater noise is that of a stationary source of vessel noise at the Phase 1 Development site (e.g. from the dynamically positioned OSV) and its potential long-term effect on marine mammals.

Given the conservation status of the whale species that may be affected, data gaps in marine mammal distribution in the NFB, lack of knowledge of the long-term impact of continuous noise and difficulties in effectively mitigating this impact, the precautionary approach dictates that the residual impact rating remains '**Moderate**' (see EIS section 10.4).

1.7.4.2.3 Discharge of drill cuttings

Drilling of the development wells will result in the discharge of drilling muds and rock cuttings in the proximity of the well. Water Based Mud (WBM) and cuttings will be discharged directly to seabed. Whilst drilling the top sections of the wells, cleaned Oil Based Mud (OBM) cuttings will be discharged from the bottom sections of each well. Prior to discharge, OBM cuttings will be returned to the MODU where they will be cleaned by a Thermo-mechanical Cuttings Cleaner (TCC). The cuttings will be cleaned to ensure there is <0.5 % oil (by weight on dry cuttings) remaining, following which the cuttings will be discharged to sea.

Whilst the discharge of cuttings may impact water quality, plankton, fish and squid, the greatest impact will be to the benthic community in the area. These impacts can arise from smothering, changes to habitat, reduction in oxygen availability and the toxic effects of residues associated with the cuttings.

Modelling was carried out to determine the extent of the impacts of the cuttings in the vicinity of the wells. Although there are no known species of conservation importance in the area, the specific location of the Sea Lion Development has not yet been surveyed such that there are minor data gaps and thus a precautionary approach was taken. Using a precautionary approach, and due to the extent and duration of the impacts, the residual impact to benthic fauna is considered to be '**Moderate**' (see EIS section 10.6).

1.7.4.2.4 Atmospheric emissions (climatic factors)

Nearly all activities associated with the Phase 1 Development will result in atmospheric emissions and this was raised as a concern by stakeholders during consultations in 2015 and 2016 (see EIS Chapter 6). Emissions will result from power generation on the MODU and FPSO, well clean-ups, the flare pilot light on the FPSO and the use of all vessels, fixed-wing flights and helicopters.

Atmospheric emissions include gases which lead to global warming and ocean acidification, the best known of which is Carbon Dioxide (CO_2).

A number of emissions reduction measures are built-in to the Phase 1 project, as shown in Table 1.1 above. Moreover, in line with its HSES Policy, Premier will endeavour to minimise emissions, where possible, through operational control measures, monitoring and reporting and periodic reviews to determine whether or not the emissions remain ALARP.

Nonetheless, while the percentage contribution of emissions is minimal when compared to UK emissions, and the new development has been designed with efficiency in mind, owing to the sensitivity of the global environment as a receptor, the residual impacts of the contribution of atmospheric emissions to both global warming and ocean acidification are considered to be '**Moderate**' (see EIS section **10.9**).

1.7.4.2.5 Waste management

Waste by-products will result from nearly every activity carried out during the Phase 1 Development and waste management was raised as a concern by stakeholders during consultations in 2015 and 2016 (see EIS Chapter 6). Waste from the Development will include domestic and marine wastes, solid wastes, produced water, drainage water, ballast water, domestic waste water, food, sewage discharges and drill cuttings. Some of these wastes are hazardous, some are non-hazardous and some may be legally discharged to sea provided they undergo proper treatment. Produced water, drainage water, ballast water and drill cuttings are all described in separate chapters. With the exception of drill cuttings (see above) the associated impacts were '**Low**' such that they are not detailed in this NTS beyond their inclusion in Table 1.7 below.

Of greater significance, is the generation of solid operational wastes, all of which will be returned to shore for treatment at the FIG waste management facility or, in the event that the municipal facility is not available, for incineration at the supply base or deposition to landfill in the UK. To ensure the responsible management of waste, and compliance with Premier's Duty of Care obligations, Premier will develop and implement a project-specific Waste Management Plan (WMP) prior to the start of drilling operations.

Given that there are currently insufficient waste management facilities in the Falkland Islands, the following commitments are made by Premier:

- The planned FIG Waste Management Facility will be used to treat and dispose of project wastes, if available; or
- In the event that the FIG Waste Management Facility is unavailable, Premier may install a portable Incinerator at the supply base for the burning of suitable waste streams. The resultant ash from the incineration process will be returned to the UK for disposal if a suitable disposal route cannot be established on the Falklands.
- There will be no uncontrolled landfill of wastes to the Eliza Cove or Mary Hill Quarry sites;
- Premier will only export wastes in compliance with all applicable international and national regulations; and
- Throughout the Development the 'Waste Hierarchy' will be utilised and annual waste targets will be set, to maximise waste reduction and recovery.

Waste facilities in the Falkland Islands are currently very limited. Plans approved by the Falkland Islands Government (FIG) should deliver a new municipal integrated waste facility that is capable of receiving the waste from the Sea Lion Phase 1 project. Although it is not Premier's preferred option for the disposal of wastes, should the municipal facilities not be ready when the project starts, some waste will need to be sent to landfill in the UK. Landfill is an unsustainable practice and therefore, although the quantities of waste are comparatively small, landfill space in the UK remains limited such that the worst case residual impact of waste generation is considered to be '**Upper Moderate**' (see EIS section 10.10).

1.7.4.2.6 Risk of injury to marine mammals via collisions inshore

There is a risk of vessel collision with marine mammals (as raised as a concern by stakeholders in the 2016 scoping consultations, see EIS Chapter 6). Some of the vessels involved in the Construction phase (e.g. the LTVs) will be considerably larger than vessels employed in other aspects of the project. These vessels are required to transit to, and anchor in, Berkeley Sound where there is a seasonally high likelihood of encountering large whales e.g. sei whales (IUCN 'Endangered') and southern right whales.

Vessel speed in the vicinity of Berkeley Sound will be limited to a maximum of eight knots. All vessels will be in a state of heightened awareness due to the risks associated with inshore operations, which will aid early detection of hazards to navigation, such as non-project vessels or cetaceans. Further, the relatively slow vessel speed will reduce the likelihood of collisions and the energy behind any impacts, thus reducing the potential for lethal injury.

While the use of industry standard guidelines, reduced vessel speeds and the use of Marine Mammal Observers will all lessen the likelihood and impact of collisions, the sensitivity of the whale species that may be affected (e.g. sei whales), the limited manoeuvrability of very large whales (e.g. right whales),, the unpredictable nature of cetacean behaviour in general and data gaps in the knowledge of whale distribution mean that while the risk has been reduced to ALARP, the residual risk remains '**Moderate**' for Inshore vessels (see EIS section 10.11).

1.7.4.2.7 Risk of introducing marine invasive species

The arrival of vessels into Falkland Islands waters from elsewhere in the world may lead to the introduction of non-native marine species and biosecurity was raised as a concern by stakeholders during consultations in 2014, 2015 and 2016 (see EIS Chapter 6). The introduction of non-native species can result from discharged ballast waters or from biofouling present in the 'nooks and crannies' of a ship's hull. In the event that non-native species are introduced, there is then the potential that they may become established and spread. If this occurs, they are referred to as 'invasive species' and can dramatically alter the local ecosystem and / or outcompete native species altogether, negatively impacting the local biodiversity. Once established, marine invasive species are virtually impossible to eradicate.

The likelihood of such a species being introduced, and then becoming invasive, depends upon numerous factors e.g. whether the species comes from a similar climate and ecosystem, whether the ship passed through different climates *en route* (e.g. the Tropics) and whether or not the vessel is repeatedly 'new' to the Falkland Islands.

Industry standard and project-specific mitigation measures regarding ballast water management and antifouling of vessels go a long way to reducing the likelihood of species introduction, which may or may not then become invasive. However, the greatest risk comes from third party vessels such as the purchaser's CTT over which Premier does not have full control. On balance, given that species invasion can be difficult to detect in the short-term and can have severe effects on biodiversity which are almost impossible to reverse, the worst case residual risk of marine species invasion is considered to be '**Upper Moderate**' (see EIS section 10.12).

1.7.4.2.8 Risk associated with non-native species arriving on freight

Bringing freight into the Islands to support Premier's operations carries the risk of introducing nonnative, potentially invasive species in the cargo. As with marine invasives, If invasive species were introduced during the Phase 1 Development the impact on the ecology of the Islands through parasites, disease, competitors or predators may not be immediately evident but may have long-term implications. Initially the impact would be felt locally, however, once established invasive species may spread 'naturally' or with anthropogenic assistance to other parts of the Falklands archipelago. If found, potentially invasive species can be removed but they can be very difficult to detect and then eradicate. Vessels and charter flights will be arriving in Stanley throughout the life of the Development and a large amount of cargo will be taken onshore. The transportation of invasive species to the Falklands has happened in recent years, and the introduction of invasive species has occurred in the oil and gas (O&G) industry elsewhere in the world, such that the risk is considered possible during the Phase 1 Development. A Biosecurity Management Plan will be implemented during the Phase 1 Development to help prevent non-native, potentially invasive species being introduced. However, due to the potential impacts of invasive species and the fact that invasives have been introduced in the past, the risk of non-native species introduction is considered '**Upper Moderate**' (see EIS Section 10.13).

1.7.4.2.9 Competition for freshwater resources

Onshore infrastructure associated with the Development (e.g. the onshore supply base and the TDF) will require connection to the existing Stanley water utilities. In addition, the onshore water supply will be required to support a proportion of water use by offshore assets including vessels, the MODU and drilling requirements for muds, cements, brines and domestic use.

The FIG owned Stanley water filtration plant is the single water supplier and has a fixed capacity which is limited by the existing utility infrastructure. Water is therefore considered a limited resource. Any use of water by the Development activities or assets which is above the current baseline Stanley usage has the potential to lead to competition with the local users in Stanley.

Competition for water resources will be particularly high during the drilling stages of the Phase 1 Development and in the event that demands during these stages exceed supply, impacts upon volume will be immediately apparent to consumers and businesses. The Stanley water supply is already near capacity and, to accommodate the Development, the existing system may need to operate at a temporary deficit for short durations if no changes are made to the current FIG work practices and hours of operation.

Throughout the project, the water supply to Stanley will always be prioritised over that provided to the TDF such that the impacts of any water shortage will be felt by the Phase 1 Development rather than the Stanley users. Nonetheless, the overall significance of the impact of water competition on the human population is '**Upper Moderate**' (see EIS section 11.4).

All additional project-specific mitigation measures, including planning and logistics to reduce water use during the drilling phases, will be discussed further with FIG.

1.7.4.2.10 Competition for electricity

Onshore and at-shore infrastructure in support of the Phase 1 Development will require connection to the existing electrical power grid of Stanley. FIG is the single energy utility supplier and has a fixed power capacity from a finite number of generators at the Stanley power station and wind turbines located a few miles out of town.

Electricity is an essential utility upon which almost all daily activity depends in an increasingly electronic age. Stanley's current baseline capacity is such that it may be unable to sustain peak demand spikes in the short-term and therefore must be considered a finite resource. The use of electricity by Premier therefore has the potential to be unsustainable in the immediate term. During the Phase 1 Development, peak daytime power demands could reach the threshold where the standby generator capacity is required. In such a situation, power demand would still be within *overall* capacity, however, the operation of the power grid system using stand-by generators increases the vulnerability of the system to generator drop out.

Premier will liaise closely with FIG in preparation for 'oil readiness' to ensure that energy supply and demand are in balance. These discussions will include those based on future FIG development of power capacity.

Nevertheless, while future improvements to the FIG power station may alter the impact assessment by altering the baseline capacity against which usage is compared, these changes are currently outwith Premier's control and cannot be used as a mitigation within this assessment. Therefore, the impact of competition for electrical energy on the human population of the Falkland Islands is considered to be '**Upper Moderate**' (see EIS section 11.5).

1.7.4.2.11 Competition for use of road network

All stages of the Sea Lion Phase 1 Development will require the use of the existing road network for the movement of personnel to, from and within Stanley, for the haulage of equipment, and transport of supplies and waste between a range of different locations. Whilst road capacity and use cannot be accurately quantified, increased utilisation may be detrimental to the road surfaces and may also result in increased necessity for remedial repairs. Further, additional traffic, congestion and vehicles seeking parking may also create a nuisance to the local population and the issue of road use was raised as a concern during scoping consultations (see EIS Chapter 6).

An increase in traffic of up to 21 % in Stage 1, 18 % in Stage 2 and 14 % in Stage 3 (up to 20 years) is predicted, which could result in some degree of congestion at peak times and lessen parking availability which may cause inconvenience to other road users.

A Traffic Management Plan (TMP) will be put in place for operations, as was done for the exploration campaigns, to minimise the impacts from operational road use in this area. The TMP will highlight operating hours, signage, allowable routes, warning devices, clothing and pedestrian precautions for Premier staff and contractors. However, owing to the sensitivity of the receptor and the extent and duration of traffic increases, the residual significance of the impact of road use on the human population is still considered to be '**Moderate**' (see EIS section 11.7).

1.7.4.2.12 Disturbance to the human population from light

Throughout the Phase 1 Development the onshore supply base and port facilities in Stanley, as well as the vessels in Berkeley Sound, will create artificial light. All of these sources have the potential to create light pollution and a nuisance to local residents. It was noted during previous scoping consultations that light from the TDF, vessels and yard is noticeable to Stanley residents (see EIS Chapter 6).

To ensure a safe operation, minimum levels of lighting are required on the TDF and at the supply base as well as in Berkeley Sound on the LTV storage vessels. In compliance with safety legislation, the light levels may not be reduced below that minimum. However, mitigation measures are proposed to ensure all lights are facing inwards and to reduce light pollution both by directionally blocking lights and turning them off when not required.

Nonetheless, due to the sensitivity of the receptor (the residents of Stanley and Berkeley Sound), the longevity of the potential disturbance in Stanley and the fact that proposed mitigation measures have not proven to be fully effective during previous campaigns, the residual impact of light pollution and nuisance to the human population is considered to be '**Moderate**' (see EIS section 11.8).

1.7.4.2.13 Disturbance to the human population from noise

Throughout the Phase 1 Development, the use of helicopters, the onshore supply base, and the port facilities in Stanley all have the potential to create a noise nuisance for the local residents. Noise was noted during the scoping consultations in 2016 as a potential issue in Berkeley Sound relating to the use of a foghorn (see EIS Chapter 6) however, this is no longer part of the project scope. It was also mentioned that the existing activities in Berkeley Sound (e.g. off-loading of fish catches by reefer vessels) can already be heard by local residents.

Vessel noise from the Inshore LTV operation in Berkeley Sound is unlikely to pose a nuisance to residents. The significance of the LTV vessel noise is considered to be '**Low**' (see EIS section 11.9).

1.7.4.3 Significant residual risks associated with accidental events

1.7.4.3.1 Accidental releases of oil or diesel to sea offshore

All offshore O&G operations carry the risk of oil spills and this was raised as a concern by stakeholders during consultations in 2014, 2015 and 2016 (see EIS Chapter 6). The impacts of any given spill depend upon the type of the oil, the size and source of the spill, the prevailing winds and currents, water depth, proximity to the shoreline or to concentrations of receptors offshore, and numerous other factors. Depending upon these factors, the spill may impact upon biological, social and environmental receptors.

Lessons learned from oil spill events around the world have led to stringent industry standard practices that are required to minimise both the likelihood of occurrence of an oil spill and the consequences of such an event should it occur. Many of these preventative industry standard practices are built into the design of the facilities (section 1.4.2 above) and were therefore taken into account during the initial risk assessment.

With regard to the wells, industry standard oil spill prevention measures range from the way the wells are designed to the use of blow-out preventers, operational control procedures and manuals which ensure that due process is followed in all activities that could carry the risk of a large or small spill (section 1.4.2 above). Further, the well designs must be peer reviewed by an independent well examiner and the UK Health and Safety Executive (HSE) to ensure that the risk of an uncontrolled release is minimised.

With regard to the FPSO, the industry standard preventative requirements built-in to the design range from double-skinned and double-bottomed cargo and fuel tanks to the use of AIS and marine procedures intended to prevent collisions (section 1.4.2 above).

A range of different offshore oil spill scenarios were modelled to determine the behaviour of spills that could occur if the above preventative mitigation measures fail. The modelled scenarios included spills of reservoir oil from a well blow-out, loss of the FPSO cargo tank inventory, and spills of diesel during bunkering operations. The results of these models were used to inform the impact and risk assessments with regard to the 'Severity of Effect' of a spill.

The measures intended to minimise the consequences of an oil spill are based upon the outcomes of the spill models, as well as industry standard practice, and are written into the project-specific Offshore Oil Spill Strategy. An Oil Spill Contingency Plan (OSCP) that covers the offshore operations will be submitted to FIG before operations commence and will detail the organisational responsibilities, immediate and long-term actions, reporting requirements and resources available to ensure the effective and timely management of any spills. The Sea Lion OSCP will be compatible with the FIG National OSCP. Resources available, and described within the OSCP, will range from equipment held on-site by Premier to international resources which can be brought in to track and monitor spill trajectories and / or equipment that will be deployed to stem the release of oil if necessary.

Mitigation measures to prevent the occurrence of spills and to minimise the consequences are designed based on the outcomes of the modelled oil spill scenarios, the full details of which are provided in section 12.1 of the EIS.

Taking account of the predicted fate of Sea Lion crude and diesel in the event of a release (as indicated by the models), the worst case potential impacts of an oil spill would be to fish, seabirds, marine mammals, fisheries and the human population (in terms of potential impact upon tourism through public perception of a spill, even if none were to reach the shore). The sensitivity of each of these receptors to an oil spill was assessed during the EIA and ranged from **High** to **Very High** (see EIS section 12.1).

The *impact* of spills (i.e. the 'Sensitivity of Receptors' x 'Severity of Effect') on all the potential receptors was assessed for each spill scenario. The large volume crude spills (e.g. well blow-out, crude inventory loss) and spills that create a 'sheen' on the water (e.g. fuel spills) resulted in *impacts* of '**Upper Moderate**' and '**High**' significance to the more sensitive receptors.

As described in section 1.7.2, the *risk* assessment process applies the *likelihood* of a spill occurring to the *impacts* associated with the spill. In the case of offshore spills, the 'Likelihood of Occurrence' was estimated based on statistical information on the frequency of incidents as well as specific Quantitative Risk Assessments (QRA) for the Sea Lion Field activities. Based on these statistics, the likelihood of offshore spills ranges from '**Very Unlikely**' (e.g. for full loss of the FPSO crude inventory) to '**Possible**' (e.g. for a spill during transfer of crude from the FPSO to the CTT). Therefore, the *risk* assessment results in a worst case residual risk of '**Moderate**' (see EIS section 12.1).

1.7.4.3.2 Accidental releases of fuel oil to sea inshore

The risk of oil spill in Berkeley Sound was raised by stakeholders during consultations in 2014, 2015 and 2016 (see EIS Chapter 6). Given the elimination of the Inshore transfer oil export option, the remaining inshore spill sources include the anchored LTVs, intermittent visits to the LTVS (c. 14 trips in total) by Subsea Construction Vessel, and non-Premier third party vessels. As a result the events that may result in an inshore fuel oil spill in Berkeley Sound include fuel bunkering incidents, potential vessel collisions, and vessel grounding events.

With regard to mitigation, industry standard collision prevention measures including Automatic Identification Systems (AIS) and marine procedures will be used (section 1.4.2 above). Also, Premier will 'vet' all vessels prior to their use for project activities.

Full details of what will be vetted / audited for the nominated CTT are provided in section 5.10 of the EIS and, in summary, will include:

- Verification of compliance with all relevant MARPOL Annex requirements and other IMO requirements;
- Verification of compliance with mandatory shipping requirements e.g. Ship Inspection Report Programme (SIRE), International Association of Classification Societies (IACS) etc.;

- Verification of the Shipboard Oil Pollution Emergency Plan (SOPEP); and
- Specific checks to ensure the vessel's equipment is suitable for the operation with regard to risk management and insurance requirements.

A range of inshore oil spill scenarios were modelled to determine the behaviour of spills that could occur if the above preventative mitigation measures fail. The modelled scenarios include spills of Marine Gas Oil (MGO) and IFO and from bunkering incidents, vessel collisions and vessel grounding incidents. The results of the modelling were used to inform the impact assessment with regard to the 'Severity of Effect' of a spill.

An OSCP that covers the inshore operations will be submitted to FIG before operations commence.

Mitigation measures to prevent the occurrence of spills and to minimise the consequences are designed based on the outcomes of the modelled oil spill scenarios and full details are provided in section 12.2 of the EIS.

Taking account of the predicted fate of fuel oil in the event of a release in the Sound (as indicated by the models), the worst case potential impacts of oil spills are to fish and squid, fisheries, seabirds, marine mammals, coastal ecology and the human population (in terms of potential impact upon tourism). The sensitivity of each receptor within Berkeley Sound was assessed during the EIA, and ranged from **High** to **Very High**.

The *impact* (i.e. the 'Sensitivity of Receptor' x 'Severity of Effect') on all the potential receptors in and around Berkeley Sound was assessed for each spill scenario. The larger volume spills resulted in residual impacts of '**High**' and '**Upper Moderate**' significance to the more sensitive receptors.

Estimation of the 'Likelihood of Occurrence' of inshore spills was based on statistical information on the frequency of incidents. The assessment of the worst case residual risk was '**Low**' and '**Very Low**' for the majority of spills and '**Moderate**' for a spill of fuel oil (see EIS section 12.2).

1.7.5 EIA outcomes summary

Table 1.7 shows the significance of the worst case residual impacts and risks associated with all activities on all receptors. The overall significance of impacts associated with each activity is based upon the greatest impact / risk. In other words, if an oil spill is identified as having a greater impact on seabirds than on the benthos, then the impact to seabirds dictates the overall significance of oil spills.

Table 1.7 also indicates which of the aspects were initially raised as a concern by stakeholders during the scoping consultations (EIS Chapter 6) to enable easier review by stakeholders of the EIA outcomes for their particular area of concern.

Table 1.7: Summary of the worst case residual impacts / risks to each receptor for all Development activities, and an indication of whether they were raised as a concern by stakeholders during informal scoping consultations (definitions of impact and risk categories can be found at the foot of the table)

Very Low	Low	Moderate	Upper Moderate	High

	Activity	Residual Environmental Impact / Risk																	Worst case Residual Impact / Risk	Raised by stakeholder during scoping consultation
		Physical						Biological						Social						
		Seabed (and soil)	Water quality	Regional air quality	Global atmosphere	Marine flora	Plankton	Benthos	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Biosecurity	Land / seascape	Human population	Other sea users	Tangible property / resources	Archaeological		
	Environmental impacts and risks associated with planned activities and unplanned events																			
	Artificial light and the risk of bird-strikes inshore and offshore						Very Low		Very Low	Moderate									Moderate	✓
	Disturbance to wildlife from helicopter use									Low	Low								Low	✓
	Disturbance to seabed	Very Low						Low											Low	
	Seabed disturbance - risk of dropped objects	Very Low						Very Low											Very Low	
	Underwater noise offshore								Low	Low	Moderate								Moderate	✓
	Underwater noise inshore								Very Low	Low	Low								Low	✓
	Discharge of drilling mud and cuttings	Very Low	Very Low				Very Low	Moderate	Low										Moderate	✓
	Operational discharges		Very Low			Low	Low	Low	Low	Low									Low	✓
	Operational discharges – risk of PWRI malfunction		Very Low			Very Low	Very Low	Very Low	Very Low	Very Low									Very Low	✓
	Thermal discharges	Very Low	Very Low			Very Low	Very Low	Very Low	Very Low										Very Low	✓
	Atmospheric emissions (climatic factors)	Low	Moderate		Moderate														Moderate	✓

	Activity	Residual Environmental Impact / Risk																	Worst case Residual Impact / Risk	Raised by stakeholder during scoping consultation
		Physical						Biological						Social						
		Seabed (and soil)	Water quality	Regional air quality	Global atmosphere	Marine flora	Plankton	Benthos	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Biosecurity	Land / seascape	Human population	Other sea users	Tangible property / resources	Archaeological		
	Atmospheric emissions – risk of blowdown / venting / release of F-Gas																			✓
	Waste generation																			✓
	Waste - risk of loss of waste / improper segregation																			✓
	Risk of marine mammal collision																			
	Risk of introducing marine invasive species																			✓
	Risk of introducing terrestrial invasive species																			✓
	Social impacts and risks associated with planned activities and unplanned events																			
	Presence of FPSO / MODU and vessels offshore																			✓
	Collision between vessels and FPSO / MODU															L	I			✓
	Presence of vessels inshore																			✓
	Collision between vessels inshore																			✓
	Competition for resources – accommodation																			✓
	Competition for resources – freshwater																			✓
	Competition for resources – electricity																			✓

Activity		Residual Environmental Impact / Risk																	Worst case Residual Impact / Risk	Raised by stakeholder during scoping consultation
		Physical						Biological						Social						
		Seabed (and soil)	Water quality	Regional air quality	Global atmosphere	Marine flora	Plankton	Benthos	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Biosecurity	Land / seascape	Human population	Other sea users	Tangible property / resources	Archaeological		
	Competition for resources – air links																			✓
	Use of road network																			✓
	Disturbance to the human population – light																			✓
	Disturbance to the human population – noise																			✓
	Air quality inshore																			
	Risks associated with accidental events																			
	Oil spill - offshore																			✓
	Fuel Oil spill - inshore (IFO case)																			✓
	At-shore spill of liquid fuel or chemicals																			✓
	Spill of chemical at onshore supply base																			✓

<table>
<tr><th colspan="2">Significance Level</th><th>Impact / Risk Definition</th></tr>
<tr><td>Unacceptable</td><td>High</td><td>Action required to eliminate impact or risk via project design or to reduce it to an acceptable level via additional mitigation measures and controls which aim to minimise consequence where feasible, effective and reasonably practicable. If impact cannot be reduced, the project cannot proceed.</td></tr>
<tr><td rowspan="3">ALARP Region (Impact tolerable if demonstrably ALARP)</td><td>Upper Moderate</td><td>Impacts assessed as “Upper moderate” may not be tolerable. Action is required to eliminate or reduce impact via project design and / or additional mitigation measures and controls, which aim to minimise consequence where feasible, effective and reasonably practicable. Impacts remaining within this category are considered to be within the upper reaches of tolerability and are placed here owing to the combination of a precautionary approach based upon data gaps and / or a lack of further reasonable mitigation options. Where the impact is ALARP and remains within this category, regular reviews (at a minimum of annually) will be held to determine whether the impact can be further reduced based upon the availability of new data and / or new technology. If the impact cannot be further reduced, consideration may also be given to offsetting of the impact (see section 8.9).</td></tr>
<tr><td>Moderate</td><td>Impacts assessed as “Moderate” require action to identify opportunities for improvement via project design, additional mitigation measures and controls which aim to minimise consequence where feasible, effective and reasonably practicable. Where the impact is ALARP and remains within this category, it will be subject to regular ALARP reviews as described above.</td></tr>
<tr><td>Low</td><td>Impacts assessed as low are with the levels of existing natural environmental variability. No project-specific mitigations will be implemented over and above industry-standard measures and controls unless it is stated as a requirement in conditions to approval or Falkland Islands Legislation and / or approved policy. Nonetheless, impacts shall be regularly reviewed to ensure that suitable controls remain in place and shall be subject to continuous improvement where opportunities exist.</td></tr>
<tr><td>Broadly acceptable</td><td>Very Low</td><td>Impact barely detectable. No additional actions required beyond industry standard measures and controls. Nonetheless, impacts shall be periodically reviewed to ensure that suitable controls remain in place and shall be subject to continuous improvement where opportunities exist.</td></tr>
<tr><td></td><td>Beneficial</td><td>Has a positive effect.</td></tr>
</table>

[1] **Note:** Assessment of the Impact Significance is based on the EIA undertaken to date and detailed in this EIS. Initial views of key stakeholders were sought during the scoping consultation process (Chapter 6) Thereafter, the EIS was updated wherever applicable in response to comments / information received from the previous public consultation.

Further views of wider stakeholders on this EIS will be sought through the formal communication and consultation process. Comments received through this process will be detailed in Chapter 17 in due course (once the statutory EIS process is complete).

1.8 Environmental Monitoring and Management

To answer 'Question 6' above, the following sections describe what Premier propose with regard to mitigating, monitoring and managing the potentially significant impacts and risks associated with the Phase 1 Development throughout the life of the project.

In support of the EIS submission, Premier has, to date, developed:

- Offshore and Inshore Oil Spill Strategies;
- Oiled Wildlife Strategy (incorporated into the Inshore Oil Spill Strategy);
- Waste Management Strategy; and
- Preliminary Environmental Monitoring and Management Plan (EMMP) (Chapter 15).

These documents will be available for public consultation and will be used to develop more detailed project-specific management plans following approval and sanction of the project, and before operations commence.

The following project-specific management plans will be in place by the time operations commence and are under development:

- EMMP (see section 1.8.1 below);
- Bird Strike Management Plan (BSMP);
- Waste Management Plan (WMP);
- Harbour Management Plan (HMP);
- Biosecurity Management Plan (BMP);
- Traffic Management Plan (TMP);
- Oil Spill Contingency Plan (OSCP);
- Wildlife Response Plan (WRP); and
- Iceberg Management Plan (IMP).

1.8.1 Environmental Monitoring and Management Plan

Throughout the 'Define' and EIA phases of the project, various commitments have been made by Premier which aim to reduce the residual environmental impacts and risks. These commitments are detailed in the impact and risk assessment chapters of the EIS (Chapters 10, 11 and 12), and will be recorded in the overarching EMMP.

These commitments are in addition to the mitigation measures built-in to the design of the facilities (section 1.4.2 above) and the industry standard and legislative requirements (detailed within the EIS) all of which are considered to be a 'given'.

The specific purpose of the EMMP is to detail the actions / plans required to:

- Measure and monitor the impacts (primarily the 'Severity of Effect') of the Development;
- Check the efficacy of the project-specific mitigations in place;
- Apply adaptaive management options to further reduce impacts; and

- Fill spatial / temporal data gaps, where needed, to increase the level of confidence in the impact / risk assessment outcomes.

Should the monitoring of impacts indicate that the significance of the impacts and risks predicted in the EIS are not appropriate, and / or that mitigation is not effective, a revised mitigation measure and / or monitoring regime will be required.

1.8.2 EMMP Workshop

As described in section 1.1.1.1.3, a workshop to consider the contents of an Environmental Monitoring and Management Plan (EMMP) to accompany the Sea Lion oil field Environmental Impact Statement (EIS) was held in Stanley, Falkland Islands on 23-25 April 2019. It was attended by 25 interested stakeholders, comprising FIG, PMO, industry bodies and NGOs.

The keys aims of the EMMP workshop were to agree:

- Priorities for monitoring;
- Planned surveys, monitoring and data collection;
- Regularity of surveys, monitoring and data collection;
- Methods for surveys, monitoring and data collection;
- Reporting of data;
- Intervention thresholds and the associated adaptive management options; and
- Governance (who will oversee the work).

At the Workshop, consideration was given to eleven environmental and social impacts from the Sea Lion development where there was potentially a need for further certainty as to the actual impact. Due to the change in planned nearshore activities (the elimination of inshore ship-to-ship transfer of crude oil) the following four impacts were considered by the workshop to be out of scope for the EMMP:

- Oil spill effects on inshore seabirds;
- Effects of underwater noise on marine mammals inshore;
- Effects on squid spawning grounds; and,
- Effects on intertidal/nearshore benthic habitats.

The Summary EMMP tables are provided in section 1.8 and Chapter 15.2 in the full EIS.

Once the Development has been approved and sanctioned, the EMMP will be transferred into a live document, which will provide details on:

- Specific roles and responsibilities;
- Timelines, deadlines and ‘frequency of execution’ for actions identified; and
- Progress and completion for use throughout the life of the field.

1.8.3 Preliminary EMMP

While the EMMP will ultimately be a live document throughout the life of the Development, Table 1.8 provides a summary of the commitments made by Premier which were identified during the EIA process. As described above, a full copy of the EMMP will be made available prior to commencement of the project, upon request from Premier (Sealion.enviro@premier-oil.com).

Information arising from the EMMP commitments will be reported to the EMMP group via agreed reporting protocols. Where necessary, amendments will be discussed and the EMMP actions updated accordingly.

Table 1.8: Summary of environmental monitoring and management commitments

Environmental Aspect	Key monitoring and management commitments
Environmental impacts and risks associated with planned activities and unplanned events	
Physical presence - artificial light	• Investigate use of alternative spectrum ('green') lighting; and • Development and implementation of the Bird-Strike Management Plan (BSMP).
Physical presence - helicopter use	• Monitor regularity of complaints received.
Physical presence - Disturbance to seabed	• Marine growth and seabed surveys prior to and throughout the development.
Underwater noise	• Ground truthing of noise levels once into production; and • Marine Mammal Observers (MMOs) on board specific vessels and during certain activities.
Discharge of drilling mud and cuttings	• Pre-drilling benthic survey; • Post-drilling benthic survey; • Post-drilling cuttings pile analysis; and • Use and discharge of muds will be monitored on board throughout drilling.
Operational discharges	• Monitoring of all chemical discharges; • Oil in produced water (not normally discharged) concentrations included in environmental Key Performance Indicators (KPIs); and • Produced water re-injection uptime included in environmental KPIs.
Waste generation	• Work collaboratively with FIG on the potential for development of improved waste facilities in the Falkland Islands; • Compliance with the specific requirements of the Phase 1 Waste Management Plan • Education of offshore and onshore personnel e.g. inclusion in all personnel inductions; • Education of all personnel on the consequences for wildlife and landscape that can result from loss of waste to sea and inclusion of this in all FPSO and MODU inductions; • Use of educational posters about the potential consequence of loss of waste;

Environmental Aspect	Key monitoring and management commitments
	• Potential for litter pick-up drives / incentives for local beauty spots and protected sites; and • Periodic reviews on whether or not impacts of waste remains ALARP
Atmospheric emissions	• Recording and monitoring of all emissions and fuel use; and • Uptime of gas re-injection included in environmental KPIs.
Marine mammal collision	• MMOs regularly on board project vessels; and • Education and awareness for mariners. All collisions will be report to FIG and the IWC via: www.iwc.int\ship-strikes or shipstrikes@iwc.int.
Introduction of non-native marine species	• Specific inclusion of each vessel's ballast water management system, exchange plan, record book and biofouling management plan (BFMP) and logbook in selection and pre-mobilisation HSES audits; • Ballast water sampling programme for project vessels entering the Falklands nearshore environment; • Non-native species monitoring programme; and • Water sampling, shoreline sampling, pathways analysis and ballast water modelling.
Introduction of non-native terrestrial species	• Implementation of the Biosecurity Management Plan (BMP).
Social impacts and risks associated with planned activities and unplanned events	
Physical presence - Increased vessel presence	• AIS based survey to confirm the shipping traffic pattern; and • Monitoring of vessel movements in Berkeley Sound, under jurisdiction of the Harbour Master.
Competition for resources	• Monitoring of accommodation use and socio-economic impact on the rental market; • Use of onshore water supply will be monitored at all infrastructure locations; • Energy use will be monitored onshore and at the TDF; • Any incidental usage of existing air-links will be recorded; and • Off peak power utilisation.
Disturbance to the human population	• Monitor regularity of complaints received from local residents; • Noise monitoring during operations to validate predictions and inform ongoing practices; • Baseline levels of noise, and light to be better established. • Routine sampling and quality tests will be undertaken on all fuel supplies as part of procurement processes and audits; • Monitoring of air quality parameters will be conducted over the seasons to establish baseline levels; and • Air quality monitoring during operations to validate predictions and inform ongoing practices.

Environmental Aspect	Key monitoring and management commitments
Risks associated with accidental events	
Oil spills	• Further research into the effect of Sea Lion crude on fur; • Regular oil spill response equipment exercises to be conducted; • An oiled wildlife response workshop will be held with all relevant stakeholders to help steer the response plan, methods, funding and governance; • Efficacy tests of oil spill response equipment; • Further research to improve knowledge of species distributions, especially seabirds, marine mammals, coastal flora and fauna especially in temporal scales; and • Regular monitoring of indicator species and habitats in coastal areas.

1.9 Overall conclusion

The use of vessels, fossil fuels and onshore resources (e.g. water and electricity) is necessary to carry out any O&G operation and the generation of some waste, which cannot be re-used, recycled or converted to energy is unavoidable. Similarly, the use of third-party vessels from elsewhere in the world will always carry some risk of non-native species introduction and all oil production and export operations carry the risk of oil spill events. It is, therefore, not possible to carry out O&G operations without some degree of environmental and / or social risk and impact.

In summary following the EIA process, and the adoption of ALARP mitigations, thirteen residual impacts and risks have been assessed as significant:

- Impacts - Planned activities:
  1) Artificial light offshore and inshore - **Moderate;**
  2) Underwater vessel noise offshore - **Moderate**;
  3) Drill cuttings discharges – **Moderate;**
  4) Atmospheric emissions (climatic factors) - **Moderate**;
  5) Waste management (contingent export to UK with unrecoverable waste going to UK landfill); – **Moderate**;
  6) Collisions with marine mammals inshore – **Moderate**;
  7) Introduction of marine invasive species - **Upper Moderate**;
  8) Introduction of terrestrial invasive species – **Upper Moderate;**
  9) Competition for freshwater resources – **Upper Moderate**;
  10) Competition for energy resources – **Upper Moderate**;
  11) Competition for use of roads – **Moderate**; and
  12) Disturbance to the human population from light – **Moderate**.
- Risks - Unplanned / accidental events:
  7) Oil spill offshore and inshore - **Moderate**.

Premier believe that:

- All impacts and risks associated with the Sea Lion Development have been identified and robustly assessed;
- Impacts and risks which are ALARP and are considered to be of low significance are sufficiently controlled; and
- Impacts and risks that are currently ALARP but remain significant will be further reduced wherever practicable throughout the life of the Development.

Premier will continue to do all that is reasonably practicable with regard to monitoring and management to minimise environmental impacts / risks during both the 'Define' and 'Execute' stages of the Phase 1 Development.

All impact and risk assessments will be periodically reviewed to ensure that the controls remain in place and that activities leading to potentially significant impacts and risks are subject to continuous improvement where opportunities exist.

1.10 Formal stakeholder consultation

1.10.1 Representations by stakeholders

Following review by the FIG EPD / DMR, and confirmation by the Executive Council that the EIS complies with the Schedule 4 of the FIG Offshore Minerals Ordinance, the EIS was formally submitted. Following submission, the following are now available for review by statutory consultees and the public during the formal 42-day consultation period:

- The Non-Technical Summary;
- The EIS; and
- Documents supporting the EIS (e.g. the Oil Spill response strategies etc.).

During this time, copies of the above could be requested from the Premier Stanley office (Sealion.enviro@premier-oil.com).

1.10.2 Responses by Premier

Following the 42-day consultation, all material representations will be provided to Premier by DMR and recorded within this EIS (Chapter 17). This chapter will, where necessary, indicate what changes have been made to the EIA / EIS in response to material stakeholder concerns.

2 INTRODUCTION

Table of Contents

2.1 Introduction

Premier Oil Exploration and Production Ltd (Premier) is proposing development of the Sea Lion Field in the North Falkland Basin (NFB) with a view to the long-term production and export of crude oil. Therefore, it is necessary to conduct an Environmental Impact Assessment (EIA) and to present the outcomes in an Environmental Impact Statement (EIS).

The EIA and the development of this EIS were carried out in compliance with the:

- Falkland Islands Government (FIG) Policy Unit (Formally the FIG Environmental Planning Department (EPD)) Hydrocarbons Environmental Impact Assessment Guidance Note (FIG, 2015l); and
- Corporate Premier Standard: Environmental and Social Impact Assessment (CP-BA-PMO-HS-SE-ST-0001).

The purpose of this introduction is to:

- Provide a brief overview of the proposed Sea Lion Field Development;
- To describe the purpose of the EIA and structure of the EIS; and
- To indicate the current areas of uncertainty within the Development.

An EIS for a previous development scope for the Sea Lion Phase 1 Development was submitted and accepted in 2018 (Ref. Premier, 2018). Since then, the project scope has been developed further. While this document is a compliant standalone EIS for the current proposals, to assist readers who are familiar with the previous submission, it is noted that the following areas of the project have been optimised:

- FPSO storage capacity and location;
- Number of wells to be drilled and inclusion of a new drill centre;
- Number of well flowbacks to the MODU;
- Selection of Direct Offtake as the oil export option; and
- Rerouting and layout of the Subsea infrastructure.

The detailed project description revisions are provided in section 5.1.1. The remainder of this document refers to the revised project description, unless otherwise stated.

2.2 Overview of the Sea Lion Field Development

2.2.1 The Falkland Islands

The Falkland Islands are a UK Overseas Territory located on the edge of the Patagonian Shelf in the South Atlantic Ocean, approximately 480 km from the South American mainland. The Islands have a total land area of 12,173 km^2 (East Falkland approximately 6,700 km^2, West Falkland approximately 5,300 km^2, plus over 700 smaller islands) and a permanent population of approximately 3,000.

2.2.2 The Sea Lion Field

The Sea Lion Field lies in water depths of approximately 450 m and is located in Block 14/10 in hydrocarbon license area PL032, approximately 220 km north of the Falkland Islands (Figure 2.1). It is the first commercially viable hydrocarbon discovery in the NFB and was discovered by Rockhopper Exploration PLC (Rockhopper) in 2010.

In October 2012, Premier farmed in for 60% of Rockhopper's licence interests in the Falkland Islands which included the Sea Lion Development. Premier is now Operator of licence PL032, PL033 and PL004 (a, b and c). Further prospects in these licences were evaluated by Premier in 2015 during a three well exploration drilling campaign which was covered by a separate EIA (Premier 2014a, *Ref.* [1]). A licence map is shown in Figure 2.1

The aim is to produce oil and gas from the Sea Lion Field in a phased development and this EIS describes the EIA for Phase 1. Phase 1 is described in more detail in the Field Development Plan (Premier, 2017c, *Ref.* [2]).

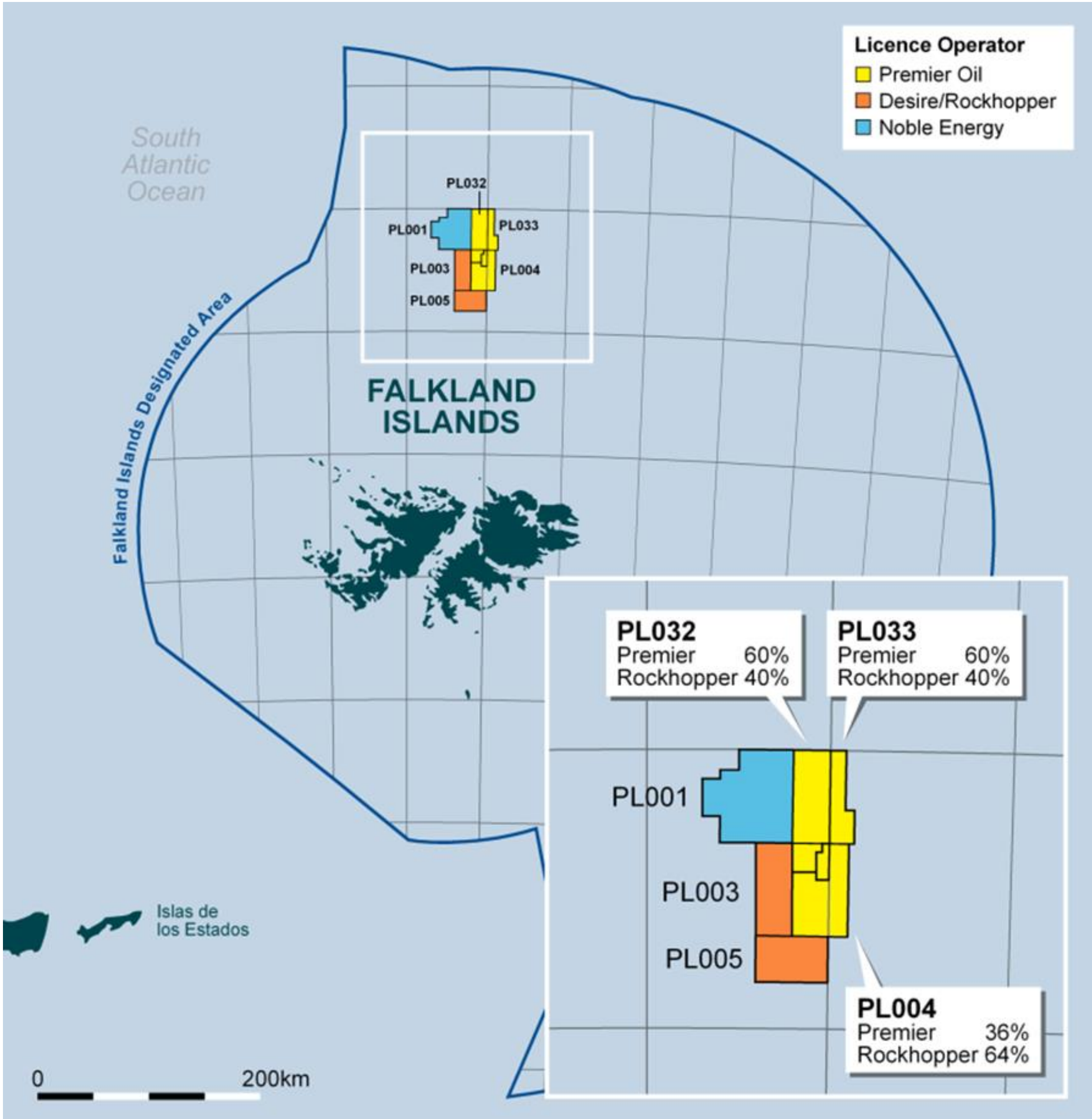


Figure 2.1: Sea Lion Field and Licence Block Locations

2.2.3 Phase 1 Development overview

The proposed Phase 1 Development of the Sea Lion Field is located in licence block PL032. A field life of 20 years has been projected and it is estimated that approximately 250 million standard barrels (MMstb) (deterministic reference case) of oil can be recovered in this Phase.

As described above, aspects of the project description have been optimised since the previous EIS submission. Further details on the changes are provided in section 5.1.1.

2.2.3.1 Drilling

If approved by the Falkland Islands Government (FIG), the Phase 1 Development will produce from up to 30 subsea wells. The development is expected to consist of 28 clustered wells (20 oil production, 8 water Injection wells) drilled and a single remote gas well. These 29 wells will be drilled across three Drill Centres (DC, the Main, Eastern, and Southern DC) and the single, remote gas well at the West Flank location. As a contingency, the drilling of an additional remote gas well at the Casper location is also included taking the maximum well count to 30 (i.e. 29 wells + 1 contingent well). To assume the environmental worst case, this EIS assesses the impact of drilling the maximum number (30) of wells.

The single remote West Flank gas well is the first well in the drilling programme. This well will drill the Chatham prospect and will confirm the presence or absence of a gas cap in the SL20 reservoir and therefore whether or not there is sufficient gas at that location to provide fuel for the Phase 1 development. Should this well confirm that the gas cap is absent or significantly smaller than expected, fuel gas will be sourced from the Casper reservoir north of the PL032 / PL004 licence boundary, through a contingent vertical gas well.

All wells will be drilled using a Mobile Offshore Drilling Unit (MODU) located within a 500 m exclusion zone. The drilling operation will be supported by two Multi-Role Support Vessels (MRSVs, as supply vessels) and an Emergency Response and Rescue Vessel (ERRV). The vessels will also have surveillance equipment onboard for monitoring oil spills.

Four of the wells to be cleaned up to the MODU, which means four wells could be flared offshore for short periods of c. 1 day each. If the levels of debris observed during the initial four well clean ups exceed safe levels for the FPSO, up to a further 17 wells may require similar clean up. It is anticipated that drilling will start approximately 19 months after project sanction.

2.2.3.2 Installation

Later, whilst drilling is ongoing, installation of subsea facilities will be undertaken by installation vessels, prior to the arrival and 'hook-up and commissioning' of the Floating Production, Storage and Offloading (FPSO) vessel. During the installation phase, up to four Large Transport Vessels (LTVs) will be used to act as floating storage vessels to support the subsea installation operations. The LTVs will be anchored in Berkeley Sound and each LTV will require its own individual 500m exclusion zone. At any one time, there will be a maximum of two LTVs present in Berkeley Sound for short periods of up to 12 months. Premier will work with the FIG Marine Authority to identify optimum locations within Berkeley Sound that will cause the least disruption to other users during periods of high marine traffic in the Sound.

The FPSO will be anchored to the seabed, surrounded by a 500 m exclusion zone, see Figure 1.2. The FPSO will be located approximately 2.1 km from the main Drill Centre (DC), 3.0 km from the Southern DC, 1.6 km from the Eastern DC and approximately 6.0 km and 5.8 km from the remote West Flank and Casper GPI well(s) locations, respectively.

The DCs will comprise a number of subsea manifolds (for example, water injection or production) depending upon location (section 5.5.2). An array of subsea pipelines and risers will be installed to connect the wells at the seabed to the FPSO.

2.2.3.3 Production

Following a period of hook-up and commissioning, hydrocarbons will be introduced onto the ship-shaped FPSO. The term ‘Hook Up and Commissioning’ (HUC) refers to the process by which the FPSO is connected to the subsea wells, via the manifolds and the pipelines, umbilicals and risers.

Oil production and processing carried out onboard the FPSO will stabilise the oil prior to its export. Once operational, the production wells will produce reservoir fluids to the FPSO. The produced fluids will consist of oil, water and gas which will be separated and treated on the FPSO. Oil will be stabilised and transferred to storage tanks within the hull structure for subsequent offloading and export to market. Gas will be used for fuel, heat and power, on the FPSO and for ‘gas lift’ in the oil production wells to enhance oil flow by reducing the density of the fluids in the well thereby enabling a higher production rate from the reservoir. During normal operations, any excess gas will be re-injected into the GPI well(s). In the event of a gas deficit, gas volumes will be supplemented by production from the GPI well(s). Produced water will be cleaned and, during normal operations, will be re-injected via the water injection wells, in combination with treated sea water, again to enhance / optimise oil recovery.

It is anticipated that ‘First Oil’ will occur approximately 42 months after sanction.

2.2.3.4 Simultaneous Operations

After First Oil, there will follow a spell of simultaneous operations (SIMOPS) with the MODU continuing to drill the remaining wells while the FPSO begins production from the initial wells. Once all the wells have been drilled, the MODU will leave and only the FPSO, in steady state production, and its support vessels, will remain.

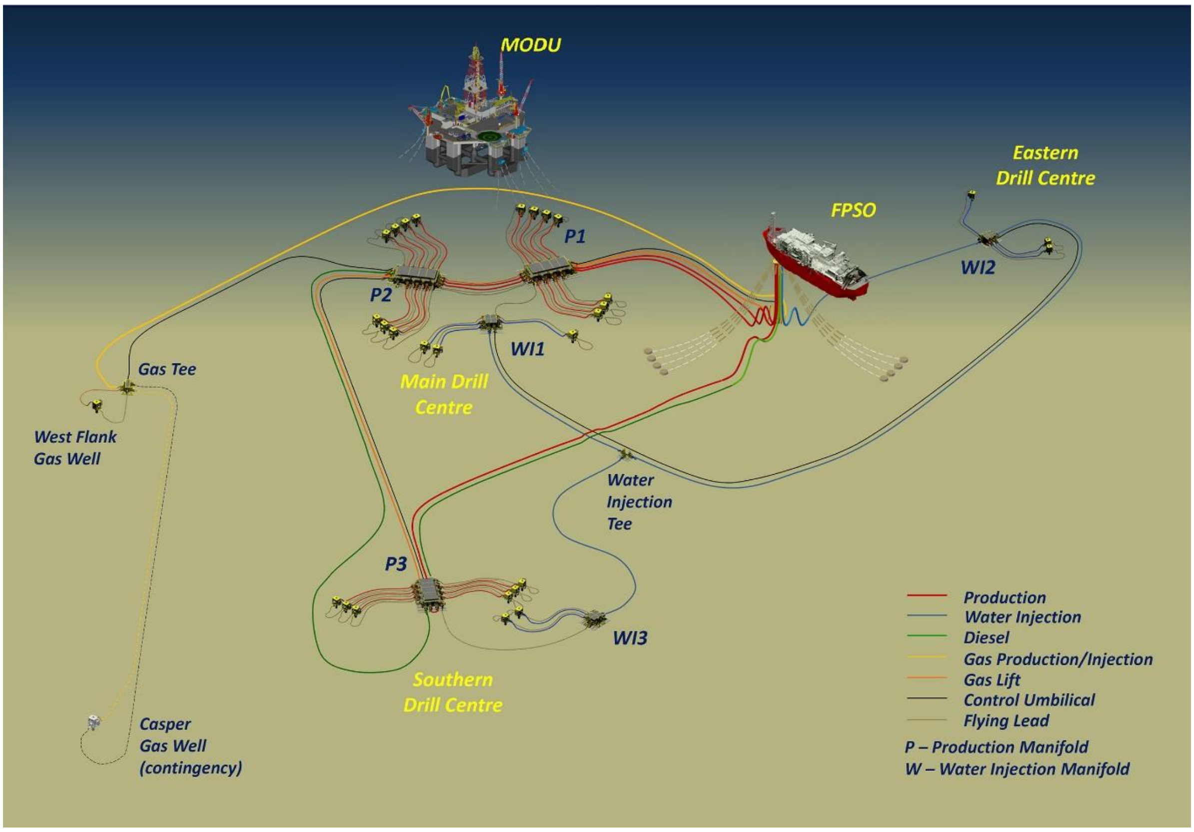


Figure 2.2: Graphic showing the Sea Lion Field in SIMOPS with both MODU and FPSO present

2.2.3.5 Oil export

The project oil export route involves the Direct Offtake of oil from the FPSO to a Conventional Trading Tanker (CTT) With Direct Offtake, the crude will be directly offloaded from the FPSO to a purchaser's CTT at the Sea Lion location and from there the crude will be exported to market. To ensure that the offloading operating conditions are maintained within strict limits, Direct Offtake will require an Offshore Support Vessel (OSV, i.e. a pull back tug) to attend the CTT offshore, in addition to the presence of the ERRV, which is always on standby.

The capacity of the purchaser's CTT oil tanker (c. 165,000 m^3 or 1,000,000 barrels) requires that two consecutive off-take operations (offloads) from the FPSO will be required to complete the CTT export parcel. As the rate of oil production reduces over time, it is expected that the oil export operation (a one million barrel parcel) will occur once every 13 days at peak production in Years 1 to 5, reducing to once every 46 days after about 10 years of operation.

The Direct Offtake operation of crude to the CTT is described below.

- The CTT will arrive in Falkland Islands' waters and a berthing crew will be transferred to the CTT by helicopter, at a safe distance from the FPSO;
- The CTT will rendezvous with the hold back tug (OSV), which will connect to the stern of the CTT;
- The MRSV (acting as an Emergency Response and Rescue Vessel (ERRV)) will be on standby duty in-field throughout the operation;

- The OSV will apply light power to control the heading of the CTT through approach and will remain connected during connection to the FPSO as well as during pumping, disconnect and departure;
- The CTT and connected OSV will approach the stern of the FPSO, and connect to the FPSO by a taught hawser. The hose will be unreeled from the FPSO and transferred to the CTT where it will make a connection at the midship manifold and the transfer will begin;
- Once the transfer is complete, the CTT and OSV will disconnect from the FPSO and move away;
- At a safe distance, the OSV will detach and the berthing crew will disembark;
- Following the receipt of one cargo of oil from the FPSO the CTT will then standby in field awaiting the second parcel of oil;
- When the FPSO has produced another cargo to complete the CTT parcel of 1,000,000 bbls, the process will be repeated; and
- Once the second transfer is complete, the OSV will detach, the berthing crew disembark and the CTT will proceed to deliver the crude to market without entering inshore waters.

2.2.3.6 Support

The drilling, installation, production and oil export operations will all be supported by an onshore supply base, liquid mud plant, and a Temporary Dock Facility (TDF) located to the east of Stanley. The offshore crew will be transported by helicopter.

2.2.3.7 Decommissioning

At the end of field life, expected to be 20 years after First Oil, the FPSO and all associated subsea infrastructure and pipelines, will be decommissioned and removed from the NFB in accordance with requirements at that time. Decommissioning will be subject to a separate EIA, submitted at a time to be agreed with FIG (most commonly a few years prior to the cessation of production).

2.2.4 Areas of uncertainty

At the time of conducting the environmental impact assessment, the following areas have not yet been fully defined:

- Final selection of the Mobile Offshore Drilling Unit (MODU) to be used;
- Final selection of offshore drilling chemicals;
- The detailed drilling schedule;
- The sources of equipment and materials e.g. Europe, Asia etc.;
- The specific vessels to be used for transportation, installation and support;
- Final selection of offshore production and utility chemicals;
- The frequency of dedicated charter flights throughout the field life;
- The frequency of coaster supply vessels from the UK throughout steady state production;
- The origin of the coaster supply vessels;

- Location of the subsea X-mas tree integrity testing;
- Details on the accommodation arrangements on the Islands;
- Precise infrastructure requirements for power, water and roads; and
- Final selection of oil spill response equipment.

These project details will be finalised following project sanction and contract award. Where project details are subject to change, the 'worst case' options were assumed for the purposes of the EIA. Where the different options may impose different impacts and / or risks, either both options or the worst case were assessed.

Therefore, as per the EPD Hydrocarbons Environmental Impact Assessment Guidance Note (FIG, 2015m), this EIS includes a 'wider range / level of activity to accommodate areas of uncertainty'.

Importantly however, further changes may also occur before commissioning of the field. If post-sanction changes occur, discussions will be held with FIG to determine the most appropriate way to manage and assess the change.

2.2.5 Subsequent phases of development

The potential for subsequent phases of development to produce the remainder of the reserves in Licence Blocks PL032 and PL004 is currently under evaluation. The outcome of this evaluation will depend upon learnings from the Phase 1 Development, knowledge gained from the 2015 exploration campaign and the forecast for global oil demand and associated prices.

Subsequent phases are, as yet, undefined and are not within the scope of this EIA which assesses the proposed Phase 1 Development only.

2.3 EIA process overview

Numerous preparatory and data gathering steps are involved in conducting an EIA. These steps aim to:

- Understand the **context** within which the EIA is being carried out:
  - Identify the legal and regulatory context within which the proposed project is to occur (section 3.1);
  - Understand Premier's Health, Safety, Environment and Security Management System (HSES-MS) which supports the proposed Development (section 3.2);
- Consider the **alternatives** to the proposed development (Chapter 4);
- Understand the **proposed development** and all the activities that may interact with the environment (Chapter 5);
- Identify any concerns that **stakeholders** may have regarding the proposed development (Chapter 6);
- Understand the environment in which the proposed Development is to occur in order to identify key **environmental and social sensitivities** (Chapter 7);

- Develop a **methodology** for assessing the environmental and social impacts of planned activities and the risks associated with unplanned and accidental events (Chapter 8);
- Conduct an **ENVironmental Impact IDentification** (ENVIID) workshop to specifically identity the impacts and risks associated with the project activities that warrant further investigation, and those that can be 'screened out' following preliminary assessment (Chapter 9);
- Assess the **significance** of all environmental and social impacts and risks that were not screened out, taking account of the base case mitigations as well as the industry-standard, legal and Premier HSES-MS requirements (Chapters 10, 11 and 12);
- Identify the need for additional **project-specific mitigation** measures that may be reasonably practicable to reduce the impact or risk to As Low As is Reasonably Practicable (ALARP) (Chapters 10, 11 and 12);
- Assess the significance of the **residual impacts and risks** which take account of the project-specific mitigation (Chapters 10, 11 and 12);
- Develop a project-specific **Environmental Monitoring and Management Plan** (Chapter 15) to list all the commitments made by Premier to reduce impacts and risks, which have been agreed in a workshop and will be reviewed by key stakeholders; and
- Address any concerns raised by **stakeholders** during the post-submission formal consultation process (Chapter 17).

2.4 Scope of the EIA

The impacts and risks assessed within this EIS are those associated with:

- Development drilling;
- Transportation and installation of all production facilities;
- Hook-up and commissioning of all production facilities;
- Production of oil and gas;
- Offloading of crude from the FPSO via Direct Offtake to CTT and then to market;
- The LTVs in Berkeley Sound and
- Associated supporting logistics and the use of onshore facilities e.g. the onshore supply base, and the 'at-shore' facilities e.g. the TDF and other port facilities.

The above are assessed to determine the impacts and risks associated with normal and planned operations as well as unplanned and emergency situations.

Following consultation with FIG (Chapter 6), and in line with FIG guidance, areas that fall out with the scope of this EIS include:

- Construction (as opposed to use) of the short-term and long-term onshore supply base and any upgrades that may be required to the TDF:
  - These will be covered by planning applications and separate EIAs as necessary.
- Decommissioning of the short-term onshore infrastructure associated with development drilling;

- Socio-economic impacts of the Development (e.g. revenue, employment etc.):
  - Independent socio-economic assessment of Oil and Gas (O&G) development has previously been commissioned by Rockhopper Exploration (Plexus Energy, 2012). More recently the Falkland Islands Government (FIG), with input from Premier, commissioned a socio-economic impact assessment to identify potential impacts and any mitigation measures required to minimise any negative impacts that could be associated with O&G development (Regeneris, 2013). Socio-economic monitoring is currently ongoing through a Social and Economic Monitoring Programme (SEMP), which incorporates public consultation. Initial SEMP results have been published by Regeneris (2015).
  - An additional separate socio-economic impact assessment, building and updating the previous work undertaken for FIG and Rockhopper by Regeneris (2013 & 2015) and Plexus (2012), has been completed by Premier (Maplecroft, 2019).
- Offshore decommissioning impacts:
  - These will be covered in a decommissioning-specific EIA prior to the cessation of production and in support of the decommissioning programme (as agreed in discussion with FIG, and in accordance with the approach taken in the UK with regard to developments on the UK continental Shelf (UKCS) and the DECC (now BEIS) Decommissioning Guidelines (BEIS, 2018)).

2.5 Purpose and structure of this Environmental Impact Statement

The EIA must be carried out in compliance with the requirements of the:

- Offshore Minerals Ordinance 1994 (and all amendments).

The EIS summarises the outcomes of the EIA and enables informed decisions to be taken on whether or not the proposed Development may proceed based on the acceptability, or otherwise, of the impacts and risks.

Specifically, the EIS informs:

- The Premier project development and design process; and
- The FIG review process.

Should the FIG Department of Mineral Resources (DMR) indicate to FIG Executive Council that a valid EIS has been submitted which is compliant with the Ordinance, a 42 day consultation period will follow. The consultation will comprise formal consultation with FIG, its statutory consultees and the general public. Premier will then respond to comments received from the 42 day consultation by updating the EIS or submitting additional information, if required, to the satisfaction of the regulator, prior to any decision being made by FIG.

2.5.1 Structure of the EIS impact and risk assessment chapters

Within this EIS, each impact and risk assessment chapter (Chapters 10, 11 and 12) follows a consistent structure as summarised in Table 2.1.

Note that many activities, e.g. the use of vessels, may have numerous impacts or associated risks and thus need to be described in more than one chapter, as shown in Table 2.2.

Table 2.1: Impact and risk assessment chapter structure

Impact / risk chapter sub-headers	Description of content
Introduction	This section describes the purpose of the chapter and gives a brief account of the subject-specific legislation and associated compliance requirements.
Sources of impact and / or risk	This section lists the Phase 1 activities that may result in the impact and / or risk and provides further detail where necessary and / or reference to the relevant section with the Development Description (Chapter 5).
Potential receptors	This section lists the environmental and social receptors that may be affected by the impact or risk (e.g. water quality, seabirds, human population etc.). Reference is made to the relevant section in the Environmental and Social Baseline (Chapter 7) for detail on the receptors, and a very brief summary of why these are considered to be receptors to the impact and / or risk in question is provided.
Characterising and quantifying the impacts and / or risks	This section provides the specific data necessary to inform the impact and / or risk assessment. Data is drawn from the Development Description (Chapter 5) the Environmental and Social Baseline (Chapter 7) and subject-specific literature reviews. The content within this section varies and is structured as appropriate to the specific impact / risk although it most commonly includes: • A description of the relevant influencing factors; • A description of the nature of the potential impact to each receptor; • Quantification of the Phase 1 outputs (e.g. how much waste, how much CO_2); and • Describes the method and results of any modelling carried out. Please note that the estimation of Phase 1 outputs (e.g. the amount of CO_2) takes account of the mitigations which are built-in to the project basis of design which are described in the Development Description (section 5.13).
Industry-standard mitigation	This section lists the industry-standard mitigation measures that are factored into the initial impact and / or risk assessment and any requirements within the Premier ISO:14001 certified HSES-MS.
Impact and / or risk assessment	This section draws on all the information above to assess the significance of the impacts and / or risks, taking account of the industry-standard mitigation measures and using the ‘sensitivity of receptor’ and ‘severity of effect’ guidelines provided in the EIA Methodology (Chapter 8). A precautionary approach is taken in all assessments. **Note**: this section aims to provide a concise assessment and refers back to previous sections within the chapter to support the statements made and the rationale behind the evaluation of impact / risk significance.
Project-specific mitigation	This section describes any project-specific mitigation measures that may be deployed, where necessary and reasonably practicable, to reduce impacts and risks to ALARP.
Residual impacts and / or risks	This section describes the residual significance of the impact and / or risk following re-assessment with any project-specific mitigation measures taken into account.
Cumulative impacts	This section assesses the Phase 1 impacts in combination with inputs from other sources as per the EIA Methodology (Chapter 8).
Confidence	This section indicates the level of confidence in the overall assessment, taking account of any data gaps etc.
Findings summary	This section summarises the complete impact and / or risk assessment chapter in a standardised table format.

Table 2.2: Summary of the assessment chapters relevant to each project activity

Assessment Chapters			Project activities											
			Drilling operations	Installation	FPSO HUC	SIMOPS	Production	Offloading from FPSO to CTT	LTVs anchored in Berkeley Sound	Use of the onshore supply base and 'at-shore' TDF	Fixed-wing flights	Helicopter use	General vessel use	Decommissioning
Environmental	10.1	Artificial light	✓	✓	✓	✓	✓	✓	✓				✓	n/a
	10.2	Disturbance to wildlife from helicopter use										✓		n/a
	10.3	Placement of objects on the seabed	✓	✓		✓	✓		✓					n/a
	10.4	Underwater noise offshore	✓			✓	✓	✓				✓	✓	n/a
	10.5	Underwater noise inshore							✓			✓	✓	n/a
	10.6	Drill muds and cuttings	✓			✓								n/a
	10.7	Operational discharges		✓	✓	✓	✓						✓	n/a
	10.8	Thermal discharges				✓	✓							n/a
	10.9	Atmospheric emissions	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	n/a
	10.10	Waste	✓	✓	✓	✓	✓		✓	✓			✓	n/a
	10.11	Marine mammal collisions	✓		✓				✓	✓			✓	n/a
	10.12	Introduction of marine invasives							✓	✓			✓	n/a
	10.13	Introduction of terrestrial invasives									✓		✓	n/a
Social	11.1	Disturbance to other users of the sea offshore	✓	✓	✓	✓	✓	✓					✓	n/a
	11.2	Disturbance to other users of the sea inshore							✓	✓			✓	n/a
	11.3	Competition for accommodation	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	n/a
	11.4	Competition for fresh water	✓	✓	✓	✓	✓		✓	✓			✓	n/a
	11.5	Competition for electricity								✓			✓	n/a

Assessment Chapters			Project activities											
			Drilling operations	Installation	FPSO HUC	SIMOPS	Production	Offloading from FPSO to CTT	LTVs anchored in Berkeley Sound	Use of the onshore supply base and 'at-shore' TDF	Fixed-wing flights	Helicopter use	General vessel use	Decommissioning
	11.6	Competition for air links	✓	✓	✓	✓	✓		✓	✓	✓		✓	n/a
	11.7	Competition for roads	✓	✓	✓	✓	✓		✓	✓	✓		✓	n/a
	11.8	Disturbance to the human population from light							✓	✓			✓	n/a
	11.9	Disturbance to the human population from noise							✓	✓			✓	n/a
	11.10	Disturbance to the human population from odour							✓					n/a
	11.11	Disturbance to the human population from visual impacts							✓					n/a
	11.12	Air quality inshore							✓					n/a
Accidental	12.1	Oil spill and chronic pollution offshore	✓	✓	✓	✓	✓	✓					✓	n/a
	12.2	Oil spill and chronic pollution inshore							✓				✓	n/a
	12.3	Oil spill and chronic pollution at-shore								✓			✓	n/a

3 EIA CONTEXT

Table of Contents

3.1 Regulatory overview and legislation

This section provides a brief overview of the system of governance within the Falkland Islands and current legislation that governs oil and gas (O&G) activities in the Islands. The information presented is based upon a review carried out by Genesis (2013).

3.1.1 Falkland Islands territorial status

The Falkland Islands is one of 14 United Kingdom Overseas Territories (UKOT), which are managed under the British Overseas Territories Act 2002.

3.1.2 Falkland Islands governance

The Islands are self-governed although supreme authority is vested in Her Majesty the Queen who is represented in the Falkland Islands by HE Governor. Defence and foreign affairs remain the responsibility of the British Government.

The Constitution of the Falkland Islands, the present version having been in place since 2008, lays out the rights and freedoms of the individual as well as setting out the ways in which the Falklands are governed and how its laws are made.

The Falkland Islands' system of government follows the Westminster Model and is divided into:

- Elected Members of the Legislative Assembly (MLA) and associated Legislative and Executive Councils:
  - Eight MLAs are elected as independents by the Falkland Islands' Community to serve a four-year term.
- *Ex officio* members from the Falkland Islands Government (FIG), British Forces and the Governor:
  - The Governor is appointed by the Foreign and Commonwealth Office (FCO).

Legislative Assembly meetings are held in public (FIG, 2015b) and are chaired by a Speaker chosen from the community by Assembly Members. The meetings are attended by the MLAs and two *ex officio* members, namely the Chief Executive and the Financial Secretary. The Attorney General and the Commander of the British Forces South Atlantic Islands (CBFSAI) are also entitled to attend.

The Legislative Assembly is empowered to pass legislation for the peace, order and good governance of the Falkland Islands, subject to the approval of Her Majesty the Queen and acting through her Secretary of State for Foreign Affairs.

Each year, the MLAs elect three of their number to the policy making body of the Government known as the Executive Council (ExCo) which is chaired by the Governor. Membership includes the same *ex-officio* members who sit on the Legislative Assembly. In addition, the Attorney General and CBFSAI may attend and speak on any matter although only the three elected MLAs are able to vote on ExCo (FIG, 2015b).

3.1.3 Governing bodies for O&G activities in the Falkland Islands

The Falkland Islands offshore hydrocarbons industry is regulated by the FIG's Department of Mineral Resources (DMR). The Department obtains specialist advice from a number of UK Government organisations, such as: the Health & Safety Executive (HSE), the Department of Business, Energy and Industrial Strategy (DBEIS), and the British Geological Survey (BGS). The Department has limited executive approval powers, and makes recommendations for approval to ExCo through the Mineral Resources Committee (a non-executive advisory committee). Ultimate approval for a number of Mineral Resources-related matters, such as the granting of licences and changes of licence ownership, is retained by the UK Secretary of State for the Foreign & Commonwealth Office.

The Planning and Building Committee is the authority responsible for statutory planning determinations within the Falklands. Any aspects of a hydrocarbon development occurring within the 12 nm limit or onshore will fall under statutory planning regulations.

Ultimate power in mineral regulatory matters lies with the Governor. The Governor consults with the ExCo, which in turn is advised by the DMR, the Policy Unit and Planning and Building Services (previously the Environmental Planning Department (EPD)) (FIG, 2014d). DMR is responsible for leading on the assessment of the EIS and ultimately makes a recommendation to ExCo as to whether the EIS meets the requirements of the Offshore Minerals Ordinance 1994 (as amended) (section 3.1.6.3.1).

3.1.4 The Environmental Charter

The Environmental Charter is a joint agreement between FIG and the UK Government and was signed in 2001 (FIG, 2015d). The Charter lists ten guiding principles and the UK and Falkland Islands Governments have each made eleven commitments therein, all intended to ensure environmental management within the Islands.

One of the UK commitments within the Environmental Charter is to 'assist the Falkland Islands in reviewing and updating legislation'. Environmental legislation that applies to O&G activities within the Falkland Islands is based on that for the United Kingdom Continental Shelf (UKCS). However, given that the O&G industry within the Falklands is in its infancy, guiding legislation specific to the Falklands is currently limited. FIG are undertaking a review to ensure the development of appropriate legislation (section 3.1.5.1). While this process is underway however, and in the absence of specific FI legislation, the preparation of required consents shall be based on UK guidance.

3.1.5 Falklands Islands policies and codes of practice

3.1.5.1 Offshore environmental policy review (2016)

As part of its 'oil readiness planning', FIG has reviewed its current legislative structure in respect of environmental regulation of offshore hydrocarbon activities and several crucial gaps have been identified. Consequently, a consultation was held on proposed offshore environmental legislation This proposed legislation should provide the Falkland Islands with a modern regulatory regime, granting regulatory powers that are appropriate to the Falkland Islands' constitutional obligations. Further, the proposed legislation will ensure that environmental impacts and risks are appropriately regulated given the logistical and operational challenges inherent in operating in the South Atlantic. Therefore, it is likely that offshore environmental legislation will be updated prior to the commencement of in-field work on the Sea Lion Development.

3.1.5.2 Hydrocarbons Development Policy Statement 2013

In order to plan for the future development of the hydrocarbons industry in the Falklands, a Policy Statement was prepared to provide clarity on the purpose of hydrocarbon development and how the implications of developments will be managed. In 2013, the Falkland Islands Hydrocarbon Development Policy Statement (158/13) was released with the following recommendations:

- Hydrocarbons in Falkland Islands waters belong to the people of the Falkland Islands and their exploitation must be to the benefit of the people of the Falkland Islands, both those of today and future generations;
- The FIG will maintain constant supervision and control over all hydrocarbon activities within the Falkland Islands Designated Area;
- Petroleum discoveries must be efficiently managed and exploited to maximise economic recovery and to ensure the development of a long-term industry presence that will benefit the Islands for decades to come;
- Development of the hydrocarbons industry must ensure the protection and conservation of the Falkland Islands environment and biodiversity;
- Development of the hydrocarbons industry must take into consideration existing commercial activity and promote the development of local business capacity;
- The exploitation of finite natural resources will be used to develop lasting benefits to society across the whole of the Falkland Islands;
- Transparency and accountability must be present throughout the hydrocarbon development process from all parties involved; and
- The Falkland Islands will only consider onshore hydrocarbon facilities if they are considered to be in the best interests of the Falkland Islands, and can be proven to satisfy all of the above policy goals.

3.1.5.3 Local Content Code of Practice for Procurement by Oil and Gas Companies and their Subcontractors Operating in the Falkland Islands

The Local Content Code of Practice was developed by FIG in 2014 and sets out a series of principles, strategies and practices aimed at ensuring that local people and companies benefit, to the fullest extent possible, from opportunities generated by O&G exploration and production.

The Code applies to contracts and employment opportunities relating to onshore and offshore, field-related and non-field related projects. However, it should be noted that compliance with the Code is voluntary.

Specifically, this voluntary Code of Practice seeks to:

- Increase the stake of the Falkland Islands' people in the developing O&G industry in a sustainable manner;
- Ensure capacity development and employment of Falkland Islands' people;
- Ensure the use of Falkland Islands' goods and services;
- Ensure the transfer of technology and know-how to secure the localisation of knowledge and ownership; and
- Encourage the integration of the O&G sector with the other sectors of the Falkland Islands' economy to effectively support national growth and development through joint projects / facilities, joint ventures and partnerships.

In line with the Hydrocarbon Policy Statement described above, the Code seeks to create a legacy of long term benefit and growth to the Islands economy and helps to retain as much 'value' locally as possible.

3.1.6 Legislation relevant to oil and gas development in the Falkland Islands

Detail on activity-specific legislation and the associated compliance requirements is included in each impact / risk assessment chapter (Chapters 10, 11 and 12). Nonetheless, an overview of the relevant international treaties and UK regulations followed by detail on the relevant Falkland Islands national legislation is provided below.

3.1.6.1 International treaties and legislation relevant to the Falkland Islands

A 'treaty' is an agreement under international law which is entered into by sovereign states and international organisations and may also be known as an 'international agreement', 'protocol', 'covenant' or 'convention'.

Treaties can be loosely compared to contracts which provide a means for willing parties to assume obligations among themselves. Any party that fails to live up to its obligations can be held liable under international law.

The UKOTs have no legal treaty-making capacity (EAC, 2014) and ultimately, the UK concludes treaties on the UKOTs' behalf. Indeed, the UK may apply treaties to UKOTs without any consultation and the application of the treaty falls wholly within the responsibility of the UK Government (EAC, 2014). Therefore, the UK remains responsible if a UKOT violates a treaty obligation.

Additionally, in the event that the UK does *not* extend the treaty agreement to a UKOT, the UKOT may request to be party to the treaty and ratification may be extended under Article 29 of the 1969 Vienna Convention on the Law of Treaties. Ratification is a subsequent and separate process after a treaty is signed. To this end the chapter on 'Rights' in the 2009 Constitution for the Falkland Islands has been brought up-to-date to bring it in line with international agreements (FIG, 2015c).

International treaties, conventions and agreements relevant to the Falkland Islands are:

- International Convention for the Prevention of Pollution from Ships (MARPOL) 1973 (as amended by the Protocols of 1978 and 1997 and kept updated by the Marine Environment Protection Committee (MEPC)).
- United Nations Convention on the Law of the Sea 1982, specifically the ‘protection and preservation of the marine environment’.
- International Convention for the Safety of Life at Sea (1974, as amended).
- International Regulations for Preventing Collisions at Sea 1972.
- International Convention on Maritime Search and Rescue 1979.
- Kyoto Protocol to the United Nations Framework Convention on Climate Change.
- Paris Climate Agreement, United Nations Framework Convention on Climate Change (starting 2020).
- Montreal Protocol 1987 on Substances that Deplete the Ozone Layer.
- The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.
- The London Dumping Convention 1972.
- International Maritime Organisation (IMO) – International Convention for the Control and Management of Ships’ Ballast Water and Sediments.
- IMO International Convention on the Control of Harmful Anti-fouling Systems on Ships (2001) International.
- Convention on Biological Diversity 1993.
- Agreement on the Conservation of Albatrosses and Petrels (ACAP) 2004.
- International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC Convention).
- The International Convention on Civil Liability for Oil Pollution Damage.
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).
- Bonn Agreement Oil Appearance Code 2009.
- Ramsar Convention on Wetlands 1971.
- Convention on Migratory Species (CMS) (also known as the Bonn Convention) 1979.

3.1.6.2 UK legislation

It is understood that UK legislation may not be directly transferable to the Falkland Islands and each item of UK legislation that Premier propose to follow will be discussed in detail with FIG. This will ensure that it is appropriately and considerately transposed to ensure relevant elements of the legislative requirements are followed, and those that are not appropriate or relevant, are not included. Where the Falklands enact any legislation that supersedes the commitments made by Premier, the Falkland Islands’ legislation will take precedence.

UK legislation that may be of relevance to the Phase 1 Development is as follows:

- The Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1999 (amendment) Regulations 2007.
- The Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended Regulations 2011).
- The Offshore Chemicals Regulations 2002 (and all Amendments).
- The REACH Enforcement Regulations 2008.
- Climate Change Act 2008.
- Offshore Combustion Installations (Prevention and Control of Pollution) Regulations 2001 (Amendment) Regulations 2007.
- The Energy Act, 1976 (Amendment) Regulations 2008.
- The Environmental Protection Act 1990.
- Ozone Depleting Substances (ODS) Regulations 2015.
- Fluorinated Greenhouse Gases Regulations 2015.
- The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (amendment) Regulations 2007.
- Offshore Installations (Emergency Pollution Control) Regulations 2002.
- Offshore Marine Conservation of Habitat Regulations (2007, 2010).
- Offshore Marine Habitats and Species Regulations 2017
- Dangerous Substances in Harbour Regulations 1987.
- Transfrontier Shipment of Waste Regulations 2007.
- The Waste (Scotland) Regulations 2012.
- Controlled Waste Regulations 1992 (as amended) (Scotland only).
- Special Waste Amendment (Scotland) Regulations 2004.
- Standards for Training, Certification, and Watchkeeping 1978.
- The Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation Convention) Regulations 1998, 2015.
- The Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008.
- The Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2008.
- UK Merchant Shipping (Oil Pollution) Act 1971.
- Environmental Damage (Prevention and Remediation) Regulations 2015.
- Offshore Installations (Offshore Safety Directive) (Safety Case etc.) Regulations 2015.
- Offshore Combustion Installations (Pollution Prevention and Control) Regulations 2013

3.1.6.3 Falkland Islands national legislation

Falkland Islands legislation relevant to O&G developments is as follows:

- Offshore Minerals Ordinance 1994 (1997 and 2011 Amendments).

- Offshore Petroleum (Licensing) Regulations 1995 (2000, 2004, 2005 and 2009 Amendments).
- Petroleum Survey Licences (Model Clauses) Regulations 1992.
- Marine Environment (Protection) Ordinance 1995.
- Environmental Protection (Overseas Territories) (Amendment) Order 1997.
- Maritime Ordinance 2017 (as amended (2019)).
- Maritime (Oil Pollution Preparedness, Response and Co-operation Convention) Regulations 2019.
- Deposits in the Sea (Exemptions) Order 1995.
- Marine Mammals Ordinance 1992.
- Conservation of Wildlife and Nature Ordinance 1999.
- Fisheries (Conservation and Management) Ordinance 2005.
- Endangered Species Ordinance 2015.
- Planning Ordinance 1991.
- Planning (Environmental Impact Assessment) Regulations 2015.
- FIPASS Ordinance (1989).
- Harbours and Ports Ordinance 2017.
- Merchant Shipping (Registration of Ships) Regulations 2001.
- Oil in Territorial Waters Ordinance 1960.
- Maritime (Registration of Ships) Regulations 2019.
- Merchant Shipping (Confirmation of Legislation)(Falkland Islands) Order 2018.
- Offshore Installations (Prevention of Fire, Explosion and Emergecny Response) Order 2008
- Offshore Installations (Safety Case) Order 2008.

A brief summary of each of the above is provided below.

3.1.6.3.1 Offshore Minerals Ordinance 1994 (as amended) (The Ordinance)

The Offshore Minerals Ordinance 1994 (as amended in 1997 and 2011), known as ‘The Ordinance, relates to the granting and renewal of production consents for O&G field developments, the drilling of wells and the construction and installation of production facilities and pipelines in the Falkland Islands Designated Area (200 nm from shore).

The Ordinance require that any operator who wishes to carry out O&G related activities in the Falkland Islands must first conduct an EIA of the activity and then present the conclusions in an EIS. To inform this process, the specific regulations and requirements are clarified within the ‘FIG EPD Hydrocarbons Environmental Impact Assessment Guidance Note 2015’ (FIG, 2015l).

Schedule 4 of The Ordinance provides further detail on the expected content of the EIS and detail on how the Phase 1 EIS (this EIS) meets the Schedule 4 requirements is provided in Appendix A.

On formal submission of the EIS to DMR, and following review by the FIG to ensure it meets the Schedule 4 requirements (Appendix A), the Governor (in Executive Council) will indicate that the EIS is ready to go to formal public consultation (42 days). Operators are required to notify the public of the EIS submission by advertising its submission in the local press. The Non-Technical Summary (Chapter 1) and the entire EIS must be made available to the public upon request.

Once comments from the consultation have been addressed and included to the satisfaction of DMR (Chapter 17), the EIS shall be further considered at Executive Council where a decision on aceptance will be reached. The EIS is further considered, alongside the Field Development Plan, as part of the application for petroleum consent. Consent may be given or refused, or the consent may be subject to conditions that require modification to the proposed activity to reduce, remedy or offset impacts / risks to the environment. The decision will be published with detail on the review of the EIS.

Consent to begin any activity will not be given until the Governor (in Executive Council) is satisfied with the information provided and that there will be no unacceptable impact on the environment.

FIG is in the process of repealing and replacing the existing OMO with two new pieces of legislation. The first of these will provide for the licensing regime (including model clauses, oil field determination and decommissioning) and the second with be a new Offshore Minerals Safety and Environment Ordinance (OMSEO – title TBC). This will demonstrate separation of functions between licensing and safety regulation, aligned with best practice as set out in the European Safety Directive.

The proposed OMSEO seeks to modernise the environmental regulatory system governing offshore hydrocarbons by introducing a goal-setting regime. This will include an environmental assurance plan that will be integrated with the existing EIA regime. Performance will be measured against quantifiable standards based on environmental impacts and risks, with associated regular reporting, audit and review procedures. Statutory requirements for Oil Pollution and Emergency Plans (OPEPs) and the introduction of emergency intervention powers and the 'Polluter Pays' principle will also be introduced to align with UK best practice.

3.1.6.3.2 Offshore Petroleum (Licensing) Regulations 1995 (as amended)

The Offshore Petroleum (Licensing) Regulations 1995 stipulate the licensing requirements for O&G exploration and production as well as fees, royalties and working obligations of the licence holder.

They further provide a detailed description on the licensing application process, the required forms, model clauses, fees, and other requirements, such as maintenance, record keeping and reporting.

The Offshore Petroleum (Licensing) Regulations 2000 offered an open-invitation for exploration or production licences for specific blocks.

3.1.6.3.3 Petroleum Survey Licences (Model Clauses) Regulations 1992 (as amended)

The Petroleum Survey Licenses (Model Clauses) Regulations 1992 describe the framework governing offshore exploration activities including field observations, geological and geophysical investigations, the use of remote sensing techniques and seabed sampling.

These regulations were made under the Continental Shelf Ordinance 1991 and were enforced by the Offshore Minerals Ordinance 1994.

3.1.6.3.4 Marine Environment (Protection) Ordinance 1995

The Marine Environment (Protection) Ordinance 1995 implements the conditions of the London Dumping Convention 1972 and prohibits, other than under licence, the deposition or incineration of deleterious materials in Falkland Islands waters. This legislation provides a system of licensing, and licence offences, with strict liability for certain loss or damage in relation to polluting incidents.

3.1.6.3.5 Environmental Protection (Overseas Territories) (Amendment) Order 1997

The UK Environment Protection (Overseas Territories) Order 1988 is applied to the Falkland Islands by the Environment Protection (Overseas Territories) Order 1997. Although the 1997 Order is largely similar to the Falkland Islands Marine Environment (Protection) Ordinance 1995 in terms of its requirements (see above), if there is any contradiction between the two, the more stringent legislation will be applied.

3.1.6.3.6 Deposits in the Sea (Exemptions) Order 1995

The Deposits in the Sea (Exemptions) Order 1995 is similar to the Environment Protection (Overseas Territories) Order 1997; however, this Order exempts 25 specified operations from the licensing requirements under the Marine Environmental (Protection) Ordinance.

Deposits of sewage, domestic garbage, waste water generated from tank cleaning, ballast water and cooling water originating on the vessel are all exempt from licensing requirements. Further, deposits of any substance during firefighting, normal navigation or maintenance, and salvage operations do not require a licence.

Deposition of chemicals, drill cuttings and / or drilling mud are also exempt under this order but are subject to regulation through FIG Petroleum Offshore Notification (PON) 10.

3.1.6.3.7 Marine Mammals Ordinance 1992

The Marine Mammals Ordinance 1992 prohibits:

- The intentional harming, taking or killing of any marine mammal (including whales, porpoises, dolphins, otters, seals, sea lions and elephant seals);
- The use of explosives in such a manner that may cause harm to any marine mammal on land or in inland waters, territorial seas or any fishery waters of the Falkland Islands; and
- The import or export of any marine mammal, or any part of a marine mammal, living or dead, without a licence.

Within this legislation, Falkland Islands' waters correspond to the boundaries of the Falklands Outer Conservation Zone (FOCZ).

3.1.6.3.8 Conservation of Wildlife and Nature Ordinance 1999

This Ordinance repeals the Wild Animals and Birds Protection Ordinance 1964, the Nature Reserves Ordinance 1964 and the Fisheries Ordinance (1986).

Under this Ordinance it is prohibited to deliberately kill, injure, capture, replace, or disturb any protected wild animal, bird or plant without a licence. It also makes provision for the designation of National Nature Reserves (NNRs) on the seabed, on land or on private estates by agreement, with associated regulations for their preservation. Specifically, the Ordinance Schedules list protected bird, animal and plant species which may not be killed at any time but also detail the species that may be killed out with the timing of their closed seasons.

3.1.6.3.9 Fisheries (Conservation and Management) Ordinance 2005

The Fisheries (Conservation and Management) Ordinance 2005 extends the influence of the Conservation of Wildlife and Nature Ordinance 1999 (see above) beyond territorial waters (i.e. >12 nm from shore) to cover the Falklands Interim Conservation Zone (FICZ) and the FOCZ. However, the primary role of the Ordinance is to protect fisheries resources in order to:

- Meet the reasonably foreseeable needs of future generations; and
- Avoid, remedy, or mitigate any adverse effects of fishing on the marine environment so far as is reasonably practicable to do so.

The Ordinance has the following environmental and information principles:

- Associated or dependent species shall be maintained at, or above, a level that ensures their long term viability;
- Biological diversity of the marine environment shall be maintained;
- Habitats of particular significance for fisheries management shall be protected;
- Decisions shall be based on the best available information;
- Decision-makers shall consider any uncertainty in the information available in any case; and
- Decision-makers shall be cautious when information is uncertain, unreliable, or inadequate.

3.1.6.3.10 Endangered Species Ordinance 2015

The Endangered Species Ordinance 2015 upholds the Convention on the International Trade of Endangered Species (CITES) and controls the import and export of species listed under Appendix I, II and III of CITES.

3.1.6.3.11 The Planning Ordinance

The Planning Ordinance 1991 provides the regulatory framework for developments in the Falklands that have the potential to cause a significant impact to the environment or local communities.

3.1.6.3.12 Planning Environmental Impact Assessment Regulations 2015

These regulations empower the Planning Officer in the FIG EPD to require applicants to submit an EIS alongside applications for planning permission.

3.1.6.3.13 FIPASS Ordinance (1989)

The FIPASS Ordinance 1989 enables the management of FIPASS by the Harbour Master (also acting as the Marine Officer) and FIPASS Manager.

3.1.6.3.14 Maritime Ordinance 2017 (as amended)

Following a recent review of the existing legislation, the Maritime Ordinance 2017 came into effect in early 2018. The Maritime Ordinance covers a wide range of maritime activities; including vessel registration, safety, oil pollution, liability for oil pollution, wrecks and salvage.

3.1.6.3.15 Harbours and Ports Ordinance 2017

The regulations applying to Falklands Islands harbour and ports was reviewed and updated in 2017. The Harbours and Ports Ordinance 2017 establishes the maritime authority in the Falkland Islands, designates harbours and ports and permissible activity therein.

3.1.6.3.16 Merchant Shipping (Registration of Ships) Regulations 2001

The Merchant Shipping (Registration of Ships) Regulations 2001 require all vessels registered in the Falkland Islands to comply with the International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78. An exception to this is compliance with Annex IV on the discharge of sewage from ships. It was specifically requested that this annex not be applied, as the Falkland Islands is unable to comply with the legislative requirement for adequate vessel reception facilities.

Note: the UK Merchant Shipping (Oil Pollution) Act 1971 effectively implemented, and slightly extended, the International Convention on Civil Liability for Oil Pollution Damage (CLC) in the UK. This was applied to the Falkland Islands by 1975 Order in Council (SI 1975/2167 as amended by SI 1976/2143 and SI 1981/218). The UK Act regulated the responsibilities of ship owners for damage caused by oil pollution from their ships. It has not been adopted in the Falkland Islands but Parts I and II have been applied by virtue of the Falkland Islands Merchant Shipping (Registration of Ships) Regulations 2001.

3.1.6.3.17 Oil in Territorial Waters Ordinance (1960)

The Oil in Territorial Waters Ordinance prevents pollution of the territorial waters around the Falklands by oil or a mixture containing oil, and the duty to report any pollution.

3.1.6.3.18 Maritime (Oil Pollution Preparedness, Response and Co-operation Convention) Regulations 2019.

The Maritime (Oil Pollution Preparedness, Response and Co-operation Convention) Regulations 2019 defines the requirement for, and content of, Oil Pollution Emergency Plans (OPEPs).

3.1.6.3.19 Maritime (Registration of Ships) Regulations 2019.

The regulations provide for the registration of merchant ships, fishing vessels and small ships.

3.1.6.3.20 Merchant Shipping (Confirmation of Legislation)(Falkland Islands) Order 2018.

The order allows the Government of the Falkland Islands to bring into force the Maritime Ordinance 2017 (as amended), which replaces extended United Kingdom merchant shipping legislation.

The Maritime Ordinance 2017 (as amended) consolidates and modernises the merchant shipping laws of the Falkland Islands to ensure that ships registered in the Falkland Islands, as well as foreign ships in Falkland Islands waters, meet current international safety and environmental protection standards.

3.1.6.4 Petroleum Operations Notices (PONs)

The FIG provides numerous Petroleum Operations Notices (PONs) to provide guidance and *pro formas* for reporting. The PONs relevant to the Phase 1 Development are listed in Table 3.1.

Table 3.1: Summary of PONs relevant to the Phase 1 Development

PON	Purpose
PON 1	Record keeping and sampling requirements for surveys and wells.
PON 2	Reporting procedure detailing the need for progress meetings, monthly progress reports and daily drilling reports.
PON 4	Application for the Consent to Drill Exploration, Appraisal, and Development Wells and the Consent to Locate.
PON 5	Application to Abandon or Temporarily Abandon a Well.
PON 6	Application to Complete and/or Workover a Well.
PON 7	Well numbering system.
PON 8	Detailing the: • FIG reporting requirements in the event of an accidental oil / chemical release or a visible sheen; and • The use of dispersants, and surveying and tracking requirements.
PON 9	Reporting of Injuries, Disease and Dangerous Occurrences (RIDDOR).
PON 10	Application to Use and Discharge Non-Aqueous Drilling Fluids (NADF) and Associated Cuttings.

3.2 Health, Safety, Environmental and Security Management System

This section describes the Premier Health, Safety, Environment and Security Management System (HSES-MS) and how it applies to the environmental management of the Sea Lion Phase 1 Development.

3.2.1 Corporate HSES policy

Premier is committed to ensuring that all activities within the life-cycle of a project / operation are carried out in compliance with the relevant international and national legislation, and with the HSES-MS to ensure sound environmental management.

Premier will conduct the activities associated with the Phase 1 Development in a manner that is consistent with its Corporate HSES Policy (Figure 3.1), which is endorsed by the Chief Executive Officer of Premier.

PremierOil

HEALTH, SAFETY, ENVIRONMENT AND SECURITY POLICY

Premier Oil is committed to operating responsibly and will never knowingly compromise our health, safety, environmental or security standards. We will do all that is reasonably practicable to reduce HSES risks, ensure the safety and security of everyone affected by our operations and protect the environment by minimising our environmental impacts.

To achieve this we will:

- *Provide strong, visible leadership and commitment at all levels of the Company;*
- *Effectively identify hazards, and assess and manage risks;*
- *Meet or surpass our legal and other requirements (compliance obligations);*
- *Set objectives and targets to drive improvement;*
- *Support and train our people and assure their competence;*
- *Provide appropriate resources;*
- *Encourage open and honest communication;*
- *Effectively manage the HSES risks associated with contracted work;*
- *Maintain clean, safe, healthy and secure workplaces;*
- *Maintain high quality documented systems and processes;*
- *Plan and prepare for potential emergencies;*
- *Report, investigate and learn from any incidents and near misses;*
- *Routinely inspect the workplace and audit systems and processes;*
- *Seek opportunities to continually improve our performance.*

It is the responsibility of everybody involved in Premier Oil to comply with our policies and to assist the Company in their implementation.

Tony Durrant

Chief Executive Officer, Premier Oil plc
July 2018

Figure 3.1: Premier Health Safety, Environment and Security Policy

3.2.2 Falkland Islands Business Unit HSES-MS

Premier's Falkland Islands Business Unit (FIBU) HSES-MS sits within the Premier Corporate HSES-MS and applies specifically to all activities associated with the FIBU assets, projects and operations.

The FIBU HSES-MS has been developed in line with:

- Premier's Corporate HSES Policy (CP-CP-PMO-HS-ZZ-PC-0001);
- Premier's Corporate HSES-MS Framework Document (CP-CP-PMO-HS-ZZ-FD-0001);
- Premier's Corporate Major Accident Prevention Policy (CMAPP) (CP-LN-PMO-HS-ZZ-PC-0002);
- Internationally recognised standards ISO 14001 and OHSAS 18001; and
- Industry organisation's Management System Models (e.g. IOGP).

Where necessary, the FIBU HSES-MS interfaces with the both the Premier corporate HSES-MS and the relevant contractor management systems as shown in Figure 3.2

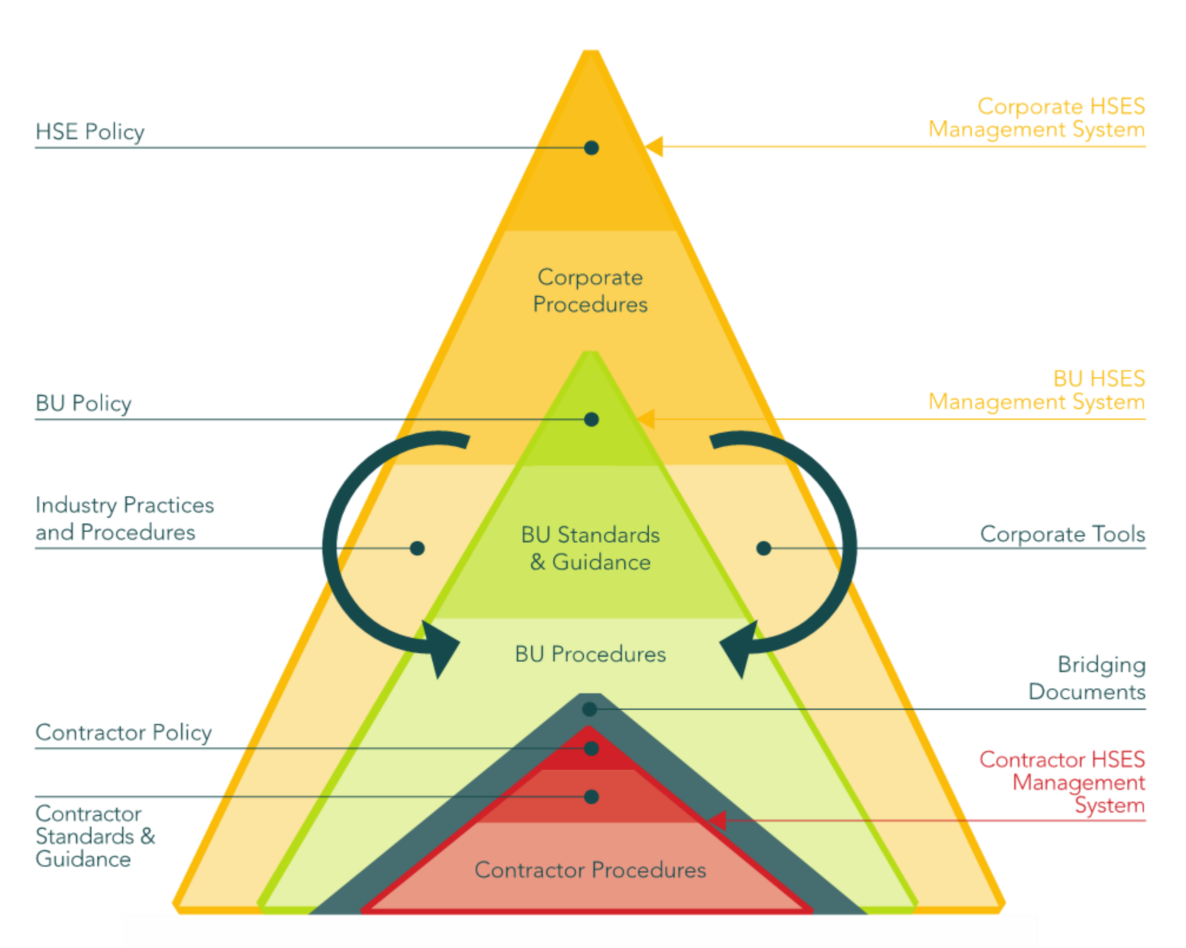


Figure 3.2: Relationship between the corporate, business unit and third party management systems

3.2.2.1 Premier Oil HSES-MS Elements

The FIBU HSES-MS comprises ten key elements which sit within the standard 'Plan, Do, Check, Review' model (Figure 3.3). Each of the ten elements provides a set of compulsory expectations, which are summarised in Table 3.2 and described fully in:

- CP-CP-PMO-HS-ZZ-FD-0001 HSES-MS Framework Document

A series of standards, guidance documents and procedures define how each of the ten elements should be implemented in order to manage HSES impacts and risks during the execution of work activities. Where work is to be conducted by third parties, bridging documents are developed to describe the interface between the two companies' management systems (Figure 3.2 above) prior to the start of activities to ensure that the ten elements are sufficiently met.

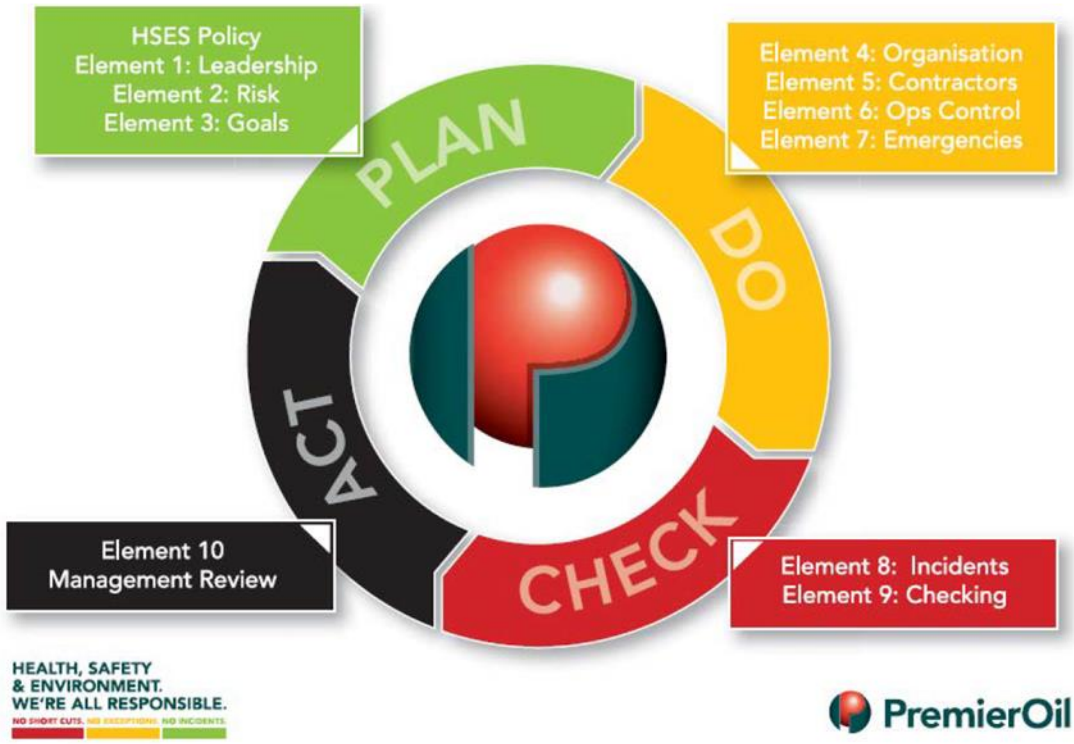


Figure 3.3: HSES-MS model

Table 3.2: Summary of Premier Oil's HSES Management System Elements

Element	Element Category	Element Description
1	**Leadership**: Leadership & Just Culture	Leaders at all levels of the Premier organisation shall demonstrate visible commitment and active participation in HSES management, ensuring the provision of the resources required to implement, control and improve the HSES-MS.
2	**Risk**: Risk Management	Premier shall implement a comprehensive risk assessment process that systematically identifies, assesses and then appropriately manages HSES risks arising from its operations to a level that is As Low As Reasonably Practicable (ALARP). Planned changes in design, operations, facilities, procedures, standards, or organisation shall be evaluated and managed via a structured process to ensure that HSES risks arising from these changes remain at an acceptable level and are communicated to all those potentially impacted by the change.
3	**Goals:** Objectives, Targets & Programmes	HSES objectives and targets relevant to business activities and considering, legal and internal management system requirements shall be established, maintained and documented, at each relevant function and level within Premier. HSES Plans shall be developed and maintained to document how HSES objectives, and the requirements of the HSES-MS, will be achieved.

Element	Element Category	Element Description
4	**Organisation:** Organisation, Capability & Communication	A clear organisational structure shall be established alongside defined and documented roles, responsibilities and accountabilities for all those who are involved in managing Premier's HSES risks.
5	**Contractors:** Contractors and Other Operators	Premier shall develop and maintain a system to ensure that its contractors perform in a manner that is consistent and compatible with Premier's HSES requirements. Systems for HSES contractor management shall define requirements for the effective mobilisation, on-going HSES surveillance and close out of contracted work.
6	**Operational Controls:** Systems of Work	Premier shall implement procedures for the management of projects that are understood, available and executed by qualified personnel. Key lifecycle stages in a project will be subject to formal independent HSES review. Premier shall ensure that HSES critical equipment and systems are identified and appropriately managed so that they are in service and functioning correctly.
7	**Emergencies:** Emergency Preparedness & Response	Plans and procedures to identify, prepare for and respond to potential emergencies shall be developed, documented, tested and maintained. The effectiveness of emergency response plans shall be routinely assessed via a programme of exercises and drills, and plans shall be revised to address any deficiencies identified.
8	**Incidents:** Incident Management	All incidents, near misses and potentially hazardous behaviours and situations shall be consistently and promptly reported to statutory bodies, across the Premier, Premier and wider industry as appropriate. Investigations shall focus on determining root causes, with the objective of identifying corrective actions that minimise the potential for recurrence and broadly sharing lessons learned in a timely manner.
9	**Checking:** Performance Monitoring and Audit	A process shall be established and maintained to measure and monitor the implementation and efficacy of operational controls, track HSES performance and evaluate the achievement of HSES objectives. Monitoring results shall be regularly communicated throughout the Premier, Premier and externally as appropriate. An independent Verification Scheme will be established and implemented on all assets to provide the required assurance that all HSES critical equipment and systems continue to perform in accordance with their defined performance standard. Programmes shall be established for auditing compliance with applicable legislation, Premier Corporate Policies and Systems, HSES Plans and the HSES-MS.
10	**Review:** Management Review	Periodically, Premier's management shall formally review the HSES-MS, to ensure its continuing suitability, adequacy and efficacy.

3.2.3 Project planning and review

The Premier Production and Development (P&D) Asset Management Lifecycle structure is designed to provide assurance to the Premier Executive Committee that the project team has completed all the necessary work associated with each phase of the project development. To achieve this, P&D Asset Management formalises a 'gated' process for progressing a project through six distinct phases (Figure 3.4).

When following the process, it is necessary for the project team to provide key deliverables before progressing through each 'gate' and on to the next phase of the project. To ensure that all deliverables are identified and met, the project development assurance process is supported by a six stage Project Safety Review (PSR) process. The PSR process is described in:

- Corporate Premier Process: Project Safety Review Procedure (CP-BA-PMO-HS-ZZ-PR-0003).

PSRs that must be held are as follows:

- PSR 0 at the end of the project identification stage and prior to commencement of the concept selection phase (Select Phase);
- PSR 1 prior to commencement of the Front End Engineering and Design (FEED) stage (Define Phase);
- PSR 2 prior to commencement of the detailed design stage (Execute Phase);
- PSR 3 prior to commencement of the onshore fabrications / construction stage (Execute Phase);
- PSR 4 prior to commencement of the offshore fabrications / construction stage (Execute Phase);
- PSR 5 prior to commencement of the pre-commissioning / commissioning stage (Execute Phase – prior to introduction of hazardous materials); and
- PSR 6 during production operations (Produce Phase).

Note that decommissioning and abandonment is treated as a new project and therefore must be supported by a separate PSR plan, which required PSRs 0 to 4.

The key environmental requirements that must be verified in the PSR process for each project development phase are listed in Table 3.3.

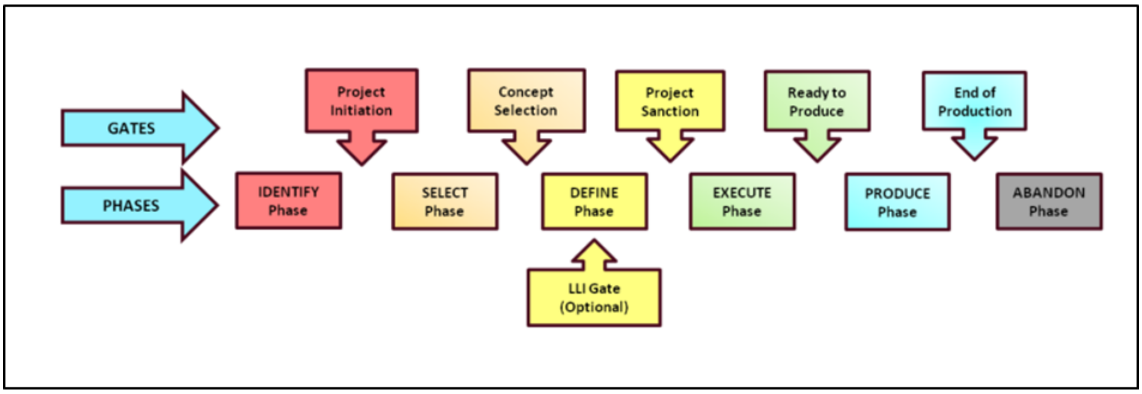


Figure 3.4: Production and development asset management lifecycle

Table 3.3: Environmental content in the PSR Plan

Project phase	Environmental requirements
Identify	• Prepare the PSR Plan; • Prepare the HSES Plan; • Prepare register of local legislation; and • Conduct PSR 0.
Concept Select	• Prepare project HSES-MS; • Prepare project HSES Policy; • Prepare development HSES-MS; • Review the HSES Plan; • Prepare Permits, Licences, Approvals, Notifications and Consents (PLANC) register; • Prepare monthly reporting process; • Conduct ENVIID; • Prepare emissions review; • Prepare outline EIA; and • Conduct safety and environmental review (PSR 1).
Define	• Review the HSES Plan; • Prepare environmental mass balance; • Prepare environmental ALARP assessment; • Prepare Social Impact Assessment; • Appoint ISO14001:2015 certification body; and • Conduct FEED safety and environmental review (PSR 2).
Execute	• Select production chemicals; • Reassess environmental mass balance; • Reassess environmental ALARP assessment; • Prepare performance standards; • Prepare HSE and operations management system description; • Prepare Safety and Environmentally Critical Element (SECE) register and verification plan; • ISO14001:2015 certification body first audit; • Review of yard safety and environmental audit; • Review HSE supervision and resources; • Review the HSES Plan; • Establish corrective action management plan; • Conduct detailed design safety and environmental review (PSR 3); • Conduct offshore construction safety and environmental review (PSR 4); • Review contractor bridging documents; • Review Oil Spill Contingency Plan/s (OSCP); • Rig / vessel / helicopter / shorebase audit and inspection plans; • Environmental performance reporting plan; and • Conduct hook up and commissioning safety and environmental review (PSR 5).
Produce	• Ongoing environmental management; • ALARP reviews of all impacts and risks; and • Conduct production safety and environmental review (PSR 6).

3.2.4 Environmental baseline data gathering

The objective of environmental baseline data gathering is to ensure that the existing environmental conditions in areas where Premier plan to operate are adequately characterised and understood. In line with HSES Element 2, this process informs the EIA and enables the identification of trends or changes when conducting monitoring throughout the project lifecycle.

Environmental baseline surveys are carried out in accordance with:

- Corporate Premier Standard: Environmental Baseline Data Gathering (CP-BA-PMO-HS-SE-ST-0003)

3.2.5 Impact and risk identification and assessment

In line with HSES Element 2 (Table 3.2 above), the environmental and social aspects, impacts and risks associated with a Development must be identified and assessed. Once the Development activities have been understood, an ENVironmental Impact IDentification (ENVIID) workshop is held to determine the ways the activities will interact with the environment (i.e. noise, emissions, discharges etc.) and what the impacts and risks might be. This process is carried out in line with:

- Corporate Premier Standard: Environmental and Social Impact Assessment (CP-BA-PMO-HS-SE-ST-0001).

The impact and risk assessment process and the assessment of mitigation measures ensures that the impacts and risks are reduced to 'As Low As is Reasonably Practicable'.

Note that, as agreed with Premier, the methodology used during this EIA is adapted from the above risk management standard and is described in full in Chapter 8.

3.2.6 Legal compliance

In line with HSES Element 6 (Table 3.2 above), all legislative requirements will be identified prior to the 'Select Phase' and the PSR 1 will verify that a Permits, Licences, Approvals, Notifications and Consents (PLANC) register exists (Table 3.3). This will be updated and verified in PSR 2.

The PLANC register will be developed in line with the:

- FIBU PLANC Procedure (FK-SL-PMO-HS-PRO-0001).

The PLANC register will define what is required for field development, who is accountable and responsible and when action is required. Therefore, the PLANC register will be used to inform all subsequent PSRs.

Where no FIG regulation exists for a given activity, or where it awaits enactment, in consultation with FIG, Premier shall adhere to agreed UK and international standards (section 3.1.6). In accordance with the FIG DMR guidance notes on operations notices, the FIG PONs will be used / applied for as appropriate (section 3.1.6.4).

3.2.7 Operational control

In line with Element 6 (Table 3.2 above), operational control is required in order to ensure that all activities are carried out in a safe and effective manner. With regard to HSE issues, operational controls also serve to prevent and reduce impacts and risks by:

- Preventing an impact from occurring;
- Minimising the impact;
- Remediating the impact;
- Preventing, or reducing the likelihood of, an unplanned event from occurring; and / or
- Minimising the severity of effect in the event of an incident.

Operational controls include:

- Elimination controls e.g. electing not to commence with a specific operation / activity;
- Substitution controls e.g. electing to carry out the activity in a different way, place or time;
- Engineering controls e.g. use of Best Available Technology (BAT) or deployment of additional or alternative equipment; and / or
- Administrative controls e.g. use of standard operating procedures and / or development of project-specific operating procedures / plans where necessary.

Elimination and substitution controls are built-in to the project basis of design such that the project will always endeavour to minimise impacts and risks. During the EIA process, where impacts or risks are deemed significant despite the base case mitigations and industry-standard safeguards, it is necessary to determine what additional, project-specific, controls may be required. All additional project-specific controls intended to prevent or mitigate impacts and risks will be utilised where they are deemed to be ‘reasonably practicable’.

The process for identifying the need for project-specific controls and mitigation options is described further under the EIA methodology (Chapter 8).

Specifically in relation to waste management, Premier has developed a Waste Management Plan to ensure all wastes arising from operations in the Falkland Islands are managed in line with Premier’s requirements as well as any applicable legislation:

- Sea Lion Waste Management Plan (FK-SL-PMO-EV-PLN-0009).

3.2.8 Safety and Environmentally Critical Elements register

In line with Element 6 (Table 3.2 above), Safety and Environmentally Critical Equipment (SECE) must be identified and performance standards developed that describe and define the equipment’s requirements in terms of functionality, availability, reliability, survivability and its interdependence on other systems. The SECE Register will be verified in PSR 3 which is required prior to commencement of the onshore fabrications / construction stage (in the Execute Phase) and again in PSR 4 as described in:

- Corporate Premier Process: Project Safety Review (PSR) Procedure (CP-BA-PMO-HS-ZZ-PR-0003).

3.2.9 Emergency response

In line with Element 7 (Table 3.2 above), Emergency Response Plans (ERPs) will be in place for all operations and will be developed for potential emergency scenarios. Oil Spill Response Strategies and Oil Spill Contingency Plans (OSCPs) will be developed to cover all stages of the Phase 1 Development and will be reviewed and approved by FIG prior to commencement of the operations.

3.2.10 Incident management

In line with Element 8 (Table 3.2 above), all environmental incidents will be recorded and investigated. All incidents will be reported in internal HSE performance reports as well as to the statutory authorities in keeping with the required FIG reporting protocols. Incident reporting and investigation will be carried out in line with:

- Corporate Premier Incident reporting procedure (CP-BA-PMO-HS-ZZ-PR-0006); and,
- Corporate Premier Incident investigation procedure (CP-BA-PMO-HS-ZZ-PR-0009).

3.2.11 Monitoring and measuring

In line with Element 9 (Table 3.2 above), monitoring and measuring requirements appropriate to the Phase 1 Development were identified throughout the EIA process and will be used to:

- Provide assurance of compliance with regulatory requirements standards and FIG policies;
- Determine progress in achieving the objective and targets outlined in the HSES Plans;
- Provide an early indication should any of the operational controls fail to achieve acceptable standards;
- Enable Premier to take remedial action if unexpected problems or unacceptable impacts arise;
- Monitor the performance of the project and the efficacy of project-specific mitigation measures (IEMA, 2008);
- Evaluate any actual environmental impacts;
- Verify the environmental impact predicted in the EIA studies; and
- Provide auditable data.

Priorities for monitoring will include:

- Environmental aspects for which significant residual impacts were predicted;
- Environmental aspects for which successful mitigation is essential to avoid significant impacts; and
- Impacts for which there is a high degree of uncertainty (i.e. a low confidence score) in the impact predictions or in the likely success of the proposed mitigations.

Aspect-specific monitoring and measuring requirements are described in each impact and risk assessment chapter (Chapters 10, 11 and 12) and are listed, with defined responsibilities for implementation, in the outline Environmental Monitoring and Management Plan (Chapter 15) as required by the:

- Corporate Premier Standard: Environmental and Social Impact Assessment (CP-BA-PMO-HS-SE-ST-0001).

3.2.12 HSES Plans and environmental objectives and targets

In line with Element 3 (Table 3.2 above), the FIBU will develop project-specific environmental objectives and targets to ensure compliance with its HSES Policy and continual improvement in environmental management throughout all stages of the Phase 1 Development.

The objectives and targets, and the programmes by which they are met, will be incorporated into the relevant Sea Lion HSES plans, which will include detail on the responsible person and a means of tracking progress in line with:

- Corporate Premier Standard: HSES plans (CP-BA-PMO-HS-ZZ-ST-0013).

The HSES Plan will be drafted at the project initiation / kick off phase (Identify Phase), and will be reviewed and updated for each PSR (section 3.2.3).

3.2.13 Environmental performance

Once the Phase 1 Development commences, data on the Key Performance Indictors (KPIs) (e.g. carbon emissions, waste volumes, oil in water concentrations etc.) will be gathered on a monthly basis and reported to the Premier Board in line with Elements 3 and 9 (Table 3.2 above). Performance monitoring will be carried out in compliance with:

- Corporate Premier Standard: Environmental Performance Reporting Standard (CP-BA-PMO-HS-SE-ST-0004).

Specifically, and as a minimum, performance monitoring will be carried out via:

- Participation in daily calls during the Development to discuss the project / operations status, any issues that have arisen and proposed solutions (where necessary);
- Receipt of daily, weekly and monthly reports to track HSES performance and provide detail on how any issues were closed out;
- Receipt of daily reports including, where relevant, chemical use;
- Monitoring of all waste streams to ensure waste is properly handled; and
- Presence of an HSES representative on board the rig / FPSO to ensure effective environmental management.

3.2.14 Audit and review

In line with Element 9 (Table 3.2 above) and the EPD EIA Guidance Note (FIG, 2015l), the FIBU will carry out periodic audits to ensure that the Sea Lion Development is being carried out in compliance with:

- Regulatory requirements;
- Contractual obligations; and
- Commitments in the EMMP and other management plans.

FIBU processes and tools will be used to assign, schedule and track all corrective or preventive actions.

Environmental audits / reviews that will be required prior to, and during, the Phase 1 Development operations include:

- Internal audits / reviews:
  - Top Management Review in line with:
    - Corporate Premier Standard: Management Review (CP-BA-PMO-HS-ZZ-ST-0016);
  - PSRs at the start of each project development phase in line with:
    - Corporate Premier Process: Project Safety Review Procedure (CP-BA-PMO-HS-ZZ-PR-0003);
  - Operational Controls Review;
  - Internal reviews to ensure impacts and risks continue to be ALARP;
  - Internal HSES-MS audits in line with:
    - Corporate Premier Procedure: HSES Management System and POMS Assessment (CP-BA-PMO-HS-ZZ-PR-0005);
- Contractor, Joint venture Management System Audits:
  - Pre-Award HSES audits / reviews;
  - Pre-mobilisation HSES audits or readiness reviews;
  - Premier on site monitoring and inspection;
  - Premier HSES audit; and
  - Contractor self-monitoring / inspection / auditing.
- External audits e.g.:
  - Audit of the HSES-MS to ensure is maintains ISO Standard 14001: 2015 verification.

3.2.15 Contracting strategy

The service sector requirements of the Sea Lion Phase 1 Development will be quantified, sourced and contracted in line with the:

- Premier Oil FIBU Logistics and Infrastructure Sourcing Strategy (FLK-SL-PMO-LO-PLN-0001).

The strategy lays out the system of local consultation and capacity evaluation that will be followed within the tender and contracting process.

The strategy complies with the:

- Premier Oil Policy and Principles of Procurement;
- Premier Local Content Policy;
- Hydrocarbons Development Policy Statement 2013 (section 3.1.5.2); and
- Voluntary Falkland Islands Local Content Code of Practice (section 3.1.5.3).

The Falkland Islands are at the end of an extended supply chain, and tender evaluation will assess the security of that supply chain, the geographical location of supply and the capacity to supply.

The long-term nature of the Development and field production encourages market investment and expansion (over that achieved during temporary short-term exploration) and contract durations will be assessed and set in order to best achieve capital investment and innovative solutions to service provision.

The contracting strategy will normally incorporate an initial pre-qualification process. This will comprise the first screening in evaluating the capacity and long-term security of supply delivered by the tenderer, prior to full evaluation in the tender bid process.

It is thus assumed that economic market forces of supply / demand will respond to Development service needs whether that be through local or external contractors and that the tender process is robust in evaluating market response to ensure local supply is not impacted.

3.2.16 Contractor management

In line with Element 5 of the HSES-MS (Table 3.2 above), the FIBU will evaluate contractors based on their ability and qualification to appropriately manage HSES risks arising from their work. Bridging documents between the FIBU and contractor management systems will be defined and documented to ensure effective mobilisation, ongoing HSES surveillance and close out of contracted work as shown in section 3.2.2 above (Figure 3.2).

HSES impacts and risks associated with contracts will be identified, properly assessed and competently managed in line with:

- Corporate Premier Standard: HSES Contractor Management (CP-BA-PMO-HS-ZZ-ST-0004).

3.2.17 Management of Change

In line with Element 2 of the HSES-MS (Table 3.2 above), it is important for the Phase 1 Development to be able to accommodate changes and respond to a need for further environmental and social impact and risk assessment if it arises throughout the different project stages.

The need for further impact and risk assessment may occur for the following reasons:

- If changes to the project design become necessary at the post-FEED stage; and / or
- A new environmental sensitivity is identified as a consequence of changing environmental conditions / evolving trends that are identified via monitoring or additional surveys.

The Offshore Minerals Ordinance (Amendment) 2011 states that environmental impacts that are substantially different, or significantly greater, than those already presented in an EIS will trigger an additional EIS. However, if it can be demonstrated that the impacts are not substantially different then the Governor can waive the need to produce a new EIS.

As explained in the EIS Introduction (section 2.2.4), there are still specific details that can only be confirmed upon completion of contractual negotiations for the Execute Stage. This is normal when preparing an EIS for a large project and the approach taken has been to use experience from similar projects to propose conservative analogies to ensure that this EIS assesses the worst credible case so that it should encapsulate all eventualities, preventing the need for an additional EIA/S.

However, if significant post-FEED changes do occur, the impacts will be reviewed and assessed as part of the PSR process and discussions will be held with FIG to determine the most appropriate way to manage the EIS and EMMP.

3.2.18 Stakeholder management

In line with Element 4 of the HSES-MS (Table 3.2 above), key stakeholders in the Phase 1 Development have been identified and a plan developed to enable identification and recording of stakeholder concerns throughout the process as described in:

- Corporate Premier Standard: Environmental and Social Impact Assessment (CP-BA-PMO-HS-SE-ST-0001); and
- Premier's Community Investment Policy.

The results of the informal pre-submission scoping consultations, which were carried out to inform the EIA process, are recorded in Chapter 6. Representations from the formal post-submission stakeholder 42-day consultation period, and Premier's responses to these, will be provided in Chapter 17.

3.2.19 Project-specific environmental management

3.2.19.1 Sea Lion management plans

Management plans are designed to identify and communicate environmental management requirements and commitments to all key personnel and to ensure the implementation of controls.

Management plans will be required in compliance with:

- Corporate Premier Standard: Environmental and Social Impact Assessment (CP-BA-PMO-HS-SE-ST-0001);
- The terms and conditions of the Drilling and Production Licenses;
- The FIG EPD EIA Guidance Notes 2015 (FIG, 2015l);
- The FIG Guidance Note on Approvals Required for Offshore Operations in the Falkland Islands (02/13) (FIG, 2013b); and
- The outcomes of the EIA (that are reported in this EIS).

Project-specific management plans that will be in place for the Phase 1 Sea Lion Development include:

- Environmental Monitoring and Management Plan (EMMP) (Chapter 15 below);

- Oil Spill Strategies, which informs the development of Oil Spill Contingency Plan(s) (OSCPs), the latter to be developed during the Execute Stage:
  - Provides detail on the actions to be taken in the event of an unplanned release of hydrocarbons and must align with the Falklands National Oil Spill Contingency Plan (NOSCP). Specifically, the OSCP will:
    - Assess the potential consequences of an oil spill from drilling or production operations ;
    - Define the roles and responsibilities of all emergency response parties;
    - Detail the action plan in the event of a spill;
    - Detail the available oil spill response resources available;
    - Outline and reference the proposed response procedures; and
    - Detail the regulatory spill reporting requirements (e.g. FIG PON 8).
  - Oil spill response planning is based on oil spill trajectory modelling and findings from the EIA. The OSCP must incorporate any learnings and best practice from throughout the industry and it must include an assessment of the worst case oil spill scenario for each operational area and a detailed analysis of the availability and mobilisation timetable for oil spill response.
- Wildlife Response Plan (WRP) (part of the Oil Spill Strategy, FK-SL-PMO-EV-STY-0007):
  - Detailing the oiled wildlife response strategy to be implemented in the event of an unplanned release of hydrocarbons. Premier will work with wildlife response providers and FIG to ensure the plan defines relevant details including:
    - Initial response requirements;
    - Management / coordination structures; and
    - Appropriate local responder organisation / involvement.
- Waste Management Plan (WMP) (FK-SL-PMO-EV-PLN-0009):
  - The WMP ensures that:
    - The hierarchy of waste management is applied (5 Rs);
    - Waste is minimised, handled, stored and transported appropriately;
    - Waste is reported on correctly; and
    - The risks of cross-contamination at source and loss of containment are minimised.
- Iceberg Management Plan (IMP) (FK-SL-PMO-NA-STY-0001):
  - Describes all response actions required in the event of iceberg presence.
- Biosecurity Management Plan (BMP) (FK-BU-PMO-SE-PLN-0009):
  - Provides a framework for the processes intended to reduce the likelihood of introducing terrestrial or marine non-native species, which may then become invasive to the ecosystem of the Falkland Islands.
- Bird Strike Management Plan (BSMP) (FK-SL- PMO-HS- PLN -0008):

  - Detailing measures to ensure the monitoring, recording and reporting of bird-strikes as a result of artificial light as well as detail on how to manage / handle birds in the event of strikes.
- Harbour Management Plan (HMP) (FK-SL-PMO-HS-PLN-0010):
  - Informed by a project-specific navigational risk assessment, the HMP includes:
    - Pre-notification protocols associated with the entry of vessels into Stanley Harbour;
    - Pre-defined passage routes within Stanley Harbour;
    - Procedures associated with vessel collision; and
    - Emergency response.

3.2.19.2 Environmental Monitoring and Management Plan

The EMMP captures all commitments relevant to environmental monitoring and management and will list these in one place alongside detail on the responsible person and the frequency of the requirement to enable tracking of actions throughout the life of the Phase 1 Development. Specifically, the EMMP will list:

- Legislative and corporate monitoring requirements;
- Baseline data and survey work proposed;
- Environmental research and studies relating to uncertainties in the EIS;
- Conditions associated with drilling and production license approvals; and
- Any actions falling out of the stakeholder consultation process.

It is anticipated that initially the EMMP will be overseen by a group of key stakeholders who will discuss and steer the issues and actions.

Throughout field life, information arising from the EMMP process will be reported to the EMMP Steering Group on a regular basis, relevant actions discussed and the programme of work updated as necessary. Meetings of the Steering Group will be open to FIG and invited or statutory stakeholders with outputs reported publicly.

The basis of the EMMP, which is specifically informed by this assessment, is provided in Chapter 15 and will be translated into a live commitments and compliance register for use during the 'Execute' phase (section 3.2.3).

4 CONSIDERATION OF ALTERNATIVES

Table of Contents

4.1 Introduction

This chapter describes Premier's project development process and the alternatives that were considered with regard to the development of the Sea Lion Field.

4.2 Premier project development process

All Premier engineering projects go through the following concept phases:

- Appraise (evaluation of project feasibility, identification of options);
- Select (detailed evaluation of options);
- Define (definition of selected option and Front End Engineering Design (FEED));
- Execute (detailed engineering and construction); and
- Operate (start-up and ongoing operation).

When evaluating the options during the 'Appraise' and 'Select' project phases, balanced consideration of the following is required:

- Health and safety;
- Environment;
- Technical feasibility;
- Financial; and
- Strategic implications.

Thus far, the Sea Lion Development Project has gone through two phases leading to the selection of the chosen option:

- **Concept** '**Appraise**' - early phase concept screening to identify technically feasible concepts for development of the Sea Lion Discovery was undertaken by Rockhopper Exploration PLC (Rockhopper) in 2011-2012, during which thirteen options were identified, evaluated and reduced to three options; and
- **Concept** '**Select**' - Pre-FEED Engineering Concept Screening by Premier in 2013 - 2015, where the three options were further considered.

Assessment of the proposed options was carried out by a multi-disciplinary team, including environmental and technical specialists, as well as stakeholder liaison personnel. Further, a number of technical and environmental supporting studies were undertaken to inform the EIA and final concept selection.

The Sea Lion Development is now approaching the end of the 'Define' phase, which, importantly, has been significantly informed by the outcomes of the EIA process. During the 'Define' stage the iterative EIA and FEED process identified the most suitable technical design for the development and addressed areas of uncertainty.

4.3 Project alternatives

When determining whether or not any project is feasible, and prior to advancing to the 'Define' stage which is informed by the EIA process, it is necessary to identify the:

- Key challenges which may present obstacles; and
- Concepts available to overcome the obstacles.

4.3.1 Oil production

Oil production refers to the process of producing the crude oil and gas resources from the subsurface reservoirs to the processing installation in order to ready them for use on the installation, or export to market.

4.3.1.1 Key challenges

In order to minimise the emissions and discharges that may result from any development, the key technical challenges must be identified and considered. The following were therefore considered during the appraisal and selection processes:

- Reservoir properties:
  - Subsea hot water injection is required to maintain reservoir pressures and oil sweep;
  - Artificial gas lift is required for all production well to increase the fluids flow rates as it is produced from the reservoir; and
  - The waxy nature of sea lion fluids needs to maintained at temperature above 60degC above at normal operating conditions, this is to minimise the wax deposition and avoid gelling issues. The live fluid have potential gelling issue, and hence facilities system has been designed to manage the issue during turn down and start up operations via a diesel displacement system.
  - Artificial lift is required for all production wells, especially for subsea tie-backs to increase the fluid flow rate as it is produced from the reservoir.
- Water depth (approximately 450 m at Sea Lion):
  - Limits the feasible choices for drilling and production installation facilities; and
  - Location and water depth gives a low seabed temperature, which exacerbates the flow assurance issues described above.
- Remote and isolated location:
  - Limited infrastructure to support oilfield development, production or crude oil export currently exists within the Falkland Islands;
  - Limited existing logistics means essentially dedicated additional capacity is required, necessitating extensive planning and innovation for personnel and materials management;
  - Facilities / equipment reliability needs to reflect long response time for support requiring high redundancy, spares inventory and crew maintenance capabilities;
  - No existing oil market and isolation from regional market requiring dedicated oil export arrangement; and
  - Political isolation limiting 3rd party participation in supply chain and logistical support.
- Risk of oil spills:
  - Prevention and management of oil spills in remote location.

- Weather conditions:
  - Prevailing metocean conditions resulting in a significant percentage of time with high winds and moderate sea states, little seasonal variation and few periods of benign conditions. This impacts the choice of installation type, offshore construction and subsequent operations including resupply, personnel movements and oil offloading (see section 4.3.2).

4.3.1.2 Concept appraisal

4.3.1.2.1 Options identified

As shown in Figure 4.1, there are many types of offshore exploration and production facility and screening of the Sea Lion Field production options commenced in 2011. Screening studies highlighted that the options were limited in a remote region and in a water depth of 450 m. Subsequently, a number of concepts considered were discounted in the early phases. In particular, the water depth of 450 m precluded bottom founded structures and dictated that some form of floating facility would be required.

As identified during the 'Appraise' phase, the following were considered for use during the Sea Lion Development:

- Semi-submersible drilling and / or production installation;
- Tension Leg Platform (TLP); or
- Floating Production, Storage and Offload (FPSO).

A description of the above and a list of the advantages and disadvantages of each is provided in Table 4.1.

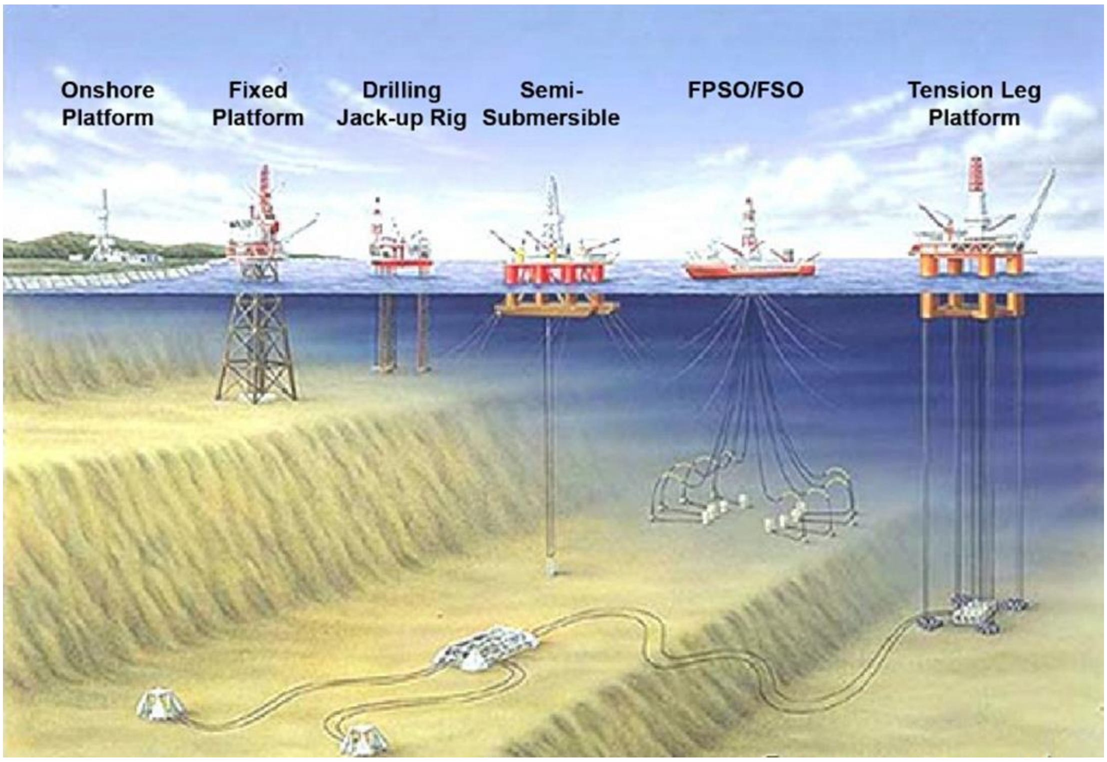


Figure 4.1: Types of offshore exploration and production facilities

Table 4.1: Comparison of the offshore production options identified during the 'Appraise' phase

Production installation	Description	Advantages	Disadvantages
Semi-submersible	Floating platform with hull pontoons that can be flooded to submerge the vessel to a pre-determined depth with the columns supporting the deck above the sea surface	• Relatively stable platform • Capable of drilling and production in water depths ranging from 600 - 3,600 m	• Lack of deck storage space • Unable to support topside (dry) wells • Need for separate Floating Storage and Offloading (FSO) vessel
TLP	Has a similar configuration to a semi-submersible but is moored to the seabed with vertical tethers	• Stable platform • Able to support dry trees • Capable of drilling and production in water depths ranging from 300 - 1,500 m	• Limited weight carrying capacity • Need for separate FSO vessel
FPSO	A ship-shaped floating structure which is either based on a (converted) oil tanker hull, or a new build	• Large oil storage capacity within the hull • No need for an FSO • Substantial open deck space on which process and utility equipment can be placed.	• Unable to support topside (dry) wells • Requires a complex mooring system

4.3.1.2.2 Option appraisal

Having identified the feasible options above, it was necessary to further assess each option to determine whether the wells would be able to flow sufficiently. To improve oil recovery from the reservoir, the alternatives included gas lift to reduce the density of the oil and make it flow more easily and the use of Electric Submersible Pumps (ESPs) or Hydraulic Submersible Pumps (HSPs).

Following further screening of the identified options (Table 4.1), the semi-submersible option was rejected on the basis that, with wet (subsea) X-mas trees and the need for an FSO, it offered no benefit over the TLP or FPSO options.

Therefore, three options were further shortlisted for technical assurance and economic analysis during the 'Select' phase:

- FPSO with artificial lift from downhole HSPs;
- FPSO with gas lift; or
- TLP with FSO and dry tree ESPs and wet tree HSPs.

4.3.1.3 Concept selection

More detailed evaluation of the options led to the conclusion that the following two options were the most viable:

- A turret moored FPSO with artificial lift provided by gas lift to subsea (wet) oil production trees; or
- A TLP with artificial lift provided by ESPs (to dry oil production trees) and gas lift (to wet oil production trees) together with an FSO for oil storage.

The Concept Select assessment ranked the proposed options in terms of performance and opportunity to minimise environmental impact against five environmental criteria (Table 4.2). Within each criterion, differentiators were selected to focus attention on those aspects where significant differences between the options might result (Table 4.2).

Following the Concept Select phase, both TLP and FPSO options were considered acceptable in terms of environmental criteria. The TLP approach was originally preferred, as it enabled full field development however, the FPSO provided greater flexibility and enabled a phased development of the field.

Therefore, the FPSO with a detachable turret and gas lift was ultimately selected for the Phase 1 Development because:

- The use of gas lift provides reliability (no rotating equipment in the wells) and acceptable flow performance when compared with the use of ESPs;
- Inclusion of production and storage on an FPSO avoids the need for two infield installations:
  - Minimises the number of crude transfers between the producing, storage and export processes i.e. FPSO direct to oil tanker rather than TLP to FSO to oil tanker, and thus reduces the risk of oil spill;
  - Reduces the potential risk of collision with just a single infield installation and reduced resupply requirements;
- The FPSO can be disconnected from its mooring system and depart from the field should this be necessary (this would be a planned operation rather than an emergency response);
- Use of subsea wells in 450 m is a well-established, proven, and low risk practice with initial drilling undertaken by a dedicated Mobile Offshore Drilling Unit (MODU) which is only in the field during initial well drilling and for any subsequent well intervention if it were to be required; and
- The FPSO is more economic for the operation of up to 30 wells.

Table 4.2: Concept screening differentiators

Environmental criteria	Differentiator
Air quality	Emissions from fuel gas usage from <20 - >50 MWth
Discharges	Number of personnel (<100 - >200)
Structural seabed disturbance	Areal extent from <200,000 m^2 - >300,000 m^2
Pipeline seabed disturbance (Areal Extent)	Areal extent from <15,000 m^2 - >20,000 m^2
Resource usage	Steel / material use from <100,000 tonnes (te) - >125,000 tonnes (te)

4.3.2 Oil export

The oil export system concerns the delivery of the oil from the FPSO, which is permanently moored in the Sea Lion Field, to the market. The three main functions of the export system are illustrated in Figure 4.2.

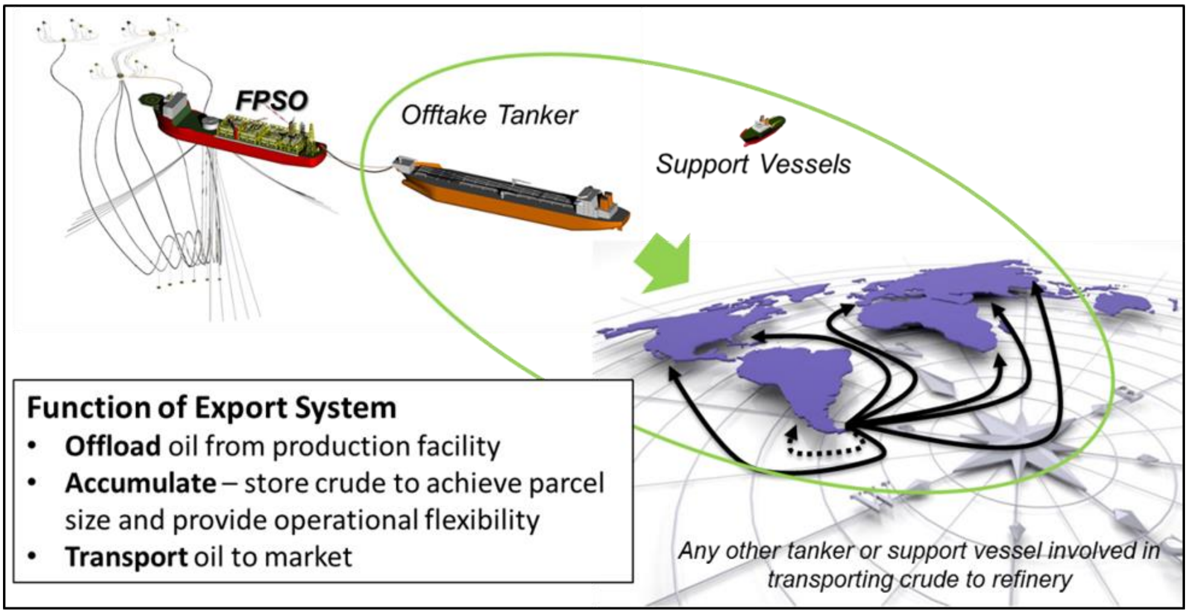


Figure 4.2: Illustrating the key functions of the oil export system

4.3.2.1 Key challenges

The key challenges to the export system were identified as follows:

- Oil type:
  - Sea Lion crude has high wax content and associated high pour point. The crude is particularly suited to being processed in relatively complex, high upgrading (cracking) refineries which will be able to enhance the value of the crude oil; and
  - Given the high pour point, Sea Lion crude oil will require heating in transit and during storage at the refinery. The requirement for heating the cargo in transit is significant as not all trading tankers are suitably equipped with tank heating.
- Production rate:
  - The frequency of offtake operations is directly dependant on the production rate and therefore reduces significantly as the production rate decreases throughout the life of the field.
- Metocean conditions:
  - The metocean conditions at the Sea Lion Field need to be considered for the export system as the tandem offloading operation from the FPSO to the tanker is limited by wave and wind conditions..
- Market:
  - The remoteness of the Sea Lion field means that there are significant travel distances involved in order to access the markets for waxy crude oil.
- Geopolitical situation:
  - Consistent delivery of oil to a purchaser is a prerequisite for its sale and generation of revenue.

- The ongoing sovereignty dispute over the Falkland Islands has an impact which extends to other countries in the region. It affects both the potential for local / regional markets and the ability to use existing oil transhipment facilities in South America.

4.3.2.2 Concept appraisal

4.3.2.2.1 Options identified

An export parcel size of 165,000 m^3 (approximately 1,000,000 bbls) has been determined to be the most suitable for Sea Lion. This is the largest parcel that can be accommodated by regularly available trading tankers with tank heating; this size is referred to as Suezmax. This is also the largest size available for offshore loading high specification tankers using current technologies. A large parcel size provides the most economic transportation for the long distances to the anticipated refineries for Sea Lion crude. It has been determined that sales to Far East and US refineries are both likely and important to ensure market price competitiveness.

Screening studies identified the export system options that could be technically feasible in Sea Lion as follows:

- Offload from the FPSO and transport direct to market using:
  - Conventional Trading Tankers (CTT); or
  - A fleet of suitably equipped vessels.
- Offload from FPSO to an Offshore Loading Shuttle Tanker (OLST) and Transfer to CTT at:
  - An offshore / near shore location;
  - A sheltered location in another country; or
  - A sheltered location in the Falkland Islands.

4.3.2.2.2 Option appraisal

Early concept work for the development of the Sea Lion Field envisaged that oil would be loaded using a Direct Offload, tandem mooring, arrangement straight from the FPSO to a CTT, which would transport the oil to market.

Due to uncertainties around offloading availability, and in discussions with FIG and FIG's advisors in the UK (the Health and Safety Executive (HSEx)) it was decided that Inshore Transfer at a sheltered location in the Falkland Islands should be progressed as the project base case and, in parallel, the systems to offload directly to a CTT would also be developed.

The Direct Offload work included:

- Gathering updated and enhanced metocean datasets (including direct measurements from metocean buoys at the Sea Lion Field location); and
- Following the commencement of the Front End Engineering and Design (FEED), and with the support of an experienced FPSO operator, undertaking further studies to attempt to enhance the design of the Direct Offtake to a CTT from the FPSO to maximise availability and reduce risk, enhancing the likelihood of Safety Case acceptance by FIG and the HSEx.

This additional analysis built upon a previous study, the Direct Offloading to CTT Feasibility Study (Premier, 2017b), which identified seven key areas where the use of a CTT to offload from the FPSO (the Direct Offtake option) differed from the use of an OLST (the Inshore Transfer option).

Proposals for ways in which these seven areas could be managed to try to ensure that they are acceptable in terms of operational risk and health and safety are presented in Table 4.3 below.

During FEED Premier Oil have:

- Completed further technical studies;
- Gathered additional metocean data;
- Sought lessons learned from operators of FPSOs in similar and worse metocean conditions; and,
- Engaged with FIG and the UK Health and Safety Executive.

PMO and FIG are now satisfied that Direct Offtake is viable from the start of operations and no contingency for Inshore Transfer is required. Direct Offtake represents the best commercial, inherently safest and best environmental option (section 1.1).

Table 4.3: Seven key areas that require management to successfully complete Direct Offtake

Key area	Issue	How this is being addressed by Premier
Tanker suitability and crew competency	The CTT (a 'tanker of opportunity') is not dedicated to this duty and it may be its first time in the Sea Lion Field	• Tanker vetting and verification process implemented to select tankers to ensure they meet a pre-defined specification that includes assessment of suitability of equipment and crew competence; • Minimum standard set for tanker crew competency and experience; and • Tanker Berthing crew will be sent to the CTT consisting of the Mooring Master and Assistant to supplement the CTT crew
Personnel transfer	Safety of personnel (Berthing crew) being transferred to the CTT	• Preferred option for transfer of personnel is via helicopter with the use of winch to deck of the CTT; a routine activity for pilot boarding in the North Sea; • Safe personnel transfer supported by a detailed procedure; • In addition to personnel (Berthing crew) a 'mooring and offloading tool box' will be transferred. The preferred method of transfer of the tool box is via the CTT crane from the MRSV in the field.
Tanker manoeuvring	CTT has no Dynamic Positioning (DP) but is connected to a hold-back tug; and Harsh environmental conditions	• Given the harsh environmental conditions a controlled and consistent approach of the CTT to the FPSO is essential and should have sufficient uptime probability; • The berthing of the CTT has been assessed under various conditions via Bridge Simulations involving the CTT and hold-back tug. Conditions including 3 m significant wave height and 30 knot winds were investigated and found feasible, meaning safe berthing is possible in Sea Lion conditions and: ○ Manoeuvring only requires a single tug; there was no occasion where a second tug was required at the bow of the CTT during simulations; ○ The governing factor of a safe approach is the ability to safely abort the procedure, so a low speed of approach is required; and ○ It is recommended the approach of the CTT and tug is monitored electronically. In addition to speed of approach aids, GPS units may be a useful addition.

Key area	Issue	How this is being addressed by Premier
Connection and disconnection	Safety of personnel; and No bow loading system on the CTT; connection will be to a midship manifold	• Optimising hawser design to minimise risks during connection and disconnection shall be reviewed during Detailed Design; • Residual risks to be mitigated through development of detailed procedures for safe boatless hawser handling and midship loading hose operations; • All operations can be performed without the need for a workboat (i.e. only personnel on the FPSO and CTT are involved); • Acceptable environmental operating conditions have been developed for approach and berthing including: ○ Mean 10-min wind speed < 30 knots; ○ Significant wave height <3 m; and ○ Visibility > 1,000 m.
Maintaining appropriate position	CTT has no Dynamic Positioning (DP) but is connected to a hold-back tug	• During offloading, the CTT and its hold-back tug shall assure safe position, heading control and monitoring; • An operability study has been undertaken to determine the feasibility and uptime for offtake under prevailing metocean conditions. The study showed a high availability for Direct Offtake, taking into account the limiting environmental conditions and procedure limits shown above. • There are two specific dynamic interactions between the CTT and FPSO that could give particular cause for concern: ○ Fishtailing (or yaw); and ○ Surging. • These can potentially lead to high hawser tensions and the need for disconnection if the CTT cannot maintain proper alignment. The studies performed to date have indicated these risks are not significant.
Safety systems	CTT has no Dynamic Positioning (DP) but is connected to a hold-back tug; No 'green line system established'[a]	• Manual shut down interface and firefighting capabilities shall be in place on both the FPSO and CTT during transfer operations; • A tanker position reference system will be provided and shall comply with relevant maritime recommendations, following the 'Tandem Loading Guidelines'; • The tanker position reference system will be equipped with a capability to interface with various controls, monitoring systems and communication systems allowing the Berthing Master to initiate manual

Key area	Issue	How this is being addressed by Premier
		emergency shutdown. This would cause the FPSO cargo offloading pumps to stop and the offloading valve to close); • During offtake, the CTT crew shall monitor the mid-ship manifold and bow mooring. In case of any abnormality the CTT cargo control room and Mooring Master will be informed and action initiated; • The MRSV located near to the operation, but outside the 500 m exclusion zone, shall have firefighting capabilities.
Emergency disconnection	No bow loading system on the CTT; connection will be to a midship manifold	• In case of emergency all effort will be made to stop offload and disconnect the hose in a controlled manner prior to hawser disconnection (and CTT departure) to prevent engaging of the Marine Breakaway Coupling on the floating hose; • Controlled emergency disconnection shall be achieved within 30 to 60 minutes; and • An emergency disconnection can take place in less than one minute by release of the hawser Quick Release Hook from the FPSO and parting of the Marine Breakaway Coupling on the floating hose.

[a] In the North Sea, DP OLSTs use the term “greenline system” to describe the “permit to pump” telemetry system installed. Sensors are fitted to various systems on the tanker and it is only when all of these sensors are in the correct position that the permit to pump signal is given to the FPSO, which allows the offloading pump to be started.

4.3.2.3 Concept selection

4.3.2.3.1 Option selection

Direct Offtake of Sea Lion crude oil direct from the FPSO in the field has been chosen for oil export. This option was selected because it represents the best environmental, inherently safest and most economic case.

A summary of the strengths and weaknesses of the oil offtake option via Direct Offtake in the Sea Lion field is provided in Table 4.4.

Table 4.4: Oil Export via Direct Offtake in the Falkland Islands

Strengths	Weaknesses
Avoids bringing crude oil inshore	Longer transfer hose means a bigger potential transfer spill inventory
Inherently safer as removes 3 vessles from the field and avoids two oil transfer operations (i.e. FPSO to OLST and then OLST to CTT)	FPSO offloading undertaken by tankers of opportunity so crew competency requires assurance
Best energy efficient option as three vessels are removed	Limited associated employment opportunities (local content)
Low fixed costs	-
No DP operations reduces underwater noise	-
Large available fleet of CTTs (i.e. no single point failure)	-
Only one support vessel required	-
No permanent exclusion zones in Berkeley Sound	-

4.4 Mitigations not used

As required by the FIG Policy Unit Guidance (formally EPD) (section 3.1), Table 4.5 below lists the mitigation measures potentially available but not proposed for this project, and why they are not considered appropriate for this development.

Table 4.5: Mitigations potentially available but not used for the Phase 1 Development

Chapter	Potential mitigation not proposed	Notes
10.1 Artificial light	None	Investigate the use of alternative spectrum (green) lighting; Investigate switching off / dimming of any lighting not required for safety / navigation purposes (for the MODU in consultation with the Duty Holder); Other proposals (light shields etc.) are not realistic as would not be allowed for navigation / safety
10.2 Disturbance to wildlife from heli use	None	-
10.3 Seabed disturbance	Cuttings:	-

Chapter	Potential mitigation not proposed	Notes
	Re-injection of cuttings not viable in terms of the cost of drilling a disposal well. Shipping all cuttings back to shore – no viable disposal route in the Falklands and impractical to send back to the UK for treatment. Use of Water Based Mud (WBM) in reservoir sections (see 10.6 below). <u>Marine growth</u> Use of slick paints being investigated for the FPSO hull	
10.4 Underwater noise offshore	None	-
10.5 Underwater noise inshore	None	-
10.6 Drilling muds and cuttings	WBM cannot be used for lower sections of the Sea Lion wells as OBM gives confidence around hole stability through highly deviated sections.	-
10.7 Operational discharges	<u>Hydrotest water:</u> Hydrotest water is not being be routed back to the FPSO during commissioning	Premier will investigate routing of hydrotest water in detailed design to determine whether any can be returned to the FPSO and before being injected downhole.
10.8 Thermal discharges	None	-
10.9 Atmospheric emissions	None	Produced gas is being re-injected; The FPSO will use reservoir gas rather than diesel; DLE ready turbines are proposed.
10.10 Waste	Construction and operation of a Premier landfill site in the Falklands has been discounted as this is not considered viable financially. Additionally, it is considered more beneficial for a collaborative approach to be taken in long-term waste plans.	Premier will collaborate with FIG on longer-term waste plans.
10.11 Collisions between vessels and marine mammals	Lower speeds (than those proposed by NOAA guidance) for Berkeley Sound approaches were not adopted due to the additional navigational risks and the overall increase in the length of inshore operations	Avoidance areas (as per NOAA guidance) could be developed throughout the project but cannot be implemented yet - further data from MMO reports may help to develop such areas.
10.12 Marine invasives	None	-
10.13 Terrestrial invasives	None	-
11.1 Disturbance to other users of the sea offshore	Snagging of fishing gear on subsea equipment can be mitigated by designing subsea equipment to be ‘over-trawlable’, this is not considered necessary here due to water depth	-

Chapter	Potential mitigation not proposed	Notes
	and the lack of fishing activity in the sea lion area targeting benthic species.	
11.2 Disturbance to other users of the sea inshore	None	**-**
11.3 Resource competition - accommodation	Building specific accommodation for longer-term onshore personnel (as well as other accommodation already proposed). Local market is adequate to absorb the predicted rise in work permit holders requiring accommodation in Stanley and supports local content code of practice	Not considered due to financial commitment as well as keeping project footprint and disturbance from construction to a minimum
11.4 Resource competition – water	None	**-**
11.5 Resource competition – electricity	Building local (renewable) power supply for the onshore supply base was rejected; Premier will be buying electricity off the grid	-
11.6 Resource competition – air links	None	-
11.7 Resource competition – roads	None	-
11.8 Disturbance to the human pop from light	None	-
11.9 Disturbance to the human pop from noise	None	-
11.11 Disturbance to the human pop from visual impact	None	-
11.12 Air quality	None	-
12.1 Oil spills offshore	Use of dispersants is not a viable response option for Sea Lion crude as found during oil tests (CEDRE, 2017); Oleophilic skimmers are not considered a viable response option (CEDRE, 2017); In situ burning would require FIG consent so is not included.	-
12.2 Oil spills inshore	None	**-**
12.3 Oil spills at-shore/onshore	None	-

5 PHASE 1 DEVELOPMENT DESCRIPTION

Table of Contents

5.1 Introduction

In order to identify and understand the potential environmental impacts and risks, and to enable quantification of the residues and emissions to the environment (as requested in the Falkland Islands Government (FIG) Policy Unit (formally Environmental Planning Department (EPD)) EIA Guidance Note (FIG, 2015l)), it is necessary to understand what activities will be carried out during the Phase 1 Development, and what technologies will be built-in to the basis of design.

Whilst some of the details can only be finalised upon the final award of contracts to specific vendors, the Phase 1 activities will be consistent with the description provided here which has been prepared to be conservative and therefore aims to describe the worst case with regard to the residues and emissions.

Note: the following chapter introduces many technical terms and abbreviations. The acronyms are explained at the first use in the narrative, and in the tables / figures throughout. However, they are also listed in the Abbreviations table in Chapter 19 and a Glossary is included in Chapter 19 to explain any technical terms; these two sections may be of use when reading the below.

5.1.1 Project optimisation

As noted, the project's impacts have previously been assessed and accepted as documented in a preceding revision of this document (revision B03, Premier, 2018). Since then, the project had been further optimised as follows:

- Increasing the crude oil storage capacity on-board the Floating Production, Storage and Offloading (FPSO) vessel, further details in section 5.8.6;
- Relocation of the FPSO to a new position south east of the Main Drill Centre (DC), Figure 5.2;
- Confirmation that the Phase 1 development comprises 29 oil, gas and water-injection (WI) wells plus one contingent (Casper) gas production / injection well, section 5.4.4;
- Optimisation of the subsea layout, subsea equipment, number and location of oil, gas and WI wells to eliminate flow assurance and operability issues. Further details in section 5.5.2;
- The position of the West Flank gas *c*. 2 km to the south to access a thicker part of the gas reservoir with increased gas volumes, section 5.8.
- The base case number of well clean ups to the Mobile Offshore Drilling Unit (MODU) has been revised to four (one gas well and three oil wells). An additional worst case option of the remaining eighteen oil wells requiring clean up to the MODU (in the event of significant well debris being encountered during the first four clean ups) is also included (section 5.4.9); and
- Selection of Direct Offtake (crude offloading) in preference to Inshore Transfer and export, section 5.10.

5.1.2 Project overview

The Sea Lion Field lies in water depths of approximately 450 m and is located in Block 14/10 in the hydrocarbon license area PL032, which is approximately 220 km to the north of the Falkland Islands. Hydrocarbons are reservoired in sandstones of early Cretaceous age approximately 2,000 m below the seabed. A field-life of 20 years has been projected and it is estimated that approximately 250 million stock tank barrels (MMstb) (deterministic reference case) of oil can be recovered in this timeframe.

The proposed Phase 1 Development is expected to consist of 28 clustered oil production and Water Injection (WI) wells drilled across the Main, Eastern and Southern Drill centres (DC), and a single remote West Flank Gas Production / Injection (GPI) well, all of which will be drilled by a MODU. The development also includes the drilling of an additional (contingency) GPI well at the Casper location in the event that the West Flank well has insufficient gas.

The Development may therefore involve drilling a maximum of 30 wells, which will comprise of up to:

- 20 oil production wells (hereafter referred to as just 'production' wells);
- eight WI wells; and
- two dual purpose (i.e. gas injection / gas re-injection) GPI wells.

While it is not planned, the complete re-drilling of individual wells, or of sections of wells (referred to as 'side-tracks'), may be required in response to technical problems and two side-tracks are anticipated within the assessment.

To account for the worst case (as requested in the EPD EIA Guidance Note (FIG, 2015l)), this EIS assesses the impact of the maximum 30 wells (including side-tracks) case, to take account of the potential for contingency operations.

Production operations will be carried out using a FPSO unit located approximately 2.1 km from the main DC, 3.0 km from the Southern DC, 1.6 km from the Eastern DC and approximately 6.0 km and 5.8 km from the remote West Flank and Casper GPI well(s) locations, respectively.

In addition to crude oil (which is the target product), there will also be hydrocarbon gas in the Sea Lion reservoir fluids which will be produced from the oil wells. Gas that comes out of the oil wells is referred to as 'associated gas'. In addition to this, gas will be intentionally produced from the remote GPI well(s). This is referred to as 'produced gas'. The 'associated gas' will be used for fuel on the installation, for 'gas blankets' in cargo / slops tanks and for 'gas lift' to improve the oil recovery. The 'produced gas' is primarily needed for well start-up and in the event of fuel gas shortfall (not currently envisaged). Any surplus gas (either 'associated' or 'produced') can be re-injected into the remote GPI well(s).

Seawater injection will also be used to improve oil recovery and will be carried out through the dedicated WI wells. In addition to this, the water which comes out of the reservoir along with the oil and associated gas (referred to as 'produced water') will be re-injected once it starts to arrive. In the case of temporary operational or maintenance issues the treated injection water may be disposed of overboard whilst being monitored for the specified limits (see section 10.7). The amount of 'produced water' available for re-injection will increase over time as the oil content of the reservoir depletes.

Once the oil has been processed on the FPSO, it will be ready for export to market via the Direct Offtake option. As described above, the previous base case oil export option (Inshore ship-to-ship transfer in Berkeley Sound) has been rejected in favour of Direct Offtake and is no longer under consideration. The Direct Offtake oil export option will:

- Minimise the risk of exposure of environmentally sensitive areas in, and around, the Falkland Islands to hydrocarbon spills from offloading operations; and
- Require additional offshore mitigations to be put in place i.e. an Offshore Support Vessel (OSV, i.e. a tug) to attend the Commercial Trading Tanker (CTT) offshore in addition to the presence of the Emeregcy Response and Rescue Vessel (ERRV), which is always on standby.

For the purposes of this EIS specifically, the Development has been divided into four stages. The activities and processes associated with each Stage are explained in more detail later in this chapter. However, by way of introduction, the initial development will entail:

- Stage 1:
  - All activities up to 'First-oil'- drilling / well construction and installation of production facilities, including:
    - Commissioning and operation of the onshore production support and drilling support bases;
    - Mooring of LTVs in Berkeley Sound for up to 12 months for equipment storage and associated vessel activity
    - Commissioning and operation of an onshore drilling mud plant;
    - Use of the existing Temporary Dock Facility (TDF);
    - Drilling, completion and suspension of the first tranche of wells using a MODU;
    - Installation of the MODU anchor supports, X-mas trees / conductors, FPSO mooring system, connection of the flowlines and risers to the turret buoy within the FPSO and the offshore subsea production infrastructure (e.g. wellheads, subsea manifolds, umbilicals, risers, flowlines, jumpers, hydraulic and electric flying leads and, potentially mud mats for support);
    - Pre-commissioning of the Subsea System;
    - Arrival and installation of the FPSO;
    - Hook-up and commissioning of the FPSO to the pre-installed turret buoy and subsea production equipment;
    - Introduction of hydrocarbons to the production facilities and commencement of production operations (West Flank, Main DC and Eastern DC);
    - Well flow back, injection and production testing from the oil, gas and WI wells to the MODU;

        - ‘First-oil’ from the Main DC and West Flank wells;
        - Use of supply vessels and Emergency Response and Rescue Vessel (ERRV) to support operations in the field; and
        - Use of fixed-wing aircraft, road transport, vessels and helicopters throughout.

- Stage 2:
    - Simultaneous operations (SIMOPS) - concurrent drilling and initial production (i.e. having the MODU drilling in-field with early production from the FPSO occurring at the same time):
        - Use of the onshore supply base, drilling mud plant and TDF;
        - Anchoring of LTVs in Berkeley Sound and associated vessel traffic, for up to four months, to support the Stage 2 Subsea construction campaign;
        - Drilling of the remaining production wells from the same MODU;
        - Well flow back, testing and production from the remaining oil wells via the MODU and / or FPSO;
        - Production from, and operation of, all the wells from the FPSO;
        - Direct Offtake (offload) of crude from the FPSO to the purchaser’s CTT;
        - Use of supply vessels and ERRV on standby to support operations both in the field and offshore construction vessels at the LTV mooring location in Berkeley Sound; and
        - Use of fixed-wing aircraft, road transport, vessels and helicopters throughout.
- Stage 3:
    - Steady state production:
        - Ongoing use of the onshore supply base and TDF;
        - Production and operation of all subsea wells controlled from the FPSO;
        - Direct Offtake (Crude oil offload) from the FPSO to the purchaser’s CTT for export to oil market;
        - Use of supply vessels and ERRV on standby to support operations in the field; and
        - Use of fixed-wing aircraft, road transport, vessels and helicopters throughout.
- Stage 4:
    - Decommissioning of the wells, subsea production infrastructure, and demobilisation / removal of the FPSO; and
    - Decommissioning of inshore and onshore infrastructure.

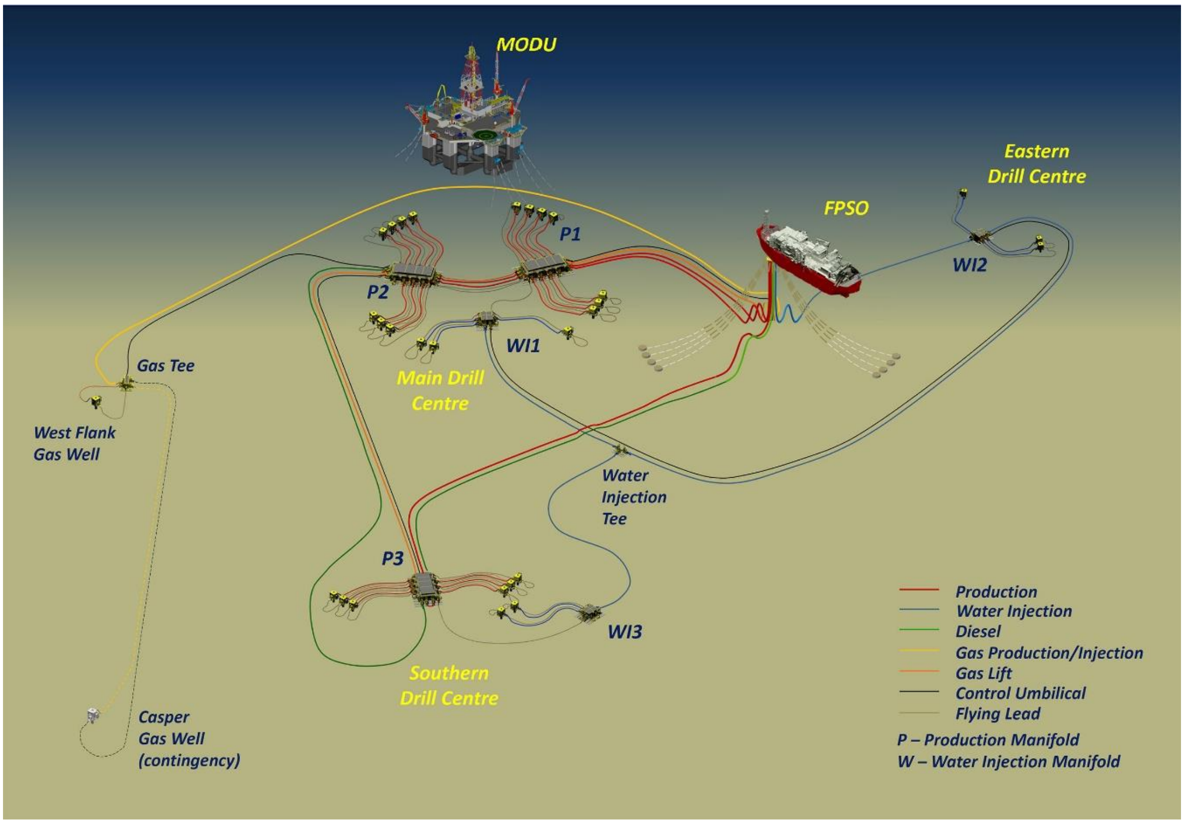


Figure 5.1: Sea Lion Phase 1 configuration (illustrative only).

Note: This figure shows 28 oil production / WI wells and two GPI wells, though fewer wells may be drilled

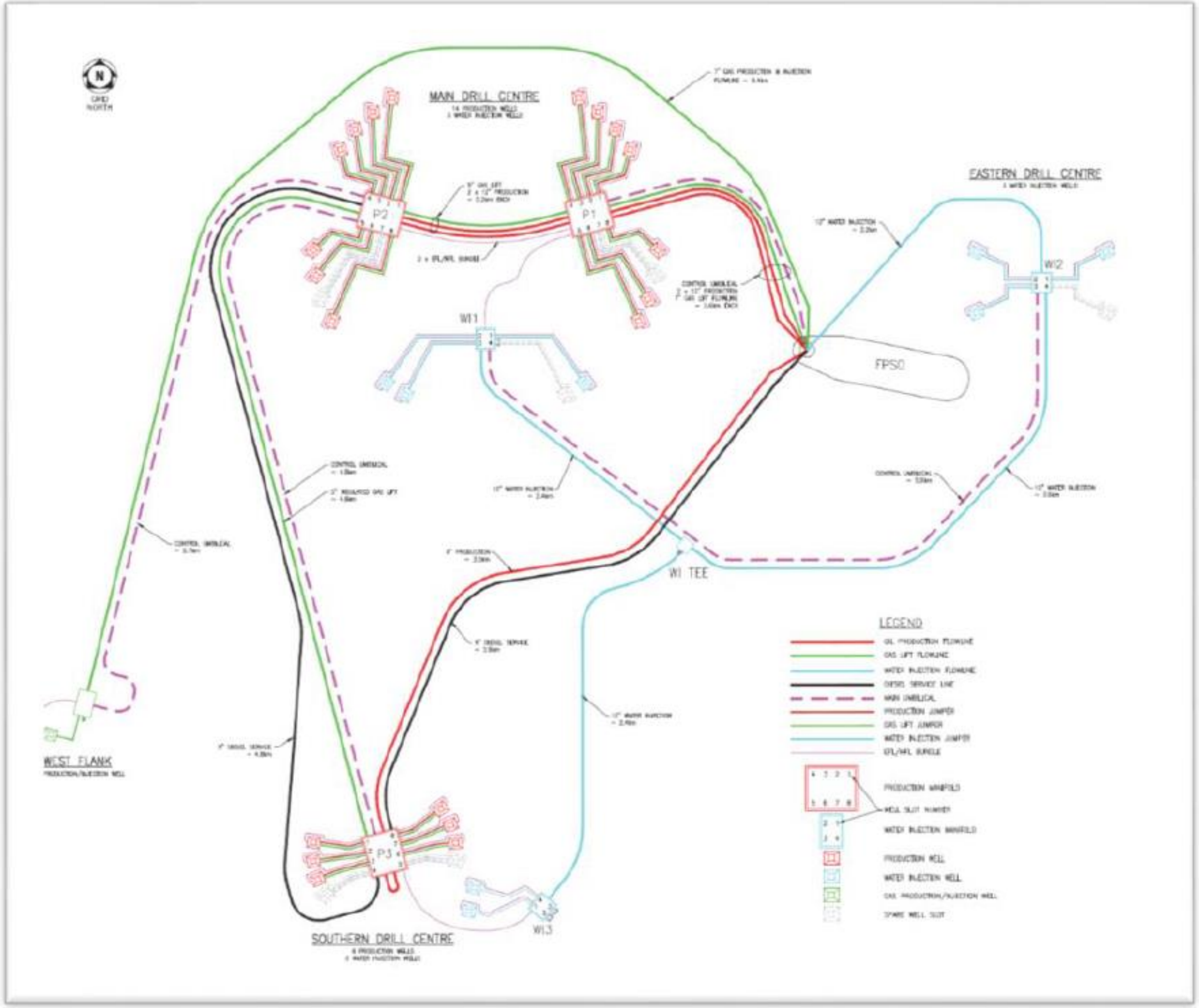


Figure 5.2: Sea Lion Phase 1 Plan of Development Layout showing three DCs and two GPI wells

5.1.3 Chapter structure

The following chapter describes:

- The project schedule (section 5.2);
- The Sea Lion reservoir characteristics (section 5.3);
- The drilling operation (section 5.4);
- Construction: installation of offshore drilling, production and export facilities (section 5.5);
- Hook-up and commissioning of the FPSO (section 5.6);
- Simultaneous drilling and production operations - SIMOPS (section 5.7):
- The production facilities (section 5.8);
- Steady state production (section 5.9);
- Oil export process and facilities (section 5.10);
- Logistics and infrastructure (section 5.11);
- Decommissioning (section 5.12);
- The Phase 1 base case mitigation technologies (section 5.13); and
- The estimated quantities of residues and emissions (section 5.14).

Sufficient detail is provided below to enable assessment of the environmental impacts of Stages 1-3 under planned, unplanned and accidental conditions. As described in section 5.12, full details on the decommissioning operation (Stage 4) will be described in a dedicated decommissioning Environmental Impact Assessment (EIA), which will be developed prior to cessation of production.

5.2 Project schedule

The approximate project timescale is provided in Table 5.1, however, note that this may be subject to change depending upon the award of project contracts.

Table 5.1: Indicative Sea Lion Development Phase 1 project timeline

Year 1				Year 2				Year 3				Year 4				Year 5				Year 6				Yr 7-23				Year 24			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Stage 1: Mobilisation of materials and equipment, drilling (commencing Year 2) / well construction installation of subsea facilities commences immediately post sanction, HUC [a] of the FPSO and 'first-oil' (from Main and West Flank GPI)																															
														Stage 2: Post first-oil drilling, and concurrent production operations and oil export *c.*3.5 years post sanction																	
																								Stage 3: Production operations and oil export							
																													Stage 4: Decom [b]		

[a] Hook Up and Commissioning – physical connection, function testing and introduction of well fluids / hydrocarbons

[b] Decommissioning is out with the scope of this EIA (section 5.12)

5.3 Sea Lion reservoir characteristics

Based upon the results of the exploration and appraisal wells previously drilled into the reservoir, Sea Lion crude is known to be a medium (density) sweet (low sulphur) crude with a high wax content (23 % using the n-alkane method and 42.3 % using the wax crystallisation method). The crude has a pour point of around 36°C (the temperature below which it does not pour out of an upturned container). The viscosity of the crude increases below 66°C, the temperature at which wax starts to crystallise, this is known as the Wax Appearance Temperature.

The crude has a live pour point of 25degC, a dead pour point of 36°C and a live wax appearance of 60degC. The viscosity increases as the temperature drops. Hence, flow assurance needs to be factored into the design of the subsea facilities, FPSO and oil export facilities (section 5.8.4.1). The Sea Lion reservoir properties are summarised in Table 5.2.

Table 5.2: Sea Lion reservoir properties

Reservoir	Eastern Area (or "East Flank") [well 14-10/5]	Western Area (or "West Flank") [well 14-10/6]
Gas Oil Ratio (GOR) standard cubic feet / stock tank barrel (scf/stb)	268 (with a range = 215-284)	418 (with a range = 403-466)
Gas Specific Gravity (SG)	0.712-0.787	0.749-0.761
API (calculated) gravity (SL10 and SL20 sands)	28-29	28.5 - 29
Reservoir depth Total Vertical Depth (TVD) Mean Sea Level (MSL)	2,415 m	
Initial reservoir pressure	242 bara (3,509 psia)	
Initial reservoir temperature	86°C	
Wax content	23 % (n-alkane method) 42.3 % (wax crystallisation method)	
Asphaltene content	0.05 – 0.7 %	
Wax Appearance Temperature (°C)	66°C Topsides, storage & offloading (dead single phase oil) 60ºC Subsea (live multiphase oil)	
Pour point crude (°C)	36°C Topsides, storage & offloading (dead single phase oil) 25ºC Subsea (live multiphase oil)	

5.4 Phase 1 Drilling operations

This section provides a description of the drilling location and schedule, the MODU and its moorings and detail on the number, type and location of wells to be drilled, the well design, management of drill cuttings and all fluids and chemicals associated with the drilling operation. The description is applicable to all wells drilled during Stages 1 and 2 of the development.

5.4.1 Drilling location

The planned locations for the Sea Lion Field main, eastern and southern DCs, and the remote gas injection well(s) are provided in Table 5.3.

Table 5.3: Sea Lion drill centre and gas well coordinates

Parameter	Northing / Easting [a]	Latitude / Longitude
Sea Lion Main Drill Centre [b]	566 335.00 E	49 15' 58.5" S
	4 542 550.00 N	59 05' 17.5" W
Sea Lion Eastern DC [b]	569 500.03 E	49° 16' 15.0" S
	4 542 000.01 N	59° 02' 40.5" W
Sea Lion Southern DC [b]	566 260.00 E	49° 17' 56.0" S
	4 538 950.00 N	59° 05' 18.7" W
West Flank Gas Production / Injection well 1	562 252.56 E	49 17' 39.6" S
	4 539 479.00 N	59° 8' 32.9" W
Casper Gas Production / Injection well 2	563 801.00 E	49° 18' 45.0" S
	4 537 433.00 N	59° 07' 19.9" W

[a] Co-ordinate system: WGS84 Transverse Mercator (TM) 60W

[b] Co-ordinates are for the centre point of the Drill Centre.

5.4.2 Drilling schedule

The indicative schedule for drilling, completion and suspension of the wells by the MODU, and flow back of the wells to the FPSO, is shown in Table 5.4. First-oil (Stage 1) from the Main DC and West Flank GPI is anticipated from the field 42 months after the project is sanctioned. Stage 2 First Oil from the Southern DC is anticipated 74 months, post sanction.

Table 5.4: Indicative drilling and well flow back schedule by MODU and FPSO at the Sea Lion Field development

Activity	Development stage	Number of wells	Number of days	Approx. time frame (years post sanction)
MODU Mobilisation	Stage 1	-	5 days mobilisation [a]	Yr 2
Drill, complete, test, clean up (if necessary) and suspend wells including initial installation of conductors. Base case is for four wells (three x Main DC oil and one x West flank GPI) to be cleaned up to the MODU, with the potential for four further wells if necessary.	Stage 1	12 (13)[b]	60 days per well	Yr 2 – Yr 4 (approximately 42 months)
FPSO arrives	Stage 1	-	-	Yr 4
FPSO installation, hook up and commissioning	Stage 1	-	-	Yr 4
First-oil	Stage 1	-	-	Yr 4
Sequentially drill, complete, test and clean up (if necessary) remaining wells. In the worst case scenario the	Stage 2	17	60 days per well	Yr 4 – Yr 7 (approximately 32 months)

Activity	Development stage	Number of wells	Number of days	Approx. time frame (years post sanction)
remaining 13 oil/gas production wells (Main and Southern DC) will be cleaned up to the MODU				
MODU moves off	Stage 2	-	5 days [a]	Yr 7

[a] As yet it is unknown where the MODU will mobilise from, this will be resolved during the rig tendering process

[b] In the event that the second contingent GPI well is required to be drilled it would be included within Stage 1

5.4.3 Mobile Offshore Drilling Unit (MODU)

Drilling operations for Phase 1 will be carried out using a semi-submersible drilling rig, an example of which is shown in Figure 5.3. Semi-submersible drilling rigs are one of the more commonly used types of MODU worldwide with the ability to drill in deeper water. The MODU will be de-ballasted during transit and ballasted down while on station and drilling to provide a stable platform and keep the MODU on location. The MODU is secured into position using anchors.

At the time of writing, the contract for the MODU has not yet been awarded for the Phase 1 Development. However, for the purposes of assessing the environmental impacts of drilling activities, generic details of an anchored MODU have been assumed. Where specific details require confirmation, worst case assumptions have been made.

While in position, a statutory 500 m exclusion zone will be established around the MODU in accordance with safety legislation. Unauthorised vessels, including fishing vessels, will not be permitted access to the 500 m zone. An ERRV (sometimes referred to as a stand-by vessel) will be present while the MODU is on location.

Figure 5.3: Photograph of a typical anchored semi-submersible drilling rig (the *Ocean Valiant*)

5.4.3.1 MODU moorings

On location, the MODU will be held in place by anchors, or will be attached to pre-installed suction anchor piles. Anchor layouts will vary based on final MODU selection. It is anticipated that, as a worst case, the selected MODU will require ten anchors with different lengths of chain required in order for the rig to maintain position. Approximately 300 m of chain are expected to be in contact with the seabed per anchor, and the anchors themselves may cause anchor mounds in the seabed sediment up to 1 m high.

When all anchors have been deployed in their correct position, the rig will be ballasted down and the anchors bedded in firmly by appropriately tensioning each chain.

Drilling of the production and WI wells will be carried out over the main DC (comprising the three manifolds), the eastern (comprising one manifold) and the southern DC (two manifolds). All of the oil production and WI wells at each DC will be accessible to the MODU without the need to relocate anchors. However, the mooring will be recovered and re-laid in the event the MODU is required to move from one DC to another and when drilling the GPI well(s) which are remote from the DCs. Anchors will also be re-laid if the MODU has to move away from the DCs for any reason. If suction anchors are used, as opposed to embedment anchors, these will be left in place around the DCs and drag anchors will be used at the remote GPI well(s).

Details on the vessels used to transit, position and anchor the MODU are provided in section 5.11.2.

5.4.4 Number and type of wells

For the Phase 1 Development a maximum of 30 wells, drilled by the MODU, will be connected ('tied-back') to the FPSO. There is a risk during initial flow back that debris, resulting from casing and formation perforation, causes damage to the turret internals resulting in a loss of containment. The initial flow back of the first three oil production wells and the gas lift well will therefore be to the MODU. The MODU is set up to remove solids, i.e. drill cuttings, from the well fluids and can handle perforation debris without risk of damage. This allows the project to test the volume and size distribution of perforation debris and confirm whether the remaining production wells can be brought in to service directly to the FPSO. If the perforation debris returns are at a level where damage could occur to the FPSO all remaining 17 production wells, and the contingent gas well, will require clean up via the MODU. In this scenario, all hydrocarbons would be flared for a short flow period of *c* 1 day.

Once clean, all wells will enter full service via the High Pressure (HP) separators on the FPSO. It is not expected that the water injection wells will be flowed back to the FPSO prior to entering service. The maximum 30 development well configuration comprises up to:

- 20 oil production wells (hereafter referred to as just 'production' wells);
- 8 WI wells; and
- 2 dual purpose (i.e. gas injection / gas re-injection) GPI wells.

The production and WI wells will be drilled across three (clustered) DC (section 5.4.4.1, section 5.4.4.2). The GPI well(s) will be drilled as remote wells.

The production wells will produce the oil (the target product), and also the 'associated gas' and 'produced water'. The associated gas from these wells will be used to:

- Provide fuel gas for power generation on the FPSO (section 5.8.3.3);
- Blanket the oil storage / slops / off-spec tanks (tank blanketing, section 5.8.4.6); and
- Improve the production of oil from the reservoir via 'gas lift', which reduces the density of the oil enabling it to flow at higher production rates (section 5.8.5.6).

The WI wells will also be used to improve oil recovery as water is injected into the reservoir to replace the extracted oil and maintain the pressure in the reservoir (section 5.8.5.6). The WI wells will initially inject heated seawater into the reservoir. After an initial period, water from the reservoir will be produced onto the FPSO with the oil (produced water), the WI wells will then be used to inject a combination of treated produced water and seawater.

The gas well(s) will be used for production and reinjection of gas. When in production mode the gas from the GPI wells will be used for:

- Well start-up;
- Fuel gas in the event of gas shortfall (i.e. not enough associated gas), and
- Gas lift (as above).

5.4.4.1 Pre-First-oil wells (Stage 1)

Of the maximum 30 wells to be drilled, 12 wells are anticipated to be fully drilled and completed before pre-first-oil. The 12 wells will likely comprise:

- Eight oil production wells in the Main DC (TBC);
- Three WI wells (Eastern DC); and
- One West Flank GPI well (remote well tied back to the FPSO separately).

For drilling efficiency, the Stage 1 wells will be batch drilled (section 5.4.5.2).

5.4.4.2 Post-First-oil wells (Stage 2)

Once production has commenced, the remaining wells will be drilled and completed sequentially using the MODU. These wells will comprise:

- Up to 12 oil production wells (i.e. remaining six wells at MDC and six wells at the Southern DC);
- Up to five WI wells (three at the MDC and two at the Southern DC); and

These wells may require clean up through the MODU and will then also be tied back, tested and produced through the FPSO.

5.4.4.3 Assumptions about the drilling operation

Development wells designed to produce hydrocarbons (either directly via oil producing wells or indirectly via injection wells) are fundamentally different from exploration and appraisal wells. Exploration and appraisal wells are most commonly drilled vertically into the reservoir with the sole objective of confirming the presence or absence of hydrocarbons. Development wells however, need to fully exploit the potential for recovery of hydrocarbons from the producing reservoir. In order to achieve this, they are typically designed to ensure maximum contact with the producing horizons of the reservoir sandstone. Therefore, while development wells are initially drilled vertically from the seabed, they deviate from the vertical as the depth increases so that when development wells enter the reservoir, they do so at a high angle, horizontally or may even follow a U-shaped trajectory through the reservoir.

Such deviated wells expose a greater measured length of reservoir and it is often necessary to control wellbore stability using drilling muds (drilling fluids) other than Water Based Mud (WBM), which has been used in all Falkland Islands exploration campaigns to date.

The current assumptions relating to the development wells are:

- Tophole well sections and conductor installation:

  - A conductor will be pile driven into place prior to drilling through the conductor with WBM;
    - In the event that it is not possible to pile drive the conductor into position, the conductors will be installed by drilling with seawater and sweeps (a small volume of viscous drilling fluid designed to sweep or remove any debris) and displacing to an inhibited WBM to keep the hole open at target depth prior to installation of the conductor pipe.
  - The tophole sections of the wells will be drilled using seawater and sweeps and displaced to an inhibited WBM sequentially to keep the hole open at target depth prior to installation of the first casing string; and
  - Tophole cuttings and associated sweeps and displacement WBM will be discharged to sea.
- The production wells will most likely have a horizontal well section through the reservoir;
- The WI wells will likely have a high angle section into the reservoir of approximately 70°;
- The GPI well(s) will be vertical into the reservoir;
- Lower well sections will be drilled using a Non-Aqueous Drilling Fluid (NADF);
- Cuttings associated with NADF[1] will be treated to meet Falkland Islands Government (FIG) regulations / UK guidelines and OSPAR requirements to remove the NADF[1] prior to discharge of the cuttings (section 5.4.5.3.2);
- Wells drilled from the MODU will be cased and cemented through the reservoir and then suspended with a mechanical barrier (a retrievable plug) and kill weight suspension fluid prior to completion (a kill weight fluid is a fluid of sufficient hydrostatic density to exceed the reservoir pressure); and
- Well completions will be perforated from the MODU and wells will then either be cleaned up at the MODU, or routed for production at the FPSO.

Note: Throughout the drilling campaign, contingency plans must be maintained to address unexpected geological or drilling problems. This could involve re-drilling wells or individual well sections in addition to the requirement for an additional remote GPI well.

5.4.5 Well design

5.4.5.1 Drilling, casing and wellheads

The basic well profile for each of the maximum 30 wells is summarised in Table 5.5. Each well will have a different trajectory and endpoint and well sections will vary in length along with overall volumes of cuttings and mud. These profiles are based on the longest planned well and therefore the assessment that follows is precautionary for the Development as a whole.

It is possible that, in the event that the progress of a well is not satisfactory, it is sealed downhole and a new trajectory is drilled from within the existing wellbore, this is known as a ‘side-track’. This is not a planned event and is difficult to predict so two side-tracks have been allowed for, assuming that two already-drilled tophole sections can be used. The time taken to undertake these side-tracks is included in the overall forecast of rig time and therefore emissions and discharges are included in the assessment.

The development wells will be drilled in three to five sections, depending on the well type. The diameter of the wellbore will decrease with each subsequent well section (Table 5.5). The lengths and diameters of each section of the well are determined prior to drilling and are dependent on the geological conditions through which the well is to be drilled. Once each section of the well has been drilled, the drillbit and drillpipe (or 'drill string') is lifted out of the wellbore and a protective steel casing is lowered into the well and cemented into place.

While all casings are essential to support the wellbore and thus contribute to well control, blow-out prevention and environmental management, each type of casing serves a different purpose. In particular, the conductor casing provides structural strength to support the wellhead and the Blow-Out Preventer (BOP), which is used during drilling, and latterly the subsea X-mas tree which is used during production. Further, the conductor prevents unstable upper formations from caving in and sticking the drill string to the side of the wellbore or forming large caverns in the wellbore.

Currently, Premier is considering two different options for the installation of the well conductor pipes:

- Pile-driving a 36" conductor section into position from the MODU or an installation vessel. Following this, the seabed inside the conductor would be drilled out using a 17.5" bit and the full contents discharged at the seabed along with the bentonite sweeps; or
- Drilling a 42 / 36" diameter tophole and cementing a 36" casing in place from the MODU before drilling and casing a 26" and / or a 16" section with all cuttings discharged at the seabed along with the bentonite sweeps.

Which option is selected depends upon the means of installation i.e. the MODU or an installation vessel. The two different options will have differing environmental impacts. Pile driving the conductor will result in increased noise and drilling the topholes will create more cuttings. Therefore, the worst case component of each option has been modelled to cover the impacts of both within this EIS.

Therefore, the main subsea infrastructure that requires installation prior to, and during, the drilling operation includes the following:

- Well conductor and casings:
  - Conductor will be pile-driven by the MODU or an installation vessel, or drilled and cemented into place by the MODU. Subsequent casing sections will be drilled and cemented by the MODU.
- A wellhead for each well:
  - Landed on the conductor by the MODU.
- A BOP for each well:
  - Installed onto the wellhead by the MODU.

The tophole sections of wells will be drilled with the drill string and drillbit left open to the seawater (riserless drilling). Consequently, drilling mud and cuttings are discharged straight to the seabed as there is no means of containing them. The conductor and surface casing are then cemented into position.

Once the conductor and surface casings have been installed, a temporary BOP is installed on the wellhead to maintain well control during drilling (section 5.4.5.4).

Prior to drilling the lower-hole sections of each well, a pipe known as a 'marine riser' will be run from the MODU and secured to the wellhead on the seabed. The drill string will subsequently be deployed through the centre of this riser. The marine riser provides a closed system through which the drilling mud can be circulated into the well (through the centre of the drill string) and returned to the rig in the annular space between the drill string and the casings and the riser. Once the lower-hole sections have been drilled and the intermediate casings cemented in place, four wells will be flowed back to the MODU for clean up. Premier has also included a worst case option of the remaining 17 oil / gas wells requiring flow back to the MODU (i.e. in the event of significant well debris being encountered during the first four well flowbacks (section 5.4.9). All production wells will be completed and suspended from the MODU in readiness for flow back to the MODU / FPSO for clean-up and hydrocarbon production.

Table 5.5: Phase 1 Development well profiles

Hole section	Casing	Drilling fluid	Section length (m)
Oil Production Wells (x 20)			
42”	36” conductor	Seawater with viscous sweeps	77
26”	20” surface casing (if required)	Seawater with viscous sweeps	350
17 ½ ”	13 $^{3}/_{8}$” intermediate casing	High Performance Oil Based Mud (OBM)	400
12 ¼”	9 $^{5}/_{8}$” production casing	OBM	3,500
8 ½ ”	7” production Liner	OBM	1,500
WI Wells (x 8)			
42”	36” conductor	Seawater with viscous sweeps	77
26”	20” surface casing	Seawater with viscous sweeps	350
17 ½ ”	13 $^{3}/_{8}$” intermediate casing	OBM	1,400
12 $^{1}/_{4}$”	9 $^{5}/_{8}$” production casing	OBM	3,400
GPI Well (x 2 (i.e. 1 well plus 1 contingency if required))			
42”	36” conductor	Seawater with viscous sweeps	77
17 ½ ”	13 $^{3}/_{8}$” intermediate casing	Seawater with viscous sweeps / WBM / OBM [a]	700
12 $^{1}/_{4}$”	9 $^{5}/_{8}$” production casing	WBM / OBM [a]	1,350

[a] **Note:** the GPI wells may be drilled with WBM in each section, or with WBM in the tophole sections followed by OBM in the lower sections. Details are provided below, see Note in section 5.4.5.3.1.

5.4.5.2 Drilling sequence (batch or sequential drilling)

The Stage 1 (pre-first-oil) oil production and WI wells will be batch drilled and completed. This is where all the drilling operations for each well are performed first followed by all the completion operations (when production tubing is installed in the well) for those wells. Batch operations are generally more efficient with regard to mud use and time. The drilling operations may be further sub-divided into batch drilling all the tophole sections and then all the lower-hole sections, however this is yet to be determined.

The Stage 2 (post first oil) wells in the Main and Southern DCs will be drilled sequentially (i.e. not batch drilled) to enable the use of each well as soon as it is completed.

5.4.5.3 Drilling muds and drill cuttings management

During drilling operations, mud of a specified density (or 'weight') is pumped down the drill string to the drillbit. Drilling mud performs the following functions:

- Ensures that the hydrostatic pressure in the wellbore is higher than that of the surrounding formation so that the well is 'overbalanced', thus preventing a 'kick' of formation fluid flowing into the wellbore and causing a potential well blow-out;
- Removes the drill cuttings from the bottom of the wellbore and carries them to the surface where they are either:
  - Discharged to sea in riserless drilling (tophole sections); or
  - Treated on the MODU once the marine riser is in place (bottom-hole sections).
- Suspends the drill cuttings in the wellbore in the event that circulation / drilling is interrupted;
- Lubricates and cools the drillbit as it penetrates the formation; and
- Deposits an impermeable 'mudcake' on the wall of the well bore, which effectively seals the wellbore and stabilises the formation while it is being drilled and prior to installation of the casings.

Two types of mud will be used in the Phase 1 Development:

- Tophole sections (42" and 26" sections) - Seawater with high-viscosity sweeps with heavier WBM pumped downhole to maintain well stability prior to running the conductor or casing; and
- Lower-hole sections (17 ½", 12 ¼" and 8 ½" sections) – High Performance OBM (i.e. a NADF as referred to in the FIG PON 10 (section 3.1.6.4).

5.4.5.3.1 Seawater, sweeps and WBM: tophole sections

As a worst case from the perspective of drill cuttings and WBM discharge, the 42" and 26" top-hole sections will be drilled with seawater and periodic bentonite viscous sweeps, with mud and cuttings being discharged directly to the seabed (Table 5.6 below). Bentonite viscous sweeps will be circulated to remove debris and residual fluids. Once the tophole sections have been drilled, the wellbore will be filled with a WBM to maintain wellbore stability prior to running the conductors / casings.

Note: it is anticipated that the first GPI well will be drilled with *all* sections in WBM, which is suitable for the simple vertical well that is required. However, if a second GPI well is required, or if the sequence of wells alters, one or both GPI wells may be drilled after the rig has already been configured for (OBM) operations. If this is the case the 12 ¼" section of the GPI well(s) may be drilled in OBM to avoid the environmental and logistical implications of re-configuring the rig systems to handle WBM (including the additional oily waste that would be returned to shore and the additional emissions during this change over period). Similarly, the 17 ½" sections of all wells may be drilled with *either* WBM or OBM depending on whether the rig is configured for WBM or for OBM at the time; if the rig has been configured for OBM operations the 17 ½" sections will be drilled with OBM.

5.4.5.3.2 Oil Based Mud: Lower-hole sections

Following installation of the marine riser, the 17 ½" (where applicable, see previous section), 12 ¼" and 8 ½" sections (where applicable) will be drilled with OBM (Table 5.6). The OBM and cuttings will be circulated within the closed system and returned back to the MODU for treatment.

The discharge of OBM contaminated cuttings will be managed in accordance with FIG Petroleum Operations Notice (PON) 10 to ensure best practice (section 3.1.6.4). FIG PON 10 reflects the requirement of OSPAR Decision 2000/3 on the 'Use of Organic-Phase Drilling Fluids (OPF) and the Discharge of OPF-Contaminated Cuttings' and prohibits the following:

- The discharge of whole OPF (e.g. OBMs);
- The discharge of whole OPFs when drilling tophole sections; and
- The discharge of cuttings contaminated with oil based fluids at a concentration >1 % by weight on dry cuttings.

A Thermo-mechanical Cuttings Cleaner (TCC) unit will be used on the MODU to process the OBM contaminated cuttings which are returned to the MODU via the marine riser. The TCC (Figure 5.4) will separate the mud and the cuttings to maximise recovery of the mud for re-use during drilling. Prior to discharge, the cuttings will be heated to evaporate the remaining oil and then powdered. They will then be tested to ensure that the concentration of OBM is less than 1 % by dry weight on the cuttings at which point they will be discharged to sea below the waterline. If any cuttings are sampled that are not <1 % by weight on cuttings, the outlet of the mill can be manoeuvred onto a skip and the material can then be returned to the feed hopper for re-processing.

The TCC unit will be spared (i.e. critical spares will be held in Stanley) and maintained to sustain the required reliability. In the event of a major malfunction, initial cuttings would be stored in skips offshore whilst awaiting the TCC unit to be re-instated. Untreated cuttings will not be discharged to sea. If the failure of the TCC unit continues, there are two options:

- The skips of un-treated cuttings may be shipped to shore whilst the TCC is re-instated or a replacement unit is brought in. The stored cuttings could then either be re-transported out to the rig for treatment or sent for treatment elsewhere in the world.
- Alternatively, drilling could cease until the TCC unit is commissioned and ready to accept cuttings.

The batch sequencing of the sections means that changes in the mud system (from WBM to OBM and *vice versa*) are kept to a minimum, as are unused or waste volumes of mud. Once the drilling operation is complete, OBM left in the mud pits will be returned to the mud plant at the onshore supply base along with other rig materials. All unwanted inventories will be disposed of in line with the available outlets and principles in the Waste Management Plan. No discharge of whole OBM to sea will occur.

Table 5.6: Typical mud requirements and cuttings volume per well for Sea Lion wells

Hole section	Mud	Volume of mud used (m^3)	Cuttings volume (m^3)	Fate of mud and cuttings
Oil Production Wells (x 20)				
42”	Seawater with viscous sweeps	2,000	75	Discharged at seabed
26”	Seawater with viscous sweeps		125	
17 ½ ”	OBM	1,550	65	Cuttings cleaning up via TCC and dry cuttings discharged from MODU with oil content on cutting of <1 % dry weight. . The reclaimed mud will be re-used.
12 1/4”	OBM		250	
8 ½ ”	OBM		55	
Total	-	**3,550**	**570**	-
Side Track Contingency (x 2)				
26”	Seawater with viscous sweeps	1000	125	
17 ½ ”	OBM	1,550	65	Cuttings cleaning up via TCC and dry cuttings discharged from MODU with oil content on cutting of <1 % dry weight. . The reclaimed mud will be re-used.
12 1/4”	OBM		250	
8 ½ ”	OBM		55	
Total	-	**2,550**	**495**	-
WI Wells (x 8)				
42”	Seawater with viscous sweeps	2,000	75	Discharged at seabed
26”	Seawater with viscous sweeps		125	
17 ½ ”	OBM	1,500	65	Cuttings cleaning up via TCC and dry cuttings discharged from MODU with oil content on cutting of <1 % dry weight. The reclaimed mud will be re-used.
12 1/4”	OBM		260	
Total	-	**3,500**	**525**	-
GPI Well (x 2 (i.e. 1 well plus 1 contingency if required))				
42”	Seawater with viscous sweeps	2,000	75	Discharged at seabed
17 ½ ”	Seawater with viscous sweeps / WBM / OBM [a]		125	
12 1/4”	WBM / OBM [a]	1,500	260	WBM: Discharged at seabed; or OBM: Cuttings cleaning up via TCC and dry cuttings

Hole section	Mud	Volume of mud used (m^3)	Cuttings volume (m^3)	Fate of mud and cuttings
				discharged from MODU with oil content on cutting of <1 % dry weight. Mud reused.
Total	**-**	**3,500**	**460**	**-**

[a] **Note:** as stated above, it is anticipated that the first GPI well will be drilled with all sections in WBM, which is suitable for the simple vertical well that is required. However, if a second GPI well is required, or if the sequence of wells alters, the lower section/s of one or both GPI wells may be drilled after the rig has already been configured for OBM operations. If this is the case the 12 ¼" section of the GPI well(s) may be drilled with OBM to avoid the environmental and logistical implications of re-configuring the rig back to WBM e.g. the additional oily waste that would be returned to shore and the additional emissions during this change over period.

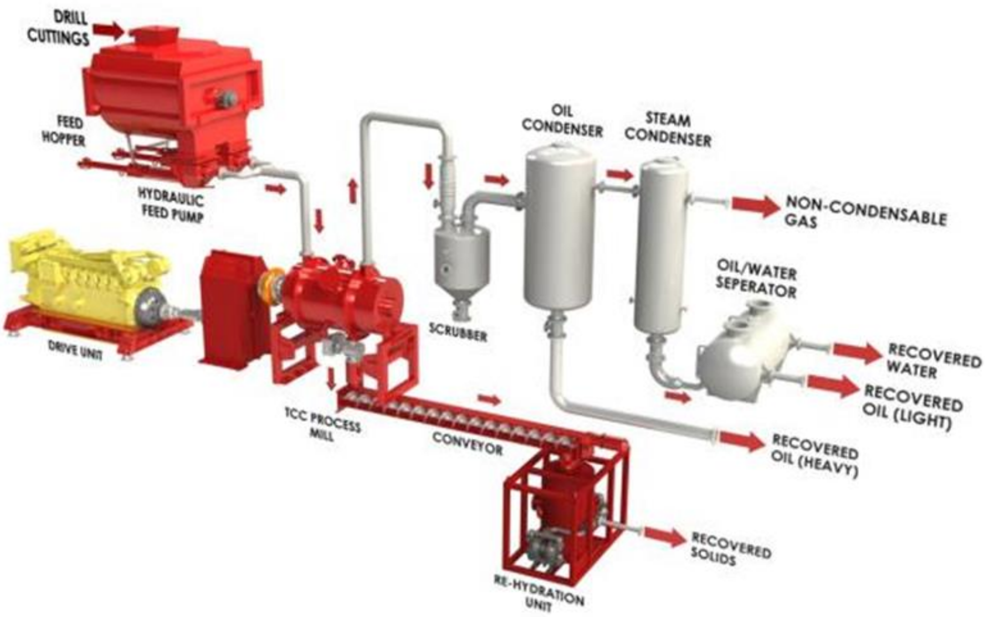


Figure 5.4: Typical Thermo-mechanical cuttings cleaner used to treat OBM coated drill cuttings

5.4.5.4 Well suspension

Following the batch drilling process for the Stage 1 wells, all wells will be suspended by the MODU using an engineered plug to preserve the integrity of the well bores allowing the BOP to be removed. This is followed by batch completion by the MODU involving reattachment of the BOP, removal of the plug, and installation of the completion and X-mas tree (section 5.4.9).

Oil production and WI wells will be suspended using retrievable plugs to seal the well. A 'kill weight' (very dense) brine will be used to ensure that the pressure in the wellbore is greater than that in the formation (overbalanced). Both the plugs and the brine create blow-out barriers in addition to the BOP.

The GPI well(s) will be suspended in an underbalanced state (where pressure in the wellbore is less than that in the surrounding formation) to facilitate the initial flow of gas to the FPSO.

All wells will be suspended in accordance with FIG / UK legislation and regulatory requirements, as well as industry-standards e.g. Oil and Gas UK guidelines.

Further detail on well suspension will be available nearer the time of project execution and presented within the subsequent PON applications submitted to FIG for prior approval (section 3.1.6.4).

5.4.5.5 Well completion

Well completion refers to the equipment and process of installing the final flow conduit from reservoir to wellhead. This includes the selection of established safety components and materials of construction appropriate for the well fluids and conditions.

For Sea Lion, the completion phase shall:

- Install an upper completion with pressure containing capability consisting of completion tubing, production packer (a device used to isolate the annulus and anchor or secure the bottom of the production tubing string), tubing hanger (a device attached to the topmost tubing joint in the wellhead to support the tubing string) and downhole safety valve (all well types);
- Test the critical pressure retaining equipment items;
- Deploy and initiate downhole perforating guns (which are explosive devices designed to make holes in the casing in order to create a flow path from reservoir to surface); and
- Enable compliance with the industry principle of ensuring two barriers are in place to prevent uncontrolled flow at all stages of the well completion sequence.

All completion operations shall be performed from the MODU. Materials, tubing sizes and perforation techniques will vary between well types but the design principles above shall be consistent. The detailed design shall be documented in the Sea Lion Completion Basis of Design.

Further detail on all well completions will be available nearer the time of project execution and presented within the subsequent PON applications submitted to FIG for prior approval (section 3.1.6.4).

5.4.5.6 Well flow back and testing

Prior to the commissioning of the wells, it is necessary to flow back the production wells to ensure the removal of:

- All suspension and / or completion brines;
- Chemicals dosed into the brines;
- Residual drilling mud; and
- Residual amounts of perforation related debris, gun debris, and formation debris.

Four wells will be flowed back to the MODU for clean-up. An additional worst case option of the remaining 17 oil wells requiring flow back to the MODU (for example, in the event of significant well debris being encountered during the first four well flowbacks which could damage the FPSO turret swivels) is also included (section 5.4.9).

In the event that the remaining 17 oil wells do not require clean up to the MODU, they will be flowed back to the FPSO, as previously planned and detailed in the previous EIS (Premier, 2018). Wells will be flowed through the production flowlines / risers (section 5.5.2) back to the FPSO and then through temporary and removable strainers / screens, which will capture any remaining debris prior to entry into the turret swivels.

5.4.6 Well chemical use and discharge

Details on the specific well chemicals which will be used during the Phase 1 Development drilling are not yet known. Importantly however, throughout the Development, all chemicals will be selected to minimise environmental impacts as much as possible, in compliance with legislation. Moreover, all chemical use will be included in PON applications submitted to FIG for approval prior to use (section 3.1.6.4).

For the purposes of this EIS, analogue chemicals have been used to enable a representative impact assessment, as detailed in the relevant chapters below.

5.4.6.1 Drilling chemicals

It is necessary to add various chemicals to the drilling mud to further ensure the correct properties are maintained. Mud additives may be dosed into the mud prior to drilling or may be available as a contingency in the event that they are needed.

Mud additives dosed into the high-viscosity sweeps and displacement WBM will be discharged to sea along with the mud volumes. Mud additives dosed into the whole OBM will not be discharged to sea as the used OBM is recycled. Very small quantities may be present on the OBM cuttings, discharges of which will comply with OSPAR 2000/3 (section 5.4.5.3.2).

Typical primary and contingency mud additives include:

- Potassium chloride (KCl) based fluid for chemical inhibition;
- Weighting agents;
- Viscosifiers for pressure regulation;
- Mud filtrate reduction, and filtrate control agents;
- Oxygen scavenger for corrosion control;
- Buffers to regulate pH;
- Polymer addition for clay cuttings encapsulation;
- Starch / cellulose;
- Naturally occurring fibrous, filamentous, granular or flake materials;
- Glycol for hydrate suppression and fluid lubricity; and
- Lime, for H_2S neutralisation, should it be present (not expected).

5.4.6.2 Cementing chemicals

The cement used to secure the well casings requires several additives to manage its working characteristics, thus ensuring that the casing is safely adhered to the well bore. For example, the speed at which cement sets can be affected by numerous factors such as depth, temperature and pressure, and may require chemical manipulation to achieve optimal results in each section.

Typical cementing chemicals include:

- Anti-settling agents used to stabilise mixed cement;
- Wetting agents used to alter the 'wettability' of the casing / formation from 'oil wet' to 'water wet' to ensure an improved cement bond;
- Cement slurry dispersants used to reduce the viscosity of the slurry and aid displacement;
- Fluid loss reducers used to control water loss from cement slurries;
- Cement slurry spacer viscosifier used to build weighted fluid spacers to separate cement slurry from drilling muds during slurry displacement;
- Cement slurry retarders for use in well bores where the temperature range is between 50 - 120°C; and
- Cement accelerants used to reduce the time taken for cement to set.

At the time of writing the detailed cement design has yet to be finalised, however, estimates of cement volume are provided in Table 5.7. Conductors will be cemented to seabed some cement will be discharged at the seabed; cement depositions will extend a matter of 10-15 m away from the well. All cement will be mixed as required and as a result there should be limited operational discharge of any mixed cement or mix-water.

Table 5.7: Typical cement requirements per well

Conductor / Casing	Volume of cement (m^3)
36" conductor	20
20" surface casing	120
13 $^3/_8$" intermediate casing	110
9 $^5/_8$" production casing	40
7" production liner	20

5.4.6.3 Well suspension, completion, flow back and testing chemicals

Full details on the chemicals required during the suspension, completion, flow back and testing of the Phase 1 wells will be provided in the Completion Programme, post project sanction.

5.4.6.3.1 Well suspension

Suspension brines are weighted according to the well type and design and will be dosed with various chemicals as considered necessary. Typically, however, suspension fluids will comprise brine dosed with:

- Weighting agents;
- Corrosion inhibitor;
- Biocide; and
- Oxygen scavenger.

5.4.6.3.2 Completion chemicals

Completion fluids are required to optimise the functionality of the well and to prevent damage to the formation. Completion fluids typically include:

- pH management chemicals;
- Biocides; and
- Pipe dope (lubricating grease that prevents thread galling) / asphaltene / oil dissolvers.

5.4.6.3.3 Well flow back and testing chemicals

Well flow back chemicals typically required include detergents and solvents.

5.4.7 Other MODU discharges

Liquid storage areas on the MODU, and areas that might be contaminated with drilling muds and additives, are segregated from other deck areas to ensure that any contaminated drainage water can be treated prior to discharge, and that leaks / spills to deck can be contained.

Drainage water from these areas, and from machinery spaces, is collected and treated to reduce hydrocarbon concentrations to less than 15 ppm prior to discharge to sea, as is required under the MARPOL Convention 73/78 Annex I. Black (sewage) and grey (domestic) water is also collected and treated to meet the requirements of the MARPOL Convention 73/78 Annex IV prior to discharge to sea.

During well completion, the OBM fluids are pumped out of the well by circulating a brine mixture so that brine containing residues of OBM is returned to the MODU. In line with UK practice, once returns are visibly oil-free they will be sampled and discharged to sea. Any returns with visible oil would not be discharged and would be treated before discharge either onshore or offshore.

Similar returns of contaminated brine or seawater may occur if the MODU needs to detach the marine riser while drilling with OBM. In this case, the riser is first displaced to brine or seawater before it is detached to prevent a release of OBM. This may be necessary during periods of extreme weather for example. Brine or seawater subsequently returned to the MODU during riser disconnection and reconnection would be treated in the same way as well clean-up fluids.

5.4.8 Use of explosives

Explosives may be required during the drilling operations as follows:

- To perforate the liner downhole once the final production casing has been installed to create holes in the liner (or casing) which will enable the oil to flow into the well; and
- As a contingency if the drill string gets stuck in the wellbore.

The explosives used are typically a series of small charges directed horizontally to perforate the sides of the well. The charges will be detonated in the reservoir section of the well, between 1.8 – 2.2 kilometres underground, such that the noise from the explosion is not be expected to be detectable at the seabed.

All explosives will be stored as described in section 5.11.1.2.

5.4.9 Initial well testing

Well testing, to measure individual well flow rates, is normally carried out throughout the life of the field as part of day-to-day operations (section 5.8.5.7) and results in limited, or no incremental flaring emissions. Four well flowbacks to the MODU for well clean-up purposes and production tests (3 x oil wells and 1 x gas well, West Flank) are included in this assessment. The objectives of the flow backs include confirmation of the:

- Capacity of the West Flank reservoir / GPI well as a secure supply of gas for the start-up of wells (gas lift) and FPSO (power generation); once confirmed this will reduce the probability of needing to drill the Casper contingency gas well (with incremental drill cuttings and emissions);
- Integrity of the well completion, repeatability of the original 14/10_5 well test and well productivity;
- Injectivity of the reservoir; and
- Potential for solids carry-over to the FPSO during commissioning and start-up, thereby minimising potential damage to the FPSO turret swivel and delays to first oil dates.

During the flow backs to the MODU both gas and oil will be produced from the well to temporary testing equipment on the MODU. There will be the need to flare both gas and oil due to the volumes that will be received for the test. The environmental impact of flaring is assessed in this EIS (section 10.9).

A of four well tests (3 x oil wells and the West Flank GPI gas well) will be tested at the rates summarised in Table 5.8 and Table 5.9. The base case is for:

- 1,262 tonnes of reservoir oil and 105 tonnes of gas to be burned from each oil well; and
- 751 tonnes of gas and 76 tonnes of reservoir oil to be burned from the gas well.

Base oil will also be used to promote efficient combustion and minimise risk of drop-out from the flare from the well tests. This is common practice whereby the flare is initiated with base oil, which is highly combustible in the atomised form that is emitted from the flare tip, and pumping of base oil continues while crude oil and gas are also sent to the flare. Due to the waxy nature of Sea Lion crude, a higher quantity of base oil will be required to support the combustion of oil wells compared with gas wells, than previously anticipated.

These operations will be conducted with the highest regards to safety of personnel, infrastructure and duty of care to the environment. Flow period durations and produced volume estimates for each required well test would be established in advance to enable assessment of associated emissions. Residual product from the well after flaring will be stored, transported to the Islands and then processed in the incinerator at the supply base, or, if not suitable, would be prepared for transfer to the UK for disposal.

Table 5.8: Quantities of oil and gas produced during the three well clean-ups

Well testing quantities					
Oil		Gas		Base oil	
Well test (stb / day)	10,000	Well test mmscf / day	4.18	Per well test (stb)	4,500
Duration / well (days)	0.9	Duration / well (days)	0.9	Duration / well (days)	n/a
Total volume oil (stb) / well test	9,000	Total volume gas (mmscf) / well test	3.762	Total volume oil (stb) / well test	4500
stb to m^3 conversion	0.1589	Mmscf to m^3 conversion	28,317	stb to m^3 conversion	0.1589
Total volume oil (m^3) / well test	1430	Total volume gas (m^3) / well test	106,529	Total volume oil (m^3) / well test	715
Density oil (t / m^3)	0.8828	Density (kg / m^3)	0.982	Density base oil (kg / m^3)	885
Tonnes of oil / well test	**1262**	**Tonnes of gas / well test**	**105**	**Tonnes of oil /well test**	**633**
No. of well tests	3	No. of well tests	3	No. of well tests used for oil wells only)	3
Total oil flared (t)	**3,787**	**Total gas flared (t)**	**314**	**Total base oil flared (t)**	**1,898**

Table 5.9: Quantities of oil and gas produced during the clean-up of the West Flank GPI

Well testing quantities					
Oil		Gas		Base oil	
Well test (stb / day)	600	Well test mmscf / day	30	Per well test (stb)	300
Duration / well (days)	0.9	Duration / well (days)	0.9	Duration / well (days)	n/a
Total volume oil (stb) / well test	540	Total volume gas (mmscf) / well test	27	Total volume oil (stb) / well test	350
stb to m^3 conversion	0.1589	Mmscf to m^3 conversion	28,317	stb to m^3 conversion	0.1589
Total volume oil (m^3) / well test	86	Total volume gas (m^3) / well test	764,559	Total volume oil (m^3) / well test	48
Density oil (t / m^3)	0.8828	Density (kg / m^3)	0.982	Density base oil (kg / m^3)	885
Tonnes of oil / well test	**76**	**Tonnes of gas / well test**	**751**	**Tonnes of oil /well test**	**42**
No. of well tests	1	No. of well tests	1	No. of well tests	1
Total oil flared (t)	**76**	**Total gas flared (t)**	**751**	**Total base oil flared (t)**	**42**

The results of the first four well flowbacks will be analysed and shared with FIG to determine whether the flowback objectives (described above) have been achieved. In the event that the data from the first four flow back tests demonstrates the presence of unacceptably high quantities of well or reservoir debris within the produced fluids (which could damage the FPSO turret swivel and also impact the FPSO schedule), Premier has included the worst case contingency option of flowing back the remaining 17 production wells to the MODU (Table 5.10). Any decision to pursue this worst case option would require consultation and the approval of FIG.

The atmospheric emissions associated with these well tests are presented in section 10.9.

Table 5.10: Quantities of oil and gas produced during the clean-up of the remaining 17 wells (worst case option)

Well testing quantities					
Oil		Gas		Base oil	
Well test (stb / day)	10,000	Well test mmscf / day	4.18	Per well test (stb)	4500
Duration / well (days)	0.9	Duration / well (days)	0.9	Duration / well (days)	n/a
Total volume oil (stb) / well test	9,000	Total volume gas (mmscf) / well test	3.762	Total volume oil (stb) / well test	350
stb to m^3 conversion	0.1589	Mmscf to m^3 conversion	28,317	stb to m^3 conversion	0.1589
Total volume oil (m^3) / well test	1,430	Total volume gas (m^3) / well test	106,529	Total volume oil (m^3) / well test	715
Density oil (t / m^3)	0.8828	Density (kg / m^3)	0.982	Density base oil (kg / m^3)	885
Tonnes of oil / well test	**1,263**	**Tonnes of gas / well test**	**105**	**Tonnes of oil /well test**	**633**
No. of well tests	17	No. of well tests	17	No. of well tests	17
Total oil flared (t)	**21,462**	**Total gas flared (t)**	**1,778**	**Total base oil flared (t)**	**10,758**

5.4.10 Well control and blow-out prevention during drilling

Well control and blow-out prevention during drilling is managed by:

- Well design based on appreciation of the formation pressures;
- The use of appropriately weighted drilling muds to overbalance the well so that pressure in the wellbore is greater than the pressure of the surrounding formation, but is less than the formation fracture pressure;
- The use of mud with appropriate weighting additives;
- The use of appropriate well casings and a wellhead; and
- The use of a Blow Out Preventer (BOP) stack.

Details on the drilling mud, additives, casings and wellheads are provided above. In addition to these, a BOP 'stack' will be installed onto each wellhead for the duration of the drilling operation. The function of the BOP is to prevent uncontrolled hydrocarbon flow from the well by positively closing in the well bore in the event that flow from the wellbore is detected.

The development wells of the Phase 1 operation are not expected to encounter any zones of abnormal pressure and the BOP will be rated for pressures sufficiently in excess of those predicted. BOP integrity will be tested prior to usage and rated over the range of pressures predicted to occur within the wells. Further tests will be conducted on the BOP approximately every three weeks during drilling operations. Small amounts of water-based hydraulic fluid will typically be discharged every three weeks when valves are actuated during regular operational testing of the BOP.

Pressure testing of the BOP will be undertaken in line with the drilling contractor and Premier's standards and procedures and in line with FIG / UK legislation and industry-standards.

Use of the BOP is temporary and specific to drilling activities. Following completion of the well the BOP will be removed and replaced with a permanent subsea X-mas tree, which is used during the production phase to ensure well control. Detail on the installation and operation of the X-mas tree is provided in section 5.8.1.3.

5.5 Construction: Installation of drilling, production and export facilities

In order to produce oil from the Phase 1 Development, and to export the oil to market, it is necessary to install:

- MODU foundation anchors (see section 5.4.3.1);
- Subsea well infrastructure e.g. well conductors and casings, wellheads and BOPs;
- Subsea production facilities e.g. manifolds, umbilicals, X-mas trees, flexible flowlines / risers, flexible jumpers, flying leads; and
- The FPSO mooring system, including foundation anchors.

The offshore installation process will be supported by a total of four Large Transport Vessels (LTVs), although a maximum of two LTVs will be present at any one time (see below and also section 5.11.2). These vessels will act as floating logistics and storage bases while installation vessels will transit between the LTVs and the Sea Lion Field picking up equipment for installation.

Each LTV will be spread moored, using anchors, and a 500 m radius exclusion zone is provided to give a safe clearance. The LTVs will be around 160 m in length and the anchor lines are 100 m horizontally from the bow to the anchor point. Indicative locations for the mooring of three LTVs in Berkeley Sound (LTV1 51.582800 S,57.886686 W; LTV2 51.582800 S, 57.872336 W; LTV3 51.582800 S, 57.857986 W) is shown in Figure 5.5. The temporary anchorages will be 1.2 nm (or more) from shore and may be slightly further east or west than shown. The positioning of all LTVs in Berkeley Sound is to be agreed with the Harbour Master.

In Stage 1 of the subsea construction campaign, three LTVs will be used over a twelve month period, although the current schedule expects that the LTVs are present in Berkeley Sound for only eight months (c. August-2022 to end March-2023) which supports the target of avoiding competing for sea room during the peak fishing period. The phasing of the subsea installation campaign results in a maximum of two of the three LTVs being moored in Berkeley Sound at any one time during this period. Stage 2 - which will provide the drilling and subsea infrastructure in support of the Southern DC - only requires one LTV to be moored for a duration of approximately four months from c. mid December-2025.

Detail on the installation process, quantities and / or dimensions of each are provided below. Detail on all transportation and installation vessels required throughout the development is provided in section 5.11.2.

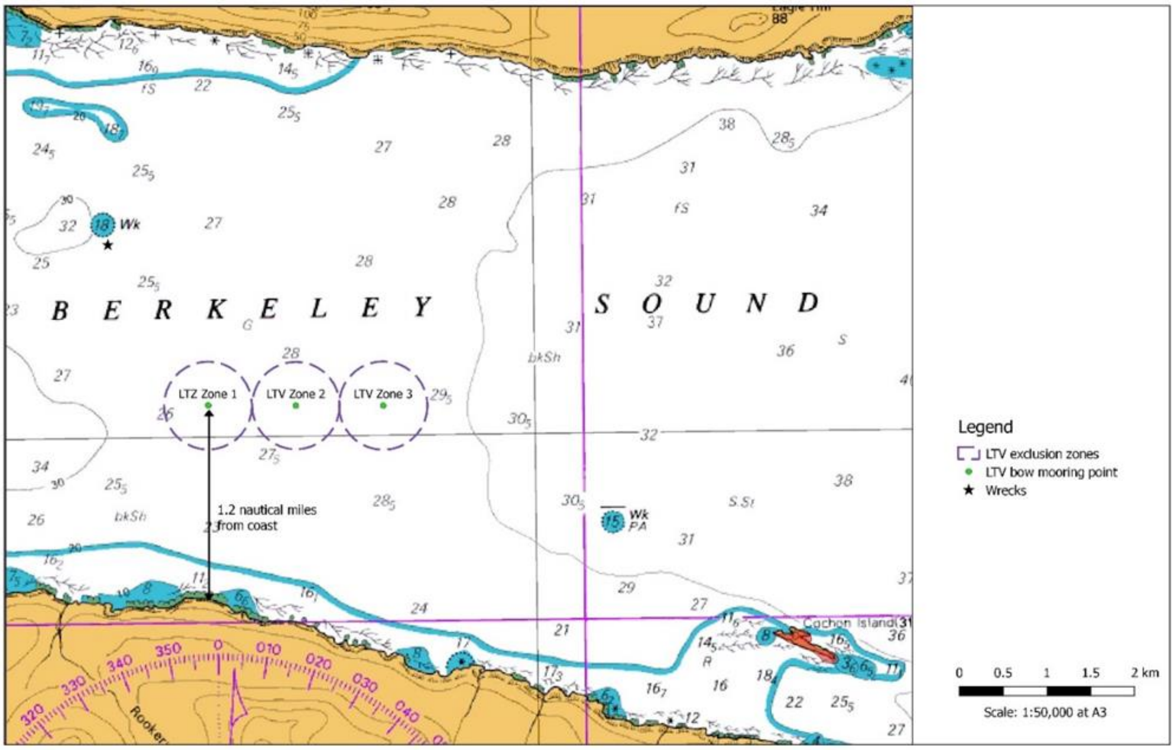


Figure 5.5: Indicative positioning of LTVs (three potential locations shown, maximum two LTVs anchored at any time) in Berkeley Sound during the installation period.

5.5.1 FPSO mooring system

The FPSO mooring will comprise 12 anchors connected to the FPSO turret buoy. The anchors are expected to be suction piles approximately six metres in diameter and the installation aids will protrude from the top of the suction anchors by about 1-2 metres.

The 12 anchor lines will consist of chain, polyester rope and spring buoys, which will be installed and attached to the FPSO turret buoy. Up to approximately 300 m of mooring line is expected to be in contact with the seabed, per anchor.

The turret buoy, which connects directly to the turret mounted in the forward part of the FPSO, will be submerged at a depth of 50 m when the anchors and lines are installed, awaiting arrival and hook-up to the FPSO.

5.5.2 Subsea production facilities

As described in section 5.1.1, the previous subsea layout has been optimised to address potential operability and flow assurance issues. The detailed changes to the subsea layout include:

- Inclusion of the new Eastern WI DC;
- Relocation of three WI wells from Main to Eastern DC;

- Relocation of two Production wells from Main DC to Southern DC;
- Relocation of Southern DC 750m further south;
- Rerouting of diesel service line from FPSO to P3 manifold and separate diesel line from Production manifold P2 to P3;
- P3 manifold tied back directly to FPSO via single production line;
- Insulation of gas lift line; and
- Replacement of two x methanol cores in umbilical with two x diesel cores to enable diesel to be used to displace hydrocarbons in subsea lines during shutdowns.

As a result other minor engineering modifications have occurred, for example, engineering changes to the FPSO turret to accommodate two additional risers (for the new Southern DC and a spare riser slot).

The subsea production facilities consist of:

- A X-mas tree located on each well;
- Subsea manifolds and pipelines:

  Up to six subsea manifolds for production and WI wells;

  Subsea Umbilicals, Risers and Flowlines;

  Flexible flowlines between the manifolds and the FPSO;

  Flexible 'jumpers' between the manifolds and between wells and manifolds;

  Hydraulic and electric 'flying leads' between the manifolds and between wells and manifolds;

  Control and chemical injection umbilicals;
- Installation supports:

  Sandbags, grout bags and gravel bags used as markers and construction aids; and

  Temporary clump weights for installation of equipment and downlines for hydrotesting.

5.5.2.1 Subsea X-mas trees

The X-mas trees used to enable well control during production are installed from the MODU during the well completion stage. The temporary BOP will be removed from the wellhead and replaced by the X-mas trees. Those for the Stage 1 wells (drilled pre-first-oil) will be installed in batches to optimise efficiency of the operation. The Stage 2 post-first-oil wells will be installed sequentially following completion of each well so that each well can start producing as soon as it is completed.

The X-mas trees will be fully tested on leaving the manufacturer and again onshore in the Falkland Islands for integrity testing prior to installation rather than conducting the testing offshore.

5.5.2.2 Subsea manifolds and pipelines

The flowlines between the manifolds and FPSO will include both a seabed and midwater (riser) section. These flowlines will convey:

- Produced fluids (oil, gas and water) from the wells to the FPSO (production);
- Water and gas from the FPSO to the wells (injection); and
- Diesel from the FPSO to Production manifolds P2 and P3 for flowline displacement purposes.

Full detail on the planned Subsea Production Systems (SPS) and Subsea Umbilicals, Risers and Flowlines (SURF) including function, installation, number and dimensions are provided in Table 5.11. The water depth and fishing methods in the area means that it is appropriate for the seabed equipment to be designed to resist snag loads rather than to be overtrawlable (section 7.7.3.1.1.1).

5.5.2.3 Installation supports

Sandbags etc. are used as markers and construction aids during installation of the subsea equipment. These will be left on the seabed until decommissioning.

Detail on the grout bags and clump weights, including function, installation, number and dimensions are provided in (Table 5.11).

Table 5.11: SPS and SURF requirements for Sea Lion Phase 1 Development

Facility / SURF	Description	Location / Route		Dimensions nominal	Installation and support
		From	To		
Manifolds	Production manifold (3) each with 8 well tie-in slots	Towards middle of each Drill Centre		21.7m x 13.7m	Lift installed by installation vessel on seabed with gravity based foundation
	Water Injection manifold (3) with 4 WI well tie-in slots			10m x 9.6m	
Water Injection Tee	Water Injection Tee (1)	SW of FPSO location		10.3m x 5.7m	Lift installed by installation vessel on seabed
Gas Tee	Gas Tee (1)	Towards middle of West Flank Drill Centre		6.5m x 10.7m	Lift installed by installation vessel on seabed
Subsea X-mas trees	Up to 30 x vertical subsea X-mas trees:	At each individual well		5.25 m x 4.1m x 3.7m	Installed by MODU onto each wellhead
Umbilicals	1 x Main Drill Centre Dynamic Umbilical	FPSO	Main Production manifold P1	Outer Diameter (OD) 237 mm x 1.8 km	Installed by installation vessel mainly on seabed with riser section to Turret Buoy supported midwater in 'Lazy Wave' configuration by distributed buoyancy modules
	1 x West Flank Remote Gas Production and Injection Well (1) Umbilical	Main DC Production manifold P2	Remote gas well	OD 84 mm x 5.5 km	Laid on seabed from reel on installation vessel
	1 x Casper Remote Gas Production and Injection Well (2) Umbilical (Contingency)	West Flank Remote gas well 1	Casper Remote gas well	OD 84 mm x 2.9 km	Laid on seabed from reel on installation vessel
	1 x Southern DC umbilical	Main production manifold P2	Southern Production manifold P3	OD 128 mm x 3.9 km	Laid on seabed from reel on installation vessel
	1 x Main – East DC Dynamic Umbilical	WI manifold WI1 (Main DC)	WI manifold WI2 (Eastern DC)	OD 100 mm x 5.7 km	Laid on seabed from reel on installation vessel
Production flowlines / risers	3 x insulated flexible production flowlines / risers in continuous length	Main Production manifold P1	FPSO	OD 470 mm x 2.6 km	Installed by installation vessel mainly on seabed with riser section to Turret Buoy supported midwater in 'Lazy

Facility / SURF	Description	Location / Route		Dimensions nominal	Installation and support
		From	To		
					Wave' configuration by distributed buoyancy modules
		Main production manifold P1	Main production manifold P2	OD 470 mm 2 x 0.2 km	
		FPSO	Southern production manifold P3	OD 470 mm 1 x 3.5 km	
WI flowline / riser	1 x insulated flexible WI line	FPSO	East WI2 manifold	OD 501 mm x 1.6 km	
	1 x insulated flexible WI line	East DC	WI Tee	OD 501 mm x 2.9 km	
	1 x insulated flexible WI line	WI Tee	Main DC	OD 501 mm x 2.8 km	
Gas Lift flowline / riser	1 x ID flexible Gas Lift line	FPSO	Main production manifold P1	OD 372 mm x 1.9 km	
Gas Lift riser	1 x flexible Gas Lift line	Main production manifold P1	Main production manifold P2	OD 372 mm x 0.136 km	
2 x Diesel service flowline	2 x flexible flowlines	FPSO / P2	Main production manifold P3	OD 402 mm x 4.2 OD 402 mm x 2.8	
Production flowline	1 x insulated flexible production flowlines	FPSO	P3	OD 470 mm x 2.9 km	Laid on seabed and connected by installation vessel
Water injection flowline	1 x insulated flexible water injection flowline	WI Tee	Southern DC	OD 501 mm x 2.9 km	
Gas Lift	1 x insulated flexible Gas lift line	P2	P3	OD 332 mm x 3.9 km	
GPI flowline / riser	1 x flexible Gas Production & injection line	West Flank Remote GPI well	FPSO	OD 255 mm x 7.5 km	
GPI flowline / riser	1 x flexible Gas Production & injection line	Casper Remote GPI well(s)	West Flank Remote GPI well	OD 191 mm x 2.7 km	

Facility / SURF	Description	Location / Route		Dimensions nominal	Installation and support
		From	To		
Flexible Jumpers	24 x Insulated production flexible jumpers	Main and Southern production manifold P1, P2	Production wells	OD 191 mm x typically 110 m	Laid on seabed and connected by installation vessel
	12 x Insulated WI jumpers	Main, Eastern and Southern WI manifolds	WI wells	OD 191 mm x typically 110 m	
	24 x Gas lift flexible jumpers	Production manifolds P1, P2, P3	Production wells	OD 100 mm x 110 m	
	1 x Insulated Gas Injection / production jumper	West Flank Remote GPI well	WI wells	OD 357 mm x typically 90 m	
Flying Leads	38 x Flying Leads including electrical, hydraulic and chemical injection paths to each well	Main DC Production & WI manifolds	Production and WI wells	OD 120 mm x 167 m (worst case, longest length)	Laid on seabed and connected by installation vessel
	Inter-manifold flying leads including electrical, hydraulic and chemical injection paths	Production manifolds P1, P3	WI manifolds W1, W3	OD 120 mm x 198 m (worst case, longest length)	
	Inter-manifold flying leads including electrical, hydraulic and chemical injection paths	Production manifold 1	Production manifold 2	OD 120 mm x 130 m (worst case, longest length)	
Crossing	1 x GRP Bridge Crossing Structure installed to allow laying of flexible production and diesel service lines over pre-existing Eastern Infield Umbilical and 12" WI flowline	Location between WI1 manifold	WI Tee	13.6 m x 7 m	Laid on the seabed by installation vessel
Sand, grout, gravel bags, additional clump weights, tethers	Used as markers and construction aids during installation of the subsea equipment	As required	As required	TBC but an estimated 10 % of total seabed disturbance area is allowed for in the assessment	Laid on the seabed by installation vessel

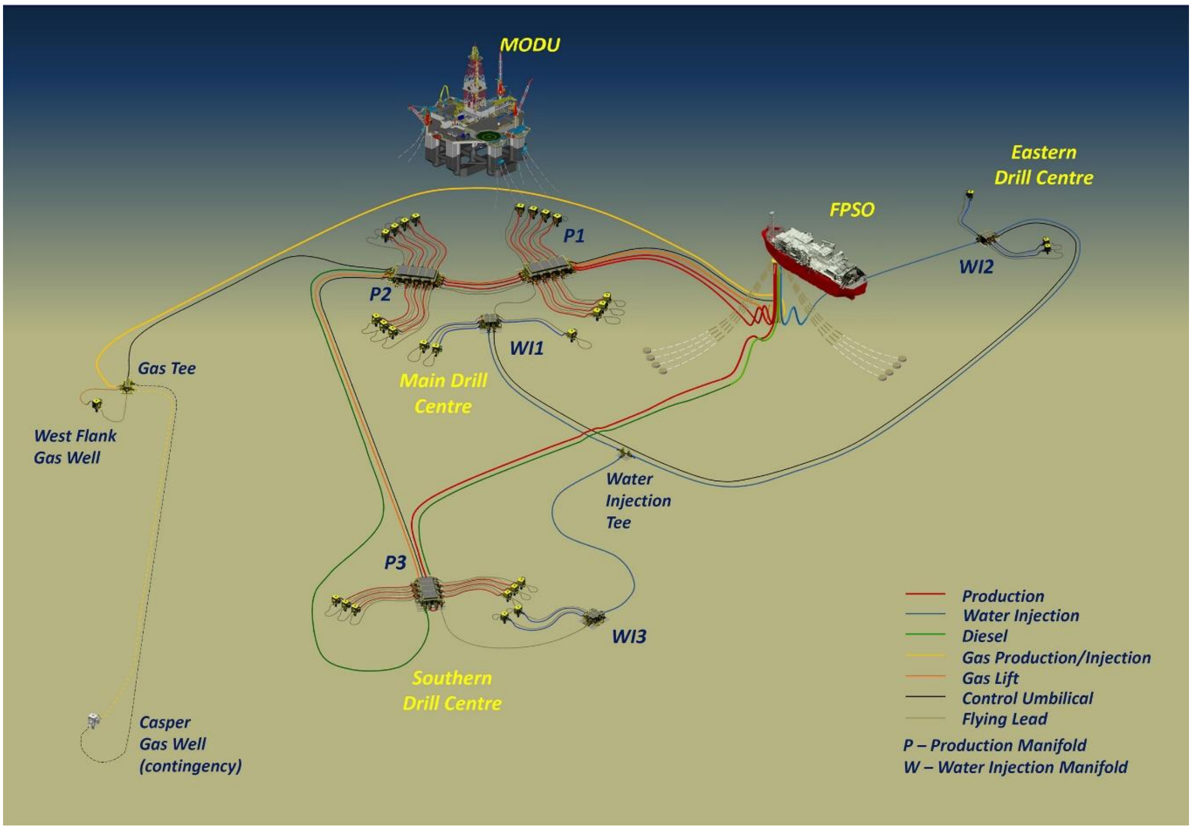


Figure 5.6: Layout of the subsea production facilities (illustrative only)

5.5.3 Arrival and positioning of the FPSO

All practicable pre-commissioning and commissioning activities (section 5.8.2) will be completed prior to the arrival of the FPSO in Falkland Islands waters

The FPSO will be towed to the Falkland Islands using three tugs. The route will be selected in consultation with other users of the sea, with the aim of minimising interference to other vessels, the risk of collision, and security risks.

On arrival in Falkland Islands waters, the FPSO is expected to transit directly to the Sea Lion Field where the pre-installed turret buoy will be connected to the turret within the FPSO (Figure 5.8). The connection operation will be undertaken with the assistance of support vessels, which will arrive with the FPSO or will already be in the field supporting the drilling operation (section 5.11.2).

5.6 FPSO Hook-up and commissioning

Once the FPSO is connected to the turret buoy (which will already be carrying the flowlines, risers and umbilicals), the hook-up operation to the SPS and SURF will be completed and commissioning activities will commence. This is collectively referred to as the Hook-up and Commissioning (HUC) process.

The FPSO ‘hook-up’ refers to making connections between:

- The wells and the FPSO e.g. connecting the flowlines / risers to the FPSO piping within the turret; and
- All utility and control facilities e.g. connecting the subsea umbilicals with the FPSO.

The 'commissioning' process refers to activating the system once it is hooked up. This involves numerous tests to ensure that:

- The system is safe for the introduction of hydrocarbons; and
- All production systems are working appropriately prior to commencement of production.

Leak testing will be carried out on the necessary elements of the systems, including those between the subsea facilities and the FPSO. Any leak testing with water will use seawater containing a biocide, an oxygen scavenger, a corrosion inhibitor and tracer dyes, which will ultimately be discharged to sea. As with all chemical use, chemicals will be selected to minimise environmental impact in line with legislation.

A summary of the transportation and installation vessels used during the Development is provided in section 5.11.2.

5.7 Simultaneous Operations (SIMOPS): drilling and initial production

Once the first tranche of wells (nominally 12 pre-first-oil) has been drilled and the FPSO has been hooked up and commenced production, there will follow a period of concurrent production and drilling (simultaneous operations). At this time, the MODU will drill the second tranche of wells (up to 17 post-first-oil wells) while the FPSO produces oil.

The field layout is illustrated in Figure 5.6. The FPSO location is approximately 2.1 km from the main Drill Centre (DC), 3.0 km from the Southern DC, 1.6 km from the Eastern DC and approximately 6.0 km and 5.8 km from the remote West Flank and Casper GPI well(s) locations, respectively. These distances accommodate the simultaneous use of the MODU and the FPSO, each of which will have a 500m safety exclusion zone.

With regard to the export of oil during this stage, the separation distance between the FPSO and the MODU will be sufficient to ensure that the CTT, which offloads crude from the FPSO (section 5.10), remains outside of the MODU 500 m safety zone.

Support vessels used during the FPSO and MODU SIMOPS are described in section 5.11.2.

5.8 Production facilities

The locations of the FPSO, Drill Centres and GPI wells are shown in Table 5.12.

Table 5.12: Co-ordinates of Production facilities

Parameter	Northing / Easting [a]	Latitude / Longitude
FPSO (centre of turret)	568 024.00 E	49 16' 36.3" S
	4 541 360.00 N	59 03' 53.2" W
Sea Lion Main Drill Centre [b]	566 335.00 E	49 15' 58.5" S
	4 542 550.00 N	59 05' 17.5" W
Sea Lion Eastern DC [b]	569 500.03 E	49° 16' 15.0" S
	4 542 000.01 N	59° 02' 40.5" W
Sea Lion Southern DC [b]	566 260.00 E	49° 17' 56.0" S
	4 538 950.00 N	59° 05' 18.7" W
Gas Production / Injection well 1	562 252.56 E	49 17' 39.6" S
	4 539 479.00 N	59° 8' 32.9" W
Gas Production / Injection well 2	563 801.00 E	49° 18' 45.0" S
	4 537 433.00 N	59° 07' 19.9" W

[a] Co-ordinate system: WGS84 Transverse Mercator (TM) 60W

[b] Co-ordinates are for the centre point of the Drill Centre.

5.8.1 Subsea production facilities

This section describes the purpose of the SPS and the SURF and both the subsea and topside facilities required to enable control of the reservoir via the FPSO.

5.8.1.1 Subsea Production System (SPS)

The SPS comprises the main DC (2 x production manifolds and 1 x WI manifold), the eastern DC (1 x WI manifold) and the southern DC (1 x production manifold and 1 x WI manifold) together with the jumpers, flying leads, the wellheads and X-mas trees for the production and WI wells and the wellhead and X-mas tree(s) for the remote GPI well(s) (Table 5.11 above). A safety zone will be established around the sub-sea installations.

The production manifolds act as subsea flow routers and are connected to the production wells via short flowlines referred to as jumpers. The production manifolds receive the fluid from each production well and co-mingle the produced fluids, which are ultimately carried to the FPSO by the flowlines / risers.

To achieve water injection, the seawater and / or produced water is pumped from the FPSO, via a WI flowline, to the WI manifold which distributes the water to the WI wells, again via jumpers. Manifolds thus reduce the number of flowlines / risers which need to be connected to the FPSO.

The subsea X-mas tree is an assembly of valves, spools, and fittings, which caps the well and controls the flow out of, or into, the well thereby enabling control of the wells during production.

5.8.1.2 Subsea Umbilicals, Risers and Flowlines (SURF)

The SURF (Table 5.11 above) enables:

- The transportation of reservoir fluids from the production wells to the FPSO;
- Communication between the FPSO and the SPS; and
- Injection of fluids and gas to the wells from the FPSO.

Risers refer to the length of flowline that runs upwards through the water column between the seabed and the FPSO. Umbilicals are used to provide power, electrical and hydraulic control and chemicals to the subsea equipment.

5.8.1.3 Subsea Controls

The SPS and SURF facilities will be controlled by the Master Control System (MCS) and monitored by the Integrated Control and Safety System (ICSS) located in the FPSO Central Control Room.

The ICSS regulates the production process and provides the functionality to:

- Remotely control and monitor all the wells, subsea facilities (manifolds and X-mas trees), and electrical trace heating (if required) in the flowlines from the FPSO; and
- Monitor the chemical metering (where provided) and chemical transfer systems to ensure an adequate supply of production chemicals to the relevant injection points within the production system.

5.8.2 FPSO design

Premier propose to use a 'lease and operate' FPSO for the field-life of 20 years. The FPSO will be a new build FPSO (hull form similar to a Suezmax tanker) that will be moored at the Sea Lion Field upon arrival in the Falkland Islands (section 5.5.3). The cargo diesel tanks of the vessel will be double hulled and the new build will involve the installation of the following onto the new hull:

- Processing facilities, utilities and control systems;
- Living quarters; and
- An internal turret mooring system which will be dis-connectable (Figure 5.8) and will enable the FPSO to weather vane.

The FPSO (Figure 5.7) will operate as a self-sufficient unit with export of produced oil via offloading directly to a CTT (Figure 5.8). The oil export process is further described in section 5.10.

The hull, with an estimated dry weight of 159,000 tonnes, will be designed to comply with FIG / UK legislation, flag state and will be DNV GL registered for offshore classification rules. The design, and all topsides pipework, equipment, skids, instrumentation, fittings and installation materials, will be:

- Sufficient to operate in the Sea Lion Field metocean conditions under continuous offshore duty for the 20 year service life;
- Rated for the range of ambient and extreme temperatures likely to be experienced; and
- Designed to withstand all forces and movement resulting from the sea state and wind conditions.

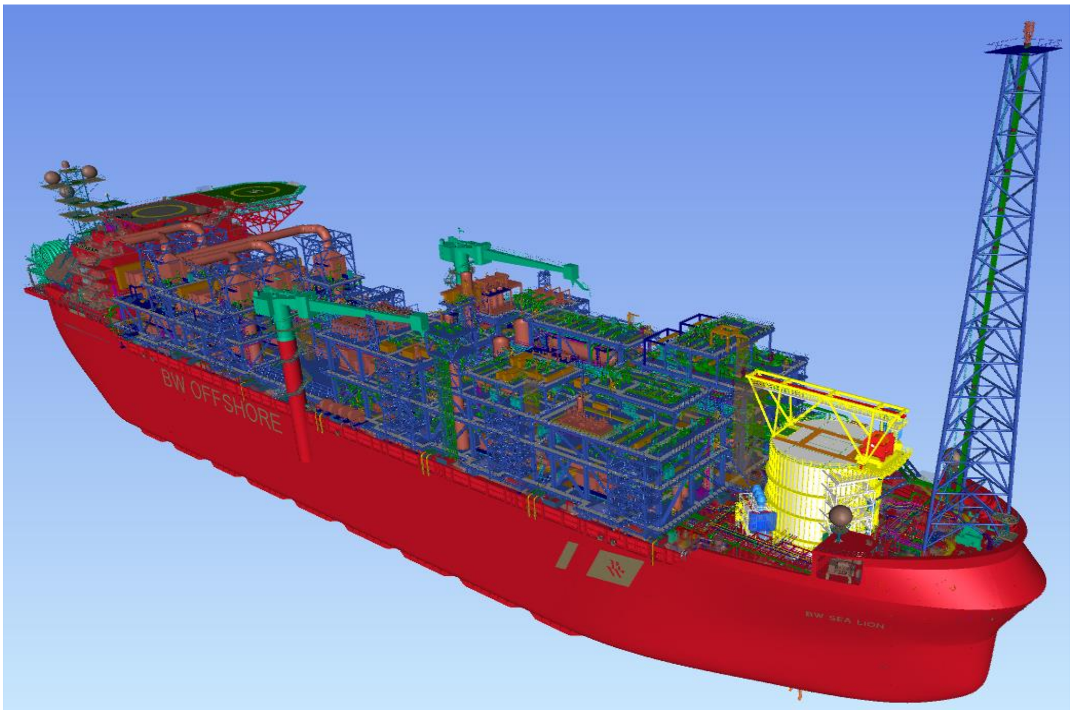


Figure 5.7: An illustration of the Sea Lion FPSO

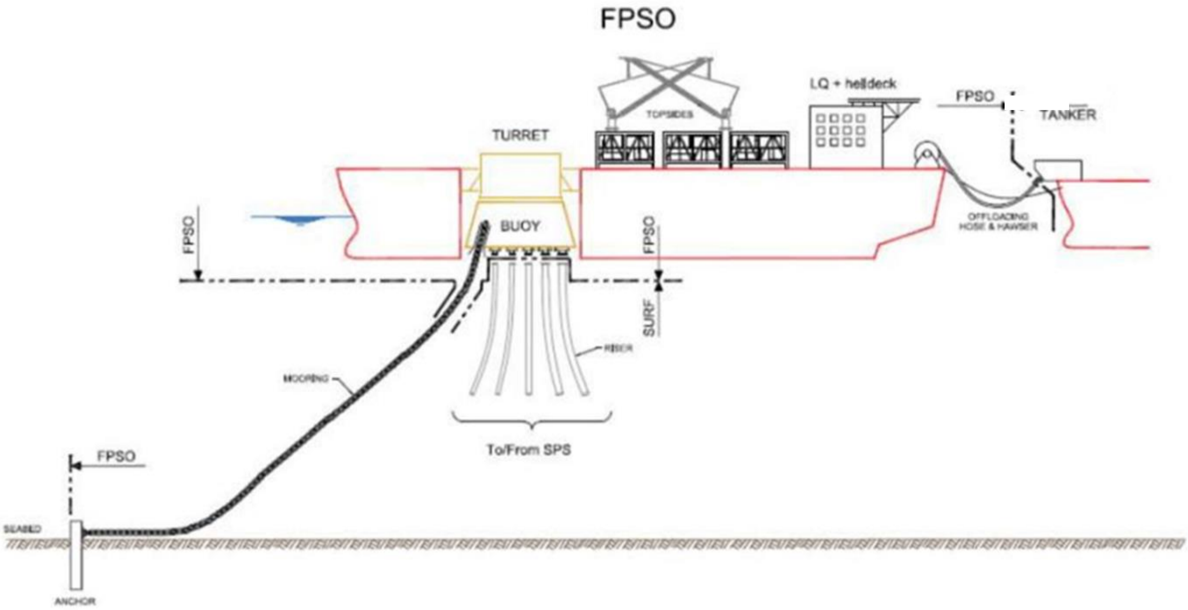


Figure 5.8: FPSO schematic showing the dis-connectable turret and offloading tanker

5.8.2.1 FPSO Drainage facilities

It is necessary for the FPSO to be designed in such a way that fluids exposed to the deck e.g. operational fluids, spills / leaks to deck and water from heavy rainfall, waves and firewater deluge can be segregated, contained, routed and managed via a series of drains.

The FPSO drains system will:

- Be compliant with current FIG / UK regulations and standards;
- Ensure all discharges are compliant with MARPOL 73/78 Annex I;
- Prevent hydrocarbon / chemical spills overboard;
- Prevent hydrocarbon / chemical spills to deck;
- Prevent hazardous liquids collecting on module floors, due to the risk of pool fires and slip hazards;
- Enable recovery of hydrocarbons / chemicals from fluids prior to disposal via the drainage system;
- Prevent the migration of spills, gas and / or fire between process areas or modules via the drains system;
- Allow the safe disposal of clean water from rain / firewater, deluge and drains systems effluent; and
- Ensure segregation exists between hazardous and non-hazardous open drains systems.

The FPSO drains system will comprise:

- Open Drains - which will be routed to the slops tank:

  - Hazardous open drains – for collection of liquids from hazardous areas, or directly from hydrocarbon processing equipment, which has been depressurised (in some cases via a Process Drain) or operates at atmospheric pressure;
  - Non-hazardous open drains – for collection of liquids from equipment located in non-hazardous areas, or directly from non-hydrocarbon processing equipment, which has been depressurised or operates at atmospheric pressure;
  - **Note:** all open drains will be sent to the slop tank for separation. The oil phase will be skimmed with recovered oil pumped back to the separation train. The water phase will be sent to a slop water treatment package for further cleaning to meet MARPOL 73/78 Annex I requirements prior to discharge to sea.
- Deck drains – these drains will be fully contained and collected fluids (i.e. from deluge operation, heavy rain and spray) routed overboard after passing through an oil interceptor type system.
- Closed Drains - the closed drains system will be part of the oil processing system and will be segregated from the open drains systems. The closed drains collect liquid hydrocarbons, produced water or other hazardous substances directly from equipment that normally operate at pressure. Liquid hydrocarbons will be routed to a Closed Drains Vessel from where they are pumped back into the oil processing system.

5.8.2.2 FPSO capacity and production

The FPSO processing capacity will be designed to meet the requirements of Phase 1 production volumes, with estimated peak production rates (Table 5.13) determining the design capacity of the FPSO topsides. The forecast production profiles for oil, water, gas and total fluid for Phase 1 are plotted in Figure 5.9. The actual production and injection rates will vary according to the performance of the reservoir and the production systems.

Table 5.13: Facility design rates

Service	Peak steady state design rate
Oil production capacity	85,000 bbl/d
Total produced liquids (oil, gas and water) capacity	120,000 bbl/d
Injection water (produced water + seawater)	130,000 bbl/d
Gas handling capacity	120 mmscfd (50 mmscfd gas lift + 70 mmscfd produced gas)
Sea Water Lift	283,000 bbl/d (topsides, marine and firefighting requirements on the FPSO)

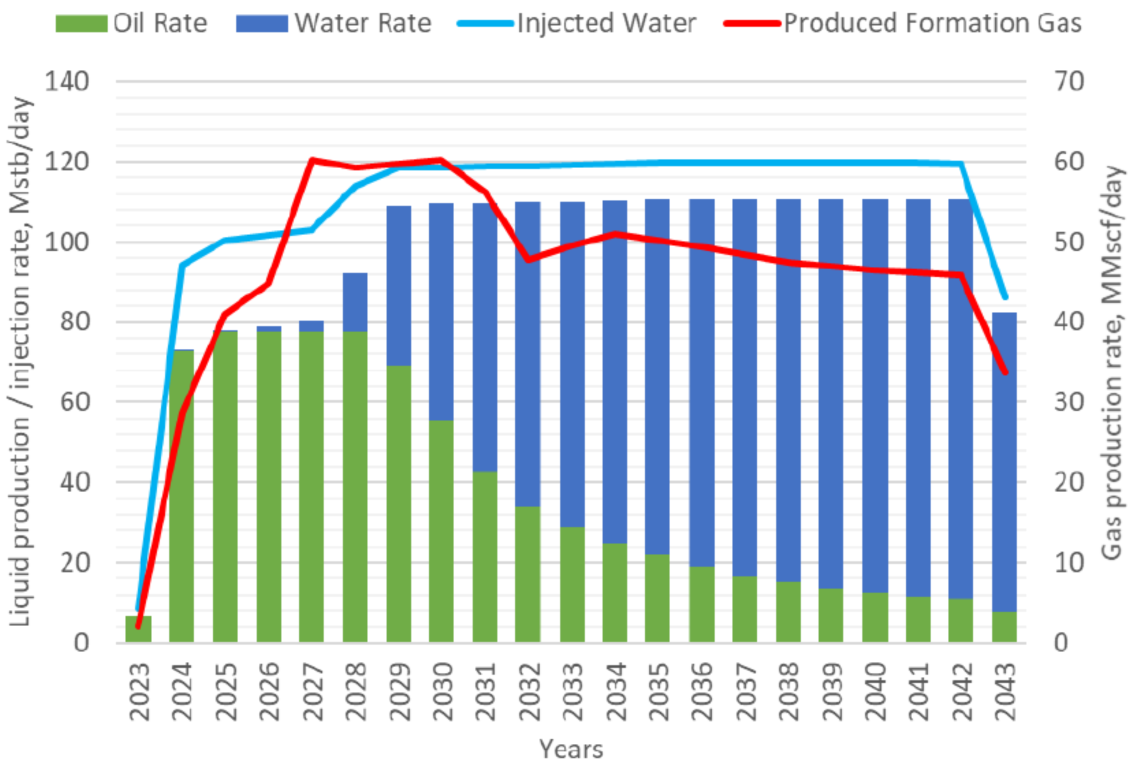


Figure 5.9: Production forecast

5.8.3 FPSO vessel utility systems

The following sections describe the utility and safety systems of the FPSO.

5.8.3.1 Anti-fouling

Anti-fouling paint will be applied to the hull of the FPSO prior to its departure for the Falkland Islands to prevent fouling of the steel by marine growth. This prevents additional weight on the hull structure and reduces drag as well as minimising the risk of introducing non-native species upon entry in to Falkland Island waters.

5.8.3.2 Heating, ventilation and air conditioning (HVAC)

HVAC systems will be provided for accommodation and enclosed spaces within the hull that are regularly accessed by authorised personnel.

Ozone Depleting Substances (ODS) will not be used in the HVAC systems which will deploy F-Gases instead. During the design process, Premier aim to use F-Gases which have a comparatively low Global Warming Potential (GWP) such as R134a (GWP of 1,300). No F-gases will be released under normal operations.

5.8.3.3 Power generation and fuel sources

Considerable effort has been invested in ensuring that power generation onboard the FPSO is as efficient as possible. Energy efficiency and the minimisation of atmospheric emissions was evaluated as part of the decision-making process when assessing options for the main fuel consumption items e.g. power generation, gas compression, artificial lift, water injection and oil export. Fuel use will therefore be minimised throughout design and subsequent operation.

Specific details on the FPSO combustion equipment are not available. However, for the purpose of the environmental impact assessment, the worst case has been assumed from within foreseeable options.

The power generation package will comprise three dual fuel (fuel gas and diesel) turbine drivers with electric motor driven gas compression. Waste heat will be recovered from the exhaust gas of the main power generation system and will be utilised to meet the heating demand on the FPSO and so reduce overall fuel consumption. Equipment defined as essential will be provided with an uninterruptable electrical power supply according to DNV GL and SOLAS (International Convention for Safety of Life at Sea) rules. Dedicated emergency power generation will be available on the FPSO.

Two types of fuel will be used on the FPSO, namely produced gas (i.e. associated gas or gas purposefully produced from the GPI well(s) if necessary) and diesel (Marine Gas Oil or Marine Diesel Oil). Diesel fuel will be required for the following single-fuel users:

- Emergency and essential power generation;
- Fire pump diesel drivers; and
- Totally Enclosed Motor Propelled Survival Craft (TEMPSC).

Note: the deck cranes are electro-hydraulic and so will not use diesel fuel.

However, the use of diesel for the main power generation is limited by both the available storage on the FPSO and resources in the Falkland Islands. It is therefore anticipated that, out with the above essential consumers, the oil and gas process will be reliant on associated gas produced from the oil wells which will be the primary fuel source on the FPSO (section 5.8.4.3).

5.8.3.4 Bunkering and bulk storage

5.8.3.4.1 Diesel bunkering, storage and treatment system

Diesel will be stored in multiple single hulled storage tanks within the engine room. In total, approximately 2,130 m^3 of diesel (i.e. Marine Gas Oil, MGO) will be provided for the following diesel consumers:

- Single-fuel diesel consumers (section 5.8.3.3); and
- Dual fuel consumers when fuel gas is unavailable.

An additional 2,660 m^3 storage will be provided for the subsea flowline displacement system used for flow assurance (section 5.8.4.1) in the event of an extended shutdown, which would lead to unacceptable cool down of the flowlines.

A diesel bunkering point will be provided on the starboard side of the FPSO. Bunding will be arranged at the receiving manifold and hose handling area to contain inadvertent spills during bunkering operations.

The diesel treatment system will be designed to ensure management of any diesel contaminated with water and particulates in order to meet the turbine cleanliness requirements.

5.8.3.4.2 Chemical bunkering and storage

During production, numerous chemicals will be required in order to facilitate the process. The hull of the FPSO will be designed to enable the storage of bulk chemicals following receipt via either bulk hose transfer directly into the hull, or tote tanks from the supply vessels. A laydown facility will be provided on the FPSO to enable storage and decanting of chemicals from tote tanks into hull storage when required. The method of chemical receipt (i.e. via bulk hose transfer or tote tank) will be dependent on the volumes and frequency of delivery.

The production and utility chemical groups required during the production of oil and gas are provided in Table 5.14 alongside detail on the function of the chemical, the volumes that the hull tanks will be designed to carry and the most likely method of delivery.

Table 5.14: Production chemical functional groups and hull chemical tank storage volumes

Chemical type	Chemical function	Maximum FPSO storage capacity (m^3)
Demulsifiers	Used to break emulsions in the produced fluids i.e. separate the oil and water phases. The type of demulsifier selected depends on the type of emulsion, either oil-in-water or water-in-oil	29 m^3
Deoilers	Used to destabilise the oil in water emulsions	12 m^3
Biocides	Two biocides will be used to kill bacteria in the injection water and produced fluids to prevent or remove biological contamination	5 m^3 / biocide
Solid flocculants	Flocculants are used to aid in the removal of solids from the seawater and produced water by intentionally gathering together small particles and making them larger and thus easier to remove (flocculation)	13 m^3
Oil antifoams	Used to prevent foaming in hydrocarbon based fluids by decreasing surface tension	19 m^3
Water antifoam	Used to prevent foaming in water based fluids by decreasing surface tension	8 m^3
Oxygen scavengers	Used to remove or decrease the level of oxygen in injected seawater to prevent oxygen induced corrosion	8 m^3
Hydrate Inhibitors	Triethylene glycol (TEG) - used to dehydrate gas and lower the dew point of gas Methanol - used for hydrate inhibition in the production and gas flowback system.	10 m^3 471 m^3
Scale inhibitors	Used to prevent the precipitation of inorganic solids from produced formation water and as formation water and injected seawater commingle. Typical scales are calcium carbonate and barium sulphate. Carbonate scales primarily form when produced water becomes supersaturated with salts due to variation in temperature, pressure or pH. Barium sulphate scale deposition can occur due to mixing of incompatible waters with differing water chemistries A broader range of scales also can be observed, depending on the reservoir conditions and production regime	45 m^3
Wax Treatment chemical	(also known as pour point depressant) Used to minimise wax deposition, oil viscosity and restart pressures after gels have formed	660 m^3

Chemical type	Chemical function	Maximum FPSO storage capacity (m^3)
Wax Dissolvers	Used to dissolve wax in the event that it forms	Brought on board as required
Calcium nitrate	Used to prevent the formation of hydrogen sulphide. Calcium nitrate will only be utilised if the Sea Lion reservoir becomes sour (not expected)	126 m^3
Diesel	There will be a separate storage tank for diesel which will be used for flowline displacement (section 5.8.4.1)	2,660 m^3

5.8.3.5 Freshwater systems

Freshwater is required on the FPSO to provide:

- Drinking (potable) water for personnel;
- Hot and cold water for domestic use;
- Make-up volumes for the cooling and heating water systems;
- Water for the safety showers, general utilities and workshops; and
- Water for slop tanks washing.

Freshwater will be generated on the FPSO from seawater using a desalination plant. Seawater will be pumped onboard via seawater lift pumps and the water systems will be designed to produce, bunker, store, sterilise and distribute potable water for domestic consumption and service water for general use on the FPSO.

Based on an estimate of 60 tonnes / day of freshwater required for the marine and topside systems (including personnel water usage), it is estimated that 276 m^3 per day of hypersaline water may be discharged from the FPSO desalination plant.

5.8.3.6 Vessel and domestic waste treatment systems

Waste water and food that will be generated on the FPSO includes:

- Food waste from the galley;
- Grey water (from showers, wash basins, kitchen and laundry);
- Black water (domestic waste water arising from toilets); and
- Bilge water (from machinery spaces, which may contain traces of hydrocarbon, grease etc.).

The following treatment facilities will be in place:

- Food waste:
  - Food waste will be ground to an extent that it can pass through a 25 mm grid before being discharged overboard without further treatment.
- Grey water:
  - Galley drains receiving grey water will be fitted with grease traps; and
  - Laundry drains will be fitted with lint filters.

- Black water:
  - A macerator will be fitted to the inlet of the sewage unit to macerate biodegradable solids prior to discharge.
- Bilge water:
  - Drains from the equipment in the machinery spaces will be pumped into a bilge holding tank for separation;
  - Water from the holding tank will be further treated in an oily water separator to ensure a maximum Oil in Water (OiW) concentration of 15 ppm is not exceeded prior to discharge; and
  - Separated oil or sludge will be routed to the waste oil drain tank, which will be transferred to tote tanks for onshore recovery or disposal. Alternatively, the separated oil will be recycled via the hazardous open drain tank (section 5.8.2.1) and thus routed back into the oil processing stream.

All treatment and discharge of grey and black water will be in compliance with FIG / UK environmental regulations and classification requirements, and with MARPOL Annex IV. Similarly, the bilge system will comply with FIG / UK environmental regulations and MARPOL 73/78 Annex I.

5.8.4 FPSO oil and gas utility systems

The following sections describe the FPSO utility systems that support the production and processing of oil and gas.

5.8.4.1 Flow assurance facilities

During production, it is necessary to ensure that the produced fluids can flow from the reservoir to the FPSO process equipment, into the storage tanks and on to the point of sale without interruption, deterioration of the crude quality and / or asset damage. Maintaining the ability of the fluids to flow is called 'flow assurance'.

Flow assurance plays a major part in how the Sea Lion system is to be designed owing to:

- The waxy nature of the Sea Lion crude oil, which has a Wax Appearance Temperature of between 60 - 66°C and Oil Pour Points of 25 - 36°C;
- The total fluids propensity to form hydrates which are ice-like solids that form when free water and natural gas (both of which will be present in the produced fluids) combine at high pressure and low temperature; and
- The ambient sea temperature, which ranges from 3 - 9°C.

In addition to the nature of the crude, flow assurance can also be affected by produced fluid chemistry, injection water chemistry and synergistic effects between the production chemicals used. Therefore, maintaining flow assurance and production chemistry is most commonly achieved using a combination of both chemical *and* technical measures, with effective technical design minimising the need for chemicals.

All subsea and FPSO facilities will be designed to prevent the formation of hydrates, waxes and gels, which may block the system. However, facilities will also be designed to mitigate their effects should blockages occur, and to enable their safe removal.

Table 5.15 gives an overview of the technical flow assurance facilities built-in to the well system and the SPS, SURF and FPSO during the development of the project. These will be developed further after the project is sanctioned. The table lists those methods that will be applied on a continuous and preventative basis as well as those that may be applied on an active, or intervention basis e.g. following a shutdown (section 5.9.4). Detail on the production chemicals that may be required for flow assurance during steady state production (Stage 3) is provided in section 5.9.1.1.

Table 5.15: Technical flow assurance strategy for continuous operation & interventions in the Sea Lion Development

Facility	Preventative flow assurance method	Intervention (active) flow assurance method
Downhole production tubing	Passive – Vacuum Insulated Tubing Active – Wax Treatment Chemical / Pour point depressant chemical injection	Wax deposition on the upper section in the tubing. Chemical Injection to reduce the gel strength and reduce the wax deposition.
SPS Equipment	Passive – insulation	Displacement of production fluids by methanol or diesel
SURF - production (flexible flowlines / risers)	Passive – insulation (maintaining topside arrival temperatures in excess of the live oil wax appearance temperatures)	Displacement (from FPSO through either flowline, with diesel)
FPSO and export tankers	System drainage, heat tracing for piping and equipment not in continuous operation, insulation to maintain temperatures. Injection water leaving FPSO is heated so that the flowing bottom hole temperature is >60°C. Crude oil storage tank heating up to 60°C for both the FPSO and export tankers	Flushing - connections for piping, instruments and equipment provided.

5.8.4.2 Heating and cooling facilities

During steady state operating conditions, it is anticipated that well fluids will be between 60 – 80 °C depending on the level of reservoir depletion. As the proportion of produced water ('water cut') increases, FPSO arrival temperatures will increase. As described above, it is necessary to manage the temperature of the Sea Lion crude as it flows through the subsea and topside processes to ensure that it is hot enough to remain in a fluid phase. However, it is also important that the crude is not too hot for the storage tanks.

Both heating and cooling, as necessary, are managed by closed loop systems that will provide efficient and reliable heating / cooling whilst minimising environmental impact.

The heating medium used in the closed loop will recover waste heat from the main power generator gas turbine exhausts via Waste Heat Recovery Units (WHRU).

The cooling medium is cooled by cross exchange with seawater and within this system; approximately 72,000 m^3 of seawater at 28°C will be discharged to sea per day.

5.8.4.3 Gas management system

Produced gas (associated gas from the oil wells and gas purposefully produced from the GPI wells) will be required on the FPSO to provide:

- Fuel for the FPSO power generation and seawater heaters;
- Tank blanketing (section 5.8.4.6); and
- Gas lift for the production wells that require artificial lift (section 5.8.5.6).

The FPSO has a gas handling / compression capacity of 120 mmscfd (e.g. for 50 mmscfd gas lift + 70 mmscfd produced gas for fuel / blanketing).

The daily fuel gas requirement is expected to be approximately 10 mmscfd and the gas requirement for gas lift averages at approximately 40-50 mmscfd, which is recycled. Therefore, there may be an excess of gas produced daily that would require disposal. Where possible, any gas not required for fuel or lift gas will be re-injected into the GPI well(s). The maximum amount of gas to be reinjected into the gas well is assumed to be 45 mmscfd.

5.8.4.4 Flaring facilities

The design shall be based, as far as possible, on a ‘zero flaring’ philosophy during steady-state production with flaring only permitted for significant process upsets, process shutdowns, emergency shutdown or unavoidable maintenance.

On the High Pressure (HP) flare system there are no continuous sources such that no recovery system is required. However, as a safety measure, the HP flare will support a pilot flame to ensure its readiness for sudden reliefs from the process. The pilot flame is expected to burn 0.5 - 1 mmscfd.

In line with best practice, the Low Pressure flare will have continuous sources which will not be allowed to be flared and these streams will therefore be recovered back into the process as part of the basis of design (section 5.13).

5.8.4.5 Venting and fugitive emissions

The FPSO basis of design is such that the venting of gases will not be carried out during routine operations and mitigation measures e.g. low loss fittings, use of a Vapour Recovery Package (VRP) will be built-in to the basis of design (section 5.13) to minimise fugitive emissions of Volatile Organic Compounds (VOCs).

5.8.4.6 Tank blanketing and venting

Tank blanketing is used in the FPSO oil cargo storage tanks as well as the slops and off-spec tanks to maintain a non-explosive atmosphere in the space above the liquids inside the tanks. The Hydrocarbon (HC) gas blanketing system will use the produced and treated fuel gas on the FPSO so that oxygen is eliminated from the tanks forming an atmosphere saturated with hydrocarbon to a level above the Upper Explosive Limit (UEL), at which combustion cannot be supported (i.e. an atmosphere that cannot burn).

Advantages to the HC blanketing system are:

- Use of a gas that is readily available in large volumes, which can continuously protect a number of large tanks; and
- Evaporation in the tanks is minimal and the displaced and vented gas from the tanks can be easily recovered resulting in a safe closed system enabling substantial reduction in emissions to the atmosphere.

As the FPSO tanks are filled, HC gas from the cargo tanks and slop tanks will be routed to the VRP located on the FPSO such that the gas blanket will not be vented to the atmosphere.

In the event that the gas process or the VRP is unavailable such that fuel gas cannot be used for the blanket or that the gas blanket must be vented (respectively), inert gas from the inert gas generator exhaust will be used as blanket gas. The inert gas will comprise mainly nitrogen and carbon dioxide with restricted oxygen content below permissible levels.

5.8.4.7 FPSO slops tanks

An off-spec oil and water tank will be provided, each with a capacity of approximately 12,850 m^3. Two slop tanks will also be provided on the FPSO with a minimum combined capacity of approximately 4,400 m^3. The slops tanks and associated systems will be designed to accommodate the:

- Fluids from the open drains system (section 5.8.3.6);
- Contaminated water resulting from the flushing and cleaning of the cargo loading pipework, discharge pipework and offloading hose;
- Temporary storage of off-spec crude oil and produced water prior to their recycling back through the process for further treatment; and
- Fluids displaced to allow entry into vessels for maintenance purposes.

Prior to being discharged to sea, the slops water will be cleaned to less than 15 ppm OiW content in accordance with MARPOL Annex I regulations. To achieve this, the slops tanks will be arranged in a cascade to enable gravity and time based (two stage) oil / water separation.

Further, inline OiW monitors will be provided in order to isolate the overboard discharge and re-route any off-spec slops water back to the slops tanks for reprocessing if OiW content exceeds the allowable limits.

5.8.5 FPSO oil and gas process facilities

The following sections describe the FPSO facilities that process the produced oil, gas and water.

5.8.5.1 Total fluid separation

The fluid produced from the oil production wells will contain oil, water, gas and possibly solids (predominately sand) and is therefore a multiphase fluid. This multiphase fluid is referred to as 'total fluids'. The ratio of each of the components will change over time as the reservoir becomes depleted and as injection water passes through the reservoir, 'breaks through' at the production wells and starts to be produced. Once the multiphase fluid from the wells is produced onto the FPSO, it is necessary for it to be separated into the different components.

The purpose of the separation process is to:

- Remove as much of the water and gas from the oil as possible prior to oil offload and export;
- Remove water from the gas so the gas can be compressed and made ready for use as fuel gas (section 5.8.4.3), or gas lift (section 5.8.5.6.2), or in the event of excess gas reinjection into the reservoir via the GPI well(s); and
- Clean the produced water prior to re-injection into the reservoir for Improved Oil Recovery (IOR) (section 5.8.5.6) or prior to discharge to sea in the event that the Produced Water Reinjection (PWRI) system is unavailable.

The FPSO for the Sea Lion Development will be equipped with two High Pressure (HP) separators, which are used for the initial separation of the total fluids. During normal operations, the reservoir fluids, which have been co-mingled at the subsea manifolds, will arrive at the FPSO and will be routed to the HP separators. The internal structure of these separators promotes the separation of the phases owing to the different specific gravities of oil, gas and water.

Following initial separation, each component must then be further treated and stabilised to enable its export as the target product, its use elsewhere on the FPSO, or its discharge to the environment in line with regulatory limits. To achieve this, the different components are distributed accordingly into the 'oil process', the 'gas process' and the 'produced water process' (Figure 5.10).

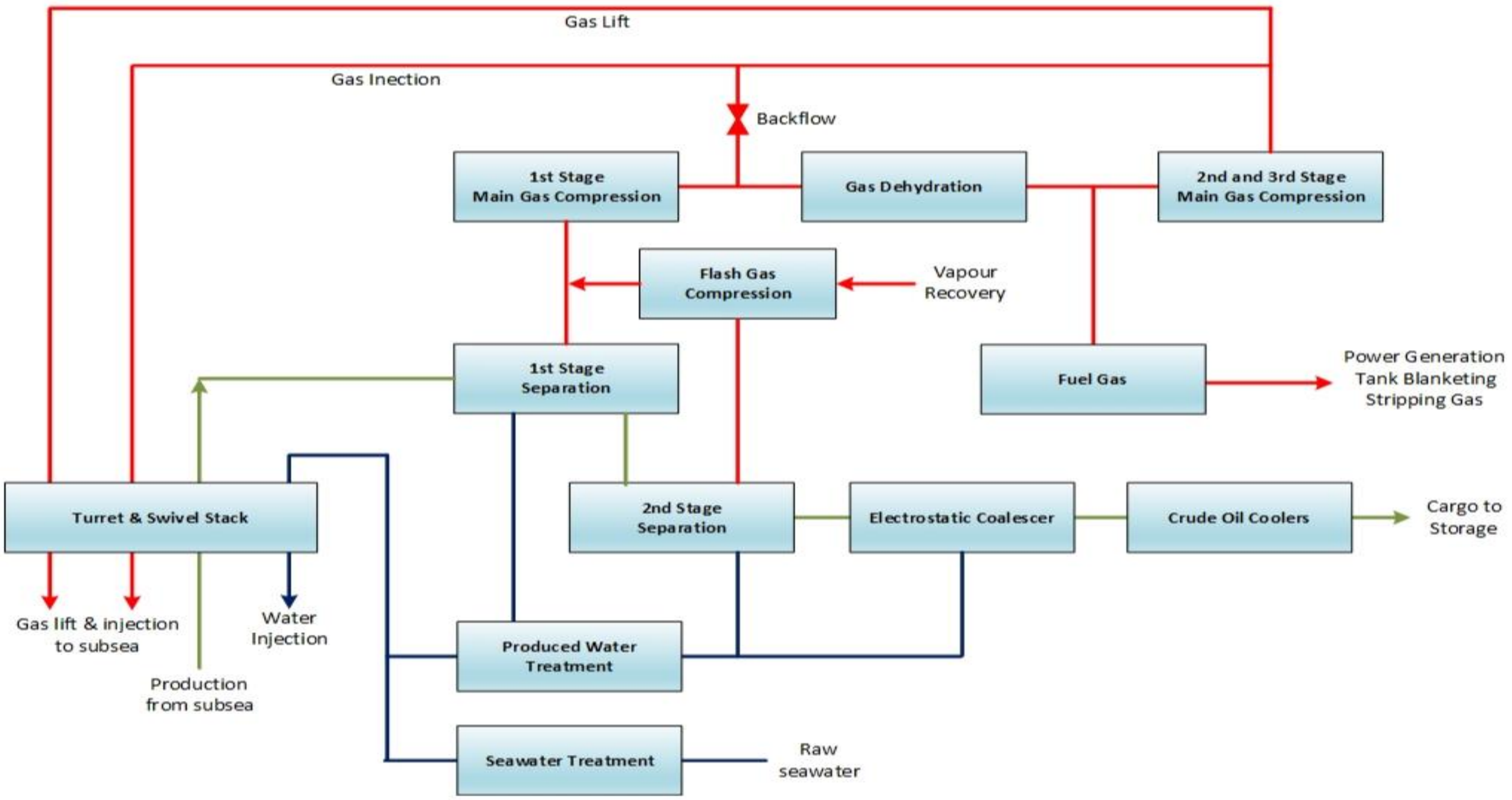


Figure 5.10: Block flow diagram of the FPSO separation and stabilisation processing facilities (Green = oil, Red = gas, Blue = water)

5.8.5.2 Oil Process

The oil process facilities will receive production fluids at between 60 - 80°C. Following initial separation, oil from the HP separators will be routed to the Low Pressure (LP) separator and electrostatic coalescer where it is stabilised to meet the export specification. From here, the oil will be treated to achieve the export specifications for salt and water content.

As shown in Figure 5.10, all oil process vessels, piping and instruments with the potential for wax deposition will be trace heated and insulated to prevent the crude cooling and solidifying in the lines. The stabilised oil will then be cooled to the appropriate storage temperature to avoid damage to the cargo tanks, while maintaining sufficient heat to prevent the crude oil solidifying, thus maintaining flow assurance to allow offload.

The oil export and storage specification is presented below in Table 5.16.

Table 5.16: Stabilised oil specification

Parameter	Specification
Pressure	Atmospheric
CO_2	0.1 mol%
H_2S	3 ppm weight (No H_2S removal facilities shall be provided. H_2S management shall be via injection of calcium nitrate)
Reid Vapour Pressure (RVP)	8-10 psia max
Basic Sediment & Water (BS&W)	0.3%
Salt	40 pounds per thousand barrels
Methanol	≤ 25 ppm (export specification)
Crude Oil Temperature	55°C min (FPSO storage / tanker) 60°C max (offload)
Export Pressure	Minimum 2barg delivered to offtake tanker

5.8.5.3 Gas process

Gas in the process will originate from the GPI well(s) and from the oil production wells.

Following initial separation, the gas process includes:

- Compression in three stages, depending upon the fate of the gas (fuel gas, gas lift or reinjection); and
- Dehydration.

5.8.5.3.1 Gas compression

The aim of the gas compression system is to compress the gas extracted from oil in the separation system, maximising the gas available for re-injection, gas lift and fuel gas. Gas compression occurs in three different stages within the gas processing system. Gas used as fuel gas will be compressed in the 1st stage of the Main Gas Compression Package and dehydrated prior to use. Following the dehydration process, gas required for gas lift and reinjection will be compressed in the 2nd and 3rd stages of the Main Gas Compression package prior to use.

5.8.5.3.2 Gas Dehydration

After first stage of compression the gas stream will be dehydrated. The gas stream is dehydrated to a water dew point of -2°C (therefore below the ambient seabed temperature of 3°C) to minimise the water content and therefore avoid formations of 'hydrate' in the gas injection or gas lift systems, which could cause blockages.

5.8.5.4 Produced water process

The 'produced water' refers to all the water that is produced with the oil from the oil wells and comprises a mixture of:

- Formation water from the reservoir;
- Seawater which has been injected (or produced water that has been reinjected) into the reservoir and has flowed through the reservoir and 'broken through' at the production wells such that it is produced with the total fluids back to the FPSO; and
- Solids / sand which is suspended within the water (not expected).

Following initial separation in the HP separator, it is necessary to further clean, treat and de-sand (if necessary) the water in the 'produced water process' so that it may be used for Produced Water Re-Injection (PWRI) for IOR (section 5.8.5.6). The produced water treatment facilities comprise of de-oiling hydro-cyclones, a compact gas flotation unit, degasser and a cartridge filter downstream of the main produced water treatment vessels. To increase the efficiency of the produced water treatment equipment, deoiler injection points have been included.

In order to be suitable for reinjection back into the reservoir, the OiW concentration needs to be <10 mg/l at the point prior to the produced water / sea water mixing point.

Oil removed from the water during the produced water treatment process will be routed back to the 'oil process' and gas will be routed to the 'gas process'. Sand removed from the process will be treated as described in section 5.8.5.5 below.

5.8.5.4.1 Discharge to Sea

In the event that the PWRI units are unavailable, or that the OiW concentration cannot be reduced to <10 mg/l, the treated produced water will be diverted to the produced water off-spec storage tank which is heated to assist in gravity separation of oil and water. In the event that the primary produced water off-spec tank is unavailable, there is an alternate produced water off-spec tank. The tank volumes are 12,850m^3 which is approximately 70% of the expected maximum daily produced water rate of 110,000 bbl per day. During normal production, both off-spec tanks should remain empty.

The Sea Lion reservoir has no active aquifer and the development is therefore critically dependent on water injection for pressure maintenance to support production and deliver reserves. Hot Sea Water will initially be injected on Sea Lion to assure crude mobility and a such the water injection wells will not thermally fracture, as is the case in other oil fields, but will instead rely on hydraulic fracturing from surface pumps. Produced Water Re-Injection will follow later once injection water breakthrough occurs at production wells.

Over time, and despite adopting best available technologies, physical and thermal effects and chemical reactions in the receiving reservoir can cause significant losses in produced water injectivity. In the case therefore that produced water reinjection causes a significant reduction in injectivity, it will be discharged overboard, whilst maintaining compliance with OSPAR and the UK OPPC regulations (i.e. sample concentrations that would amount to a monthly average of <30 mg/l and no single sample exceeding 100 mg/l).

In the event that produced water needs to be discharged, Premier will sample the produced water twice daily to determine the OiW concentration to ensure compliance. Further, the FPSO will have constant inline OiW measuring devices. If the OiW content is higher than the set limit, the stream will be re-routed back to the tanks for further separation. In practice, it is anticipated that any produced water discharged to sea will have an OiW concentration in the region of 10 - 15 mg/l.

5.8.5.5 Management of Solids

The production of sand in the multiphase fluid is not anticipated. However, in the event that sand is present, it will most likely fall out of suspension within the HP separator and within the produced water process.

Any sand retrieved from the separators and water production process vessels will be tested for Naturally Occurring Radioactive Material (NORM) and to measure its oil content and will be:

- Re-injected, if possible; or
- Transported to shore for clean-up and disposal.

The management of hazardous waste is described in section 10.10.

5.8.5.6 Improved Oil Recovery (IOR)

IOR will be required for the Sea Lion Field as the reservoir pressure will decline during the field-life. IOR will be achieved using water injection / reinjection and gas lift, as described below.

5.8.5.6.1 Water injection / reinjection facilities

Water injection will achieve ‘voidage replacement’ in order to maintain reservoir pressure whereby oil is extracted and replaced with water. For normal voidage replacement, the WI system will have a total maximum injection rate of 130,000 bbl/d. Water will be heated and injected into the reservoir by pumps on the FPSO.

Sea Lion crude oil has a significantly higher viscosity than that of water which means that the water injected into the reservoir will not only mobilise the oil but will also flow through the reservoir and ‘breakthrough’ at the production wells. This water will be produced back onto the FPSO along with the oil.

During the first few years of production, when mostly ‘dry’ oil is being produced with little water, the WI system will use treated and heated seawater up to a maximum injection rate of 110,000 bbl/d; limited by the capacity to heat seawater to the necessary temperature for injection into the reservoir. After the injected water starts to be produced with the oil, (following ‘breakthrough’), a combination of seawater and treated produced water will be re-injected, up to a maximum injection rate of 130,000 bbl/d. The mixture of seawater and produced water will meet the required reservoir specifications (Table 5.17) prior to re-injection in to the reservoir.

Table 5.17: Injection water treatment specifications

Parameter	Specification
Temperature	63 - 80 °C for all WI wells
Filtration	98% removal of particles ≥ 10 microns Total Suspended Solids (TSS) < 2.0 mg/l
De-aeration	<10 ppb O_2
Sterilisation	Sodium hypochlorite in seawater = 1 ppm (achieved by continuous dosing) Bacteria and micro-organisms < 500 Bac/l
Produced Water	Free oil in water < 10 mg/l

5.8.5.6.2 Gas Lift Facility

Gas lift will be used to improve oil production rates of individual wells particularly when the water-cut increases.

Approximately 50 mmscfd of produced and treated gas from the associated oil production and / or gas production well will be injected into the oil production wells to reduce the density of the produced fluids so they can flow more easily to the surface. The gas within the gas lift system will be circulated through the production system such that it will not be released to atmosphere.

5.8.5.7 Field life well testing

Well testing of the oil production wells is periodically carried out to:

- Broaden the knowledge and understanding of hydrocarbon properties and characteristics of the reservoir; and
- To obtain data on the individual well flow rates, water cut and Gas to Oil Ratio (GOR).

The wells will ultimately be tested by a substitution process between the two separators such that no flaring will routinely occur during well testing and no discharges will result.

In order to provide data for use in optimising the performance of the field each oil production well should be tested at least once per fortnight. Care will be taken to test the wells as close as possible to normal production conditions.

Further detail on well tests will be available nearer the time and presented within the subsequent applications (section 3.1.6.4).

5.8.6 FPSO crude storage tanks

The FPSO crude oil storage capacity will be approximately 157,000 m^3 (990,000 bbls) arranged in five pairs of cargo tanks of similar size (Figure 5.1:). These tanks are situated within the inner hull, being surrounded by either water ballast tanks or void spaces.

Note: the forward most pair of cargo tanks in the FPSO hull, which surround the turret, will be configured as void spaces or used for bulk chemicals.

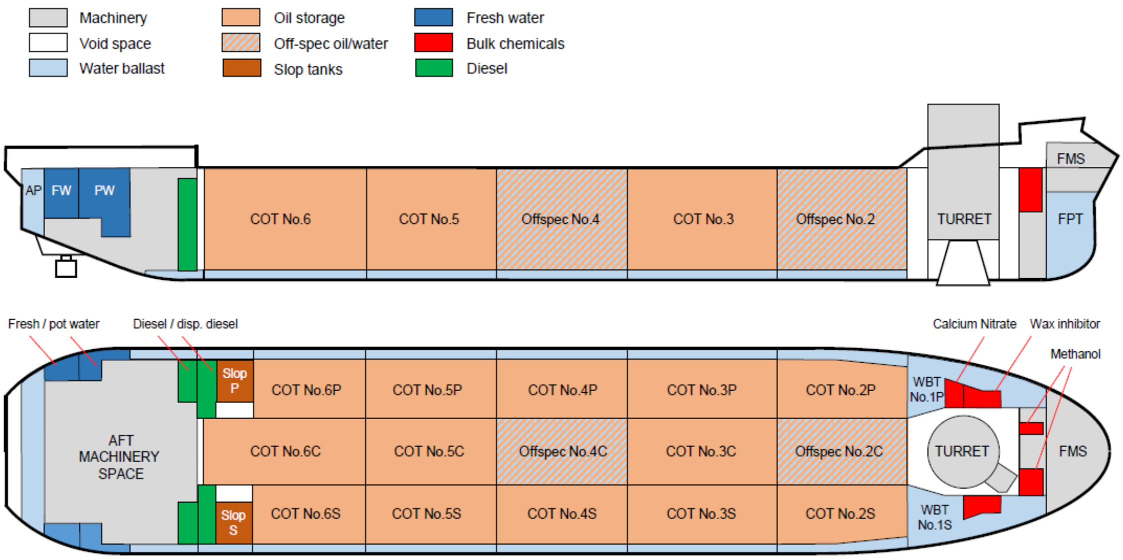


Figure 5.11: FPSO storage tanks layout

5.9 Steady state production

5.9.1 Chemical use

Chemicals used during the operations include:

- Operational Chemicals; and
- Non-operational Chemicals e.g. laboratory chemicals.

5.9.1.1 Operational chemicals

Operational Chemicals include:

- Production chemicals e.g. for enhancing and maintaining flow assurance, maximising separation of the multiphase fluids, preventing corrosion, treating water for injection, treating gas for use as fuel, use as the actuating fluid in hydraulic control systems, use in closed systems which require periodic refill; and
- Utility chemicals e.g. detergents and turbine wash chemicals.

Under normal operations, chemicals dosed into the produced fluids to aid flow assurance and separation will not be discharged to sea and will either be exported with the oil or re-injected downhole with the produced water.

Details on the specific operational chemicals which will be used during the Phase 1 Development are not yet known. Nonetheless, all operational chemicals used during the Phase 1 Development will be selected to minimise environmental impacts as much as possible. Moreover, all chemical use will be included in PON applications submitted to FIG for approval prior to use (section 3.1.6.4).

For the purposes of this EIS, analogue chemicals have been used to enable a representative impact assessment, as detailed in the relevant chapters below. The functional groups of chemicals which may be required during the steady phase production of Sea Lion crude are listed in Table 5.18.

Table 5.18: Production and utility chemicals which may be required during steady phase production

Operational facility	Functional chemical groups anticipated for use [a]
Wells	Wax treatment chemicals / Pour point depressants and methanol
Gas Injection System	Continuous methanol injection will be required during gas production from the gas production / injection well.
SPS / SURF	Wax treatment chemical / Pour point depressants, methanol, demulsifier, water based hydraulic control fluids
Topside production process	Demulsifier, scale inhibitor, wax treatment chemical / pour point depressants, oil anti-foam, de-oiler, solids flocculant, and methanol
Topside WI process	Scale inhibitor, sodium hypochlorite, biocides, water anti-foam, oxygen scavenger, solids flocculant and calcium nitrate
Topside process utilities	Heating water corrosion inhibitor, heating water, biocide, Triethylene glycol (TEG), TEG pH adjustor, diesel biocide, cooling medium, cooling medium corrosion inhibitor and cooling medium biocide.
FPSO utilities	Detergents and turbine washes

[a] Note that the actual chemicals intended for use are not yet known. Where necessary, analogue chemicals have been used during the current impact assessment as detailed in the relevant chapters below.

5.9.1.2 Non-operational chemicals

Non-operational chemicals include:

- Domestic chemicals e.g. potable water additives, detergents, cleaning products;
- Fabrication chemicals e.g. paints and other coatings (including those supplied in aerosol cans);
- Laboratory chemicals e.g. for checking OiW concentration; and
- Other chemicals e.g. fuels, lubricants, fire-fighting foams and other chemicals in firewater systems, chemicals in 'closed systems' where periodic refill is *not* needed and hydraulic fluids used in cranes and other machinery.

Non-operational chemicals are not covered under the OCNS or the UK offshore Chemical Regulations (2002). They are however covered and assessed under the UK Control of Substances Hazardous to Health (COSHH) Regulations 2002.

The majority of non-operational chemicals will not be discharged to sea. Where they will, or may be, discharged to sea e.g. in bilge / drainage water contaminated with emulsified oil and grease, diesel, hydraulic oil, lube oil, marine fuel oil and grey water etc., these discharges will comply with the requirements of MARPOL 73/78.

5.9.2 Routine monitoring and maintenance

Routine monitoring and maintenance will be carried out on the FPSO and SPS / SURF to ensure the integrity and efficiency of all equipment. Maintenance will be carried out using a Centralised

Maintenance Management System (CMMS) to enable the prioritisation and regular inspection / maintenance of safety and environmental critical equipment.

5.9.3 Well workovers

Wells must be monitored and maintained over the course of the field-life and, in some cases, it can be necessary to mechanically alter the well in response to changing conditions. The latter is referred to as a well workover. The intention however, is to have a minimum intervention policy and as such, there are no workovers planned.

Should a well workover become necessary, it will only be performed if it is economically viable with regard to the mobilisation / demobilisation of a MODU. In the event that a well workover is considered economically viable, discussion will be held with FIG on the most appropriate way to ensure that an EIA is carried out for the operation.

5.9.4 Process shutdown and start-up

Shutdown of the process and utility facilities may be required in order to carry out maintenance activities (planned) or in the event of abnormal operation or an emergency (unplanned). However, 91 % process uptime is anticipated.

With a minimum ambient sea temperature of 3^{o}C, when planned or unplanned shutdowns occur, it is possible that the produced fluids within the subsea and topside infrastructure will begin to cool. Given the characteristics of the Sea Lion crude, cooling could lead to the appearance of wax (at < 60^{o}C), hydrate or gel (at < 25^{o}C) which in turn could lead to blockages within subsea wells, jumpers, manifolds, risers / flowlines and topsides facilities.

Shutdown, preservation and start-up procedures will be integral to prevent gelling and wax deposition. During shutdowns, the wax and gel management strategies will ensure that the system will be left in a preserved condition with a fall back strategy in the event that a restart is required with hydrates or gel plugs in the system.

Flow assurance facilities are in place within the development design to actively prevent or mitigate against blockages during times of 'no flow' and to enable start-up even if the facilities have cooled. The use of production chemicals may also be used (section 5.9.1.1).

The flaring facilities are described in section 5.8.4.4. While flaring is not anticipated during normal routine operations, it will be required during:

- Significant shutdowns;
- Plant malfunctions that require a depressurisation (blowdown) of part or all of the gas inventory;
- Process emergency shutdowns or for unavoidable maintenance reasons; and
- Potentially during depressurisation of flowlines and flexible risers when required.

5.10 Oil export process and facilities

The project oil export route involves the Direct Offtake of crude oil from the FPSO to a Conventional Trading Tanker (CTT) at the Sea Lion location and from there the crude will be exported to market. To ensure that the offloading operating conditions are maintained within strict limits, Direct Offtake will require an Offshore Support Vessel (OSV, i.e. a hold back tug) to attend the CTT offshore, in addition to the presence of the ERRV, which is always on standby.

The capacity of the purchaser's CTT oil tanker (c. 165,000 m3 or 1,000,000 barrels) requires that two consecutive off-take operations (offloads) from the FPSO will be required to complete the CTT parcel. As the rate of oil production reduces over time, it is expected that the oil export operation (a one million barrel parcel) will occur once every 13 days at peak production in Years 1 to 5, reducing to once every 46 days after about 10 years of operation.

To ensure safe and efficient offshore loading operations, each CTT shall undergo an in-depth Premier assurance process, prior to being approved for use on Sea Lion. The Premier assurance process in respect of the Direct Offtake operation is described below. Following agreement on the purchase of the Sea Lion crude 'parcel', the purchaser will nominate a CTT to Premier. At this time, Premier will carry out a series of checks and audits to vet the nominated CTT, including verification of:

- Compliance with the requirements of MARPOL 73/78 Annex I on discharges of oil to sea:
  - Oil record book.
- Compliance with the requirements of MARPOL 73/78 Annex IV on discharges of sewage to sea:
  - International Sewage Pollution Prevention Certificate (ISPPC).
- Compliance with the requirements of MARPOL 73/78 Annex V on garbage management at sea;
- Compliance with the requirements of MARPOL 73/83 Annex VI on air pollution by shipping:
  - Air quality and pollution:
    - International Air Pollution Prevention (IAPP) Certificate.
  - NOx emissions reduction:
    - Engine International Air Pollution Prevention (EIAPP) Certificate.
  - SOx emissions and particulate matter reduction:
    - Marine Fuel Sulphur Record Book.
  - VOC emissions:
    - VOC Management Plan.
  - GHG emissions reduction and energy efficiency:
    - Ship Energy Efficiency Management Plan (SEEMP) as required since 2013; and

      - The CTT's position within the Energy Efficiency Design Index (EEDI) (new vessels only).

- The validity of the Shipboard Oil Pollution Emergency Plan (SOPEP) in line with the International Maritime Organisation (IMO) regulations;
  - Oil spill risks and mitigations, including those relating to whether or not the fuel tanks are double-skinned, will be taken into account in the decision-making process and in determining whether specific operational controls should be put in place to manage risks.
- Compliance with the IMO International Convention for the Control and Management of Ships' Ballast Water and Sediments (ratified in 2017):
  - Verification of compliance with IMO Convention standards D1 and D2 (noting that D2 treatment systems need not be installed until the first vessel survey / docking following enforcement);
  - Inspection of the CTT Ballast Water Management (BWM) Plan and Ballast Water Record Book; and
  - Inspection of the BWM System International certificate (if applicable).
- Inspection of the CTT Biofouling Management Plan and Biofouling Record Book as required by IMO.

Additional requirements that may be necessary for vessel insurance (to be advised), are as follows:

- Oil / Bulk Ore (OBO) vessels will not be accepted;
- All CTTs must be double hull construction, including the vessel's fuel oil tanks;
- Maximum Length Over All (LOA) of the CTT will be specified (to be advised);
- The CTT must be equipped with eight wire mooring lines on fixed drums forward and aft, complete with rope tails, capable of mooring four head, two breast and two springs both forward and aft;
- The CTT will have aft towing bitts with a minimum 80 tonne SWL (Safe Working Load). These mooring bitts will be used for securing the tug towing wires;
- The CTT will have an amidships crane with minimum SWL of 15 T with a 4.5 m outreach;
- CTT manifolds will be fully compliant with OCIMF recommendations;
- CTT manifolds and cargo systems will be capable of carrying out vapour balancing with the FPSO;
- The CTT's main engine will be capable of running astern continuously for an extended period;
- The CTT must be fitted with helicopter landing / winching area;
- The CTT must be capable of slop reception in an emergency pollution incident;
- The CTT must be capable of purging H_2S in cargo tanks;
- Ballast water exchange will be carried out in open ocean when *en route* to the Falkland Islands, in full compliance with MARPOL. Preference will be given to vessels with a ballast water treatment system following the implementation of the IMO ballast water treatment

requirements in 2017. However, some exceptions may be made until the legislation is mandatory for all vessels in 2024; and

The following sequence will then take place:

- The purchaser's CTT will arrive in Falkland Islands waters and will tender its Notice of Readiness;
- When the offload operation is imminent, the Berthing crew will be transferred to the CTT by helicopter,;
- The CTT will proceed to rendezvous with the Offshore Support Vessel (OSV), i.e. a tug with sufficient bollard pull to safely support the manoeuvring of the CTT and an over-the-bow winch so it can stay bow on to the CTT;
- The OSV will connect to the stern of the CTT and remain connected while applying light power to control:

  Heading through approach;

  Connection to the FPSO; and

  Pumping, disconnect and departure.
- There will also be the MRSV (acting as ERRV) on standby duty in the field and equipped with oil spill response equipment;
- The CTT and OSV will approach the stern of the FPSO, and will manoeuvre into position, followed by connection of the hawser. A tight hawser connection will be made;
- Once the hawser is connected, the transfer hose will be unreeled from the FPSO and passed to the tanker using its winches. The hose will connect to the manifolds amidships, on one side of the CTT. No additional vessel is required for this process;
- Once connection has been completed, the oil transfer will commence slowly until proven, and then increased to full rate;
- Once completed, the CTT will disconnect and move away from the FPSO. Once the CTT and OSV are at a safe distance, the OSV will detach from the CTT and the Berthing crew will disembark via helicopter once clear;
- The CTT will wait for a second parcel, moving under low power down-current of the FPSO. The OSV will be released for other duties at this time;
- When the FPSO has enough cargo to complete the required CTT parcel of around 1,000,000 bbls, the process is repeated;
- The Berthing crew will disembark via helicopter from the CTT at a safe distance from the FPSO and at least 12 nm from the Falklands; and
- The CTT will then proceed to deliver the crude to market.

5.11 Logistics and infrastructure

The logistics and infrastructure support required by the Sea Lion Phase 1 project includes:

- **Port facilities and onshore supply base**: including the Temporary Dock Facility (TDF) onshore laydown yards, storage bases and offices;
- **Use of vessels**: for the movement of materials and equipment, installation and support;

- **Personnel transportation facilities**: including fixed-wing flights, helicopters and land transportation; and
- **Use of finite resources**: e.g. accommodation, freshwater, electricity, roads and waste management / disposal facilities.

5.11.1 Port facilities and onshore supply base

Although the plan for the Phase 1 Development is to make use of the existing port and onshore yards where possible, it is anticipated that there may be a need to develop further facilities. Discussion on the EIA requirements for the construction of any new facilities will be held with FIG prior to the submission of the relevant planning applications. However, the use of the proposed facilities required to support the Phase 1 Development is covered in this EIS and therefore, it is necessary to describe what may be required.

5.11.1.1 Port facilities

The existing port facilities used for a variety of operations including loading, offloading, vessel crew change, refuelling, re-supply of chemicals and consumables include:

- The TDF;
- Falklands Interim Port And Storage System (FIPASS), owned by FIG; and
- Mare Harbour, operated by the Ministry of Defence (MoD).

Logistics will be centred on the TDF and adjacent area onshore for the onshore supply base.

5.11.1.1.1 The Temporary Dock Facility (TDF)

The TDF in east Stanley is a floating barge facility with pontoon causeway installed by Premier and Noble Energy Falklands Limited (NEFL) in 2014-15 for the combined exploration drilling campaign (Figure 5.12). The TDF is the principal port facility that will be used to support the Sea Lion Phase 1 Development.

All vessels, with the exception of the tankers and the Large Transport Vessels (LTVs) (section 5.11.2), are expected to use the TDF during Sea Lion Phase 1 Development.

It may be necessary in future to conduct an operational upgrade to the TDF e.g. to improve the causeway, create a berthing pocket and / or install fuel and water lines. Any additional works may require a full EIA to support the planning application, and this would be dependent upon the scale of the upgrade and any potential environmental impacts arising. In the event that any additional upgrade is required, discussions will be held with FIG to determine whether an EIA is necessary.

Figure 5.12: Photograph of the existing Temporary Dock Facility with an MRSV alongside

5.11.1.1.2 FIPASS

FIPASS is located 500 m to the west of the TDF. Due to the weakness of the deck plates, FIPASS is not able to support the loading or unloading of heavy items of cargo or equipment, however, it may be used to load fuel and water onto vessels, and for importing initial construction materials, in the event that this cannot be done at the TDF.

5.11.1.1.3 Mare Harbour

Outside of Stanley Harbour, the only alternative port facility which has the capability of handling and unloading large items of equipment is the military port at Mare Harbour. This is because it has a deep water draught of nine metres, a concrete quayside and a Roll On-Roll Off (RO-RO) ramp.

The use of Mare Harbour does not form part of the base case but may be considered during the life of the project in consultation with MoD and FIG. If Mare Harbour is to be used in future, this may be subject to planning permission and an associated EIA. However, it is expected that the environmental impacts and risks from Sea Lion activity at the Mare Harbour location would be similar to those presented here and that the impacts to the local population in Stanley would be much reduced.

5.11.1.2 Onshore supply bases

The onshore supply base used during the 2015 exploration campaign is located in the Gordon Lines area to the east of Stanley and extends to approximately 51,000 m^2, see Figure 5.13, and includes:

- A drilling yard to accommodate pipe laydown areas and bulk warehousing;
- Spare parts and maintenance areas;
- Storage of Oil Spill Response (OSR) equipment (Tier 2);
- Storage of drilling chemicals;

- Facility vehicles such as forklift trucks, cranes, minibuses, 4x4 and heavy equipment transporters;
- Power generation in the form of generators with dedicated fuel storage to enable self-sufficiency; and
- A waste storage and management area.

Detail on the additional supply base facilities required for the Phase 1 Development is provided in Table 5.19.

Figure 5.13: Schematic of the supply base developed to support exploration drilling campaigns

A schematic of the liquid mud plant is provided in Figure 5.14.

Figure 5.14: Schematic of the liquid mud plant to support exploration drilling campaigns

Table 5.19: Potential supply base requirements for the Phase 1 Development of the Sea Lion Field

Facility	Exploration yard space (m^2)	Estimated area Required for Phase 1 (m^2)	Duration of requirement
Drilling Yard: • Storage base; • Pipe laydown yards (covered & open); • Contractors' yard; • Waste storage and management yard; • Oil spill response equipment storage; • Onshore storage and testing area for subsea X-mas trees; • Waste storage and management area; and • Radioactive sources which will need to be sited appropriately.	51,000	120,000	5 years
Quayside oil based mud and bulks facility: • Oil based mud plant; • Bulks plant; • Water header tank; and • TDF car parking.	-	7,500	5 years
Operations support base: • Re-supply base; • Production chemical laydown yard: ○ A facility to store 24,000 litre production chemical ISO (International Standards Organisation) tanks	-	30,000	23 years

Facility	Exploration yard space (m^2)	Estimated area Required for Phase 1 (m^2)	Duration of requirement
from the time when they arrive on the islands to the time they are transported offshore to the FPSO; and ○ A separate isolated laydown area to store methanol which will require its own bespoke fire detection and protection system. • Materials, equipment, maintenance & spare parts storage base; • Oil spill response equipment storage; • NORM contaminated materials; • Diesel generators; • Explosives which require a bespoke and secure storage facility; and • Waste incinerator (section 5.11.1.2.2)(if required)			
Total area required	**51,000**	**157,500**	-

5.11.1.2.1 Diesel generators

The base case assumption is that electricity at the onshore supply base will be provided by Stanley power station. However, in order to ensure reliable operations in the event that the municipal power supply is not available, Premier intends to install up to three diesel generators. The generators will only be used in the event of interruptions to the Stanley power supply at critical times such that it is not possible to estimate running hours. However, if deployed, the use of fuel for the supply base generators would be offset against the reduced fuel use at the power station such that no additional emissions would result.

At the time of writing, the generator models have not yet been selected but these would be provided through the mud plant service company or through the supply base owner, and would be selected in line with the contract management process (section 3.2.16) which would include a pre-selection review of environmental performance.

5.11.1.2.2 Waste incinerator

The Falkland Islands Government is building a new waste management facility to service the needs of the community and industry. The proposed facility has the capacity to take the majority of Sea Lion project waste and Premier plans to enter into an agreement with FIG to secure this as the primary route for project wastes.

The project had previously planned to install a portable incinerator at the onshore supply base as a means of:

- Reducing the volume of waste that requires disposal, thus mitigating against landfill impacts; and
- Reducing the number of shipments of waste back the UK.

This option would now only be reinstated if a change to the FIG's waste infrastructure upgrade plans occurred and resulted in the new facilities not being available to the project. The exact model of portable incinerator that could be used has not yet been decided and will be subject to

Premier's tender process. However, if utilised, the model will comply to all UK standards enabling incineration of all combustible materials, including plastics and rubbers.

The resultant ash from the incineration process will be returned to the UK for disposal if a suitable disposal route cannot be established on the Falklands.

The final location of the incinerator would be developed in discussion with FIG and with stakeholder input through the planning process.

5.11.1.2.3 Oil spill response equipment

The local storage of oil spill response (OSR) equipment is necessary to efficiently mitigate the consequences of spill incidents occurring offshore and at-shore locations. While offshore OSR equipment will be stored on various vessels (section 5.11.2), equipment onshore will be stored at:

- The TDF; and
- The operations support base.

5.11.1.2.3.1 *OSR equipment at the TDF*

The OSR equipment at the TDF will be used to minimise the consequences of any diesel spills at the TDF. The proposed OSR equipment at the TDF is as follows:

- 400 m of absorbent boom in bales;
- 100 m of 750 mm high fence boom;
- Delta head / dragonfly skimmer;
- Portable transfer pump;
- Four Intermediate Bulk Containers (IBC) for use as storage tanks;
- Coils of rope;
- Metal anchor stakes; and
- Personal Protection Equipment (PPE) for up to 20 persons.

The main response would be to use the absorbent materials to contain and collect any spilled diesel. Some provision will be made to 'wring out' and temporarily store the recovered sorbents after use prior to incineration. Conventional oily waste skips will be used for this purpose.

The fence boom will be used to protect the dock area and the entrance to the Canache, or can be deployed in the harbour to 'corral' any spills. In addition, a simple weir / delta head skimmer and pump system will be used to recover / transfer spilled products. The recovered oil will be stored in the IBCs prior to final disposal.

5.11.1.2.3.2 *OSR equipment at the Operational Base*

Additional OSR equipment will be stored within the operation support base (Table 5.19 above) for use in a Tier 2 response to an incident at the LTVs in Berkeley Sound. The proposed equipment is listed in Table 5.20. Further, the base will be equipped with a workshop to undertake a planned maintenance programme and will carry critical spares for both the shore-based and the vessel-based OSR kit to ensure the key equipment will be reliable and effective should it be required. For more information see Chapter 12.

Table 5.20: Indicative oil spill equipment

Category	Quantity	Description
Komara star skimmer & power pack	4	Skid / trailer mounted self-contained toothed disc Heavy Oil skimmer – mechanical skimming unit suited to recovery of viscous oils in coastal waters. Helicopter deployable if required.
Inshore protection boom and ancillaries	1,500 m	Inshore protection and deflection boom in 20 m lengths (complete with ancillaries - ropes moorings, blowers etc.) Can be stored at the Supply base with potential to be deployed onto vessel decks if required.
Oil snare sorbents	2,000 m	Oil sorbent snares on rope. Designed for use in inshore waters, will be used to protect shoreline and prevent oil from entering kelp beds. Very effective with viscous oils. Stored in Supply base.
Oil snare	10	Bales of oil sorbent 'pom-pom' snares. Can be used to 'mop' heavy oil patches of oil in the inshore areas. Very effective with viscous oils. Stored in Supply base.
Waste oil transfer pumps, power packs and hoses	4	Skid mounted positive displacement screw pumps with associated power packs and discharge hoses to transfer oil to Shuttle or other tanker.
Steam generators	2	Skid mounted gas / oil fired portable steam generators to heat oil in recovered oil tankage.
High pressure cleaners / washers	4	Used for cleaning hard surfaces / equipment.
Big bag waste sacks	1,000	Waste storage bags to handle recovered oil.
HD plastic sacks	10,000	Used for waste oil storage.
Decontamination equipment	20	Decontamination sets for responders.

5.11.2 Use of vessels

Vessels are required throughout the Phase 1 Development to serve the following purposes:

- To tow and position the MODU and associated anchors;
- To transport and install the subsea drilling, SPS and SURF infrastructure;
- LTVs to provide floating logistics / lay-down barges in Berkeley Sound for storage of equipment awaiting installation;
- To tow and position the FPSO and support the HUC process;
- To support the oil offloading and export operations Direct Offtake requires:
  - Conventional Trading Tanker (CTT);
  - 1 Offshore Support Vessel (OSV); and
  - 1 MRSV (acting as ERRV).
- For oil spill response / waste oil storage; and
- For operational supply and support.

A detailed summary of all the vessels that may be used is provided in Table 5.21, which aims to:

- List the worst case number of vessels anticipated for use in each stage of the Development;
- Describe the purpose of the vessel; and
- Provide a credible worst case estimate of vessel use with regards to:
  - The origin of the vessel;
  - The time in transit (i.e. to and from the Falkland Islands); and
  - The time in-field (i.e. on location in the Sea Lion Field or in Berkeley Sound).
  - **Note:** where the vessel is frequently in transit between the Sea Lion Field and the Islands themselves, the time is averaged out.

At the time of writing, there is a degree of uncertainty over the number and type of vessels that will be used and whether or not synergies will be possible to minimise vessel use. It is known that synergies will exist between the standard supply vessels / AHTs and the oil spill support vessels as many vessels will be used to store immediate oil spill response equipment. However, it may also be possible for the supply vessels (the MRSVs), to be used for the installation of moorings instead of using dedicated AHTs.

The specifics on the vessel type and use, and any synergies, will not be known until contracts are awarded following project sanction. Therefore, the data in Table 5.21 assumes the maximum number of vessels to provide the worst case for all impact and risk assessments relating to the use of vessels e.g. emissions, underwater noise, disturbance to other users of the sea, introduction of non-native species and collision risks etc. Specific detail on the behaviour of the vessels as it pertains directly to the EIA are provided, as necessary, in the EIA chapters below (Chapters 10, 11 and 12).

Table 5.21: Summary of the worst case vessel activity anticipated during the Phase 1 Development[a]

Vessel		Vessel purpose	Shipping from	Duration			Time in transit (days)	Time in field / on standby (days)
				Number of vessels [b]	Duration of use (days)	Total days in service		
Stage 1: Subsea installation and MODU Drilling operations - pre-first-oil wells, FPSO arrival and installation, and 'first-oil' (approximately 42 months (1,277 days))								
MODU transit, positioning and use	Tugs / Anchor Handlers	Towing and positioning of MODU to the Falkland Islands and between the DC and the GPI well locations [c]	Europe	3	85	255	255	0
	MODU when drilling	Pre-first-oil drilling. Potential installation of conductors [d] and, definite installation of casings, wellheads, BOP and X-mas tree upon well completion for first tranche of wells	n/a	1	913	913	0	913
Transportation installation and floating logistics vessels	Large Transport Vessel (LTV) (No. 1)	Transportation of drilling, SPS / SURF, FPSO mooring infrastructure, equipment and bulks to the Falkland Islands; and Service as floating storage / logistics barges located within Berkeley Sound for up to one year during installation processes. Materials and equipment will be collected from the LTVs and transported offshore to Sea Lion for installation Up to two (maximum) LTVs may be moored in the Sound at any one time, though these may change out over the course of the year	Europe	1	120	120	50	60
	LTVs (No. 2)		Europe	1	270	270	50	200
	LTV (No. 3)			1	160	160	50	80
	LTV (No. 4)		Europe	1	200	200	50	120
	Installation Vessel	Potential installation of conductor pipe [d]	Europe (potentially West Africa)	1	66	66	20	46
	Large Offshore Construction Vessel (OCV)	Installation of SPS and SURF	Norway	1	180	180	39	141
	Fast Transit Carrier	Transportation of FPSO mooring infrastructure to Falkland Islands and storage during installation	Spain	1	120	120	60	60
	Anchor handling tugs (AHTs)	Installation of FPSO mooring system with support from the main installation vessel	West Africa	2	135	270	270	

Vessel		Vessel purpose	Shipping from	Duration			Time in transit (days)	Time in field / on standby (days)
				Number of vessels [b]	Duration of use (days)	Total days in service		
FPSO tow, positioning and HUC	FPSO (towed by 3 tugs) [e]	Transportation to Falkland Islands	TBC	3	50	150	150	0
Support vessels	Coaster Vessels	Delivery of materials to the Falkland Islands	UK	15 (trips)	60	900	900	0
	Multi-Role Support Vessel (MRSV) (No. 1 and 2) [f]	Supply ship: provision of supplies to the MODU during initial production	Between FPSO and Stanley	2	1,277	2,554	2,554	
	MRSV No. 3	Emergency Response and Rescue Vessel (ERRV): Provision of standby emergency support for the MODU	On standby in field	1	1,277	1,277	1,277	
Stage 2: Concurrent drilling and initial production (approximately 29 months (882 days))								
MODU operation and removal	MODU Operational	Post-first-oil drilling. Potential installation of conductors [d] and, definite installation of casings, wellheads, BOP and X-mas tree upon well completion for remaining wells	DC and GPI(s)	1	882	882	0	882
	Tugs / Anchor Handlers	Removal of MODU from the Sea Lion Field	Falkland Islands to TBC	3	85	255	255	0
Oil export vessels (also with oil spill response capability)	CTT [h]	Purchaser's vessel used for receipt of Sea Lion crude and export to market	Unknown	n/a	n/a	n/a	n/a	
	OSV[i]	Used to escort / assist the CTT when connecting to the FPSO and throughout the Direct Offtake operation	Between FPSO and Stanley	1	221	221	221	

Vessel		Vessel purpose	Shipping from	Duration			Time in transit (days)	Time in field / on standby (days)
				Number of vessels [b]	Duration of use (days)	Total days in service		
Support vessels (also with oil spill response capability)	MRSV No. 1 and 2 [j]	Provision of supplies to the MODU and FPSO during SIMOPs.	Between FPSO and Stanley	2	882	1,764	1,764	
	MRSV No. 3	ERRV: provision of standby emergency support for the MODU and FPSO [g]	On standby in field	1	882	882	0	882
	Coaster Vessels	Delivery of materials to the Falkland Islands	UK	10 (trips)	60	600	600	
Stage 3: Steady state production (per annum for 17.5 years)								
Oil export vessels (also with oil spill response capability)	CTT [h, k]	Purchaser's vessel used for receipt of Sea Lion crude and export to market	Unknown	n/a	n/a	n/a	n/a	
	OSV[i]	Used to escort / assist the CTT when connecting to the FPSO and throughout the Direct Offtake operation	Stanley to FPSO	1	45	45	45	
Support vessels (also with oil spill response capability)	MRSV No. 1	Provision of supplies to the FPSO. Will be equipped with oil spill response equipment (booms, skimmer and heated waste oil storage capacity	Between FPSO and Stanley	1	365	365	365	
	MRSV No. 3	ERRV: provision of emergency support for the FPSO	Between FPSO and Stanley	1	365	365	365	
	Coaster vessels	Provision of supplies to the Falkland Islands	TBC	4	60	240	240	

[a] Note that these data are subject to change following contract award and are estimated here for the purposes of enabling the EIA. It is anticipated that the above vessel list describes the worst case to ensure that the EIS remains representative.

[b] This refers to the number of vessels or the number of uses of the same vessel e.g. in Stage 1, a coaster vessel will be used 15 times although it may be a different actual vessel.

[c] To minimise the need for vessels, it is anticipated that the MODU supply vessels may also be used as AHTs to position the MODU. This assumption ensures that the worst case is assessed.

[d] See section 5.5.1.

[e] The base case is that the FPSO will be towed by three tugs.

[f] As yet it is unknown whether or not one or two supply vessels will be in place during Stage 1 to support the MODU during drilling and the FPSO during arrival and HUC. The latter has been assumed here to account for the worst case.

[g] In the event of a spill, the FPSO may be shut-down to enable release of the ERRV which will travel to Berkeley Sound to further support the emergency response effort.

[h] Impacts associated with the CTT outside of the 500m zone are out with the scope of this EIS as the vessel will be owned and operated by the purchaser of the crude.

[i] To support the Direct Offtake option, an Offshore Support Vessel (OSV) will be used to escort / assist the CTT when connecting to the FPSO and throughout the Direct Offtake operation. This will occur every fortnight (during peak production) for three days. The OSV would also be located in Stanley between offtake operations.

[j] As yet it is unknown whether one or two MRSVs will be used as the supply vessel for the MODU / FPSO *and* to the escort vessel for the oil export operation during Stage 2. It is assumed that two will be used to ensure a worst case assessment in this EIS with regard to emissions and impacts to other users of the sea.

[k] Number of Direct Offtakes will reduce over field-life (section 5.10) so an average of 15 Direct Offtakes per year is used to provide a credible worst case.

5.11.3 Use of helicopters - personnel transportation and search and rescue (SAR) operations

5.11.3.1 Transportation of personnel

At the time of writing, there is a degree of uncertainty over the exact frequency with which each personnel transportation method will be used. Details will be confirmed upon contract award. However, while subject to change, the below describes the transportation methods and the worst case frequency of use that are anticipated. A summary of all the personnel transportation requirements and helicopter usage is provided in Table 5.22 below. Note that the data in Table 5.22 are used as the basis for all impact assessments relating to the use of helicopter and fixed-wing flights e.g. emissions, onshore noise and disturbance and resource use etc. These data will be summarised, as appropriate, within each relevant EIA chapter (Chapters 10, 11 and 12).

5.11.3.1.1 Transportation to the Falkland Islands

During Stages 1 and 2 of the Development, which will involve the highest levels of activity, personnel will be transported to the Falkland Islands via dedicated charter flights. All fixed-wing flights will land at Mount Pleasant International Airport (MPN), which is the only airfield in the Falkland Islands that is able to receive aircraft that are large enough to fly across the Atlantic. Charter flights will operate once per fortnight pre-drilling and weekly post drilling, from Europe, with a re-fuelling stop in the mid-Atlantic.

During Stage 3 of the development (steady state production), reliance on charter flights may diminish in favour of weekly commercial flights. However, the varying options will be further informed by the Premier project design process and the FIG / public consultation processes. Details on the fixed-wing transportation requirements during each Stage of the Development are provided in Table 5.22.

5.11.3.1.2 Transportation to the Sea Lion Field

Two helicopters will be used throughout the life of the Development for routine maintenance and crew change / CTT pilot transfers. Based on the 2015 exploration drilling campaign, each crew change to the MODU / FPSO is estimated to require up to five helicopter round trips. Details on estimated helicopter flights are provided in Table 5.22.

5.11.3.1.3 Transportation between Mount Pleasant Complex (MPC) and Stanley Airport

The base case is that helicopters will be based at Stanley Airport for both operations and engineering maintenance. On crew change-out days, it is anticipated that personnel will be transported by road between the MPC and Stanley Airport, where they will be briefed prior to boarding the helicopters to fly offshore. However, there is the potential that arriving crew may be picked up directly from the MPC by helicopter.

5.11.3.1.4 Transportation to the CTT

As described in section 5.10, oil shall be exported via Direct Offtake which will require the use of helicopters to transfer berthing personnel to the CTT. In this scenario, the Berthing crew will be boarded on to the CTT at a safe distance from the FPSO.

Details on estimated helicopter flights are provided in Table 5.22.

5.11.3.1.5 Search and Rescue (SAR) exercises

The Phase 1 Development will require SAR helicopter cover. Confirmation is still required with regard to the provision of SAR helicopter(s) and the number of SAR training flights that will be required. However, for the purposes of this EIS it is estimated that 17 SAR training flights will be carried out per month as occurred during the 2015 exploration campaign (Table 5.22).

Table 5.22: Sea Lion Development transportation of personnel and SARs

Activity		Frequency of flights	Duration of Stage a	Number of trips	Duration per trip (hrs)	Total (hrs)
Stage 1: MODU drilling, installation of the FPSO moorings and subsea drilling and production facilities, FPSO HUC and 'First-oil' (approximately 42 months (1,277 days))						
Charter flights	Delivery of personnel from UK to MPC	Every two weeks then weekly	42 months (182 weeks, or 91 fortnights) [a]	139	36	5,004
Helicopter transfers of personnel to FPSO, MODU and LTVs	MODU Crew change	Ten flights per fortnight		510	3	1,530
	LTV crew change	By boat		n/a	n/a	n/a
SAR	SAR exercises and test flights	20 hours per month		280	3	840
Road transport [b]	MPC to Stanley airport (return)	Weekly		2,529	2	5058
Stage 2: Concurrent drilling, production and export (approximately 29 months (882 days))						
Charter flights	Delivery of personnel from UK to MPC	Weekly	29 months (126 weeks, or 63 fortnights) [a]	125	36	4,500
Helicopter transfers of personnel to FPSO, MODU, and CTT	FPSO and MODU crew change	Ten flights per fortnight		630	3	1,890
LTV	LTV crew change	By boat		n/a	n/a	n/a
	Transfer of Berthing crew to CTT in the Sea Lion Field	Per Direct Offtake (average of 15 per year over field-life)		75	3 (round trip)	225

Activity		Frequency of flights	Duration of Stage a	Number of trips	Duration per trip (hrs)	Total (hrs)
SAR	SAR exercises and test flights	20 hours per month		194	3	582
Road transport [b]	MPC to Stanley airport (return)	Weekly		882	2	1764
Stage 3: Steady state production and export (17.5 years (910 weeks))						
Charter flights	Delivery of personnel from UK to MPC (TBC)	Weekly	17.5 years (910 weeks, or 455 fortnights)	910	36	32,760
Helicopter transfers to FPSO and CTT	FPSO crew changes	Five flights every two weeks		2,275	3	6,825
	Transfer of Berthing crew to CTT in the Sea Lion Field	Per Direct Offtake (average of 15 per year over field-life)		525	3 (round trip)	1,575
SAR	SAR exercises and test flights	20 hours per month		1,400	3	4,200
Road transport [b]	MPC to Stanley airport (return)	Weekly		3,185	2	6,370

[a] Calculated based on an average of 30.4 days per month and seven day weeks to ensure consistent worst case estimates are made throughout the EIS.

[b] Crews will be transported to MPC either by coach or minibus. Minibuses are assumed here to give a worst case environmental impact. Stage 1 & 2 will require approx. 14 minibuses and 6 luggage vans; Stage 3 will require approx. 5 minibuses and 2 luggage vans.

5.11.4 Use of finite resources

Local resources that may be required specifically to support the Phase 1 Development include:

- Existing accommodation;
- Freshwater for potable use, top hole drilling and cementing in the event that the MODU / FPSO desalination plants malfunction;
- Electrical power supply for the onshore supply base;
- Use of existing road network: and
- Waste management facilities (if available).

Detail on the existing resources on the Islands is provided in the Environmental and Social Baseline (Chapter 7). The following estimates of resource use are based on:

- Data extrapolated from the Premier 2015 exploration drilling campaign and the associated End of Well Reports (EOWR) (rationalised where possible given that resource use during steady state production is likely to be less than during drilling and simultaneous operations); and

- The Premier Project Premise for Logistics and Infrastructure (FK-SL-PMO-LO-REP-0009-A01).

The following estimates of resource requirements are considered to be worst case.

5.11.4.1 Accommodation requirements

Stages 1 and 2 of the Phase 1 Development will require the highest total number of onshore and offshore personnel. Stage 3, steady state production, will require the least.

Accommodation will be required in Stanley for personnel who:

- Are employed at the onshore supply base;
- Are employed in Premier's Stanley office;
- Crew and maintain the helicopters;
- Crew and maintain the charter flight;
- Are in transit and resting up overnight prior to flying offshore; and
- Are being temporarily housed onshore in anticipation of being called offshore; and
- Need shelter following emergency down-manning of the drilling rig (MODU) or the FPSO.

The profile of the accommodation requirements over the life of field is as shown below in Table 5.23.

5.11.4.1.1 Accommodation provided by Premier

Recognising the current pressure on housing stock and hotel accommodation (section 7.7.4), Premier is committed to commission provision of accommodation that will me*et al*l transit and contingency needs (Table 5.23) and capacity will be fixed to meet forecast personnel accommodation need within the design. Longer-term onshore personnel accommodation requirements are expected to be met by the private sector.

Specifically, Premier commit to providing:

- Hostel-type accommodation;
- Temporary accommodation unit; and
- In-transit accommodation unit.

5.11.4.1.1.1 *Accommodation type*

Hostel-type accommodation plans are not currently finalised and will be determined through the contracting process with tenderers and assessed against a Statement of Requirements as to whether fit for purpose by Premier. It is hoped that innovative solutions will be driven by the private sector.

The hostel-type accommodation will be:

- Based on single room occupancy with double bed in normal conditions but will be equipped with second fold-down bed to double accommodation capacity;
- Suitable for short durations as in extended down-manning it would be likely that crew would be flown out of the Islands and repatriated on a specially chartered flight;

- Available for the whole field life of the Sea Lion Development; and
- Within easy access of the By-pass / Airport Road, TDF and logistical yard bases.

The hostel-type accommodation will be suitable for in-transit accommodation of crews on crew change days and to accommodate all offshore crews in the event of a down-manning of the offshore crews throughout all stages of the project.

Table 5.23: Estimated maximum accommodation requirement for personnel required during the Sea Lion Phase 1 Development

Personnel type	Accommodation Requirement [a]	Stage 1: Onshore Infrastructure and Logistics		Stage 1: Drilling and Installation (pre-first-oil)		Stage 2: Post First-oil: Drilling, Installation and Production		Stage 3: Steady State Production (per annum)	
		16 months		42 months		29 months		17.5 years	
		Max no. people	% Stanley pop [b]	Max no. people	% Stanley pop [b]	Max no. people	% Stanley pop [b]	Max no. people	% Stanley pop [b]
Construction personnel	A combination of housing, hotel/hostel and imported housing solutions will be utilised for the onshore infrastructure scope	125	5	30	1.2				
Permanent onshore personnel (office, supply base, TDF, aviation crew & support)	The ability to accommodate all the personnel employed onshore will be required nine months prior to the start of drilling activity and will continue for the duration of the Sea Lion Field life	35	1.4	35	1.4	35 [d]	1.4	30 [d]	1.2
Rotational onshore personnel required during high intensity periods	Routine & Surge hostel-type accommodation for personnel employed onshore within support yards and logistics (on a 28 x 28 day rotation), or who are on stand-by. Required from nine months prior to drilling, with a peak until the end of the drilling phase. Minimal numbers required during production.	0	0	95	3.9	130	5.1	35	1.4
Offshore personnel (in transit)	Overnight hostel-type accommodation for personnel at the beginning and end of offshore rotations	0	0	60	2.0	50	2.0	30	1.2
Contingency personnel required in emergency	Short-term contingency accommodation in the event of an emergency down manning of the drilling rig or the FPSO Required for Field-life	0	0	140	-	155	-	125	-

Personnel type	Accommodation Requirement [a]	Stage 1: Onshore Infrastructure and Logistics		Stage 1: Drilling and Installation (pre-first-oil)		Stage 2: Post First-oil: Drilling, Installation and Production		Stage 3: Steady State Production (per annum)	
		16 months		42 months		29 months		17.5 years	
		Max no. people	% Stanley pop [b]	Max no. people	% Stanley pop [b]	Max no. people	% Stanley pop [b]	Max no. people	% Stanley pop [b]
Visiting senior personnel	*Ad hoc* hotel accommodation	Not estimated as yet but anticipated to be similar to levels during the exploration campaign							
Total number requiring accommodation at any time		**160**	**6.5**	**220**	**8.9**	**215**	**8.7**	**95**	**3.9**

[a] Based on Premier's Sea Lion Phase 1 Development 'Accommodation Statement of Requirement'

[b] Stanley population from the last census, 2,460 inhabitants (FIG, 2017).

[c] Figures provided by Premier Logistics and Infrastructure Overview (FK-SL-PMO-LO-REP-0009-A01).

[d] Reducing to 25 within two years after first-oil

5.11.4.2 Freshwater requirements

Freshwater, which is a finite resource in the Falkland Islands, will be required offshore, onshore and at-shore for operational, domestic and general use.

Freshwater requirements during the Phase 1 Development include those associated with:

- Drilling offshore by the MODU (section 5.4);
- Production offshore by the FPSO (section 5.9);
- Use of vessels (section 5.11.2);
- Onshore / At-shore activities including the:
  - TDF (section 5.11.1.1.1);
  - Onshore laydown yards, storage bases and associated offices (section 5.11.1.2); and
  - Personnel accommodation (section 5.11.4.1).

The following sections aim to:

- Quantify the Phase 1 freshwater requirements;
- Describe the Phase I measures for meeting the water demands; and
- To describe activities for which local freshwater resources may be required.

5.11.4.2.1 MODU

The estimation of freshwater use during drilling is based upon the well design and the way drilling is to be managed in Stages 1 and 2 of the Development (as described in section 5.4).

The forecast water demand is based upon the daily water requirements associated with:

- Drilling;
- Cementing;
- Well suspension; and
- Completion.

In Stage 1, prior to first-oil, the wells will be batch drilled (section 5.4.5.2). This will result in peaks and troughs in water demand over time as activities that are more water intensive are undertaken at each well within the batch process, followed by activities that are less water intensive. The average water demand will be 33 m^3 / day, however, over two one-month periods water use will peak at 87 m^3 / day.

In Stage 2, following first-oil, the wells will be drilled and completed in sequence (section 5.4.5.2). Therefore, water use will decline to a more uniform 21 m^3 / day. Following the completion of Stage 2, the MODU will depart and there will be no further requirement for offshore freshwater use for drilling.

The MODU will be equipped with water-makers and is assumed to be self-sufficient for domestic uses. However, it is possible that the water-makers may not meet the need for drilling water such that there be a requirement for local water resources. This said, there is the potential to reduce freshwater demand on the MODU by substituting seawater for some activities at some well stages. The approximate savings that may be made are presented in Figure 5.15 and are discussed further in section 11.4.

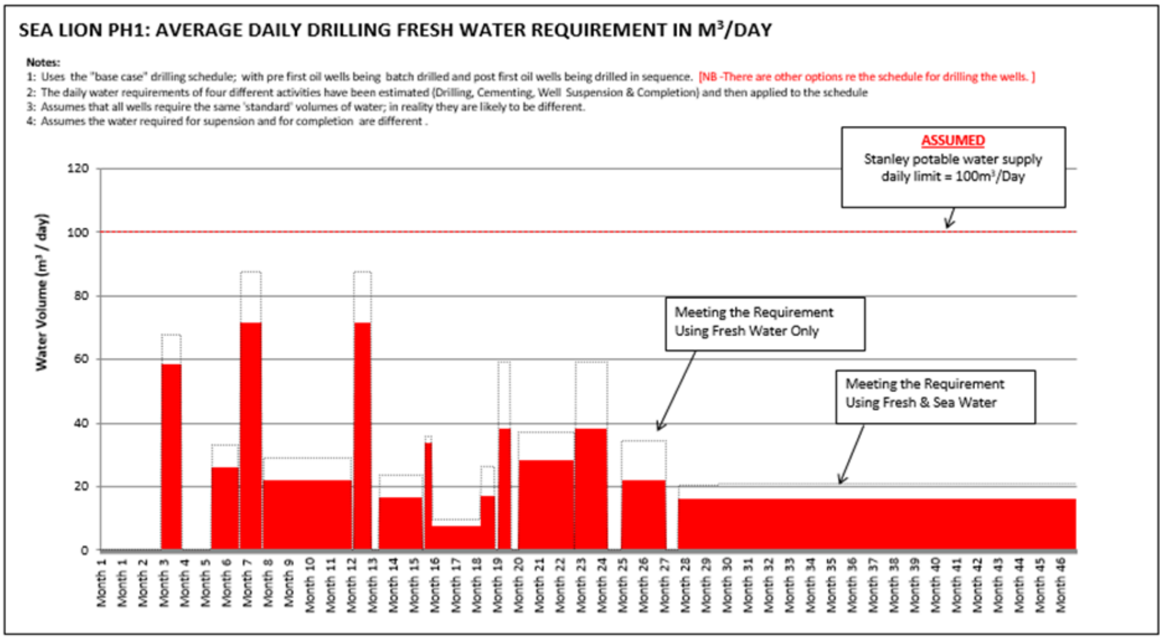


Figure 5.15: Forecast estimates of freshwater demand for drilling requirements during Stages 1 and 2 of the Sea Lion Phase 1 Development

5.11.4.2.2 FPSO

During production, the FPSO will require water for domestic use and marine and topsides systems.

It is estimated that the FPSO will require 60 m³ / day. To meet this demand, it will carry a water-maker of sufficient capacity and with redundancy (i.e. a spare unit). It is anticipated that the FPSO will be able to produce enough water to meet its own demand and thus be self-sufficient in water.

5.11.4.2.3 Vessels

The number and types of vessels required varies during the different Stages of development depending on the activities being undertaken. Vessels will be equipped with water-makers sufficient for their needs, however a contingency requirement of 10 m³ / day from local freshwater resources will be assumed for occasional opportunistic top-up of tanks when berthed at the TDF.

5.11.4.2.4 Onshore Construction

Where possible, Premier will utilise existing Stanley based infrastructure to support Sea Lion operations, acknowledging however that there will be a need to develop further infrastructure to support the project.

Additional Infrastructure requiring construction includes:

- Construction Contractors Compound (e.g. laydown area);
- Offshore Transit Hotel Accommodation;

- Wells Infrastructure – planning permission received 02/2019;
  - Liquid Mud Plant (based within property of TDF);
  - Tubing Conveyed Perforating (TCP) gun loading and storage facility (PMO to lease site from FIG);
  - Chemical Storage facility (PMO to lease site from FIG);
- Helicopter Hangar and Passenger Exchange (PMO to lease site from FIG within the curtilage of Stanley Airport);
- Upgrades and refurbishments to the existing TDF;
- Production Operations Base (Re-purposing of TCP/CSF);
- Waste Treatment Site (under construction by FIG); and,
- Additional Pipe Yard (contingent).

It is anticipated that these additional infrastructure requirements will be constructed during the first 18 months of Stage 1.

Water use for welfare of the construction team at work is budgeted at 40L per person per day. If everyone was at one location (85 people max) they would consume 3,400L per day.

Water requirements for the concrete batch plant and other construction uses is estimated at 3,000 – 4,000 m^3 over the 15 months of the construction projects. For the batch plant, peak demand will be buffered by up to 40 m^3 of water onsite..

5.11.4.2.5 Laydown yards, storage, and propriety TDF usage

The TDF has minimal use of water (i.e. <1 m^3 / day) and water use by the TDF is included within the above estimates of MODU, FPSO and vessel water use.

Water use by the on-shore laydown yard and storage facility was estimated using the 2015 exploration campaign data and has been scaled according to the anticipated changes in yard area (section 5.11.1.2).

Water use at the at-shore mud-plant, brine and bulk storage facility is included within the offshore drilling use estimates and is not considered separately to avoid double-accounting.

A freshwater tank storage will be provided to service the TDF and bulk plant needs, if required. This will buffer supply to average use levels and prevent water demand spikes during vessel supply or batching.

5.11.4.2.6 Accommodation

As detailed in section 5.11.4.1, the personnel requirements will change over the duration of the Phase 1 Development. Average water use is proportional to the number of personnel based ashore, and therefore peak periods of use relate to the two days every week when crew changes occur. Water use is based upon an average *per capita* use of 300 litres per person per day for domestic usage (UNDP, 2006)

5.11.4.2.7 Total estimated freshwater requirement for Phase 1

An estimate of the total Phase 1 water use, based on the above, is presented in Table 5.24.

In addition to direct usage by the MODU, FPSO, vessels etc., data from the previous O&G exploration campaigns indicate that an additional, but unallocated, increase in water use results from:

- The use of sub-contractors and services (e.g. offices, laundry, rental accommodation, etc.); and
- Indirect, but associated, water use by other economic sectors (e.g. hotels, hospitality, retail suppliers, etc.).

It is not possible to accurately separate the direct and indirect water use associated with the O&G industry from that associated with unrelated activities. However, in previous O&G exploration campaigns, an additional unallocated usage of *c.* 81 m^3 / day was recorded and this has been included within the estimate in Table 5.24.

Table 5.24: Estimated freshwater use by the Phase 1 Development

Activity	Assessment	Stage 1		Stage 2		Stage 3	
		Average (m^3/day)	Peak [a] (m^3/day)	Average (m^3/day)	Peak [a] (m^3/day)	Average (m^3/day)	Peak [a] (m^3/day)
Offshore Demand (supplied via TDF)							
MODU Drilling requirements inc. bulks, mud and brines	Drilling Estimates	33	87	21	21	0	0
Vessel requirements	Tank-top up allowance	10	10	10	10	10	10
FPSO	Self-sufficient	0	0	0	0	0	0
Onshore Demands							
Onshore Construction	Construction Estimates	8	44	n/a	n/a	n/a	n/a
Laydown yards and warehousing	Exploration with proportional increase	7	7	7	7	2	2
Bulk, mud & brine storage	Included in offshore drill estimates	0	0	0	0	n/a	n/a
Personnel and accommodation	*Per capita* rate of 300l/pp/day	52	90	57	116	26	56
Total O&G Demand		**110**	**194**	**95**	**154**	**38**	**68**
Unallocated activity demand [b]	Stanley total usage above allocated exploration use	81	-	81	-	81	-
Total forecast demand		**191**	**-**	**176**	**-**	**119**	**-**

[a] Peak usage relates to the month with the highest daily average usage during drilling and to accommodation during peak in-transit crew exchanges.

[b] Estimates based on the observed additional, but unallocated, increases in water use between 2014 - 2015 during exploration campaigns.

5.11.4.3 Electricity requirements

With regard to electricity requirements, the critical factor is the instantaneous power demand at any one given time, which must be matched by electrical generators within the Stanley supply system.

The following power demand figures are based upon directly recorded or estimated data by FIG Public Works Department during previous oil exploration rounds within the Falkland Islands. Where appropriate, the estimates were scaled up or down from the observed exploration use according to, for example, the increase in land area used (in the case of the laydown yard) or *per capita* personnel increases (in the case of accommodation usage).

Figures are provided in Table 5.25 for the main infrastructure centres:

- Heliops hanger;
- Accommodation facilities;
- TDF; and
- Drilling and operations bases (including the liquid mud plant, and laydown yards).

Further to these four main centres, the provision of a shore-power hook-up option for vessels berthed at the TDF will potentially be provided, although it is acknowledged that not all vessels will have the capability to 'hook up'. However, it is important to note that the shore-power hook-up for berthed vessels at night is included as a mitigation against the potential social impact of onshore noise rather than as an operational necessity. As such, it may not be required and will depend upon the outcome of monitoring and the balancing of impacts of noise versus energy use. If shore hook-up occurs, it is forecast to only occur at night when the noise of vessel generators has the greatest potential to disturb residents and therefore, will occur only during off-peak periods of power use.

In addition to the attributed infrastructure centres listed above, there are a number of directly associated miscellaneous power demands from offices (Premier and service contractors), separate rental accommodations (for oil personnel) and directly sub-contracted services, such as laundry.

Furthermore, there are associated demands from indirect economic activities such as hotels, entertainment, and retail that will increase due to the presence of oil personnel.

Finally, there may be incidental increases in demand from unassociated economic activity that is wholly separate from the Phase 1 Development activity, e.g. if fisheries cold-storage practices changed. Such changes are out with Premier's control and will affect the baseline power availability against which the Phase 1 Development power usage is compared in this EIS.

In the exploration rounds, these additional electricity requirements contributed a further 9 % to overall Stanley energy use although it is not possible to fully separate the proportional increases resulting from the those that are linked to oil activity and those which are not.

Table 5.25: Power demand of Phase 1 Development infrastructures

Facility	Peak Power (kW) use during exploration	Estimated Stage 1 & 2 peak power (kW)	Estimated Stage 3 peak power (kW)
Heliops hanger	250 [a]	250	250
Accommodation facility	120 – 140 [a]	264 - 308	120 - 140
TDF (estimate)	25 [b]	25	25
Drilling and operations bases (estimate)	75 [b]	225	45
TDF vessel shore-power connection	0	300 [c]	300 [c]
Total attributable load	**470 - 490**	**1,064 – 1,108**	**740 - 760**

[a] PWD figures (*pers. comm.* G Ross).

[b] Estimate assuming that peak power use is 5-times averaged power use over 24-hours

[c] Assumed if one large and two smaller vessels are berthed at the same time, e.g. on the outer and inner faces of the TDF. Note that this activity is most likely to occur overnight given that it is driven by the need to minimise noise disturbance from vessel generators at night.

5.11.4.4 Waste management strategy

Wastes will be managed in accordance with Premier's Falkland Islands Business Unit Waste Management Standard (FK-BU-EV-ST-0001) which sits within the company HSES-MS (section 3.2). As a responsible operator, Premier will ensure that:

- Application of the 5Rs Waste Hierarchy (Remove, Reduce, Reuse, Recycle/Recover, Residue (Treatment);
- Wastes are accurately described / characterised and consigned when they leave the Premier site where the waste was generated;
- Wastes are securely packed to ensure they do not escape in transit;
- All parties handling waste on behalf of the company are competent and authorised to do so; and
- Wastes are disposed of in an appropriate way, at a site that is authorised to accept them.

A summary of waste volumes anticipated throughout the Sea Lion Development can be found in section 10.10.4.3.

The bulk of waste, including all non-hazardous waste and potentially some hazardous waste, will require a waste handling / treatment facility. It is envisaged that additional municipal disposal facilities will be available in the Falklands that the Sea Lion Phase 1 project could use and Premier will take a collaborative approach with FIG to determine the most environmentally and economically viable solution for the Phase 1 Development and the Islands. Premier will provide details of all envisaged waste streams and planned treatment and disposal options from the commencement of field operations in a separate Waste Management Strategy document.

All waste received from the offshore Development will be transported to the onshore supply base by the supply vessels where it will be stored, in accordance with best practice, in the waste laydown area.

At the currently planned project schedule, suitable in-country waste facilities will be available at the start of operations, and as such Premier will follow the new municipal waste facility operating rules.

Wastes that are not suitable for incineration disposal on Island will be sent back to the UK for treatment / disposal (see section 10.10).

5.11.4.4.1 Oil spill waste management

In the event of an oil spill, clean-up operations intended to restore the site of the spill, will inevitably generate potentially large volumes of waste materials which can be contaminated with oil. The management of this waste up to, and including, its final disposal, can cause significant challenges for response coordinators. In order to ensure greater preparation, Premier has developed Oil Spill Strategies that detail the approach for dealing with such wastes.

The proposed approach will be to develop temporary, and lined, storage areas at strategic sites as near as possible to where the oil would be likely to beach. All solid wastes will be corralled / contained in the lined storage areas and liquid wastes (i.e. oily water from washing of equipment, for example) will be stored in drums and Intermediate Bulk Containers (IBCs). All wastes will then be transported to an area near to the operational base for interim storage. The preferred option for final disposal is controlled landfill (see section 10.10.2.3). Monitoring of the landfill site, as well as full details of the oil spill waste clean-up, will be detailed in the Phase 1 Development Waste Management Plan.

5.12 Decommissioning

The field-life of the Phase 1 Development is estimated to be 20 years. The date of Cessation of Production (CoP) and the commencement of decommissioning of associated facilities will depend upon field performance and economics. As described in section 5.1, decommissioning will be considered a separate project and will thus follow the standard Premier 'gated' project planning process (section 3.2.3) and will warrant its own EIA and EIS.

Nonetheless, the Phase 1 Development basis of design works on the assumption of complete removal of all infrastructure at the time of decommissioning, as is described below.

5.12.1 Decommissioning legislative framework

At the end of field-life, decommissioning will be carried out in accordance with the legislation in place at the time. Currently, the legislation is as follows:

- OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations;
- The UK Petroleum Act 1998;
- The UK Pipelines Safety Regulations 1996;
- OSPAR Recommendation 2006/5 on a Management Regime for Offshore Cuttings Piles;
- BEIS (previously DECC) Guidance Notes on Decommissioning of Offshore Oil and Gas Installations and Pipelines under the Petroleum Act 1998 (**Note:** these are currently under review and are due to be re-issued in November 2017); and

- The Oil and Gas UK Guidelines for the Suspension and Abandonment of Wells.

5.12.2 Facility removal

In line with the above legislation, the Phase 1 Development infrastructure has been designed to enable complete removal of all structures. Equally, the flowlines will be surface laid and will not be trenched or buried thus facilitating complete removal (noting that the seabed is very soft, so flowlines may self-bury which could change the methods required for complete removal).

Specifically, the Development has been designed to enable:

- Abandonment of wells in accordance with The Oil and Gas UK Guidelines for the Suspension and Abandonment of Wells;
- Cutting of the well casings to a level below the natural seabed, which ensures they remain below the seabed in the face of prevailing conditions;
- Removal of the suction piles for the MODU;
- Removal of the 'disused offshore installation':
  - Removal the FPSO and moorings for legitimate use elsewhere - the FPSO will be on a 'lease and operate' contract so may be re-deployed following decommissioning of the Phase 1 Development;
  - Removal of all subsea infrastructure associated with the installation (i.e. wellheads and X-mas trees) for waste recovery (e.g. reuse or recycling) or final disposal on land - any piles will be cut to a level below the natural seabed, which ensures they remain below the seabed in the face of prevailing conditions:
  - **Note:** No part of the Phase 1 installation will qualify for derogation under the current OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations. As stated, the Phase 1 Development will be decommissioned in accordance with legislation and best practise relevant to the time.
- Removal of the SURF:
  - All subsea umbilical's, risers, flowlines, and associated infrastructure will be removed unless comparative assessment of the safety, environmental, technical, societal and economic impacts indicate that leaving wholly or partially *in situ* is the best practicable option.
- Removal of any debris associated with the production or decommissioning phases.

Infrastructure removed will be transported to shore and managed in accordance with the Waste Hierarchy. Any disposal will be justified by demonstrating that recovery and recycling options are not feasible or reasonably practicable.

5.12.3 Decommissioning programme

The base case is the complete removal of all structures to approximately two metres below the seabed. However, it is not possible to assess the environmental impacts and risks associated with the decommissioning process at this time due to:

- The varying options for removal will be achieved;
- Unknowns about the status of the infrastructure at the end of field-life (e.g. flowlines may self-bury); and
- The potential for technological advances that emerge during the life of the Phase 1 Development.

Toward the end of field-life, a detailed Decommissioning Programme outlining the methods for removal and outcomes of the comparative assessment for pipeline decommissioning options will be submitted to FIG for the FPSO, pipelines and subsea infrastructure.

The Decommissioning Programme/s will be supported by:

- An ENVIID which will be carried out to inform the EIA that will accompany the decommissioning programme;
- A comparative assessment for the pipeline decommissioning options;
- An EIS detailing the impacts and risks associated with the selected removal options and waste management strategies; and
- A Stakeholder Engagement Plan.

5.13 Phase 1 base case mitigation technologies

In order to assess the impact and risks it is necessary to quantify, where possible, what the outputs of the Phase 1 Development may be e.g. how much CO_2 will be emitted, how much light, how much produced water etc. Here it is necessary to understand the project activities and the technologies used to reduce the main outputs. The base case impact and risk reduction technologies built-in to the design are listed in Table 5.26.

Table 5.26: Summary of the technologies and measures which are built-in to the Phase 1 Development basis of design in order to reduce outputs

Project activity	Mitigation technologies built-in to the Phase 1 basis of design
General	• All materials, fittings and system contents contained in the FPSO hull will be non-toxic, non-smoke emitting, fire retardant or ‘low flame spread’.
Disturbance to the seabed	• Reduced number of LTVs in Berkeley Sound to support the Stage 1 and 2 subsea construction campaigns
Drilling and production	**The following will reduce the amount of atmospheric emissions:** • The main fuel supply for the FPSO will be produced gas; • Use of waste heat recovery to reduce fuel consumption / CO_2 emissions; • No planned flaring during ongoing well testing throughout field life (as opposed to during initial well-clean up via the MODU for four wells. **Note:** a worst case of the clean-up of all 22 production wells is included in this EIS as a contingency); • No planned flaring during normal production (notwithstanding the flare pilot light); • Use of a Flare Recovery Package during normal operations; • No venting from the FPSO during normal production; • Follow international standards for piping, valves etc. and best practises for integrity management e.g. UK Step Change Hydrocarbon Toolkit • Use of Vapour Recovery Package (VRP) during normal operations;

Project activity	Mitigation technologies built-in to the Phase 1 basis of design
	• Use of F-Gases with the lowest Global Warming Potential; • Back-up inert gas generator for use as gas blanket in the event that the VRP malfunctions to prevent venting of hydrocarbon gas; • Use of Marine Gas Oil instead of Intermediate Fuel Oil (i.e. a lighter fuel) when operating inshore; • Use of a vapour balancing system to pass blanket gases from the FPSO cargo tanks to the CTT cargo tanks, when available, during transfer of oil; and • Application of BAT to the incineration process to ensure appropriate flue gas treatment that minimises emissions of pollutants to levels as low as reasonably practicable and that achieves the relevant standards of air quality. **The following will reduce the volumes of drilling discharges:** • Use of seawater sweeps, bentonite and WBM for tophole drilling; and • Batch drilling to optimise drilling mud use. **The following will reduce the volumes of, or negate the need for, discharges of oil and chemicals to sea:** • Produced Water Reinjection (PWRI) as a base case to alleviate the need to discharge produced water to sea during normal production operations; • Subsea and topside technical flow assurance measures, e.g. insulation and heating, will minimise the use of flow assurance chemicals; • Diversion of produced water to slops / off-spec tanks for retreatment in the event that PWRI is down and produced water is out with discharge specifications; and • Oil in ballast tank detection on the FPSO. **The following will reduce the volume of oily waste returned to shore:** • Use of a Thermomechanical Cuttings Cleaner (TCC) during drilling which will clean-up drill cuttings on the rig so they may be discharged to sea, reducing the amount of oily waste sent to shore for treatment. **The following will reduce the volume of waste being returned to the UK for disposal:** • Use of municipal waste facilities. **The following will reduce the competition for resources:** • Use of buffer storage water tanks at the TDF, the mud plant and potentially the at-shore bulk supply base to ensure management of peak water use requirements.
Oil spill *prevention* measures	**Note:** many industry-standard preventative mitigation measures must be built-in to the basis of design. Therefore, there are very few 'extra' base case mitigation options available and the standard requirements are summarised below: **Preventative measures built-in to the FPSO include:** • Cargo and fuel tanks of the vessel will be double skinned; • Bunding of all liquid containing equipment and chemicals; • Open deck drains to catch and collect spills to a dedicated slops tank; • High level tank filling alarm and emergency shutdown of the process; • FPSO offloading hose quick-break connectors to prevent spills on unplanned disconnection; and • Automatic Identification Systems and Marine procedures to prevent collisions. **Preventative measures built-in to the well design include:** • Development of the appropriate, and peer reviewed, well design; • Use of appropriately weighted drilling muds; • The use of appropriate mud additives to ensure over-balanced drilling; and • Use of Blow-Out Preventers and production X-mas trees.

Project activity	Mitigation technologies built-in to the Phase 1 basis of design
	Preventative measures built-in to the CTT nomination and selection include: • Cargo tanks, and potentially the fuel tanks, of the vessel will be double-skinned; • Vetting and auditing prior to acceptance of the nominated vessel; • Transfer of Falkland Islands' authorised Berthing Master / Pilot and assistant to CTT to manage the offshore Direct Offtake operation; • Cargo tank hi level and hi-hi level alarms to prevent overfilling; • Bunding of all liquid containing equipment and chemicals; and • Open deck drains to catch and collect spills to a dedicated slops tank.

5.14 Estimated quantities of residues and emissions resulting from the project

In line with Paragraph 1, Schedule 4, sub-paragraph 4c of the Offshore Minerals Ordinance (Amendment) (2011), the residues and emissions resulting from the Sea Lion Phase 1 Development are estimated in Table 5.27.

Table 5.27: Estimated quantities of residues and emissions resulting from Stages 1, 2 and 3 of the project

Type of Emission or Residue	Total quantity of emission or residue	EIA chapter / section detailing full characterisation and quantification
Disturbance footprint of temporary MODU anchors installation	0.264 km^2	section 10.3
Disturbance footprint of long-term subsea equipment and FPSO anchor installation	0.037 km^2	
Disturbance footprint of mooring systems installation, the use of the LTV anchors / MRSV / DOSRV / bunkering vessels and the contingency anchoring of the CTT	0.036 km^2	
Disturbance footprint of SPS and SURF installation	0.207 km^2	
Underwater noise offshore from installation vessel and piling (Stage 1)	217 dB re 1 µPa at 1m	section 10.4
Underwater noise offshore from installation vessel, 3 x AHV, ERRV and drilling	201 dB re 1 µPa at 1m	
Underwater noise offshore from steady state production (Stage 3)	202 dB re 1 µPa at 1m	
Underwater noise inshore from Inshore operations	174 dB re 1 µPa at 1m	section 10.5
Water Based Mud (WBM) drill cuttings discharged	16,118 t	section 10.6
WBM drilling mud discharged	23,328 t	
Oil Based Mud (OBM) drill cuttings (cleaned)	32,312 t	
OBM drilling mud discharged on cleaned cuttings	188 t	
Potential produced water (PW) discharges (7 % reinjection downtime) - early field-life	39,748 m^3	section 10.7
Potential produced water (PW) discharges (7 % reinjection downtime) - late field-life	445,714 m^3	
Grey water (over 23 years)	344,445 m^3	
Black water (over 23 years)	120,556 m^3	
Hypersaline water (over 23 years)	2,255,182 m^3	
Atmospheric emissions (over 23 years)	9,243,733 CO_2e	section 10.9
Waste (over 23 years)	25,053 t	section 10.10

6 SCOPING CONSULTATION ON THE PROPOSED DEVELOPMENT

Table of Contents

6.1 Introduction

As is described in the FIG Environmental Planning Department EIA Guidance (FIG, 2015m), it is considered beneficial for an operator to consult informally with all relevant interested parties on the proposed development plans prior to the execution of the EIA and writing of the associated EIS. This 'informal' consultation is intended to focus the EIA and ensure that the environmental assessment underlying the EIS is adequate. The relevant interested parties identified by Premier are listed in Table 6.1.

As described in Chapter 4, the Sea Lion Field was originally going to be developed by Premier via an offshore Tension Leg Platform (TLP) with numerous oil export options under consideration. Premier's direct scoping consultations on production development began in 2014 with this TLP concept and included the public, interest groups and statutory consultees.

In 2014, additional scoping and formal consultation was undertaken for the 2015 exploration drilling campaign with FIG departments, key focus groups and members of the public.

Following the decline in the oil price however, the proposed offshore component of the Sea Lion Development was changed in 2015, as is described in Chapter 4 and summarised in Table 6.2, while the various oil export options remained under consideration.

In Q4 2015 Premier undertook informal scoping consultations with the key FIG Departments on the offshore component of the Sea Lion Phase 1 Development with production using a Floating production, Storage and Offloading (FPSO) vessel.

In August 2016, Premier undertook informal scoping consultations on the whole Phase 1 Development including the offshore and oil export components with all interested parties including statutory, non-statutory consultees and the general public.

The scoping consultations typically included:

- A presentation by Premier on the scope of the Phase 1 Development;
- Detail on the key aspects of the project;
- Detail on Inshore Transfer activities and the associated oil spill response strategy, which was in development at the time
- Detail on the onshore and at-shore activities;
- A summary of the EIA / EIS process; and
- An open Q&A discussion where all comments and queries were recorded anonymously.

Some elements of the project evolved subsequent and were not consulted upon. These were:

- Anchoring of up to three Large Transport Vessels (LTVs) at any one time in Berkeley Sound, each with an associated 500 m exclusion zone prior to Inshore Transfer operations (section 5.11.2);
- A contingency option to anchor the CTT in Berkeley Sound should the Mooring Buoy not be available (This option has now been eliminated from the project);
- The option to offload crude directly from the FPSO to a CTT as opposed to conducting an Inshore Transfer is being considered (section 5.10); and

- A second contingent drill centre 3 km to the south of the main drill centre (section 5.4.1).

These items were highlighted during the public consultation in 2018 so that stakeholders had the opportunity to consider these changes.

During 2018 and 2019, the project description underwent two further iterations to incorporate:

1) FPSO changes due to start of FEED engineering with a new FPSO Contractor in respect of a new build FPSO rather than vessel conversion; and
2) Project optimisations to eliminate, or reduce, risks associated with project delivery, production operations and HSE impacts (section 5.1.1).

Table 6.1: Interested parties consulted during scoping

Interested party	General purpose	When consulted			
		2014	2015	2016	2018
Department of Mineral Resources (DMR) (FIG)	The regulatory body charged with oversight of the offshore oil and gas industry and any onshore mining or mineral exploration. Core responsibilities include the role of licensing authority, offshore health and safety enforcement, and offshore environmental approvals (FIG, 2015g)	✓	✓	✓	✓
Public Works Department (PWD) (FIG)	Responsible for Government construction projects in the Falkland Islands, including house building and maintenance as well as larger infrastructure projects such as, road maintenance, power and freshwater.	✓	✓	✓	✓
Policy Unit (FIG)	Provides economic, environmental planning and policy advice to Elected Members, the Central Management Team and FIG Departments. It also assists in the development of specific economic and social programmes, working across Government and the community to support the attainment of the goals of the Islands Plan (FIG, 2015i)	✓	✓	✓	✓
FIG Harbour Master	Marine Officer for the Falkland Islands and Harbour Master for Port Stanley. Responsible for policy development, operational tasks and regulatory functions applicable to Falkland maritime, harbour, port operation and fishery issues.		✓	✓	✓
Ministry of Defence (MoD) [a]	A military presence is based in the Falklands to demonstrate the UK Government's continued commitment to the security of UK Overseas Territories in the South Atlantic. They include air defence assets, maritime patrol capability and infantry forces (UK Gov, 2015).	See note [a]			
Falkland Islands Fisheries Department (FIFD), Department of Natural Resources (DNR) (FIG)	Responsible for the sustainable management of the fisheries within the Falkland Islands conservation zones (FIG, 2015j)	✓	✓	✓	✓

Interested party	General purpose	When consulted			
		2014	2015	2016	2018
Members of the Legislative Assembly (MLAs)	Elected members of the legislative assembly, who are empowered to pass legislation for the peace, order and good government of the Falkland Islands. All members are elected as independents (FIG, 2015b)			✓	✓
Rural Business Association	The Rural Business Association represents Camp-based business interests in discussions with the Government and other stakeholders and provides a focal point for communication with the rural community	✓		✓	✓
Falklands Conservation (FC)	A non-governmental organisation working to protect all the wildlife of the Falkland Islands for future generations (FC, 2015)	✓		✓	✓
RSPB	The Royal Society for the Protection of Birds is a charitable organisation based in the UK, working in the Falklands with BirdLife and FC			✓	✓
Wildlife Conservation Society	A US based conservation charity that owns the Jason Islands NW of West Falkland	✓			✓
Falkland Islands Civil Aviation Department (FICAD) [a]	Responsible for overseeing aviation activity in the Falkland Islands to ensure compliance with international and British Overseas Territory legislation (FIG, 2015t). The work of FICAD provides assurance that: • The aviation industry meets the highest safety standards; and • There are improvements in airlines and airports' environmental performance.	See note [a]			
Agriculture (including Biosecurity Officer) (DoA), Department of Natural Resources (DNR) (FIG)	The department engages in sheep improvement work, support for meat export and support to farmers to run their farms as profitable businesses. It seeks to foster a viable and internationally competitive agricultural industry through integrated applied research, extension, business skill development and regulatory programmes. The Department also provides veterinary, quarantine and agricultural laboratory services, FIG (2015j)	✓			✓
Falkland Islands Fishing Company Association (FIFCA)	The Association represents the interests of all holders of fisheries quota under the Falklands Individual Transferable Quota System. It works with members to ensure industry views are presented to FIG in areas of interest to the fishing industry, participates in a number of Government and non-Government committees and jointly funds and provides resources for the advancement of knowledge regarding the fishery including its biological, operational, environmental and economic aspects (FIFCA, 2015)	✓		✓	✓
Falkland Islands Tourist Board (FITB)	Constitutionally a 'Company Limited by Guarantee' responsible for the strategic development of the tourism industry in the Falklands and the marketing of the Islands' tourism product (FIG, 2015l)	✓		✓	✓

Interested party	General purpose	When consulted			
		2014	2015	2016	2018
Chamber of Commerce	The Chamber of Commerce is the Falkland Islands leading private sector, member focused business organisation. The Chamber is a key player in the Falkland Islands for lobbying, service provision and setting the business and economic agenda (FICoC, 2016)	✓		✓	✓
South Atlantic Environmental Research Institute (SAERI)	An academic organisation conducting research in the South Atlantic from the tropics down to the ice in Antarctica. SAERI's remit includes the natural and physical sciences. It aims to conduct world class research, teach students, and build capacity within and between the South Atlantic Overseas Territories (SAERI, 2015)	✓		✓	✓
Shallow Marine Surveys Group	A group of marine scientists, dive enthusiasts, and volunteers conducting research through diving and exploration in the South Atlantic (SMSG, 2016)	✓		✓	✓
Agreement for Conservation of Albatross and Petrels (ACAP) Co-ordinator (Joint Nature Conservation Committee)	Falklands based co-ordinator working to implement the plan for the Agreement on the Conservation of Albatrosses and Petrels	✓		✓	✓
BEIS (UK)	UK Department for Business Energy and Industrial Strategy, which manages oil and gas applications and permits in the North Sea	✓			✓
HSEx (UK)	UK Health and Safety Executive with responsibility for offshore oil and gas operations	✓		✓	
Berkeley Sound farm owners	Stakeholders who own or manage land directly adjacent to Berkeley Sound and whose rights and interests may not be represented during statutory consultations			✓	
General public	Wider stakeholders whose rights and interests may not be represented during statutory consultations.	✓		✓	✓

[a] **Note:** the MoD and FICAD are important stakeholders and are consulted via separate face to face meetings. As MoD and FICAD concerns are generally logistical, as opposed to environmental, they were not consulted as part of the EIA scoping consultations.

Table 6.2: Comparison between the previous and the current Sea Lion Oil and Gas Production Development (Phase 1)

Activity	Initial Proposed Development	Development Described in Previous EIS	Current Optimised Development
Number of wells:	33	Up to 30	Up to 30
Oil produced and processed by:	TLP with processed oil transferred to a permanently connected Floating, Storage and Offloading (FSO) Vessel	Floating Production, Storage and Offloading unit (FPSO) (vessel shaped)	Floating Production, Storage and Offloading unit (FPSO) (vessel shaped)
Gas management:	Gas to be used for fuel gas, gas blanketing and 'gas lift' to enhance oil recovery	Gas to be used for fuel gas, gas blanketing and 'gas lift' to enhance oil recovery	Gas to be used for fuel gas, gas blanketing and 'gas lift' to enhance oil recovery
Produced water management:	Produced water to be reinjected to enhance oil recovery	Produced water to be reinjected to enhance oil recovery	Produced water to be reinjected to enhance oil recovery
Offloading of oil:	Oil processed on TLP and transferred to FSO, then transferred to a Dynamically Positioned Offshore Loading Shuttle Tanker (OLST)	Oil processed and stored on FPSO and then transferred to a Dynamically Positioned OLST or Conventional Trading Tanker (CTT)	Oil processed and stored on FPSO and then transferred to a Conventional Trading Tanker (CTT)
Oil export:	A number of oil export options were under consideration but the preferred route was not defined	Inshore Transfer in Berkeley Sound from a Dynamically Positioned OLST to a Conventional Trading Tanker (CTT); alternative of Direct Offtake to CTT from FPSO at the Sea Lion Field	Direct Offtake to CTT from FPSO at the Sea Lion Field selected in favour of Inshore Transfer
Field Life:	25 years	20 years	20 years

6.1.1 Relevant Guidance

The informal scoping consultation process is guided by:

- FIG Guidance:
  - The Executive Council (ExCo) 'Falkland Islands Hydrocarbon Development Policy Statement, 158/13', 2013 (section 3.1.5.2);
  - The FIG EPD Hydrocarbons Environmental Impact Assessment Guidance Note 2015; and
  - Schedule 4 of the FIG Offshore Minerals Ordinance 1994 (as amended) which outlines the required contents of an EIS (section 3.1.6.3.1).
- Premier Policies:
  - Corporate Premier Standard: Environmental and Social Impact Assessment (section 3.2.5).

6.2 Scoping Consultation Process

Consultations on the Phase 1 Development were carried out in three parts:

- **Informal scoping consultation in 2014** on the proposed Sea Lion Development with production from 33 wells using a TLP:
  - This initial consultation included the public, interest groups and statutory consultees (Genesis, 2014b).
- **Informal scoping consultation in 2015** on the offshore component of the Sea Lion Phase 1 Development with production via 18 wells using an FPSO:
  - This consultation included the FIG Departments only, as described below.
- **Informal scoping consultation in 2016** on the whole Phase 1 Development (including the offshore, onshore, at-shore *and* the inshore oil export components):
  - This consultation included all interested parties including the general public.
- **Formal public consultation in 2018** on the Phase 1 Development Environmental Impact Statement (EIS) revision B01.

Although not relating to the Phase 1 Development, Premier also carried out consultations prior to the 2015 exploration drilling campaign covering the drilling operation and associated activities. This consultation included statutory and non-statutory consultees, as well as the general public. The information gathered during this consultation contributed to the overall scoping boundaries for the Phase 1 Development scoping exercises so is mentioned here for completeness.

6.2.1 Informal Scoping Consultation in 2014

The informal consultation in 2014 included all the interested parties, as listed in Table 6.1 above, and was carried out via:

- Organised meetings with FIG Departments - feedback was received following a presentation describing the TLP Development; and
- Open public meetings and workshops.

A summary of the key outcomes is provided in section 6.3.

6.2.2 Informal Scoping Consultation in 2015

While representations from the 2014 public consultation on the full field TLP development remained relevant and were carried forward, it was considered necessary to carry out a secondary informal consultation following the adjustment of the Development to 18 wells and an FPSO (section 6.1).

However, given that the public had already been consulted on the offshore component when the Field was to be produced using 33 wells and a TLP, the second consultation included FIG Departments only. This decision was based on:

- The interests of avoiding stakeholder fatigue given that numerous other consultations had been carried out for the previous exploration campaigns by Premier and other operators;
- Recognition that Premier had not yet decided upon the oil export process which was likely to be the subject of most interest;
- The fact that the opportunity to comment on the whole development would be provided in 2016.

The 2015 scoping consultation with FIG Departments was conducted via an informal scoping workshop. This aimed to provide an opportunity for stakeholders to raise any issues given the changes to the offshore component of the project.

6.2.2.1 Informal Scoping Workshop

The scoping consultation with the statutory consultees was carried out in a Scoping Workshop on the 24th November 2015, in the Premier Office, Argos House, Stanley, Falkland Islands.

A basic pre-read document describing the revised offshore development was issued to workshop participants and used in the Workshop to identify potential environmental impacts associated with the offshore development.

Workshop participants representing FIG were as follows:

- Department of Mineral Resources (DMR);
- Environmental Planning Department (EPD);
- Department of Natural Resources (DNR);
- Policy Unit; and
- Public Works Department (PWD).

The main objectives of the workshop were to:

- Provide statutory consultees with an update on the proposed offshore development;
- Inform statutory consultees of the EIS delivery timeline;
- Provide statutory consultees with an indication of the current EIA scope and content in order to determine:
  - Whether this was in keeping with their expectations with regard to Schedule 4 of the Minerals Ordinance (section 3.1.6.3.1); and
  - What is 'in-scope' and 'out-of-scope' in the EIA in order to comply with the Ordinance.
- Identify potential environmental impacts and risks of concern to the consultees to ensure these are included within the EIS, where appropriate.

6.2.2.1.1 Determination of EIA scope

With regard to meeting the requirements of the Ordinance, it was demonstrated that the EIA methodology provides for the assessment of the 'sensitivity of', and 'severity of effect on', all the environmental components listed in Clause 4 (2). However, clarity was sought from the consultees on whether or not SAERI's interpretation of 'Human Population' and 'Tangible Property' was appropriate with regard to the inclusion of social impacts and risks.

The FIG EPD Hydrocarbons Environmental Impact Assessment Guidance Note 2015 (FIG, 2015l) lists the following impacts as unlikely to be relevant within the scope of an EIS:

- Tax revenues;
- Wages / cost of living;
- Threats and opportunities for local businesses;

- Land value / rents; and
- Availability of housing and services / facilities (e.g. hospital and school capacity).

Therefore, with regard to these components, SAERI proposed assessment of the following:

- Human Population:
  - Competition for resources including:
    - Accommodation;
    - Fuel;
    - Freshwater;
    - Food;
    - Landfill sites;
    - Port facilities (Stanley Harbour, FIPASS, TDF)
    - Electricity;
    - Sewage facilities; and
    - Space on MoD Airbridge flights.
  - Disruption to other users of the sea:
    - Impact from presence of other vessels;
    - Risk of collision between boats; and
    - Risk of snagging by trawlers.
- Tangible Property:
  - Port facilities;
  - Fishing industry;
  - Road networks;
  - Airports and airlinks;
  - Waste facilities;
  - Tourism facilities; and
  - Protected sites supporting wildlife and managed tourism.

Note that, in addition to direct consideration of the above, Human Beings as a species (*Homo sapiens*) are also considered to be a receptor within the EIS where necessary e.g. the potential impacts on human health from changes in inshore regional air quality and the potential impacts of onshore / inshore light and noise etc.

Therefore, in terms of what is considered 'in-scope' and 'out-of-scope', it was agreed that social impacts, such as those listed above were in-scope, and economic issues e.g. impacts upon revenue and house prices etc. were out-of-scope based on interpretation of the Ordinance and the EPD EIA Guidance Note (FIG, 2015m). In light of this agreement, disruption to other users of the community, with regard to impacts on health services, police services, civic amenities etc. was considered out-of-scope.

Importantly however, the need for awareness, assessment, reporting and mitigation of economic impacts and risks was noted by all at the workshop, but it was agreed that, under the Ordinance (as of November 24th 2015), the EIS is not considered the appropriate vehicle for assessing and reporting these issues. As described in section 6.2.3.2, an additional and separate socio-economic impact assessment, building and updating the previous work undertaken for FIG and Rockhopper by Regeneris (2013 & 2015) and Plexus (2012), will be completed by Premier prior to sanction of the Phase 1 Development.

6.2.3 Informal Consultation in 2016

Scoping consultations for the whole Phase 1 Development were held between the 15th and 26th August 2016 and were carried out via:

- Workshops / meetings with:
  - FIG departments: DMR, EPD, PWD, DNR, Policy, Harbour Master;
  - Members of the Legislative Assembly (MLAs);
  - Chamber of Commerce members and Tourist Board;
  - Fishing Company representatives (FIFCA) and Fisheries Department (FIFD);
  - Falklands Conservation;
  - Environmental NGOs including: Shallow Marine Survey Group and ACAP Co-ordinator (JNCC);
  - Other Groups: SAERI and the Offshore Hydrocarbon Environmental Forum (OHEF);
  - Public in Stanley, and Camp (Hill Cove, Fox Bay, Goose Green and Lorenzo); and
  - Berkeley Sound residents and land owners.

6.2.3.1 Consultation format

During the scoping, statutory stakeholders and key stakeholders were invited to:

- 'By invitation' sessions which included a presentation by Premier on the scope of the project identified to date followed by a Q&A session;
- Open sessions which were held for all stakeholders, including the public at various locations, both in Stanley and in Camp (both East and West Falkland). This again consisted of a presentation followed by open Q&A sessions; and
- Individual consultations which were offered to land owners and managers whose land is directly adjacent to Berkeley Sound.

Additionally, drop in sessions were offered to all public, statutory stakeholders and NGO's e.g. RSPB. A follow up session was offered to the fisheries groups (FIFD and FIFCA), which was taken up by FIFCA.

A project Pre-Read was distributed to the stakeholders, made available at the sessions and emailed or posted to them directly on request. Notice of the Sea Lion Environmental Impact Assessment Scoping Consultation Sessions were advertised in the Penguin News along with a dedicated consultation contact number and an email address for queries and comments.

6.2.3.2 Premier commitments resulting from the 2016 scoping

As a result of discussions during the scoping consultation, Premier committed to:

- Produce a Socio-economic Impact Assessment (SIA) for consideration by FIG, although it was agreed this EIA / EIS was not an appropriate vehicle for this assessment. Premier will produce an additional and separate socio-economic impact assessment, building and updating the previous work undertaken for FIG and Rockhopper by Regeneris (2013 & 2015) and Plexus (2012);
- Continued discussions with DMR on offsetting;
- Conduct further work on the effect of Sea Lion crude on fur and feathers, weathering and persistence effects and toxicity. This is planned both pre and post submission of the EIS;
- Hold an Environmental Monitoring and Management Programme (EMMP) workshop to determine scope, protocols, methodology, reporting and governance (Chapter 15);
- Hold a Wildlife Response Workshop to determine scope, protocols, methodology, reporting and governance which will further inform the Wildlife Response Plan. This was incorporated into a wider Oil Spill On Paper Workshop held in June 2017 (Premier 2017f);
- Share the outcomes of the ongoing waste assessment with interested parties (e.g. FIG departments).

6.2.4 2018 Consultation

During 2018, public consultation in support of the revised Environmental Impact Statement (Rev B03), was held between 10th January and 9th March. The public consultation process included face to face briefings to FIG departments, NGOs, the general public and other materials including:

- Project fliers
- Advertisements placed in Penguin News
- Posters
- Maps
- Computer models of reservoir (Subsurface)
- Video (drone footage), sound files and animations
- Samples of crude and drill cuttings
- Radio and TV Interviews

The range of Consultees included:

- Statutory stakeholders: MLAs, DMR, EPD, PWD, DNR, Policy;
- Industry Reps: CoC, FIFCA, RBA, Tourist Board ,FIDC, Museum / NT;
- NGO's: FC, SMSG, New Island Trust, ACAP (JNCC);
- Others: FIOHEF, SAERI, Berkeley Sound farm owners; and

- General Public

Public consultation was completed on the 9th March 2018 and the EIS was finalised. On the 10th April, Premier submitted responses to c.300 points raised by 11 parties.

Key points raised during the consultation phase included the following aspects:

1) reinforcement of the importance of progressing Direct Offtake evaluation/decisions
2) Querying the welltest volumes of 5,000 tonnes in each of 3 wells
3) Update the underwater noise assessment, as new standards had recently been issued
4) Include an air quality assessment for oil spills
5) Management of artificial light and potential for bird strike
6) How will the EMMP will operate
7) Coverage of Baseline survey data
8) Interpretation of oil spill impact
9) Additional scientific papers to be included
10) How social impacts will be addressed (via separate studies - the EIS is compliant).

Overall - in all the representations - a total of 270 ‘clauses’ required a detailed and thoughtful response.

The additional underwater noise assessment continued past the end of the consultation period and was submitted to FIG at the end of May 2018.

As a result of discussions during the 2018 consultation, Premier committed to:

- Update the project Socio-economic Impact Assessment (SIA)
- Responses to Bank Due Diligence
- Hold an Environmental Monitoring and Management Programme (EMMP) workshop to determine scope, protocols, methodology, reporting and governance - Environmental Management and Monitoring Workshop in;
- Berkley Sound Bird Survey
- Invasive Species Monitoring Programme
- PLANC Review and Update

6.3 Scoping consultation outcomes

Table 6.3 provides a summary of the key themes that were raised by the consultees during all three consultation processes. An indication of the number of times that the theme was raised, and guidance on where in the EIA the comment has been addressed is provided. For the socio-economic and economic issues that are out-with the scope of the EIA (see above), reference is made to the relevant documentation.

The number of consultees met during each consultation is as follows:

- TLP **124 stakeholders** met (2014);
- Exploration programme **63 stakeholders** met (2014);
- Offshore component of 2018 EIS with FIG Departments only, **10 stakeholders** met (2015); and
- All components of current EIS **130 stakeholders** met (2016).

The key themes highlighted by stakeholders following the most recent 2016 consultation were:

- Control of vessels and general management in Berkeley Sound;
- Oil spill mitigations and clean-up;
- Onshore infrastructure;
- Offsetting;
- Decommissioning;
- The impact of this particular type of crude;
- Jobs, employment and numbers of people; and
- Standards and governance.

Table 6.3: Summary of informal consultation outcomes from 2014, 2015 and 2016 consultations

Consultation	Theme	Concern / comment	Number of mentions [a]	Pos / Neg [b]	Addressed
2014, 2015 & 2016	Social	The carrying capacity of existing onshore infrastructure	11	Neg	Section 11.3; Section 11.4; Section 11.5; Section 11.6; and Section 11.7.
2014, 2015 & 2016	Social / Environmental	Competition for resources e.g. waste facilities, food, water, power supply, health services, schools, aggregates and rental accommodation	10	Neg	Section 11.3; Section 11.4; Section 11.5; Section 11.6; and Section 11.7.
2014, 2015 & 2016	Environmental	Risk of oil spills	10	Neg	Section 12.1; Section 12.2; and section 12.3.
2014, 2015 & 2016	Socioeconomic	Local content and employment related challenges, including wage inflation, labour shortages and immigration	10	Neg	SIA (section 6.2.3.2).
2014, 2015 & 2016	Economic	Inflation e.g. impacts on food prices and availability, and rising costs for housing	10	Neg	SIA (section 6.2.3.2).
2014, 2015 & 2016	Environmental	Mitigation measures and offsetting	9	Neg	Chapter 8 (section **8.9**); Chapter 10; Chapter 11; and Chapter 12.
2014, 2015 & 2016	Social / Environmental	Competition between sea users, in particular management of Berkeley Sound and exclusion zones, and risk of collision	8	Neg	Section 11.1; and Section 11.2.
2014, 2015 & 2016	Social / Environmental	Falklands services may improve, e.g. waste management, flight routes, shipping routes and medevac	8	Pos	Section 10.10; and Section 11.6. SIA (section 6.2.3.2).
2014 & 2016	Environmental	Standards applied by Premier and extent of liability, particularly in relation to the CTT	7	Neg	Chapter 2; and Section 12.2.
2014, 2015 & 2016	Socioeconomic	Other general community benefits will be made possible by economy of scale as the population grows, increased investment in the Falkland Islands	7	Pos	SIA (section 6.2.3.2).
2014, 2015 & 2016	Environmental	Waste generation and management in the Falkland Islands and offshore	6	Neg	Section 10.10.
Consultation	**Theme**	**Concern / comment**	Number of mentions [a]	Pos / Neg [b]	Addressed

2014 & 2016	Environmental	Lack of sufficient environmental data in some fields making effective assessment of impacts difficult	6	Neg	Chapter 7
2015 & 2016	Environmental	Emissions and discharges	6	Neg	Section 10.7; and Section 10.9.
2014, 2015 & 2016	Environmental	Increased light pollution with particular impact on sensitive bird species both inshore and offshore, and risk of bird strike but also as a nuisance to humans	5	Neg	Section 10.1 Section 11.1
2014, 2015 & 2016	Socioeconomic	Job opportunities and training	5	Pos	SIA (section 6.2.3.2).
2014 & 2016	Environmental	Disturbance to fisheries spawning grounds and migration routes	4	Neg	Section 11.1
2014 & 2016	Political	FIG decision and policy making perceived as reactive rather than proactive	4	Neg	Out of scope (section 6.2.2.1.1).
2016	Environmental	Vessel Traffic Management System (VTMS) in Berkeley Sound would benefit everyone	3	Pos	Section 11.2; and Section 12.2.
2014 & 2015	Environmental	Introduction of non-native species and biosecurity issues	3	Neg	Section 10.12; and Section 10.13.
2014, 2015 & 2016	Social / Environmental	Noise pollution affecting sensitive receptors including humans	3	Neg	Section 10.2; Section 10.4; Section 10.5; and 11.9.
2014 & 2016	Social / Environmental	Conversion of Stanley Common and impacts on aesthetics, visual impact	3	Neg	Section 11.1; and SIA (section 6.2.3.2).
2014, 2015 & 2016	Social	Effects on the 'Falkland Islands way of life' including increased marginalisation of Camp, the potential for increased social disturbance, crime and prostitution	3	Neg	SIA (section 6.2.3.2).
2014	Political	Security issues related to the sovereignty dispute with Argentina	1	Neg	Out of scope (section 6.2.2.1.1).

[a] **Note:** 'number of mentions' refers to the number of times an issue was raised by a group of consultees, as opposed to the number of individuals who raised it.

[b] **Note:** denotes whether the majority of comments received on this topic were considered positive or negative.

7 ENVIRONMENTAL & SOCIAL BASELINE DESCRIPTION

Table of Contents

7.1 Introduction

Having identified the proposed Phase 1 Development activities (Chapter 5.0), it is necessary to understand the local environments in which Premier will be operating and to identify the main environmental and social sensitivities.

Understanding of the environmental baseline was achieved using desktop studies and literature reviews, collation of existing survey data and execution of additional and site-specific surveys where necessary, in line with:

- Corporate Premier Oil Standard: Environmental Baseline Data Gathering (CP-BA-PMO-HS-SE-ST-0003).

Given that the production and export of oil will be carried out offshore, and that all the Phase 1 Development activities will require support from the onshore, inshore (Berkeley Sound) and at-shore bases (Chapter 5.0), the following chapter describes the offshore, inshore and onshore environments. The limits of 'coastal' and 'inshore waters' are not specifically defined; however, in general 'coastal' is used to describe waters within three nautical miles (nm) of the coastline and 'inshore waters' describes a broader zone out to approximately the limit of the Territorial Sea around the Islands (i.e. 12 nm from the coastline). The chapter concludes with an overall summary of the key environmental and social sensitivities identified in the following baseline description.

This EIS is supported by a number of surveys and reports. These supporting documents can be requested from Premier at sealion.enviro@premier-oil.com .

Note: while some detail on Stanley Harbour is provided below, the full environmental baseline of Stanley Harbour is provided in the EIS previously submitted to support the construction of the Temporary Dock Facility (NEFL, 2013).

7.1.1 Falkland Islands location

The Falkland Islands are an archipelago in the South Atlantic Ocean that sit on the Patagonian Shelf and have a cold, windy and humid maritime climate. The Islands cover an area of 12,000 km^2 and comprise of East Falkland, West Falkland and 776 smaller islands. The principal islands are about 500 km east of South America's southern Patagonian coast, and lie between the latitudes of 52 - 53°S.

7.1.2 Sea Lion (offshore) licence location

The Sea Lion Field is located in the North Falkland Basin (NFB), approximately 220 km north of the Falkland Islands, 770 km northeast of Cape Horn and 480 km from the nearest point on the South American mainland (Figure 7.1:).

The Falkland Islands' Exclusive Economic Zone (EEZ) extends up to 200 nautical miles from the Islands, and comprises two fisheries conservation and management zones which were designated in 1986 and 1990, respectively (Figure 7.1:). These are:

- The Falkland Islands Interim Conservation and Management Zone (FICZ); and

- The Falklands Outer Conservation Zone (FOCZ).

Oil and gas exploration and production licences are granted within the Falkland Islands Designated Exploration Area, the limits of which are based on the EEZ. The Designated Exploration Area is subdivided into quadrants based on one degree of latitude by one degree of longitude (Figure 7.1:), each of which is subdivided into thirty blocks. The Sea Lion Field is located in Quadrant 14, within the northern boundary of the FICZ in Licence Blocks PL032 and PL004b (Figure 7.1:). The proposed Phase 1 development of the Sea Lion Field is located in Licence Block PL032.

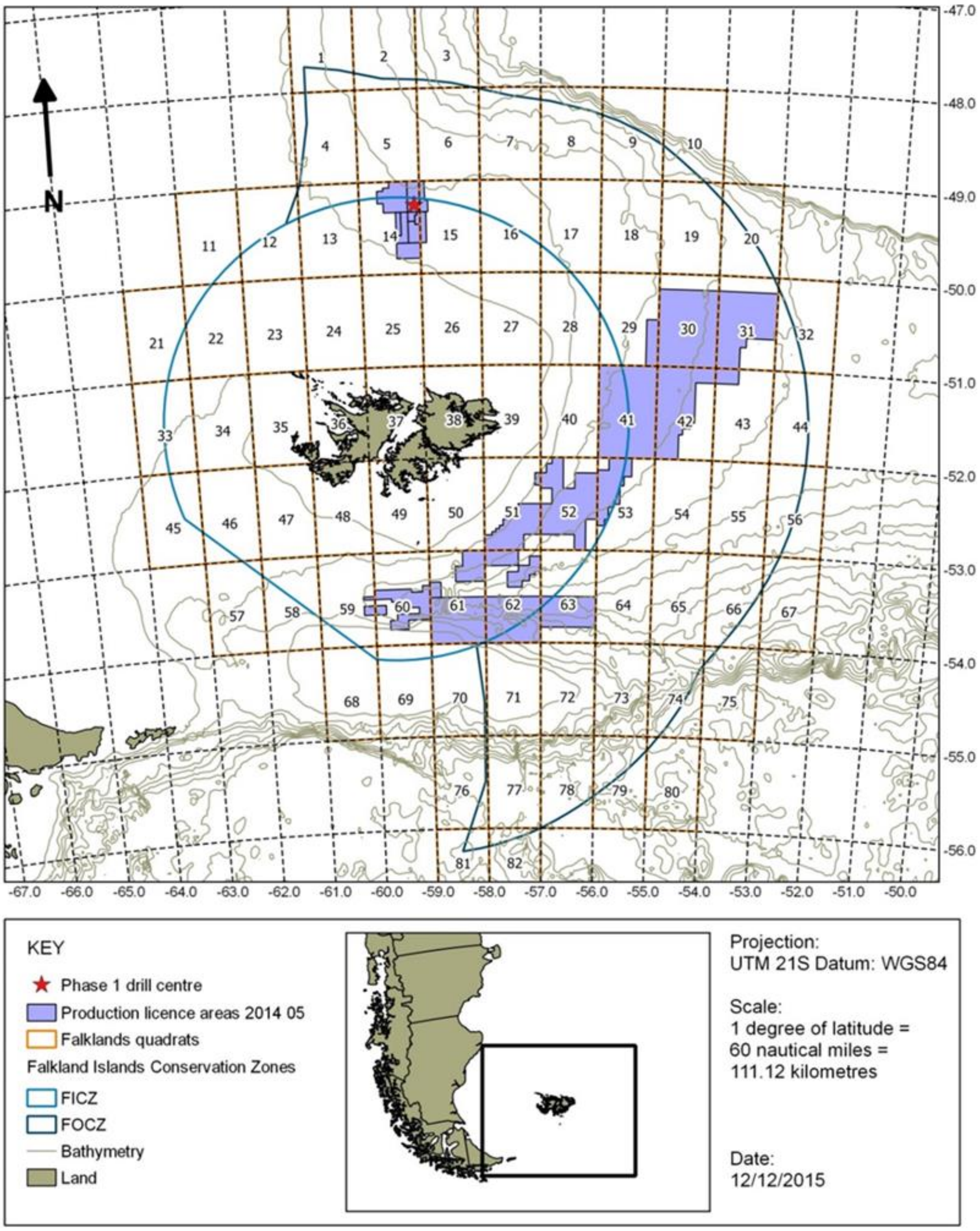


Figure 7.1: Phase 1 Development drill centre and Licence Block Locations

7.1.3 Location of Berkeley Sound in the Falkland Islands

The sheltered waters of Berkeley Sound have been chosen as the best option for a mobilisation area of LTV / HLV vessels during the construction phase of Phase 1 of the Sea Lion Field (section 4.3.2).

Berkeley Sound is a large east-facing bay in the northeast corner of East Falkland (Figure 7.2:) which is approximately 30 km long and 14 km wide at its mouth (Volunteer Point to Mengeary Point; Figure 7.3). The Sound has several smaller bays within it e.g. Port Louis Harbour and Johnson's Harbour, and contains islands such as Cochon and Kidney Islands (National Nature Reserve (NNR)), Hog Island and Long Island. Figure 7.3 provides a map of Berkeley Sound showing all the place names mentioned in this EIS. Due to differences in habitat type and species distribution it is convenient to refer to the 'inner' and 'outer' Sound, with Strike-off Point marking the boundary between the two (Figure 7.3).

Currently, Berkeley Sound's primary use is as a designated locality for the transhipment of fish and bunkering by the Falklands' fishing industry.

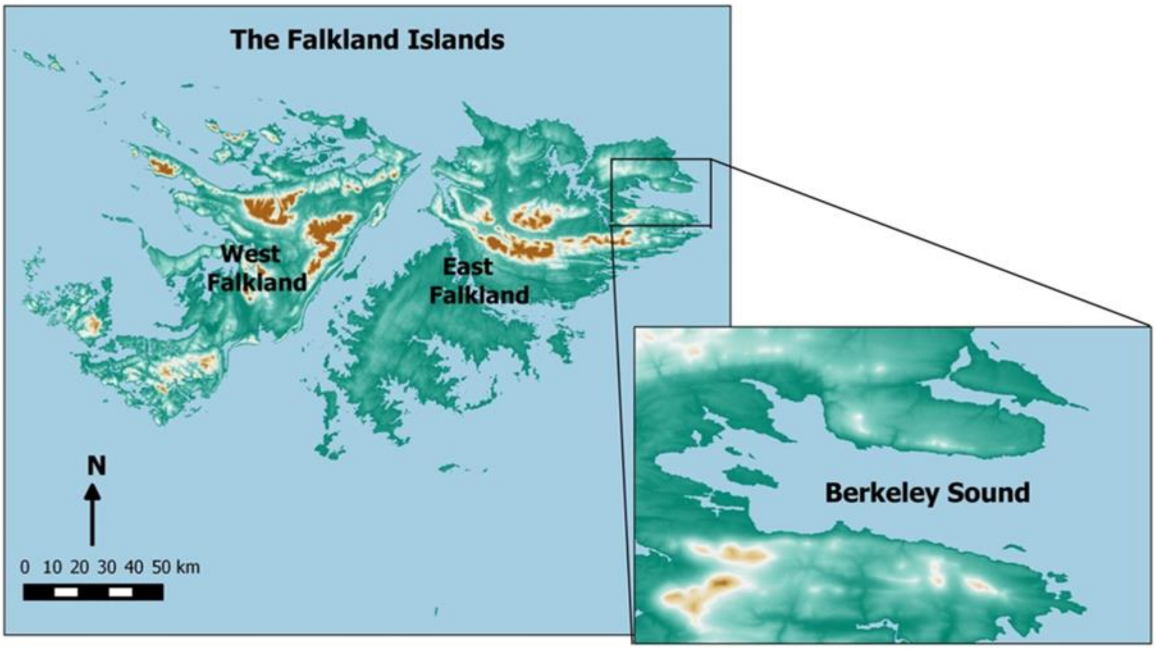
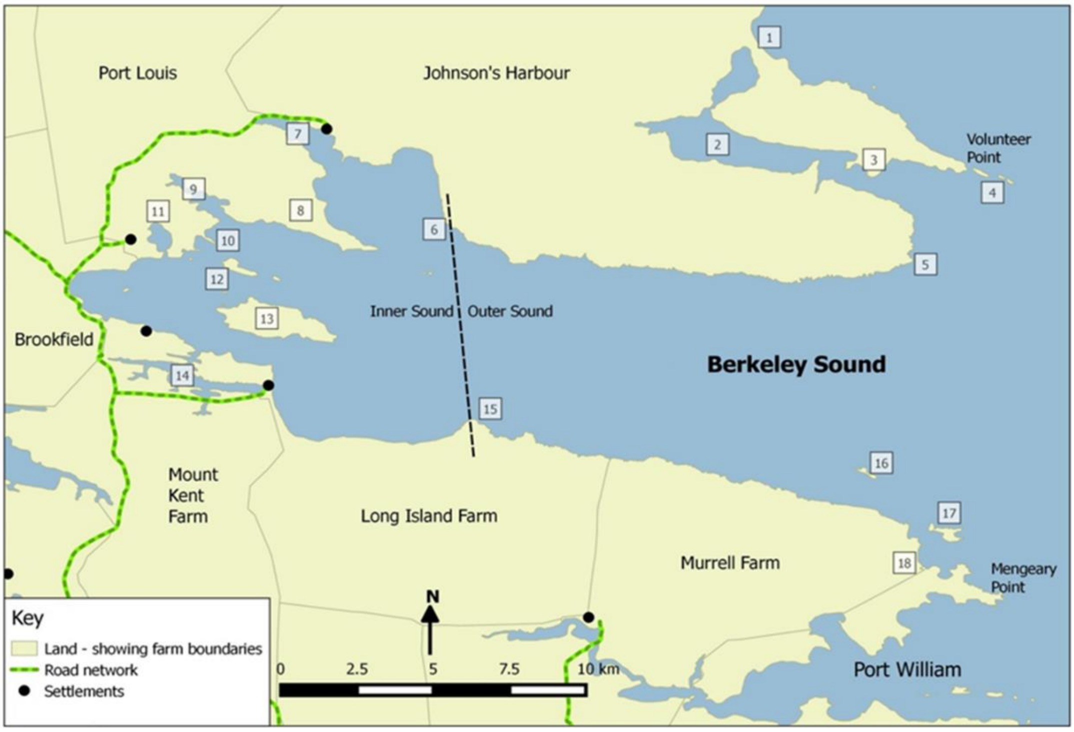


Figure 7.2: The location of Berkeley Sound within the Falkland Islands archipelago



1 Volunteer Beach	6 Lamarche Point	11 Port Louis	15 Strike-off Point
2 Volunteer Lagoon	7 Chabot Creek	12 Hog Island	16 Cochon
3 Lagoon Sands	8 Johnson's Rincon	13 Long Island	17 Kidney Island
4 Volunteer Rocks	9 Fish Creek	14 Duperrey Harbour	18 Kidney Cove
5 Eagle Point	10 Black Point		

Figure 7.3: The location of settlements and place names mentioned in the text within Berkeley Sound

7.2 Data Sources

7.2.1 Literature Sources

Literature reviews were carried out, where necessary, in order to inform understanding of the local environment. The information and data therefore come from a number of sources including scientific peer reviewed literature, scientific reports, grey literature, data provided directly by a number of organisations, and the Falkland Islands Marine Biodiversity Archive (FIMBAr), which collate information from recent surveys and historical sources (Davidson *et al.,* 2013). Where appropriate, personal observations (*pers. obs.*) and personal communications (*pers. comm.*) of learned individuals are referenced throughout the EIS.

To aid the decision-making process concerning the choice of the most appropriate inshore transfer site in particular, Premier commissioned the production of the report '*Environmental Assessment of Potential Inshore Transfer Sites*,' (Premier, 2015c). This document was one of the primary sources of information used to inform the environmental baseline of Berkeley Sound and surrounding areas described below. This inshore transfer concept is no longer valid, but Berkeley Sound will still be used as an area of mobilisation and support for the construction of Phase 1.

7.2.2 Sea Lion environmental surveys

Premier and its partner, Rockhopper Exploration, conducted an area-wide environmental baseline survey of the Sea Lion Field in 2012 to determine the physical, chemical and biological characteristics of the environment in support of future development of the area. In addition to the area-wide survey, specific well site surveys comprising 6-8 stations each were conducted for five historic well sites drilled in Quadrant 14 of the Sea Lion Field.

Several other environmental surveys have been conducted in the vicinity of the Sea Lion Field and further afield within Falklands waters, which provide background and contextual data for comparison with the Sea Lion area. Table 7.1 provides a summary of survey and drilling activities conducted in the Falkland Islands waters to date.

Figure 7.4 and Figure 7.5 show the location of the 2013 Sea Lion environmental baseline and post-drilling survey locations, and the majority of the other environmental survey sites within Falklands waters.

Table 7.1: Summary of Falkland Islands drilling and environmental survey activities

Year	Activity - Survey / Drilling	Region	Operator/Reference
1998	Environmental baseline survey – pre-drilling 'Little Blue' 14/09; 'B1' 14/05; Well 14/14, Well 14/23; 'Braela' 14/24, Well 14/19a; 'Minke' 14/13-B; 'Galapagos' 14/09.	NFB	FOSA[a], Gardline 1998a-h
1998	Drilling campaign – 6 wells	NFB	FOSA
1998	Post-drilling environmental survey – 1 well site 'Little Blue' (14/09)	NFB	FOSA, Gardline 1998h
2008	Regional environmental baseline survey – pre-drilling. SFB: Quadrants 61 and 62. Southern NFB: Quadrants 25 and 26.	SFB, southern NFB	Desire Petroleum Plc., Benthic Solutions, 2008a and b
2009	Environmental baseline survey four proposed well sites – EFB: Endeavour (31/13), Loligo (42/02), Nimrod (41/29), SFB: Toroa (61/05)	EPB, SFB	BHP Billiton, Fugro Survey 2009
2010-2011	Drilling campaign – 16 wells Drilling – 1 well	NFB FPB	Rockhopper, Desire BHP Billiton
2011	Environmental baseline surveys five proposed well sites – Hero (31/18), Inflexible (60/15), Loligo NW (42/02), Scotia East (31/13), Vinson West (53/16	EPB, SFB	FOGL, Gardline Survey 2011
2012	Drilling campaign 2 wells Drilling campaign 2 wells	SFB EPB	Borders and Southern FOGL
2012	Sea Lion Pre-development area wide survey, Sea Lion Post-drilling environmental survey – 5 historic well sites	NFB	Rockhopper, Gardline 2013 a and b

Year	Activity - Survey / Drilling	Region	Operator/Reference
2014	Coastal sensitivity to oil spill survey	NFB	Premier plc
2015	Drilling campaign 4 wells	NFB	Premier plc, MG3 2015
2015	Drilling campaign 1 well	EPB	Noble Energy Falklands Ltd
2016	Drilling campaign 1 well	NFB	Noble Energy Falklands Ltd

[a] Falklands Offshore Sharing Agreement

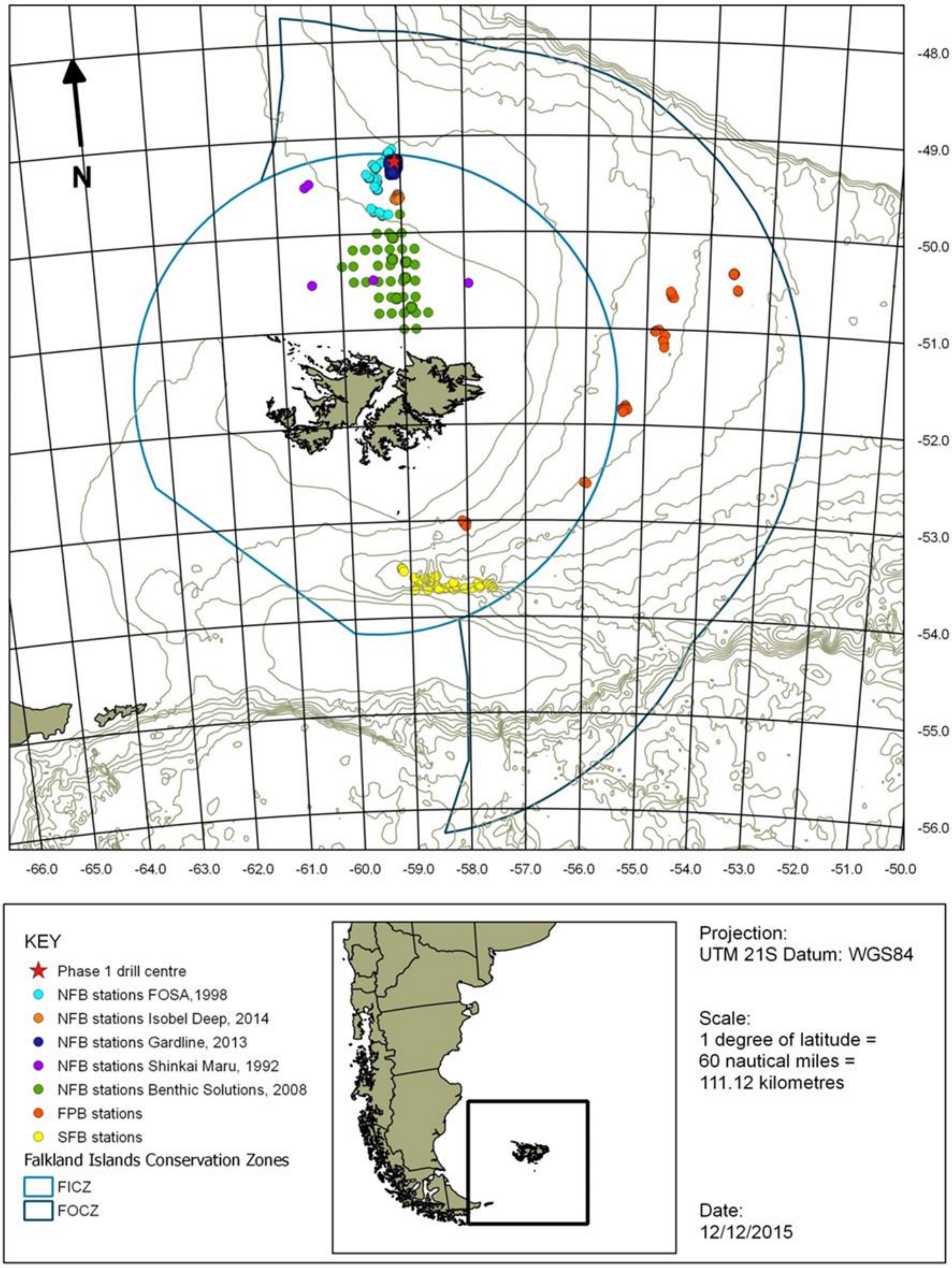


Figure 7.4: Summary of environmental survey locations on the Falklands Continental Shelf

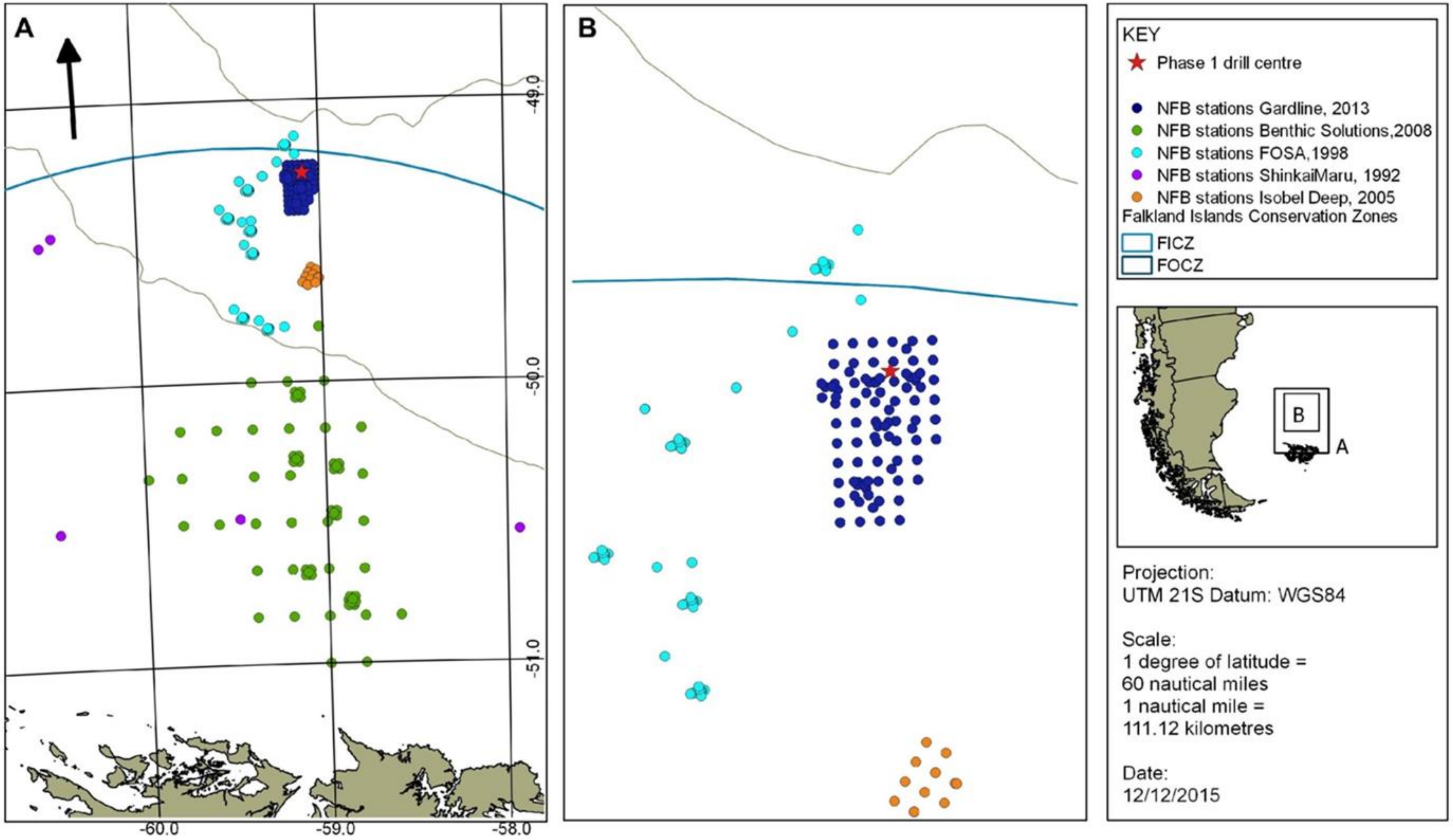


Figure 7.5: Environmental survey locations in the North Falkland Basin and vicinity of the Phase 1 Development drill centre

7.2.3 Berkeley Sound environmental surveys

Several environmental surveys have been conducted in the vicinity of Berkeley Sound (described in this document) which provide background and contextual data for comparison with the Berkeley Sound area. The following provides a summary of the surveys which are referred to throughout the baseline.

7.2.3.1 Shallow Marine Surveys Group (SMSG)

In the mid-1990s, inshore surveys were conducted around the Falkland Islands over a three month period and resulted in the production of '*The first shallow marine survey around the Falkland Islands*' (Tingley *et al.,* 1996). Although the first surveys of their kind in the Falklands, the study lacked a seasonal component and the identification of specimens was not always achieved to species level. In 2006, the Shallow Marine Surveys Group (SMSG) was established in the Falklands. The SMSG conduct regular dive surveys and have greatly advanced the understanding of the sub-tidal shallow water environment of the Islands (Neely *et al.,* 2010a; Neely, 2010). Combined, this data will go towards improving the classification of marine habitats around the Falkland Islands.

7.2.3.2 Marine Spatial Planning (MSP)

Currently, work is ongoing to produce a Falkland Islands Marine Spatial Plan (FIMSP). Following workshops in 2016, the main priorities for the MSP process in the Falkland Islands are:

To provide tools and protocols for streamlining the EIA process;

- To help manage shipping and boating;
- To facilitate emergency responses and safety protocols;
- To identify ecologically important areas; and
- To prevent introduction of marine invasive species (biosecurity).

This work is ongoing but has already facilitated the collation of many disparate sources of information, which can be analysed and displayed using Geographic Information System software. This information will be a valuable tool for future management of activities in the marine environment.

7.2.3.3 Premier commissioned environmental surveys

7.2.3.3.1 Habitat assessments of Berkeley Sound

In 2014, Premier commissioned the South Atlantic Environmental Research Institute (SAERI), along with Environment Systems (EnvSys), to conduct habitat assessments of three potential inshore transfer sites (including Berkeley Sound) on the east coast of East Falkland (Premier, 2015c). This included an assessment of the sensitivity of the coastline, which utilised satellite imagery.

7.2.3.3.2 Geophysical and environmental surveys

In 2015, Premier commissioned Benthic Solutions Ltd. (BSL) to conduct an environmental baseline survey of Berkeley Sound. The survey strategy included geophysical and environmental surveys and aimed to determine the geophysical characteristics, sediment chemistry, infaunal communities and macro-faunal assemblages (through sonar, grab and drop down camera surveys) (BSL, 2015a; 2015b & 2015c).

The survey was carried out between June and August 2015 aboard the Premier chartered vessel, *Afon Alaw*. Further details can be found in:

- BSL, 2015a: Geophysical and Environmental Programme Berkeley Sound; 1506 Volume 3: Geophysical survey;
- BSL, 2015b: Geophysical and Environmental Programme Berkeley Sound; 1506 Volume 4: Habitat Assessment Report; and
- BSL, 2015c: Geophysical and Environmental Programme Berkeley Sound; 1506 Volume 5: Environmental Baseline Survey Report.

In 2016, SAERI were commissioned by Premier to complete the baseline survey programme and worked with the SMSG and EnvSys to map the shallow marine, intertidal and terrestrial habitats found within Berkeley Sound.

7.2.3.3.3 Coastal bird survey

Premier commissioned SAERI to conduct a series of four seasonal coastal bird surveys in and around Berkeley Sound, which were carried out between February 2016 to May 2019. In the course of these surveys, the opportunity was taken to develop an initial shoreline classification index specific to the Falkland Islands for use in oil spill planning.

7.2.3.4 Third party surveys

Numerous surveys carried out by other parties are used as data sources to inform the assessment of the environmental baseline. These include, for example, those carried out by the Joint Nature Conservation Committee, Falklands Conservation, SMSG, SAERI and dedicated surveys carried out by other Oil and Gas (O&G) operators. These are described, as necessary, in the relevant sections below.

7.2.4 Data gaps

The Falkland Islands Offshore Hydrocarbons Environmental Forum (FIOHEF) was established in 2011 to facilitate discussion of environmental issues relating to current and future hydrocarbon activities in the Falkland Islands. FIOHEF established a subcommittee, the Gap Analyses Group, to examine the data gaps that needed to be addressed in order to better inform and monitor the potential environmental impacts from offshore hydrocarbon activities operating in the Falkland Islands.

Data gaps were identified and prioritised according to the urgency with which it was perceived that the data was required. Gaps of most relevance to the development include:

- Offshore benthic ecosystems with regard to collation of data, infauna sampling, sedimentology and chemistry;
- Oceanography in relation to oil spill modelling with regard to hydrographic dynamics, temporal and water column dynamics;

- Seabirds with regard to priority species and temporal movements; and
- Marine mammal (pinnipeds and cetaceans) with regard to populations and breeding activity, spatial and temporal distributions (described further in section 7.2.4.2).

Much of the data will take a number of years to collect and assimilate, and this is ongoing. There has however, been significant progress in many areas, e.g. oceanography, offshore benthos and marine mammal distribution. In this EIS, best available data has been used for the assessments including outputs from the GAP Project and parallel studies related to its recommendations.

7.2.4.1 Key data gaps relevant to the Sea Lion EIA

The GAP project is complete with most results available and it is considered necessary to acknowledge the outstanding and project-specific data gaps that have been identified during the Sea Lion EIA process.

The key data gaps of relevance to the Sea Lion EIA are:

- General
  - Predicting the likelihood of introducing invasive species;
  - Auditory sensitivity of penguins and marine mammals;
  - Quantifying the impact of bird strikes;
  - Impact of long-term noise and actual noise outputs from the operations;
- Offshore environment (NFB and Sea Lion Field):
  - Inter-annual distribution and abundance of marine mammals in the NFB;
  - Benthic habitats and fauna at the Sea Lion drill centre and flowline locations specifically;
- Inshore environment (Berkeley Sound):
  - Location(s) of loligo spawning grounds;
  - Inter-annual distribution and abundance of marine mammals.

7.2.4.2 Gap Analyses Programme

The remit of the Falkland Islands Oil and Hydrocarbons Environmental Forum (FIOHEF) Gap Analyses Group was to examine the data gaps that need to be filled in order to better inform and monitor the potential impacts to the environment from offshore hydrocarbon activities in the Falkland Islands. As a result, the Gap Analyses Programme (GAP) was established by the FIOHEF and led by the Director of SAERI. GAP was supported by two project officers, one of whom co-ordinated the seabird and marine mammal aspects of the work and the other the review, consolidation and curation of oceanic, benthic, inshore and fisheries related data. International researchers were, and continue to be, engaged in this process through workshops and collaborative peer review so the work has international standing and transparency.

7.2.4.2.1 Seabird and marine mammal telemetry

Data gaps were identified for each of the issues of concern and prioritised according to the urgency with which data are required. These data will ultimately be used to inform robust environmental impact and risk assessments for proposed operations associated with the Oil &

Gas (O&G) industry. Data collection and analyses are now complete as set out by GAPII objectives. However, it will take further analysis to determine how the results of this work can best be used to quantitatively assess the potential impact of the O&G industry in the Falkland Islands. Examples include quantitative assessments of the overlap of higher predator distribution and oil spill fate modelling for example. So, in the short-term, and until further data analysis are available, existing data will be collated and used to perform simple qualitative assessments through expert-led processes.

At the time of compiling this Environmental Baseline Description, initial analysis of data collected by the GAP project has been published (Baylis *et al*., 2019); and the results from this work are described in section 7.4.5.2.1.4 and incorporated into the species accounts in section 7.4.5.2.2.

7.2.4.2.2 Consolidation and curation of existing data

The hydrocarbons industry and other organisations have collected large amounts of information over the last twenty years whilst operating in the Falkland Islands, including data from oceanographic, metocean, seismic, benthic ecology, benthic environmental, multi-beam and Remotely Operated Vehicle (ROV) surveys. Much of these data are held at different locations and the fate / location of some remains unknown. One of the objectives of the GAP project were to create and manage a centralised data repository to hold, manage and curate environmental data collected by the Hydrocarbons Industry and other organisations in the Falkland Islands. Collation of all of the relevant environmental data in the IMS-GIS Data Centre has and will continue to:

- Provide wide spatial and temporal coverage for future EIAs;
- Avoid duplication of work effort;
- Increase the likelihood that these data will be used for future research activities and initiatives that could complement and enhance future EIAs; and
- Increase environmental knowledge of the Falkland Islands continental shelf and slope.

7.3 Physical environment

The following sections provide data on the physical environment within which the Phase 1 Development is to be carried out which will be used to inform the impact and risk assessments in Chapters 10.0, 11.0 and 12.0.

7.3.1 Global Atmosphere

7.3.1.1 Atmospheric structure

Earth's atmosphere is ultimately very thin when compared to the size of the earth and is the equivalent in thickness to a piece of paper laid over a beach ball. Nonetheless, it is responsible for keeping Earth habitable and for producing weather (NCSU, 2013).

The atmosphere is divided into five main layers, becoming thinner in each consecutive layer until the gases dissipate in space. While there is no distinct boundary between the atmosphere and space, an imaginary line about 110 km from the surface, called the Karman line, is generally accepted to be the point at which the atmosphere meets outer space (Sharp, 2012). Of the five atmospheric layers, (Sharp, 2012), the two lowest layers are of relevance to this EIA:

The **troposphere** is the layer closest to Earth's surface. It is approximately 7 - 20 km in height and contains half of Earth's atmosphere (Figure 7.6); and

The **stratosphere** starts above the troposphere and ends about 50 km above ground level. Ozone is abundant here and the 'ozone Layer' is pivotal in heating the atmosphere while also absorbing harmful radiation from the sun (Figure 7.6).

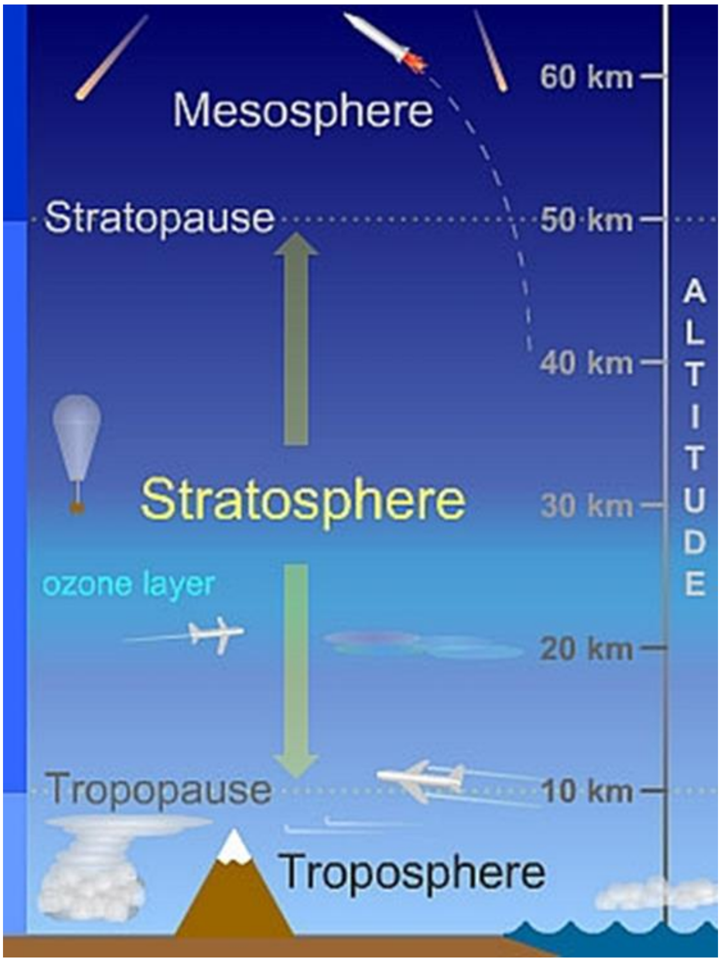


Figure 7.6: Atmospheric structure (Source: Randy Russell, UCAR)

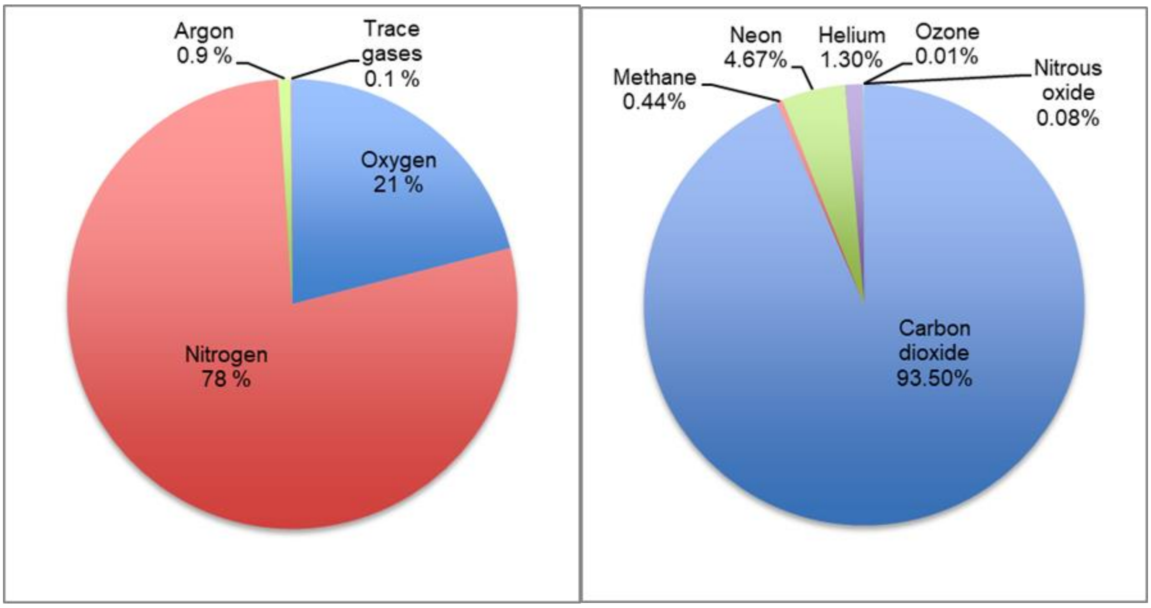
7.3.1.2 Atmospheric composition

The atmosphere contains many gases, most of which are in small amounts and water vapour. The permanent gases whose percentage contributions do not change from day to day are nitrogen, oxygen and argon. Nitrogen accounts for 78 % of the atmosphere, oxygen 21 % and argon 0.9 % (Figure 7.7). Trace gases account for about a tenth of one percent of the atmosphere, which includes; carbon dioxide, nitrous oxides, methane, and ozone collectively termed Greenhouse Gases (GHG) and the inert gases neon and helium (Figure 7.7).

GHGs have physical and chemical properties which make them interact with solar radiation and the heat given off from the Earth to affect the energy balance of the globe (NCSU, 2013). The

Earth's long-term, globally-averaged equilibrium temperature depends on the balance between the level of incoming solar energy from the sun, and the outgoing radiated heat which has been reflected or emitted from the Earth's atmosphere and the surface of the Earth. Of all the atmospheric gases, the trace GHGs have sufficient thermal absorption to capture energy from the sun and effectively trap heat within the Earth's atmosphere by a natural process known as the 'greenhouse effect'.

The percentage contribution of GHGs varies daily, seasonally and annually however, and is directly impacted by anthropogenic GHG emissions.



a) Global atmosphere b) Trace gases (as a percentage of the 0.1 %)

Figure 7.7: Atmospheric composition (adapted from: https://climate.ncsu.edu/edu/k12/.AtmComposition)

7.3.2 Meteorology of the Falklands

7.3.2.1 General conditions in the Falkland Islands

7.3.2.1.1 Wind speed

The oceanic climate of the Falkland Islands is temperate, with predominantly westerly winds (RPS Energy, 2009; Anatec, 2013). In general, the weather in the NFB is much less extreme than the area south of 50°S, with less frequent storms and squalls (RPS Energy, 2009).

7.3.2.1.2 Temperature

The Falkland Islands have a cold temperate climate with a mean annual temperature of 5.6 °C in Stanley. The range of mean temperatures does not vary substantially over the course of the year, with a summer mean of 9 °C and 2 °C in the winter, however, variability of the air temperature over the sea is always much less extreme than over land.

7.3.2.1.3 Precipitation

The mean annual rainfall in Stanley is approximately 650 mm. Given the rainfall patterns on the Islands, it is expected that the mean annual rainfall within the NFB will be less than 650 mm. Snow falls, on average, 11 days of each year, with the highest frequency occurring in August.

7.3.2.1.4 Visibility

Dense fog, reducing visibility to less than 1 km is likely to occur for approximately 5 % of the year within the vicinity of the Sea Lion Field (Anatec, 2013).

7.3.2.2 Inshore (east coast) Metocean conditions

Understanding the meteorology of the east coast of the Falkland Islands, and Berkeley Sound in particular, is highly important as the weather conditions throughout the year may have an impact on inshore activities; such as the operation of small support vessels. This impact may be from extreme winds or reduced visibility during foggy conditions. There is little meteorological data that specifically relates to Berkeley Sound; however, Premier has established a weather station at Long Island farm and a wave buoy was deployed in the Sound. At the time of writing, the wave buoy was lost and no data could be recovered and meteorological data is not available from the terrestrial station (records began in February 2017) and therefore the data is not presented here.

Weather data has been collected elsewhere on East Falkland for a number of years and is summarised below as a proxy for the conditions experienced in Berkeley Sound. The nearest source of weather statistics is Mount Pleasant International Airport (MPN) which is approximately 50 km southwest of Berkeley Sound. Metocean studies for the Sea Lion Field compared measured wind data from MPN, Pebble Island and Stanley Airport. These measured datasets were also compared with output from the regional model covering the Sea Lion location (Climate Forecast System Re-analysis data) and a higher resolution model covering the land and inshore area of the Falkland Islands (Weather Research and Forecasting). Measured wind data available from two MODUs (Borgny Dolphin for 1998 and Eirik Raude for short periods in 2015 and 2016) were also used. Comparisons of the various datasets (measured and modelled) showed good correlation in wind climate and offshore the model is considered to be reasonably representative of offshore conditions. Comparison of the various data sets is described in further detail in the Environmental Modelling Report (Premier, 2017d).

No site specific measured data is available for Berkeley Sound, although an Automatic Weather Station and Directional Waverider wave buoy were positioned within Berkeley Sound. An analysis of the wave measurements for the period July 2016 to January 2107 indicate that conditions within Berkeley Sound are more benign than the equivalent monthly averages based on modelled data alone, although further data is required to substantiate this. The results will be used to compare measured and modelled datasets as soon as practicable.

Two-dimensional gridded atmospheric data, including wind speed and direction, are also available from sources such as the Climate Forecast System Reanalysis project and the European Climate Model.

The following sections describe the wind speed and direction, air temperature and precipitation recorded at MPN over the period 1999 to 2012.

7.3.2.2.1 Wind speed and direction recorded at MPN

As is shown in Figure 7.8, over the course of the year, typical wind speeds vary from 2 m/s to 14 m/s (light breeze to strong breeze) and exceed 18 m/s (gale) rarely (1.16% of the time annually).

The *highest* average wind speed of 9 m/s (fresh breeze) occurs around October 22, at which time the daily maximum wind speed is 14 m/s (strong breeze) (Figure 7.8).

The *lowest* average wind speed of 7 m/s (moderate breeze) occurs around July 18, at which time the daily maximum wind speed is 11 m/s (fresh breeze) (Figure 7.8).

As is shown in Figure 7.9, the westerly winds are most common (36 % of the time) followed by north winds (17 % of the time), north-westerly winds (16 % of the time) and then south-westerly winds (12 % of the time). Southeasterly winds are the least common, occurring only 2 % of the time (Figure 7.9).

Overall, westerly winds are the most likely to occur on the east coast of the Falkland Islands (Figure 7.10).

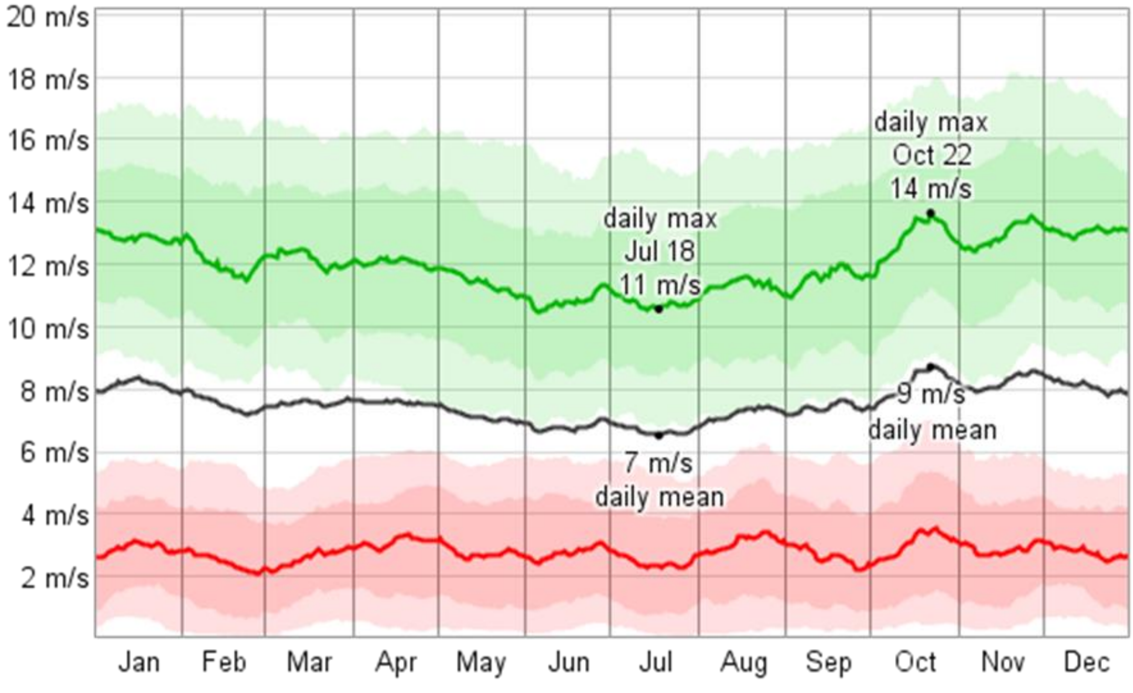


Figure 7.8: Mean, minimum and maximum daily wind speeds recorded at MPN throughout the year, 1 m/s = 1.94 knots (Source: Weatherspark, 2016)

Wind direction at MPN summarised over the entire year. Note: This figure indicates the percentage of time spent with the wind blowing from the various directions over the entire year. The values do not sum to 100% because the wind direction is undefined when the wind speed is zero. (Source: Weatherspark, 2016)

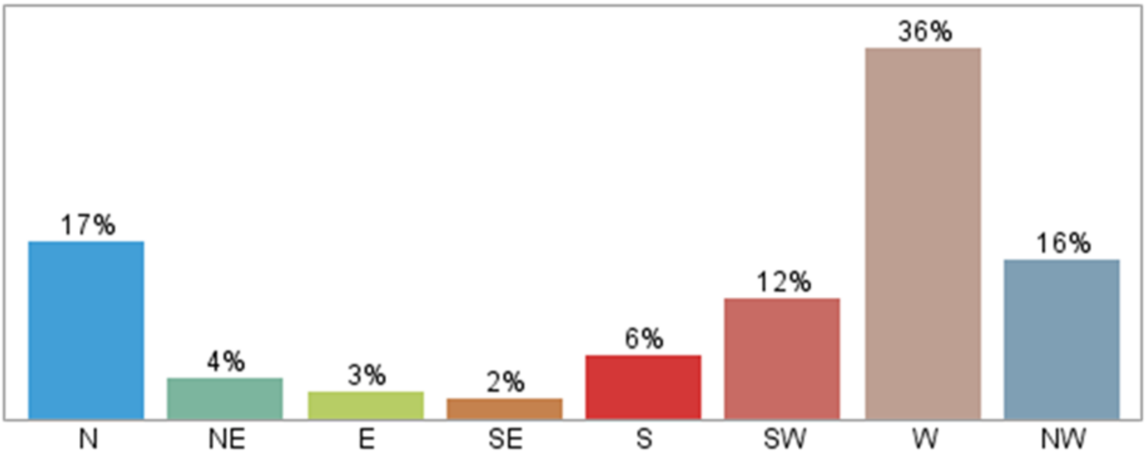


Figure 7.9: Wind direction at MPN summarised over the entire year. **Note**: This figure indicates the percentage of time spent with the wind blowing from the various directions over the entire year. The values do not sum to 100% because the wind direction is undefined when the wind speed is zero. (Source: Weatherspark, 2016)

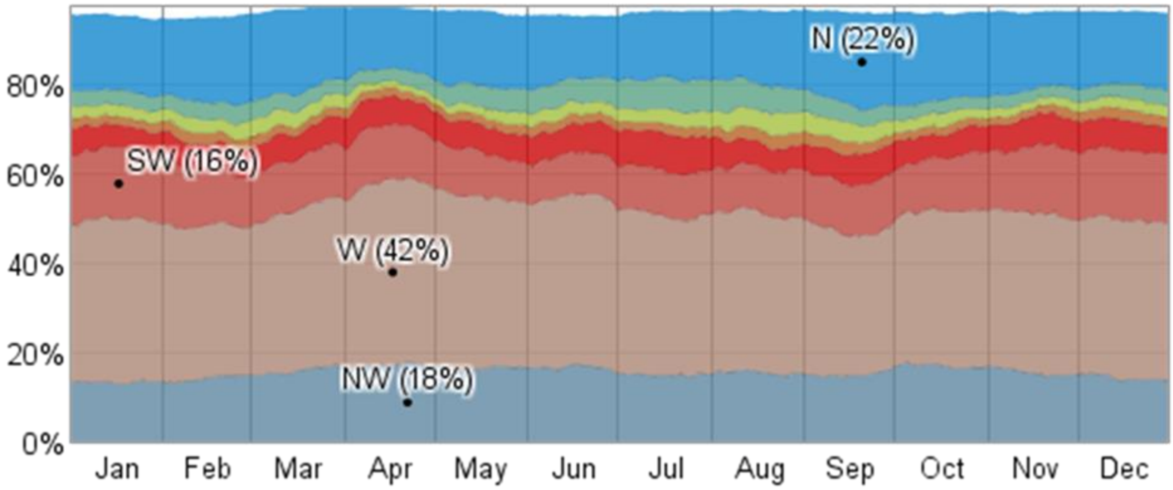


Figure 7.10: Daily probability of wind from each octant at MPN (see Figure 7.9 for colour coding) throughout the year (Source: Weatherspark, 2016)

7.3.2.2.2 Temperature recorded at MPN

As is shown in Figure 7.11, over the course of a year, the temperature typically varies from 0°C to 15°C and is rarely below -3°C or above 20°C.

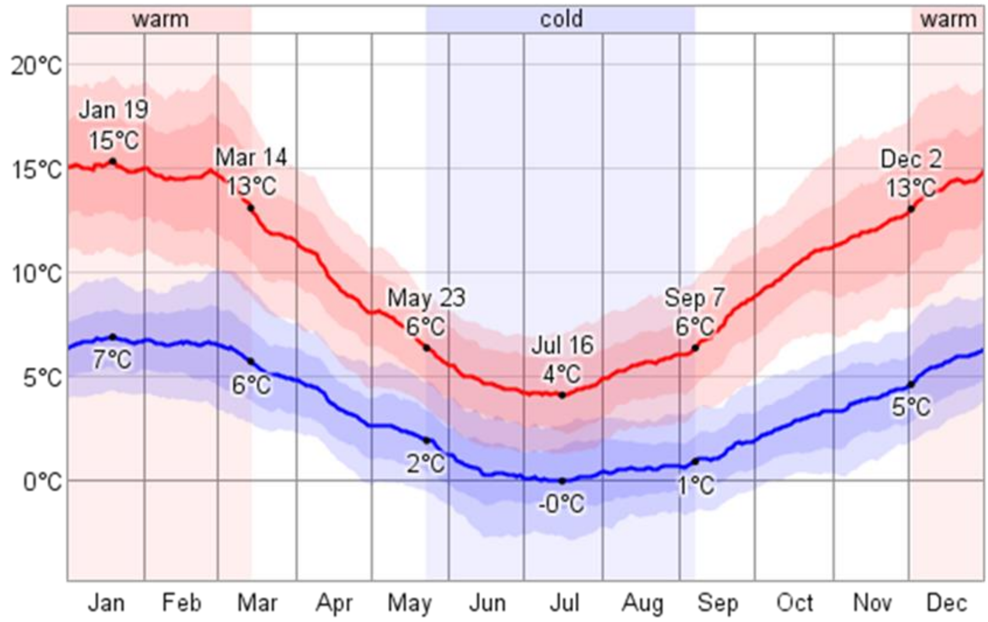


Figure 7.11: Mean daily minimum and maximum air temperatures recorded at MPN throughout the year at MPN (Source: Weatherspark, 2016)

7.3.2.2.3 Precipitation recorded at MPN

As is shown in Figure 7.12, the probability that precipitation will be observed at MPN varies throughout the year. Precipitation is most likely in June which has an 86 % likelihood of rain. Precipitation is least likely in October which has a, 66 % likelihood of rain.

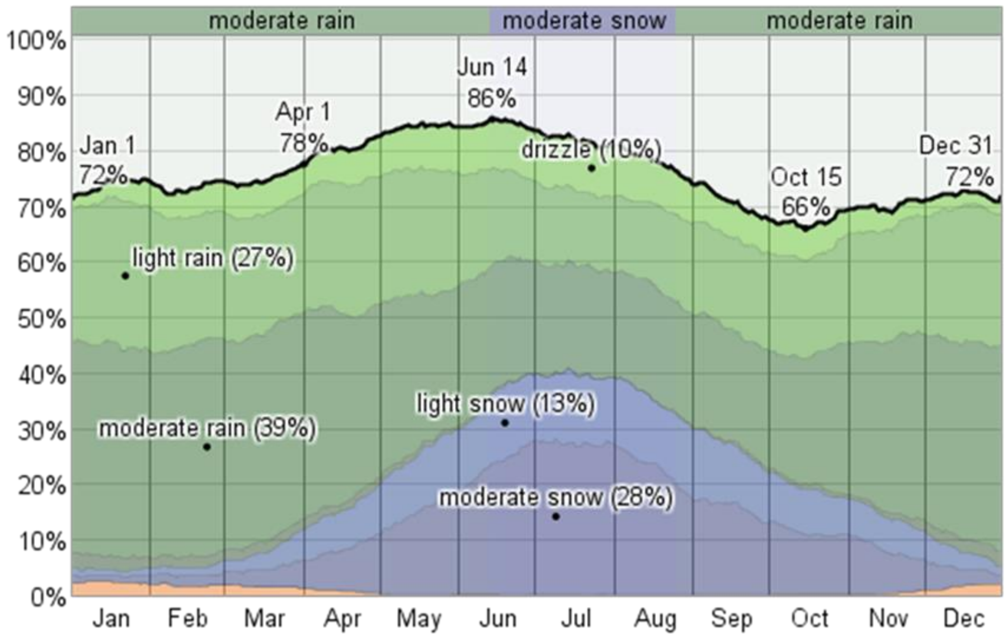


Figure 7.12: Daily likelihood of precipitation throughout the year recorded at MPN *(Source: Weatherspark, 2016)*

7.3.3 Oceanography of the region

It is essential to understand the behaviour of the oceanographic features of the southwest Atlantic owing to their influence on the potential impacts of anthropogenic inputs e.g. how discharges will behave, and also because the biological productivity of the area is a primary factor in the distribution and abundance of all the biological receptors considered hereafter. The following provides a summary of the key oceanographic features on the Patagonian shelf, which influences the NFB which then influences the Sea Lion Field.

7.3.3.1 Main oceanographic features on the Patagonian Shelf

The Patagonian Shelf is one of the most productive areas in the South Atlantic. Two marine ecosystems, the southern temperate ecosystem and sub-Antarctic ecosystem are separated by a transition zone running from the south-west to the north-east of the Patagonian Shelf through the Falkland Islands archipelago (Boltovskoy, 2000).

The productivity of the Patagonian Shelf is enhanced by the existence of several year-round tidal mixing fronts and seasonal fronts originating from cold freshwater inflows from the Strait of Magellan (Belkin *et al.,* 2009; Alemany *et al.,* 2009). On the eastern flank, the Patagonian Shelf edge is framed by the Falkland / Malvinas Current Front (FMCF, Belkin *et al.,* 2009), which runs along the continental slope from 55ºS to 37ºS and comprises multiple smaller fronts running parallel to the shelf break (Franco *et al.,* 2008). The main oceanographic feature of this front is the cold Falkland Current, which originates from the Antarctic Circumpolar Current (ACC) in the Drake Passage and flows northwards (Peterson and Whitworth, 1989). The ACC reaches the continental slope to the south of the Falklands and splits into two main northward-flowing branches (Figure 7.13), the western branch being the weaker of the two (Bianchi *et al.,* 1982). The upper 300 m water column in the Falkland Current consists of the Sub-Antarctic Surface Water mass (SASW) with deeper layers occupied by the Antarctic Intermediate Water mass (AIW) (Peterson and Whitworth, 1989).

7.3.3.2 Oceanographic features on the Falkland Islands Shelf

A number of oceanographic fronts exist around the Falkland Islands continental shelf. Primarily these are found in areas to the south and east of the Falkland Islands although, to date, a number of fronts have also been identified on the northern shelf. In particular, four frontal areas have been identified in the southern part of the FMCF (between 54°S and 48°S), all with well-resolved temperature and salinity gradients (Arkhipkin *et al.,* 2013), interspersed by areas characterised by relatively smooth gradients (non-frontal zones).

As shown in Figure 7.13, the four main fronts are the:

- Southern Front (SF);
- North Eastern Front (NEF);
- Western Offshore Front (WOF); and
- Western Inshore Front (WIF).

The Southern Front is located to the south of the Falkland Islands near Beauchêne Island where the Falkland Current meets the continental slope. It causes a strong upwelling of SASW that mixes with the Shelf water mass forming the Transition Zone (TZ) at depths of between 120-300 m (Zyryanov and Severov, 1979; Arkhipkin *et al*., 2004a). This front forms one of the most productive areas in Falkland waters and is utilised by squid and fish as a major feeding and spawning ground (Arkhipkin *et al*., 2004a; Arkhipkin *et al*., 2003, Arkhipkin *et al*., 2010). The location of the TZ on the shelf fluctuates both seasonally and inter-annually due to the variation in the intensity and position of the Falkland Current, which in turn influences the distribution of the commercially important loligo squid (Doryteuthis gahi), (Arkhipkin *et al*., 2004b).

The SF and the NEF appear when the eastern branch of the Falkland Current meanders onto the shelf and mixes with Falkland Shelf waters. However, there is no major counter current in the region, unlike the northern part of FMCF, where the Falkland Current meets with the warmer Brazil Current, creating multiple parallel counter flows along the shelf break (Acha *et al*., 2004; Belkin *et al*., 2009).

The WOF and the WIF represent the areas of mixing of the western branch of the Falkland Current with Patagonian Shelf waters and Falkland Shelf waters and the TZ respectively.

The northern part of the FMCF (37-38°S) shifts seasonally, offshore in the austral summer and inshore in spring and autumn (Carreto *et al*., 1995). Similar shifts of at least two fronts (WOF and NEF) have been observed in the southern part of FMCF (Arkhipkin *et al*., 2013). The offshore shifts of these fronts are thought to be a result of seasonal offshore movements of shelf waters. WIF and SF are quasi-stationary throughout the year. The mixing of shelf waters with SASW waters on the western side of the Falkland Current creates a band of increased primary productivity, indicated by higher concentrations of chlorophyll-a (chl-a) especially in spring and summer. This is known as the Patagonia High Chlorophyll Band (PHCB). The distribution of chlorophyll-a in PHCB is patchy and depends on seasonal variability in upwelling intensity along the FMCF (Romero *et al*., 2006).

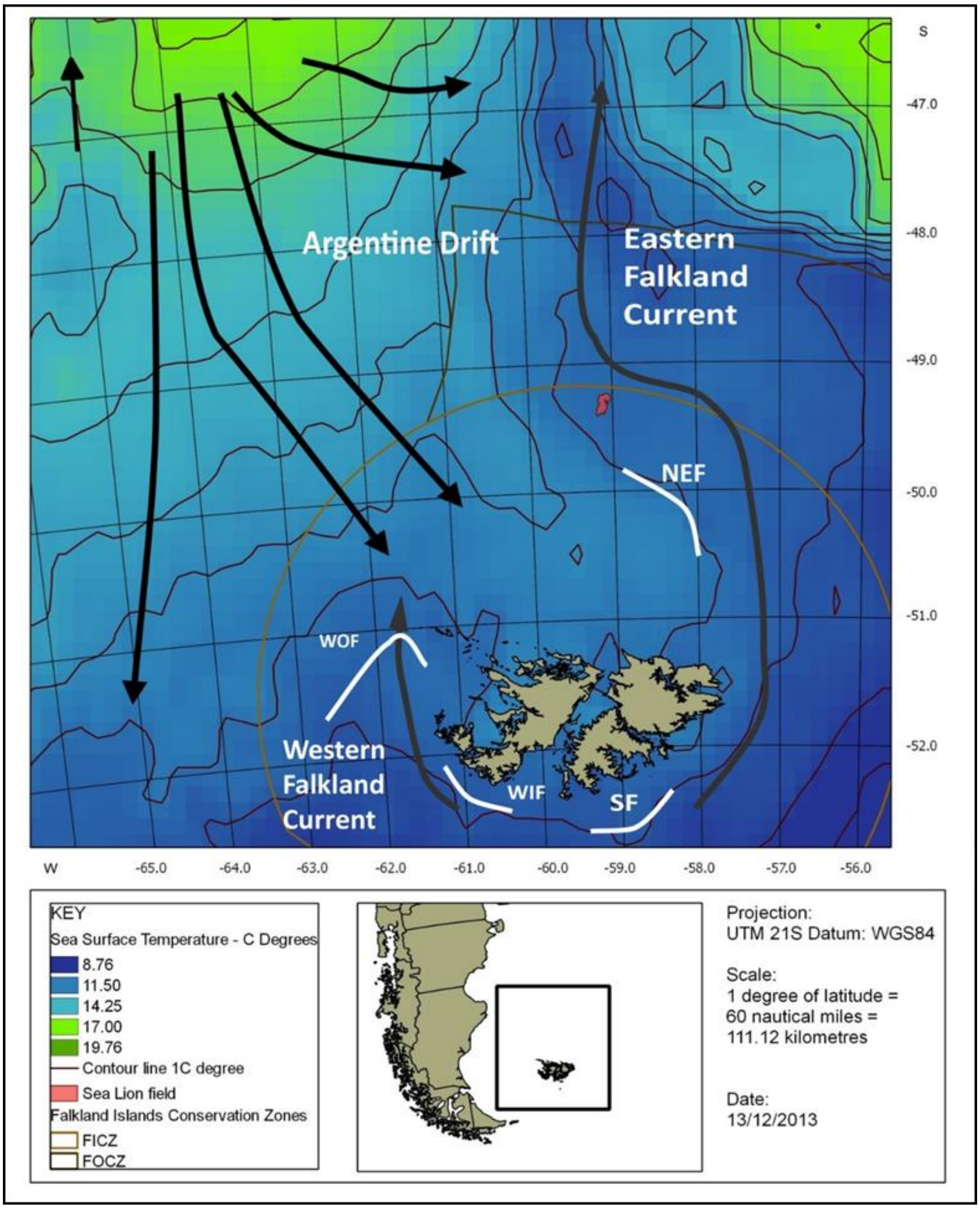


Figure 7.13: Main Patagonian Shelf oceanographic features overlain on Sea Surface Temperature map, March 2008 (WOF = Western Offshore Front; WIF = Western Inshore Front; SF = Southern Front; NEF = North Eastern Front. Adapted from Arkhipkin *et al*. (2013))

7.3.3.3 Oceanographic features in the region of the Sea Lion Field

The Sea Lion Field is located within the near shore area of the Northern Slope (NS) which marks a transition zone between Patagonian Shelf waters and the superficial SASW mass of the Falkland Current.

The currents in the Sea Lion Field predominantly move in northerly and north-westerly directions, with the current speed generally being less than 15 cm/s. At the sea bed the currents tend to move in westerly directions with the current speed typically being less than 10 cm/s.

There is only slight seasonal variation in water temperature and salinity. Surface temperatures range from 5-9°C though the year with maximum temperatures observed in April and May.

Surface salinity ranges from 34.06–34.11 practical salinity units (psu). The offshore and deeper part of the NS is covered by the SASW mass (section 7.3.3.1) and shows little variation in near-bottom temperature and salinity which range from 4.1-4.3°C and 34.1–34.2 psu respectively (Arkhipkin *et al.,* 2012a).

During a one month environmental baseline survey of the PL032 Licence Block in March and April 2012, water column characteristics were measured using 47 deployments of a CTD (conductivity, temperature, and depth) probe (Gardline, 2013a).

Vertical profiles for temperature, salinity and dissolved oxygen from the 47 CTD deployments were interpolated across horizontal depth horizons at 400 m, 200 m, and 10 m. Temperature and salinity were used to identify the main water masses and their derivatives (Bianchi *et al.,* 1982; Peterson and Whitworth, 1989). Water column dynamics and the dynamics of water masses in the area can change over time so the following is an illustration of the general water mass pattern in the area.

The CTD data reveal a well-mixed surface layer to a depth of c. 40 m. Below 40 m, a distinct thermocline was observed to approximately 80 m, below which temperature decreased gradually to the seabed. Temperature, dissolved oxygen and pH all decreased with depth. Turbidity was slightly higher in the mixed surface layer than the body of water immediately below the thermocline (Gardline, 2013a).

7.3.3.4 Oceanography of Berkeley Sound

Eight water quality profiles were completed within the Berkeley Sound survey area using a multi-profiler; four of which were at the beginning of the survey, and a further four in the same locations at the end of the sampling programme, with a temporal separation of approximately two months. The four water quality stations were positioned along an east-west transect along the centre of the Sound, and were spaced approximately 6.5 km apart (see Figure 46 and Figure 47 below). The multiprofiler, a YSI 6600 V2 model, included sensors to determine temperature, salinity, dissolved oxygen, pH and turbidity.

In addition to the above, an RBRconcerto CTD was deployed affixed to the camera frame at a total of 50 environmental sampling stations to identify the structure of the water column throughout the Sound. A detailed record of a temperature time-series was recorded on a tide gauge (RBR03); this was used to verify temporal changes and observations from the profiling instruments. This device was moored for the duration of the survey in the centre of Berkeley Sound at a depth of approximately 15 m.

Analysis of the water quality profiles taken between the beginning and end of the survey suggest that spatially this body of water is generally well mixed with very little vertical variation with depth. There is a distinct increase of freshwater influence in the west of the Sound however, owing to the proportional increase in surrounding land-mass to residual volume of water. A surface temperature of 9 - 10.5°C and a bottom temperature of 7 - 8°C is indicated by two FIG CTD casts. A seabed pressure recorder deployed during the Premier Oil 2015 survey, between 21st June and 19th August ranged from 3.3°C to 5.2°C. To date the wave buoy has recorded a minimum surface temperature of 4.1°C on 21st August 2016 and a maximum temperature of 12.4°C on 18th February 2017.

Dissolved oxygen showed little variation between the two time periods of CTD sampling, however consistently showed the same trend of decreasing oxygen concentration with depth. The dissolved oxygen concentrations were considered reasonably high, likely owing to the cold water temperature and high energy mixing through wave energy as well as tidal and wind driven systems. During the winter period when the survey was undertaken, phytoplanktonic primary production is expected to be very low, however oxygen may still enter this marine environment through macroalagae such as the *Lessonia* spp. and *Macrocystis pyrifera* kelp forests present within Berkeley Sound.

7.3.4 Bathymetry

7.3.4.1 NFB and the Sea Lion Field (offshore) bathymetry

The Patagonian continental shelf is one of the largest and flattest continental shelves in the world (Arkhipkin *et al*., 2012). For the purposes of the document; Continental Shelf refers to waters less than 200 m in depth, deeper waters are referred to as the Continental Shelf Slope. The Patagonian Shelf varies in width from a few kilometres at 55°S, south of Staten Island on the tip of Tierra del Fuego, to 850 km at 51°S (Martos and Piccolo, 1988). The Falklands archipelago is situated on the Patagonian Shelf approximately 500 km northeast of the tip of Tierra del Fuego, between latitudes 52°53'S and 51°S (Figure 7.1 above).

To the south and east of the Islands the shelf slopes steeply into the Falkland Trough (Platt and Philip, 1995), which is a west-east trench reaching depths greater than 3,000 m and extending 1,300 km from the South American continental shelf to the Malvinas Outer Basin (Cunningham *et al*., 2002). South of the Falkland Trough is the Burdwood Bank, which is a large plateau rising to 50 m below the surface and forms part of the regionally dominating Scotia Ridge. There are two major channels crossing the Scotia Ridge that facilitate inflows of the Falkland Current from the ACC. The western channel is 80 km wide and 400 m deep connecting the Scotia Basin with the Falkland Trough between Staten Island and the western Burdwood Bank. The eastern channel connects the Falkland Trough to the Scotia Basin at 55°W east of the Burdwood Bank; the channel is 130 km wide and 1,800 m deep (Guerrero *et al*., 1999).

To the west of the Falkland Islands, a north-western extension of the Falkland Trough gradually narrows and reduces in depth as it moves northwards onto the shelf break at the northwest tip of the archipelago. To the north a large area of relatively flat seabed extends to the shelf-break approximately 140 km north of Falkland Sound. Beyond this point, the continental slope represents an increase in the gradient of the seabed, which, and leads into the steep sloping Falkland Escarpment at a depth of approximately 3,000 m. The NFB is the area located between the Falkland Islands and the Escarpment. The NFB is characterised by a gently sloping gradient that increases in water depth from 150 m in the southwest to 1,500 m to the northeast (FIG, 2008a). The Sea Lion Field lies within the central area of the NFB in water depths ranging from 330 m to 463 m (Gardline, 2013a; MG3, 2014).

The seabed in the NFB is characterised by numerous indentations, troughs and trenches. Bathymetric surveys conducted over the NFB indicate the presence of poorly preserved iceberg keel scars, numerous depressions between 4 and 11 m deep, trenches 30 m deep and 500-600 m wide, and furrows or channels commonly up to 1.5 km wide and extending up to 210 km long (Gardline, 1998a-h).

A bathymetric survey of the Sea Lion Field revealed that historic iceberg keel scars and seabed pitting are prevalent throughout the area, and a large trench that runs from the southwest to the east of the survey area (Figure 7.14).

7.3.4.2 Berkeley Sound (inshore) bathymetry

The bathymetry for the main Berkeley Sound survey area was produced from the results of the concurrent geophysical site survey and is presented in Figure 7.15 and Figure 7.16 (BSL, 2015c). More detailed representations of site specific bathymetry along with seabed sample photographs and camera tracks are presented in BSL, 2015b.

Depths within the area surveyed ranged from approximately 5 m in the west to 55 m in the east. Localised gradients of up to 19° were observed at the pinnacle bedrock features with the highest point elevated 11 m from the surrounding seabed. To the east, the eastward gradient was negligible, ranging from 0.07° to 0.16°; the seabed here was considered to be generally flat, dominated by linear gravel ribbons, except along the northern and southern coasts where bedrock was observed.

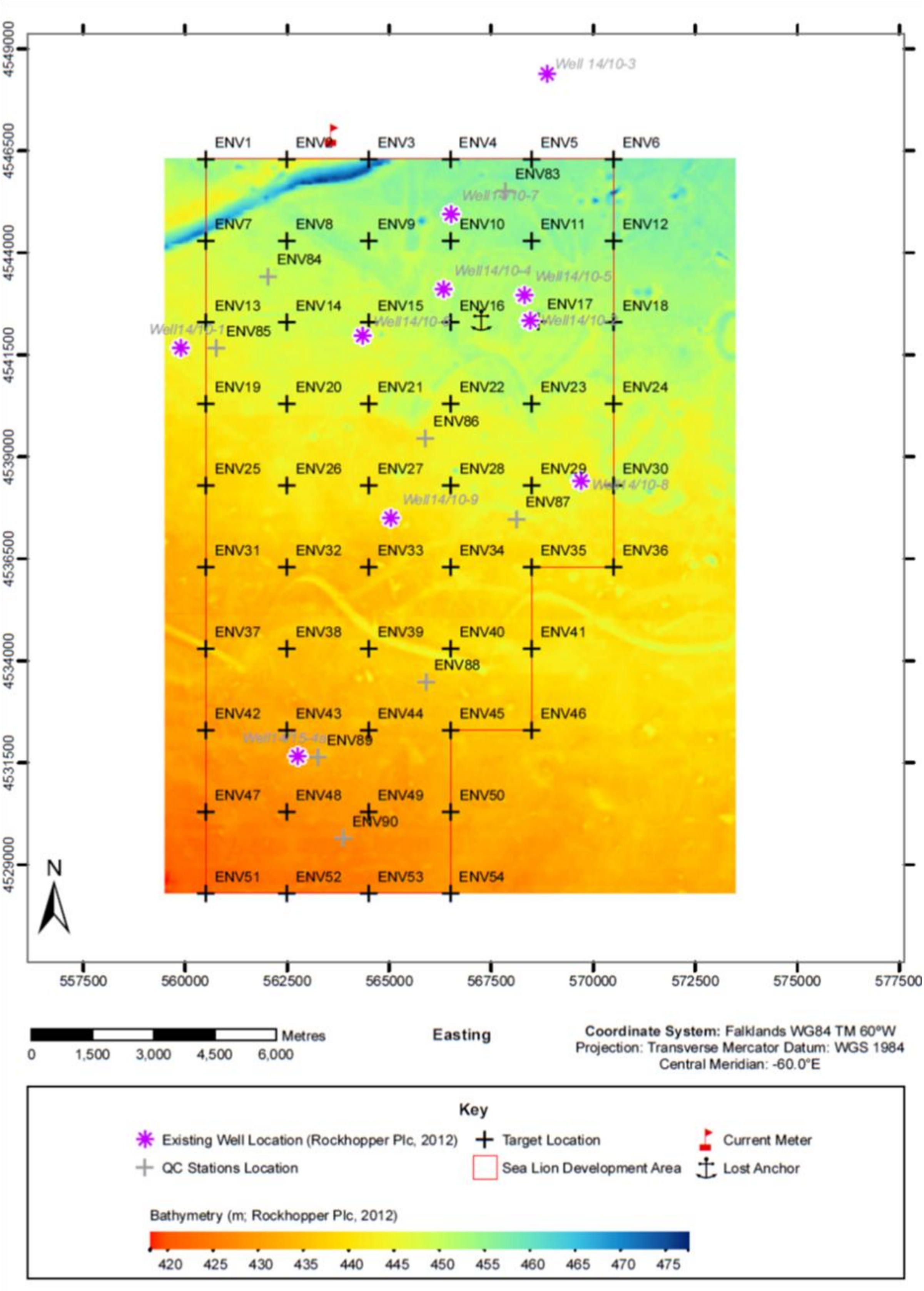


Figure 7.14: Seabed topography in the Sea Lion Field and surrounding area

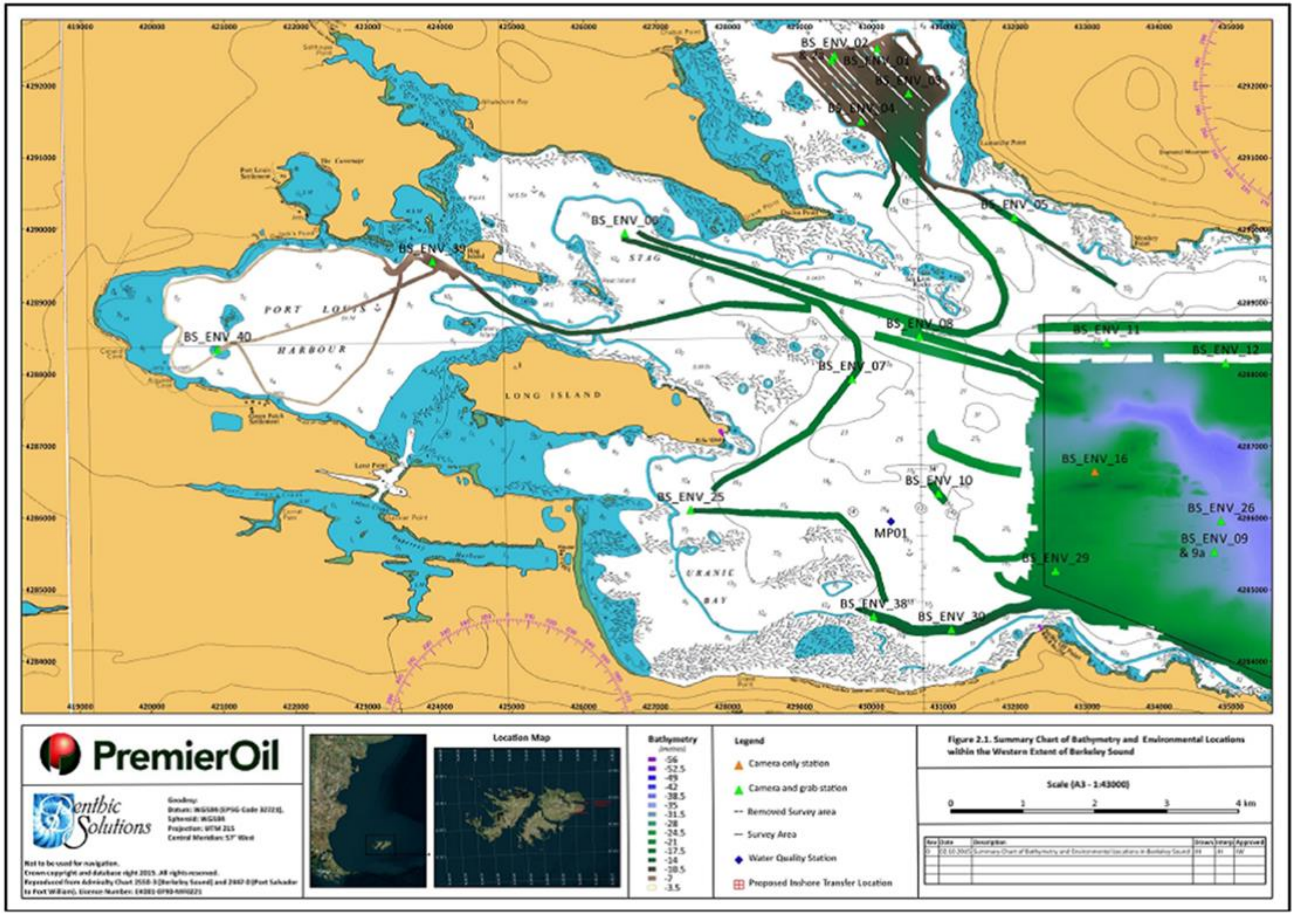


Figure 7.15: Locations of bathymetry and environmental sampling sites within the Inner Sound, the western extent of Berkeley Sound (BSL, 2015c)

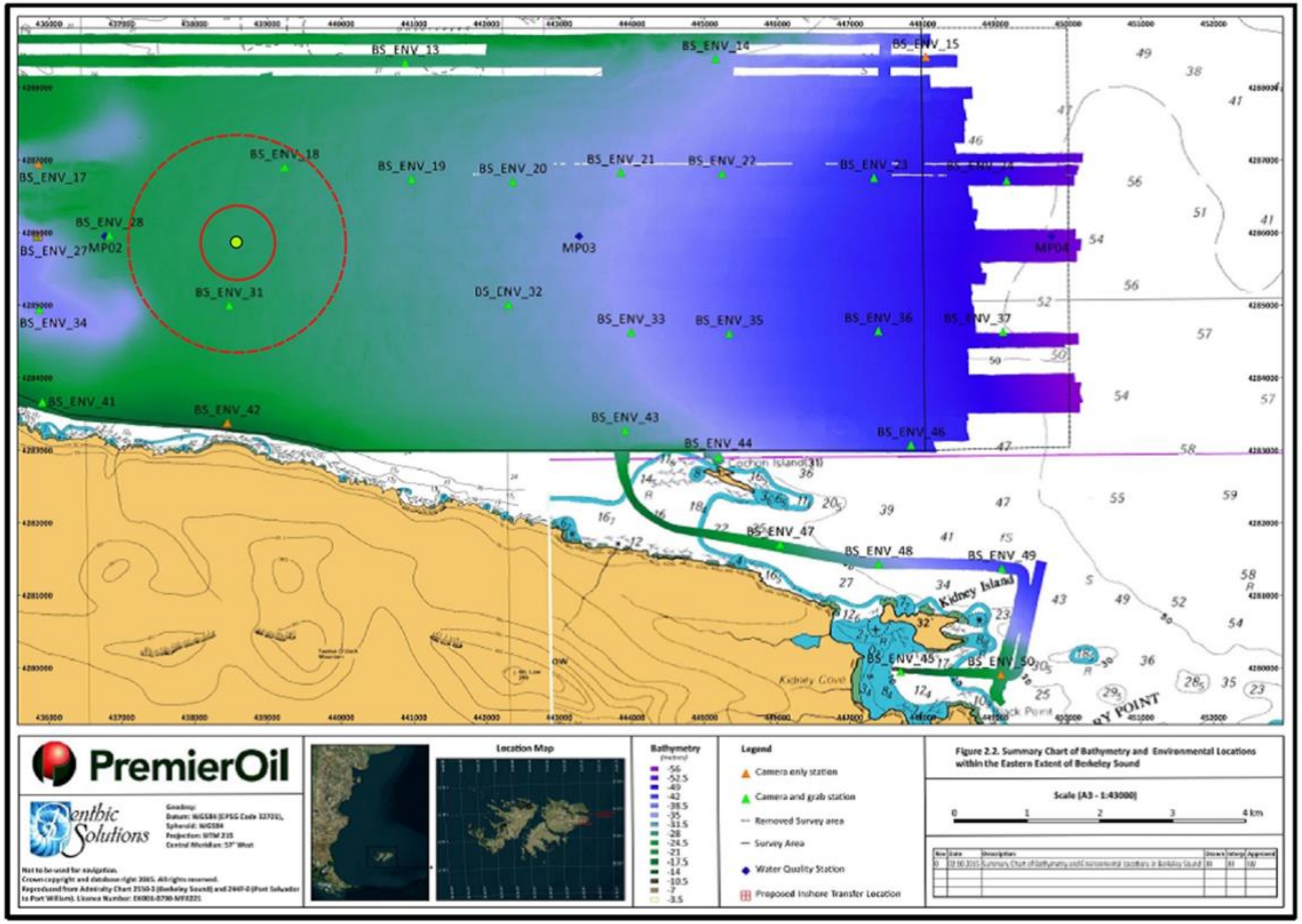


Figure 7.16: Locations of bathymetry and environmental sampling sites within the Outer Sound, the eastern extent of Berkeley Sound (BSL, 2015c), showing the formerly proposed mooring location and exclusion zones [N.B. inshore transfer is no longer an option]

7.3.5 Metocean data used in modelling

The impact and risk assessment chapters in the body of the EIA describe only the information required to ensure appreciation and understanding of the modelling results as they are used in the assessment. To avoid repetition, this section is dedicated to describing the metocean data used by Genesis and Premier to model the behaviour of discharges and releases from the Sea Lion Development.

The following metocean data was used in the modelling of:

- Drill cuttings (section 10.6);
- Produced water (section 10.7);
- Cooling water (section 10.8);
- Collision risk modelling around the Sea Lion Field (section 11.1); and
- Oil spill modelling offshore and inshore (sections 12.1 and 12.2).

7.3.5.1 Ocean currents data

A hydrodynamic modelling study has been conducted by BMT Argoss, BMT WBM and the UK Met Office to produce high resolution ocean current data sets for the region, which have been utilised as input data for modelling the behaviour of discharges and releases. Details of the hydrodynamic modelling are given in BMT Argoss (2015).

The hydrodynamic modelling consisted of three nested model domains (see Figure 7.17), which have different spatial extents / coverage and spatial resolutions. More specifically, the model system comprised a large scale regional 'oceanic' domain that covers the Patagonian Shelf, and two smaller fine resolution coastal domains that cover nearshore areas of complex bathymetry and coastline features around the Falkland Islands.

Ocean currents for the larger regional domain shown in Figure 7.17 were generated by the UK Met Office using the Nucleus for European Modelling of the Ocean (NEMO) PS4 model, whilst currents for the coastal domains were generated by BMT WBM using the TUFLOW FV hydrodynamic model. The current vectors in Figure 7.17 show the average speed and direction of ocean currents over three years of data (2010 to 2012). The strong Falklands Current, which branches of the Antarctic Circumpolar Current, is evident in this graphic and will likely be a dominant transportation mechanism for any oil discharge in the region.

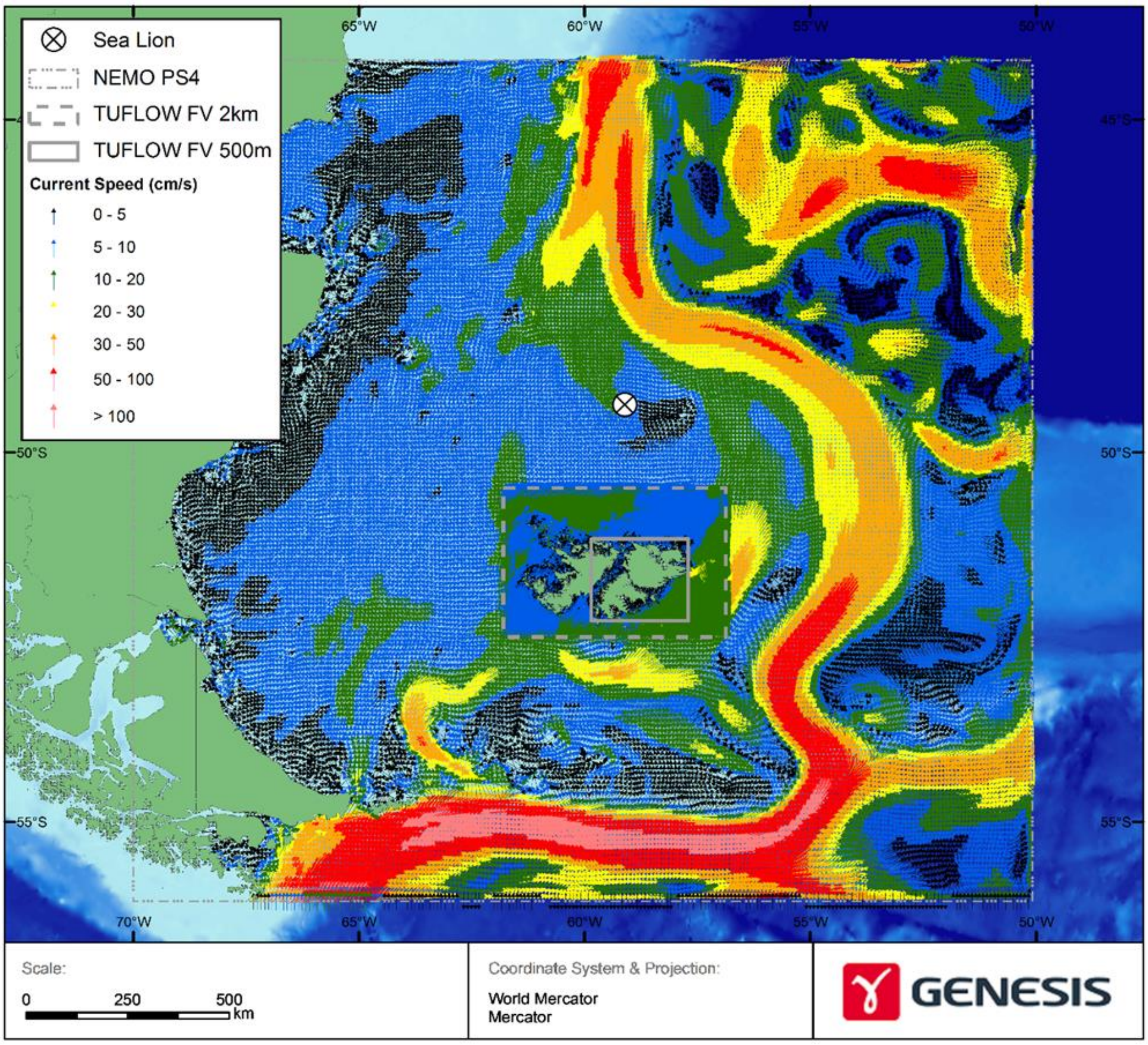


Figure 7.17: Ocean currents field obtained from the hydrodynamic modelling

7.3.5.1.1 NEMO PS4 data set

The NEMO model is a primitive equation model adapted to regional and global ocean circulation problems. NEMO is a flexible tool for studying the ocean and its interactions with the other components of the earth climate system over a wide range of space and time scales. A new NEMO ocean model configuration, named PS4, has been set up by the UK Met Office to cover the Patagonian Shelf and used to provide ocean currents for this area covering the years 2010 to 2012 inclusive.

Ocean currents generated by the NEMO PS4 model were provided on a regular grid that covers the area spanned by longitudes 50° - 70° west and latitudes 44° - 56° south (see Table 7.18 above). The NEMO PS4 currents data have a longitudinal resolution of 1/12° and latitudinal resolution of 1/16°, which is approximately equivalent to longitudinal and latitudinal resolutions of 6 km and 7km, respectively.

NEMO PS4 currents were provided in a number of depth layers varying depth resolutions. The depth layering and resolution is such that layers nearer the sea surface (where currents tend to fluctuate significantly with depth) are afforded finer resolutions than deeper layers (where fluctuation with depth is less pronounced). Fine resolution of the surface layers is also important in resolving fluctuations caused by wind driven Ekman currents in these layers. The NEMO PS4 currents were provided in layers consisting of:

- 1 m intervals from sea surface to 10 m depth;
- 5 m intervals from 10 m depths to 50 m depths;
- 10 m intervals from 50 m depths to 500 m depths; and
- 250m intervals from 500 m depths to 7,000 m depths.

The temporal resolution of the data set is 30 minutes i.e. the current speed and direction changes every 30 minutes. The spatial, temporal and depth resolution of this data set are considerably better than any previous available data sets that cover a comparable area.

The NEMO PS4 model has been validated using in situ current meter measurements at a number of different locations, and it has been shown that the agreement between modelled and measured currents is very good.

7.3.5.1.2 TUFLOW FV coastal data sets

The coastal currents data sets have been generated by BMT WBM using the TUFLOW FV hydrodynamic model, which is a numerical model that simulates hydrodynamic, sediment transport and water quality processes in coastal waters, estuaries and oceans. Currents generated by TUFLOW FV have been provided on two data grids with spatial resolutions of 2 km and 500 m (see Figure 7.17 above).

The 500 m spatial resolution data set covers the area spanned by longitudes 57.70° - 59.85° west and latitudes 51.22° - 52.35° south, whilst the 2 km spatial resolution data set covers the larger area spanned by 56.87° - 61.80° west and latitudes 50.51° - 52.57° south. Both data sets have a temporal resolution of 30 minutes and are depth layered into 15 bands with varying depth resolution. The depth layering and resolution are such that surface layers (where currents tend to fluctuate significantly with depth) are afforded finer resolutions than deeper layers (where fluctuation with depth is less pronounced). There are approximately five layers representing the top 10 m of the water column, with the remaining ten layers encompassing depths down to approximately 500 m.

Detailed example snapshots of the TUFLOW FV 500 m and 2 km resolution data sets are shown in Figure 7.18 and Figure 7.19, respectively.

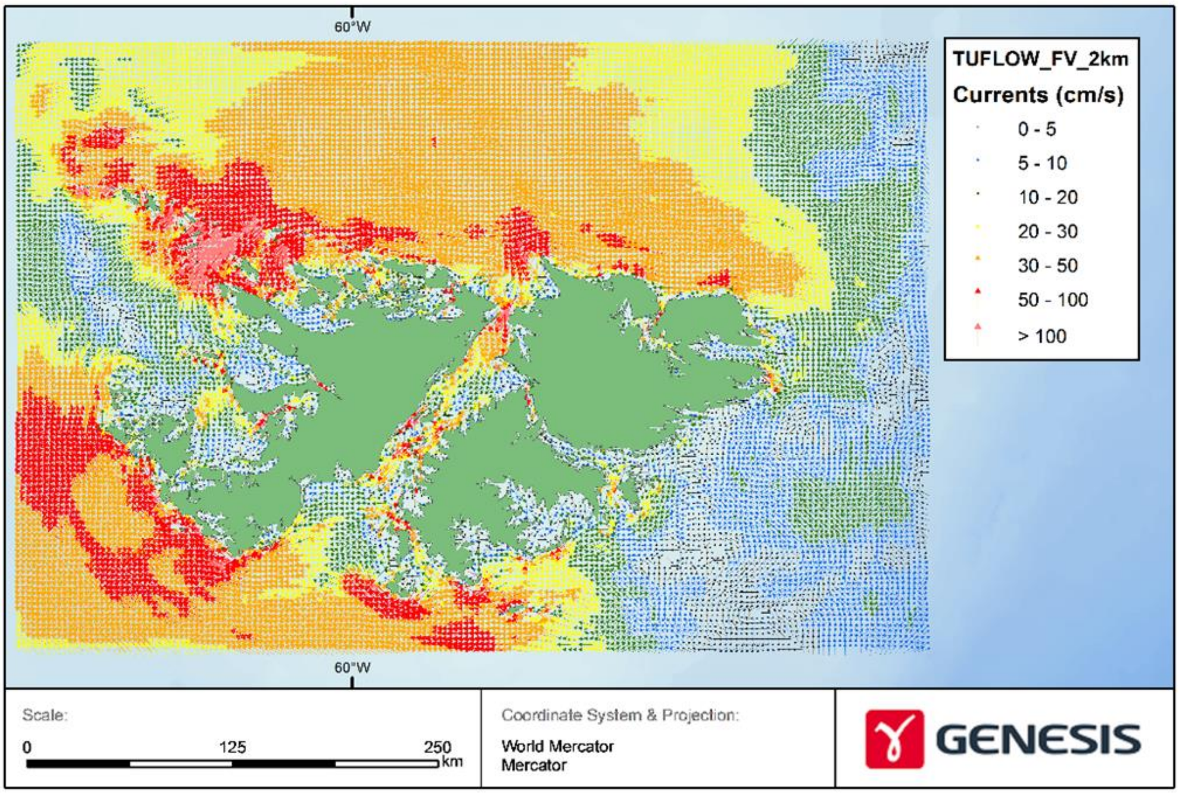


Figure 7.18: Snapshot of TUFLOW FV 2km currents grid

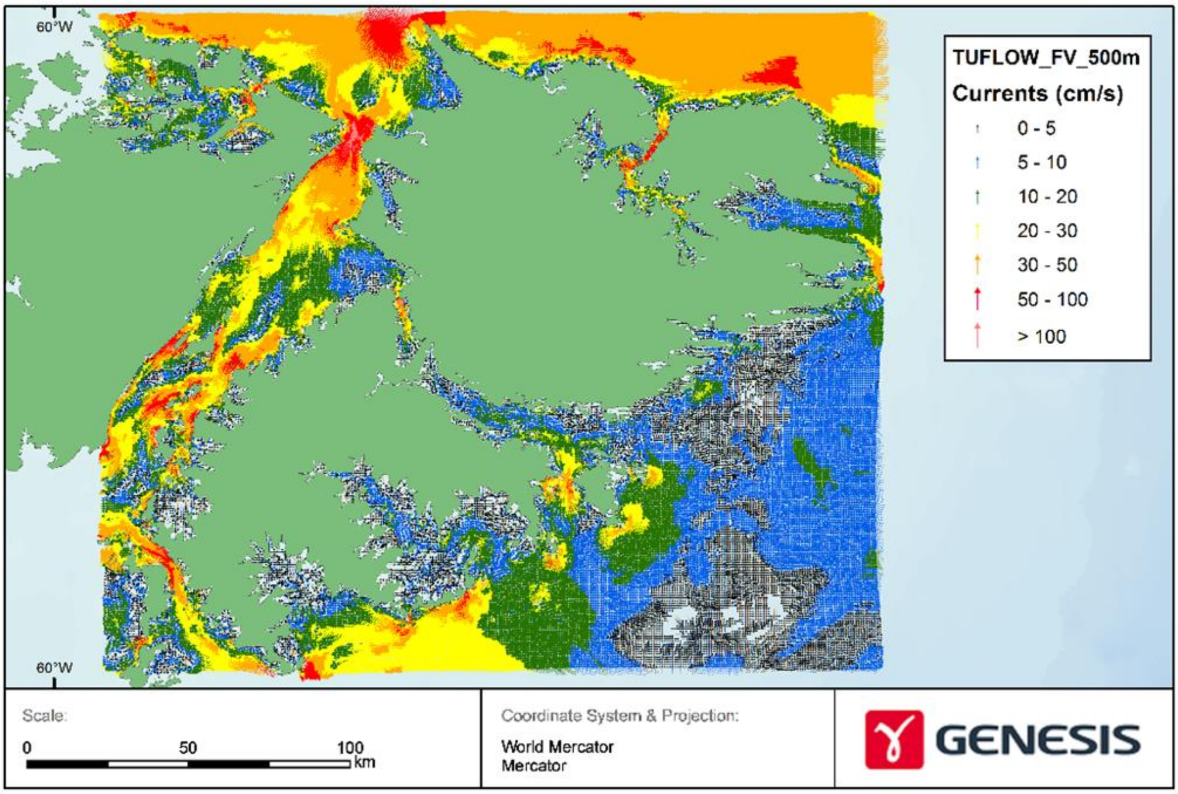


Figure 7.19: Snapshot of TUFLOW FV 500m currents grid

7.3.5.2 Current speed and direction at Sea Lion

The NEMO PS4 currents data set was interrogated at the Sea Lion location to investigate the distribution of currents in terms of speed and direction. The distribution of surface currents at Sea Lion is shown in Figure 7.20, and the distribution of currents nearer the sea bed is shown in Figure 7.21. It is observed that the surface currents predominantly move in northerly and north-westerly directions, with the current speed generally being less than 15 cm/s. At the sea bed the currents tend to move in westerly directions with the current speed typically being less than 10 cm/s.

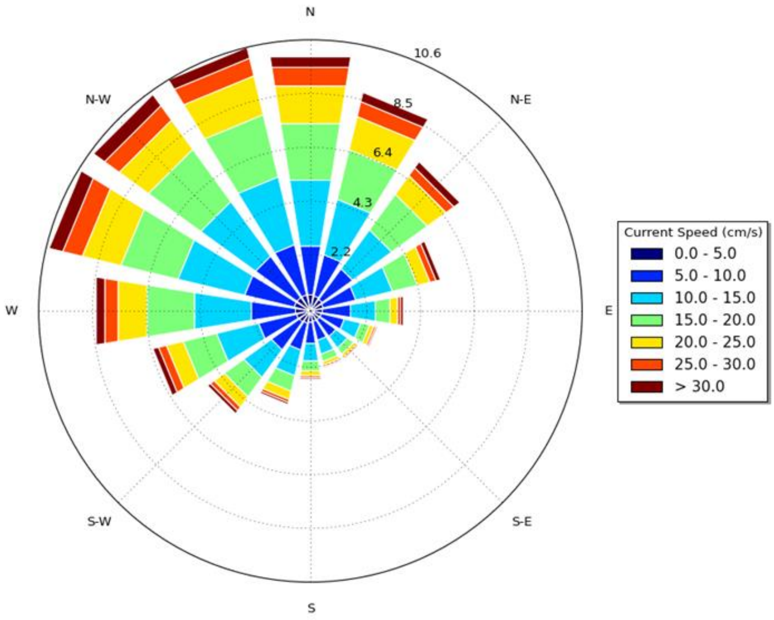


Figure 7.20: Distribution of surface currents at Sea Lion

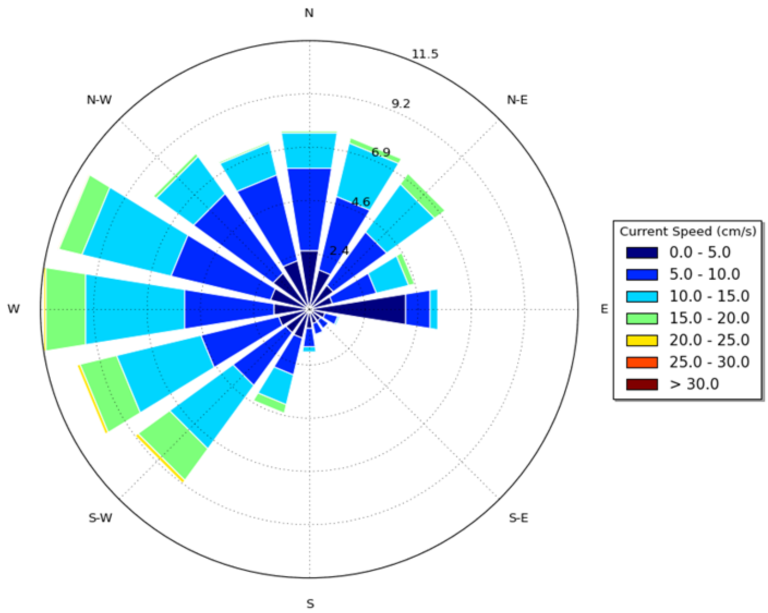


Figure 7.21: Distribution of seabed currents at Sea Lion

7.3.5.3 Wind data

To complement the current data, two different wind data sets have been used in the modelling study. A high resolution wind data set, which covers the coastal waters around the Falkland Islands, has been produced by BMT Argoss using the Weather Research and Forecasting (WRF) model. Due to the limited coverage of this data set, a second lower resolution data set that covers a larger area has been obtained from the Climate Forecast System Reanalysis (CFSR). Similar to the currents data, the wind data from the WRF and CFSR data sets are combined into a single grid. The combined wind field grid is shown in Figure 7.22, which shows the domains of both the CFSR and WRF models. The vectors displayed in Figure 7.22 show the average wind speed and direction over the full three years (2010 to 2012) of the generated wind data.

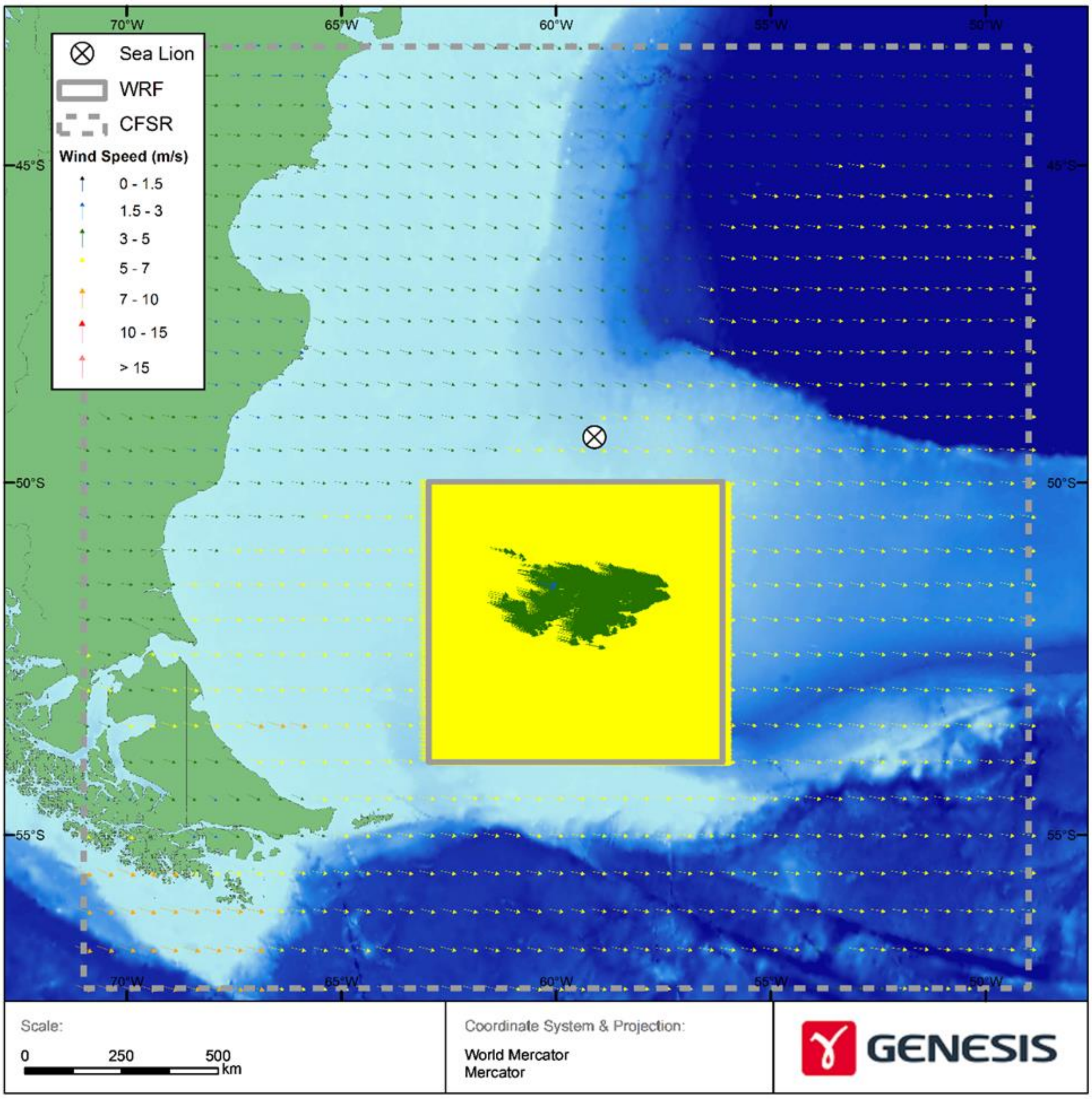


Figure 7.22: Snapshot of combined WRF and CFSR wind field grids

7.3.5.3.1 WRF wind data

The WRF model is a state of the art atmospheric modelling system designed to serve both atmospheric research and operational forecasting applications (Skamarock *et al*., 2008). The model has been developed by a number of different agencies including (but not limited to) the National Centres for Atmospheric Research's Meoscale and Microscale Meteorology Division, the National Oceanic and Administration's National Centers for Environmental Prediction and Earth System Research, and the Naval Research Laboratory.

The WRF wind data covers the area spanned by coordinates 50° - 64° west and latitudes 56° - 63° south with a spatial resolution of approximately 3 km and temporal resolution of one hour. In computing wind fields, the model makes use of high resolution topography data obtained from the Shuttle Radar Topography Mission, and takes into account land / sea effects and local-scale weather variability.

The WRF model parameters and inputs have been optimised by BMT Argoss to produce high accuracy results. The modelled wind speed and direction have been validated against in situ measurements made at Mount Pleasant and showed good agreement.

A detailed typical snapshot of the instantaneous wind field generated by the WRF modelling is demonstrated in Figure 7.23, which highlights the spatial resolution of the data set.

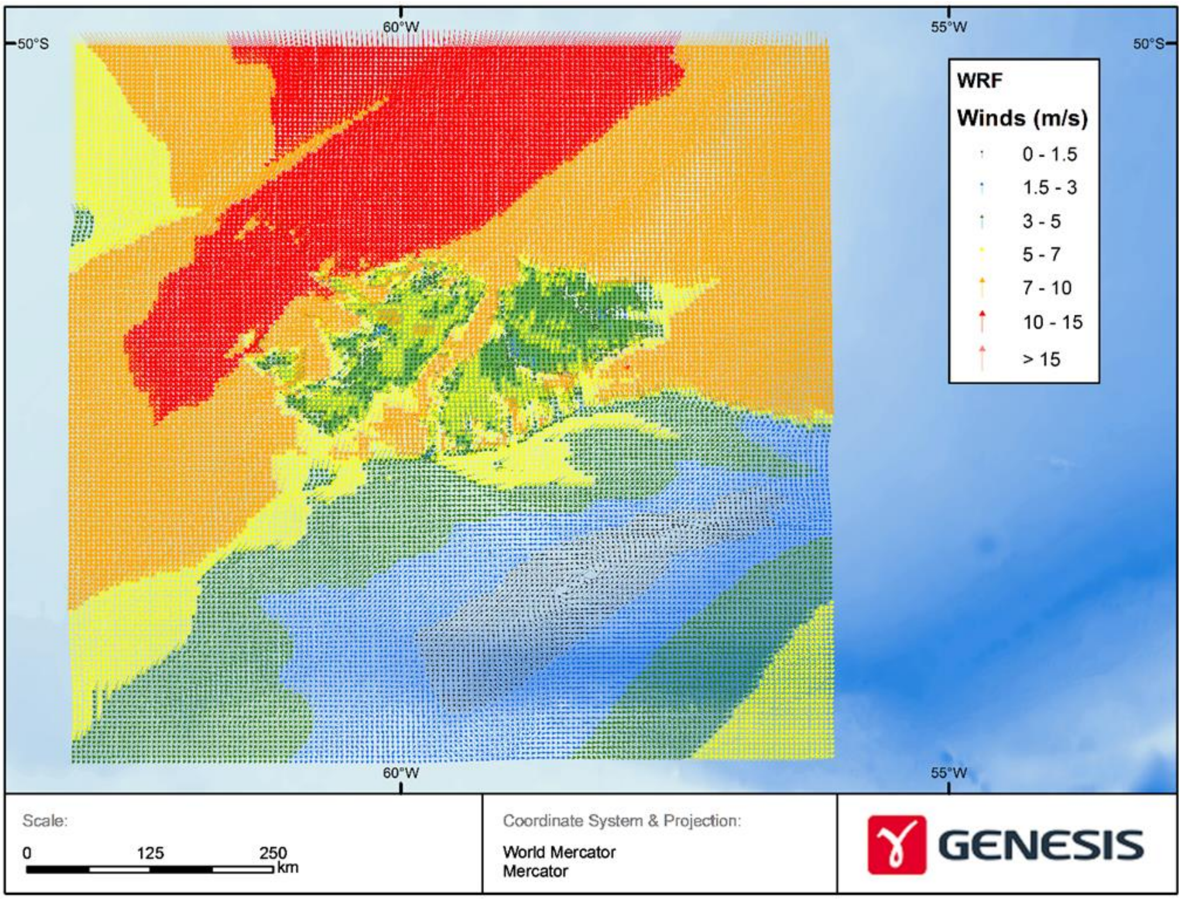


Figure 7.23: Snapshot of wind field produced by the WRF model

7.3.5.3.2 CFSR wind data

A lower resolution wind data set covering a more expansive region than the high resolution WRF data set has also been sourced from the new Climate Forecast System Reanalysis (CFSR) produced by the National Centers for Environmental Prediction (NCEP) (Saha *et al*. 2010). CFSR is a third generation global coupled reanalysis product that includes coupled atmosphere, ocean, land surface, and sea ice models, and also assimilates a wide variety of in situ and satellite observations.

The CFSR wind data set used in this modelling study contains wind vectors at a height of 10 m above sea level over the same three years as the other metocean data sets (i.e. 2010-2012). The data set covers the area spanned by longitudes 48.8° - 71.2° west and latitudes 42.8° - 56.8° south.

The temporal resolution of the CFSR data set is one hour. The longitudinal and latitudinal resolutions of the data set are 0.5°, which for the area of interest equates to longitudinal and latitudinal resolutions of approximately 36 km and 54 km, respectively. The spatial extent and resolution of the CFSR wind data is highlighted in Figure 7.22 above.

CFSR data is from an internationally recognised source with ongoing calibration and validation. Offshore wind data at the Sea Lion Field has been collected in 1998, 2015 and 2016 and reviewed by Oceanwise on behalf of Premier. There is insufficient data to make a statistical annual comparison for the Sea Lion Field, however global hindcast datasets such as CFSR are considered reliable, particularly in marine locations with no land features. In Berkeley Sound, further wind modelling was undertaken to account for local topographical features.

7.3.5.3.3 Wind speed and direction at Sea Lion

The CFSR wind data set was interrogated around the Sea Lion location in order to investigate the distribution of winds in terms of speed and direction. The rose plot in Figure 7.24 shows the distribution of wind at the Sea Lion location.

It is observed from Figure 7.24 that at the Sea Lion location the winds generally blow from westerly directions towards the east, with the wind speed typically being less than 10 m/s.

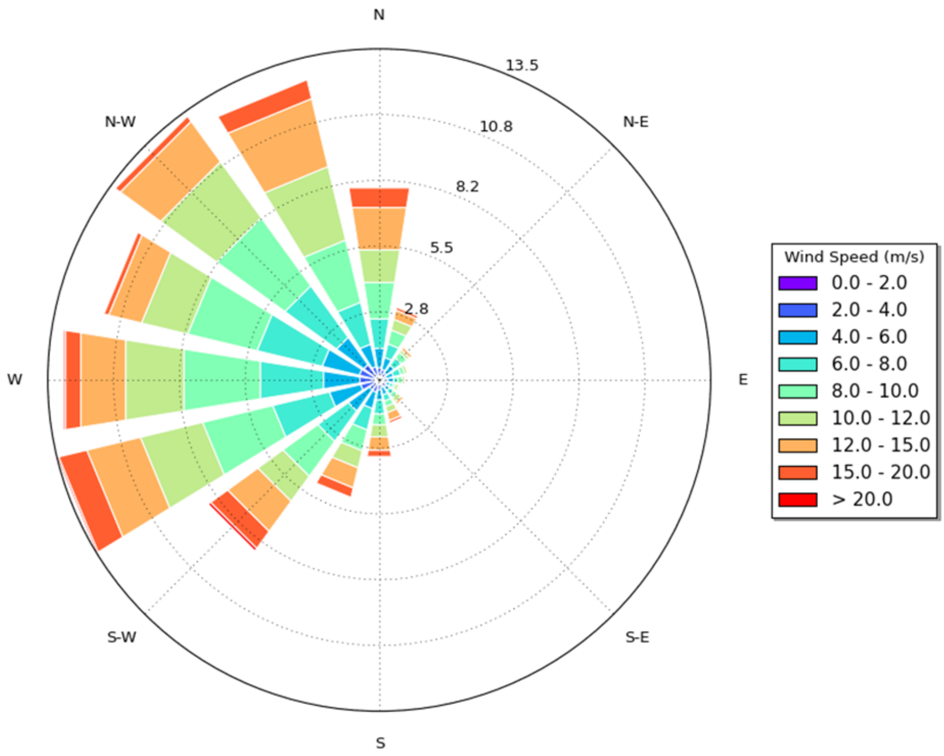


Figure 7.24: Distribution of winds at Sea Lion

7.3.5.4 Bathymetry data

The bathymetry data that has been used in this modelling study has been provided by BMT, and was created by combining ETOPO2 (a global relief model of the Earth's surface that integrates land topography and ocean bathymetry) and General Bathymetric Chart of the Oceans (GEBCO) data. For areas in the vicinity of the Falkland Islands, BMT bathymetry was used. Particular attention was given to representation of features on the shelf edge to the north east of the Falkland Islands, and also to Burdwood Bank to the south. Features were compared with Admiralty chart contours and, in some instances, local modifications were made by BMT.

The bathymetry data supplied by BMT is precisely the same data that was used in the hydrodynamic modelling to produce the ocean currents data sets discussed in section 7.3.3. This is important since it results in a perfect match between bathymetry and sea bed currents data. A mismatch in bathymetry and currents data can result in 'dead zones' near the sea bed, which could adversely affect subsea discharges.

The BMT bathymetry data was provided by BMT as irregularly spaced depth samples. This data was interpolated onto a regularly spaced grid in order to be compatible with the OSCAR model. The resulting interpolated bathymetry grid is depicted graphically in Figure 7.25.

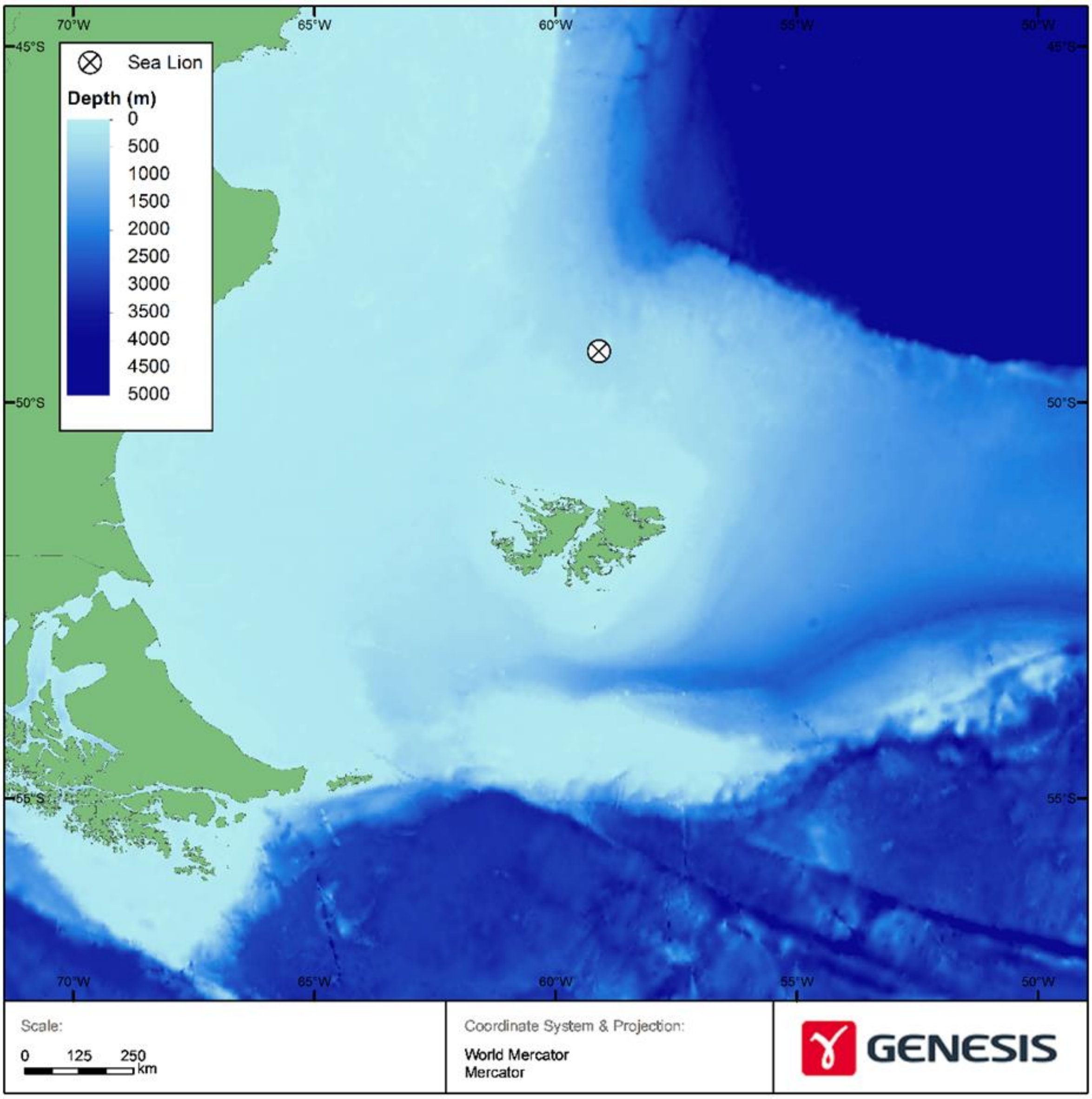


Figure 7.25: Bathymetry data used in the modelling

7.3.6 Geology and subsurface description

7.3.6.1 NFB and Sea Lion Field (offshore) geology

The NFB is the name given to the set of sedimentary basins that lie to the north of the Falkland Islands (Richards and Fannin, 1997). It consists of two main sub-basins:

- A Northern Rift Basin (NRB) in which the predominant strike of the structural elements is north to south in orientation; and
- A Southern Rift Basin (SRB) in which the predominant strike of the main structural elements is northwest to southeast in orientation.

The main graben of the NRB is about 150 km long and 50 km wide at its northern end.

The Sea Lion Field is located on the northeast margin of the NRB. The Sea Lion Field was discovered in May 2010 by Rockhopper Exploration with well 14/10-2 which encountered oil reservoirs in good quality Lower Cretaceous turbidite sandstones that form a series of deep water basin floor fans deposited into a stratified anoxic lake (Richards and Hillier, 2000; Holmes *et al*., 2015). Following discovery of the Sea Lion Field, the area was appraised by eight wells (and two sidetracks), which helped delineate the extent of the Sea Lion accumulation and in addition proved the presence of hydrocarbons in three younger fans (Casper, Casper South and Beverley). The main sediment source for the fans originated from flanking basement highs (primarily to the east), which connect into the main graben depo-centre via a series of feeder canyons or channels. Fans are highly sand-prone and were constructed by intrusive density flows. Deposition occurred from both turbidity currents and mass flows (for example, fluidised sediment-gravity flows).

7.3.6.2 Berkeley Sound (inshore) geology

The geology of the Berkeley Sound area is principally sandstone and mudstone with overlying Quaternary sediments. The Quaternary sediments have been described as 'head deposits', comprising mainly gravels and sands, formed through a process called solifluction (Andersson, 1906; BSL, 2015c; Solifluction is '*the gradual movement of wet soil or other material down a slope*').

A number of rock outcrops occur within Berkeley Sound; those near the centre of the Sound, near the proposed LTV anchorage location are thought to be composed of sandstone and mudstone, originating from the Fox Bay and Philomel formations (*Geological map of the Falkland Islands*; British Geological Survey, reproduced in BSL, 2015a). The exposures observed along the northern and southern coasts of the Sound are thought to be formed of quartzite, with origins in the Port Stanley and Port Stephens formations (BSL, 2015a). These quartzite formations are more resistant to weathering and erosion.

7.3.7 Sediment characteristics

7.3.7.1 NFB and Sea Lion Field (offshore) sediments

It is necessary to have an understanding of the baseline offshore sediment characteristics with regard to sediment types (grain size and organic matter content) and sediment chemistry in order to understand the potential impacts of discharges and disturbances associated with the Phase 1 Development.

The Falkland Islands are relatively immature in terms of O&G production and whilst 29 exploration wells have been drilled in the NFB to date there is currently no O&G production underway in the region (the Phase 1 Development is the first proposal for oil extraction). Therefore, typical background sediment types and chemistry datasets for the offshore and Berkeley Sound locations have not been formally characterised.

However, as described in section 7.2.2 above, 20 offshore benthic surveys have been conducted between 1998 - 2016 within the three main Falklands basins. These surveys cover a range of depths from 140 m to 2,100 m and a range of metocean conditions, predominantly influenced by the East Falklands Current as it flows northwards to the east of the Falkland Islands.

The data provided indicate that Sea Lion sediments are comparable to those within the wider Falkland Islands waters (Gardline, 2013a and b).

7.3.7.1.1 Sediment type

7.3.7.1.1.1 Grain / Particle size

It is important to appreciate the baseline grain sizes of sediments (e.g. fine, medium, course) in the Sea Lion area as grain sizes directly affect the composition of benthic communities.

Sediments across the NFB typically exhibit a south-north gradient of decreasing mean particle size (Gardline, 1998a). The proportion of fine material, defined as material with a diameter <63 µm, generally increases with increasing depths. In the NFB, the sediment types range from 'very fine sand' in shallower waters (225 m depth) in the southwest, to 'coarse silt' in deeper waters (464 m depths) in the northeast (Gardline, 1998a).

During the area-wide 2012 environmental baseline survey in the Sea Lion area, mean grain sizes ranging from 18 µm to 39 µm were recorded throughout the field, indicating that sediment types were generally homogenous (Gardline, 2013a). Sediments were predominantly classified as 'medium silt', with the exception of seven stations generally located in the northern part of the survey area that were classified as 'coarse silt'. The percentage of fine material (<63 µm) was high (61.6 – 79.7%) at all stations across the Sea Lion area. These results were comparable to the sediment types recorded during the 1998 Falklands Offshore Sharing Agreement (FOSA) *pre*-drilling surveys conducted at 'B1' 14/05 and 'Little Blue' 14/09 wells (approximately 8.5 km and 16 km west of Sea Lion respectively) (Table 7.1above).

Post-drilling well site surveys carried out across the Drilling Campaign Areas contained similar proportions of fines, sands and gravels to those recorded in the Sea Lion area-wide survey (Gardline, 2013a and b). Whilst the highest variation was associated with the gravel fraction (>2 mm), which ranged between 0.1 % and 10.3 % contribution, this was attributed to natural variation across the area, and may originate from glacial drop-stones as found in the FOSA area. Analysis of other parameters did not indicate any disturbance from previous drilling activities. In the shallower waters of the southern NFB (140-285 m depths) the sediments were dominated by coarser sand particles, with a mean grain size of 156.5 µm (BSL, 2008b).

7.3.7.1.1.2 Total Organic Matter (TOM) and Total Organic Carbon (TOC)

Sources of organic matter in marine sediments include photosynthetic fixation of CO_2 by phytoplankton, decomposition of dead organisms, excretions from marine fauna, terrestrial inputs from rivers etc. and the excretion of extra-cellular products by algae which liberate appreciable proportions of the compounds produced by photosynthesis into the water (Lazar *et al.,* 2012). Anthropogenic inputs to the marine environment can result in eutrophication which can enhance growth of phytoplankton and thus have the potential to upset the natural balance between organic matter deposition and the capacity of the sediment to 'recycle' the organic matter. The amount of organic matter in marine sediments is generally dominated by fluxes in the deposition of surface derived phytodetritus (decomposing phytoplankton and other plant material) to deeper water sediments.

Given that the level of organic matter in sediments can have a major influence on chemical and biological processes which occur within the sediments, as well as affecting the behaviour of other chemical components such as metals and organic pollutants (Lazar *et al.,* 2012), it is important to understand the background levels of organic matter in order to determine whether or not anthropogenic activities may have an impact.

Total Organic Matter (TOM) and Total Organic Carbon (TOC) in sediment samples taken from the Sea Lion area were measured as a percentage of total sample weight. Both TOM and TOC levels were generally found to be homogeneous across the Sea Lion area with mean values of 5.6 % (±0.5 SD), and 0.9 % (±0.1 SD) respectively (Gardline, 2013b).

Both TOM and TOC were found to correlate with particle size, with higher proportions of organic matter recorded at stations with a higher percentage of fines ($P<0.001$). This relationship is linked to both the rate of sedimentation (detrital rain) from surface waters, and the hydrodynamic regime. Lower concentrations of organic matter are generally found in sandier sediments where surface sediments indicate some mobility and consequently have a lower percentage fines.

Values for TOM were similar to those recorded during the FOSA 1998 pre-drilling survey for the 'B1' 14/05 well and the 'Little Blue' 14/09 well (mean 5.7 % (±0.5 SD) and 4.3 % (±1.9 SD) respectively) (Gardline, 1998a & b). These samples were the closest to the Sea Lion Field and were located in comparable depths (415-482 m), further indicating the homogeneity of this area of the NFB. In the southern NFB the level of total organic matter remained consistently low throughout the survey area (1.7 % (±0.4 SD)) perhaps reflecting the reduced proportion of fines and mobile sandy sediments of the shallower waters (BSL, 2008b).

7.3.7.1.2 Sediment chemistry

7.3.7.1.2.1 Sediment hydrocarbons

Total Hydrocarbon Concentrations (THC)

Hydrocarbons in marine surface sediments may have originated from a number of sources, including terrestrial run-off in coastal areas, vessel spills and discharges, plant origin, natural seeps and hydrocarbon extraction.

In the Sea Lion pre-development area-wide survey, the THC ranged from 4.7 - 15.5 µg/g (mean 9.7 µg/g (±2.7 SD)) across all stations. Samples collected during the post-drilling survey exhibited THC levels within a similar range as the area wide survey, ranging between 3.5 µg/g and 17.2 µg/g with a mean of 8.5 µg/g (±2.9 SD). Overall no spatial trends were observed and THC levels were considered to be within natural ranges exhibited by background variation (Gardline, 2013a & b).

Generally, the results from all seven FOSA survey locations show low THC with the exception of the 'Minke' 14/13 well, located approximately 24 km southwest of Sea Lion, which recorded a mean THC 4.6 µg/g (±4.1 SD) (Gardline, 1998h). Similar levels were also recorded in shallower water depths (140-285 m) during the southern NFB survey in 2008 located >50 km south of Sea

Lion (mean 4.3 µg/g (±1.4 SD)) (BSL, 2008b), although mean THC in both areas were low in comparison to Sea Lion.

Survey results suggest that levels of THC within the Sea Lion area were not above typical background levels for this region.

Hydrocarbon composition

Unresolved Complex Mixture (UCM) is a fraction of hydrocarbons, which are not fully separated during gas chromatography (GC) and appear as a 'hump' on the GC trace. This unresolved fraction consists of a number of individual components, which remain after substantial weathering and biodegradation of petrogenic inputs (Farrington *et al.,* 1977), and can provide an indication of the origin of contamination or the natural source. At the majority of stations across the Sea Lion Area, UCM accounted for the majority of hydrocarbons within the sediments, which is indicative of well-weathered hydrocarbon sources and suggests that the majority of the material did not originate from fresh hydrocarbon inputs from drilling activities (Gardline, 2013a).

Sea Lion sediments exhibited a mixture of biogenic and petrogenic hydrocarbon inputs, with a predominance of biogenic inputs. These biogenic inputs were likely to be derived from marine organisms associated with the highly productive surface water in this area of the South Atlantic and diffuse terrestrial plant sources (Gardline, 2013a). Petrogenic hydrocarbons may have been derived from various anthropogenic activities, including the historic exploratory drilling activity in the area (Gardline, 2013b).

Polycyclic Aromatic Hydrocarbons (PAH)

Monitoring the aromatic hydrocarbon type and content is particularly important due to the toxic nature (mutagenic/carcinogenic) of several of Polycyclic Aromatic Hydrocarbons (PAHs) even at very low concentrations.

PAHs and their alkyl derivatives have been recorded in a wide range of marine sediments (Laflamme and Hites, 1978) with the majority of compounds produced from what is thought to be pyrogenic sources. These are the combustion of organic material such as forest fires (Youngblood and Blumer, 1975), the burning of fossil fuels and, in the case of offshore oilfields, flare stacks, etc. The resulting PAHs, are normally transported to the sediments via atmospheric fallout or river runoff. Another PAH source is petroleum hydrocarbons, often associated with localised drilling activities. These are rich in the lighter, more volatile 2 and 3 ring PAHs (NPD; naphthalene, phenanthrene and dibenzothiophene).

Mean total PAH concentrations across the Sea Lion area were 0.12 µg/g (±0.02 SD), whilst mean PAH concentrations at the post-drilling survey stations ranged from 0.10 $\mu g/g^{-1}$ (±0.03 SD) to 0.15 µg/g (±0.01 SD). Mean total NPD concentrations across the Sea Lion area were 0.05 µg/g (±0.01 SD), compared to a range of 0.04 µg/g (±0.01 SD) to 0.065 µg/g (±0.01 SD) at the post-drilling survey stations.

When compared to the FOSA 1998 pre-drilling baseline survey, the maximum Sea Lion development area and post-drilling PAH and NPD concentrations were marginally higher than the FOSA stations, with the exception of the Minke well location, which exhibited mean PAH of 0.72 µg/g (±0.01 SD) and NDP of 0.2 µg/g (±0.01 SD). Comparison on a wider regional basis indicated that PAH and NPD levels from the SFB Burdwood Bank and Toroa surveys were approximately double the mean values recorded from the Sea Lion survey, whilst samples from the EFB were broadly comparable to those from the Sea Lion area.

Analysis of PAH composition in Sea Lion area sediments indicated that they predominantly originate from pyrogenic sources (Gardline, 2013a and b). Whilst there was no evidence of any point source contamination at any of the Sea Lion area stations, the presence of the lighter, more volatile 2-3 ring hydrocarbons is indicative of a minor source of petrogenic hydrocarbon, which may be associated with the relatively recent exploratory drilling activity, or natural diffuse hydrocarbon seeps (Gardline, 2013b).

7.3.7.1.2.2 Heavy metals

Metals occur naturally in the marine environment and are widely distributed in both dissolved and sedimentary forms. Anthropogenic inputs of metals to the marine environment are primarily as components of industrial and municipal wastes and of particular relevance to the offshore oil and gas industry are drilling discharges, which can contain substantial amounts of barium sulphate (barite) as a weighting agent (NRC, 1983). Barite also contains measurable concentrations of heavy metals as impurities, including cadmium, chromium, copper, lead, mercury and zinc (NRC, 1983).

Generally concentrations of heavy metals across the Sea Lion area and from the post-drilling survey were within background levels observed at other locations on the Falklands continental shelf and therefore considered to be within natural variability for this region. Lead (Pb) was the only exception where values from Sea Lion area were higher than those from the FOSA 1998 pre-drilling baseline survey, which were generally found to be below the levels of detectability.

When normalised to 5% Aluminium (Al), several of the metals (Copper - Cu, Nickel - Ni, Lead - Pb and Zinc - Zn) recorded significant negative correlations with mean particle size and sand, and positive correlations with fines. This suggests the metal concentrations within the survey area were largely associated with natural variation in physical sediment characteristics and therefore should be considered as background in concentration for this area of the Southern Atlantic (Gardline, 2013a).

7.3.7.2 Berkeley Sound (inshore) sediments

The sediments within Berkeley Sound are very variable, but three general seabed types have been identified: sand with gravel ribbons, mud with fine sands, and bedrock exposures. At the eastern, oceanic end of the Sound the seabed generally comprised sands interspersed with gravel ribbons and varying proportions of fragmented shell material. At the western end of Berkeley Sound and within the shallow bays, sediments were generally finer with muds and fine sands recorded. Bedrock exposures in the form of rocky escarpments were identified in the centre of the survey area, close to the proposed LTV anchorage location, and along the north and south coasts of the Sound. These exposures consisted of rock faces in a predominantly north-south orientation. Numerous variations to these very general habitats were observed throughout Berkeley Sound; these are discussed in detail in BSL's Habitat Assessment (BSL, 2015b), and are described in section 7.4.3.3.3.

Black gravels and coarse sands were present at a number of stations, possibly of volcanic origin (i.e. basalt), along with fragmented relic shell material. Other biogenic contributors to the sediments included, intact relic mussel and clam shells. Along with cobbles, these shells were often encrusted with both live and relic barnacles.

7.3.7.2.1 Sediment type

7.3.7.2.1.1 Grain / Particle size

The particle size interpretation of sediments from Berkeley Sound is based upon observations made from the acoustic and seabed photography, and from the analytical results acquired from the surface sediments at 46 locations (Figure 7.26). Material for particle size analysis was recovered from the surface 5 cm and was analysed by BSL upon return of the samples to the UK.

Particle size analysis indicated that the seabed was highly variable throughout Berkeley Sound, with varying levels of fines, sands and gravels (including pebbles). The average sediment composition was as follows:

- Fines (diameter <63 µm): mean 15.44 % ± 19.82 SD (SD = standard deviation);
- Sand (63 µm- 2 mm): mean 70.85 % ± 27.42 SD; and
- Gravel (> 2 mm): mean 13.71 % ± 20.55 SD.

The mean particle size recorded at each station is illustrated in Figure 7.26, and ranged from 40 µm to 15,540 µm (or, 15.54 mm), demonstrating the huge variability in sediment sizes based upon the proportions of silts, clays, sands and gravels recorded around a general sand profile in Berkeley Sound.

The relative proportion of sand, mud and gravel was used to classify the sediment type, using the Folk (1954) classification scheme. The dominant sediment type representing slightly gravelly sand and was recorded at 15 of the 46 stations sampled (Figure 7.27).

The geographical distribution of sandy sediments (>63 µm to 2 mm) is illustrated in Figure 7.28. This figure highlights the widespread distribution throughout the Sound with a general reduction in sands in the lower energy inshore region towards the west. Where sands were prevalent in the western inshore regions (Stations 10 and 25) they also contained a higher proportion of fines (13.49 % and 2.77 % fines, respectively) than the sands found in the east of the Sound.

The geographical distribution of sediment fines (i.e. silts and clays <63 µm), is illustrated below in Figure 7.29. This shows a distribution pattern of an increasing proportion of fines towards the western inshore regions of Berkeley Sound, with stations 02A and 40 showing the highest proportions of fine sediments with 69.2 % and 65.5 %, respectively. In addition to this, fines were also elevated in the trough of the large basin feature around station 34. Again, the percentage of fines here was mostly distributed based upon the hydrodynamic regime, with elevated levels generally located where the water flow is of a lower energy.

The spatial distribution of coarser gravel sediments (granules above 2 mm in size) is presented in Figure 7.30. Coarse sediments were recorded in all but 10 samples spread throughout the survey area; where present, they ranged from less than 0.1 % to 69.9 %, with a survey mean of 13.7 %.

Most of the coarse sediments recorded within Berkeley Sound were generally biogenic in origin, i.e. relating to shell material derived from bivalves and barnacles (including the gravel ribbons). However, at stations in closer proximity to bedrock exposures (e.g. Stations 07, 08, 11, 12, 28, 29, 41, 44), higher proportions of cobbles, pebbles and gravels, from glacial and peri-glacial deposits and from the eroded rocks themselves, were found. Coarse sediments were often encrusted with biogenic material consisting primarily of molluscs, barnacles and bryozoans.

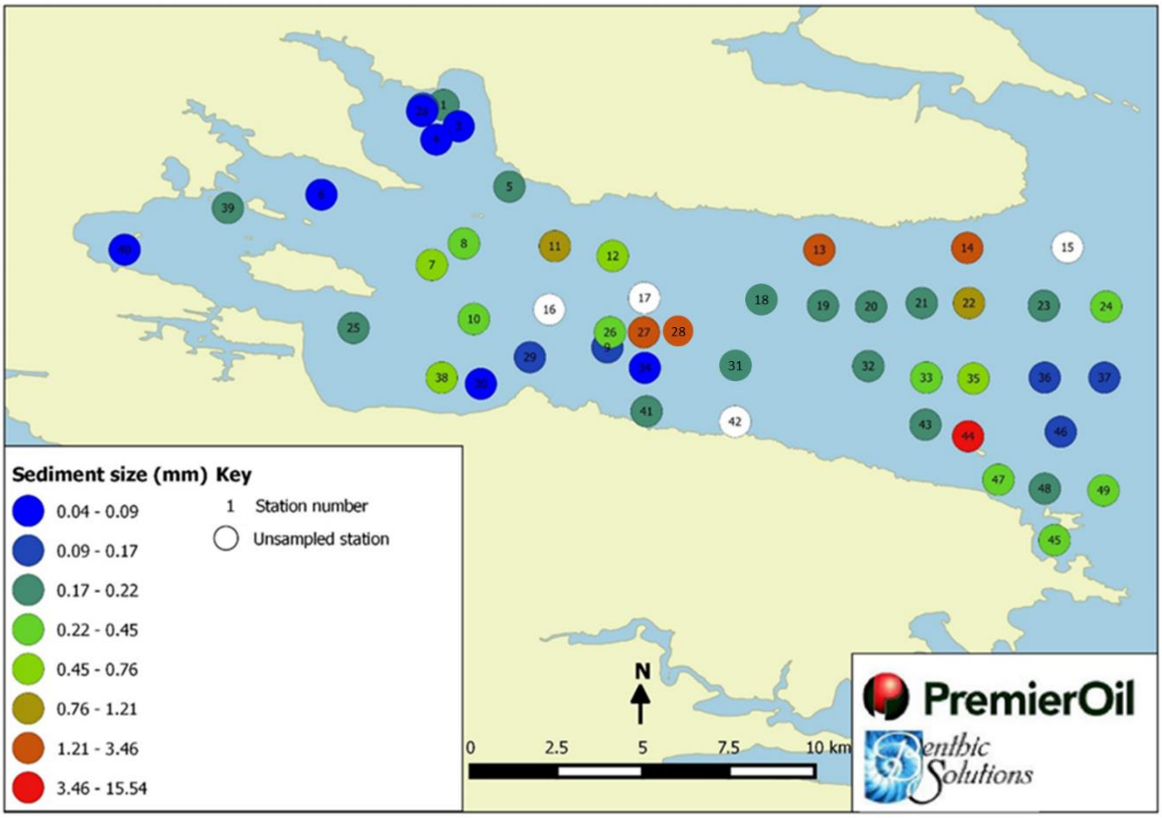


Figure 7.26: Mean particle size (mm) recorded at each of the 46 sites sampled (data from BSL,2015c)

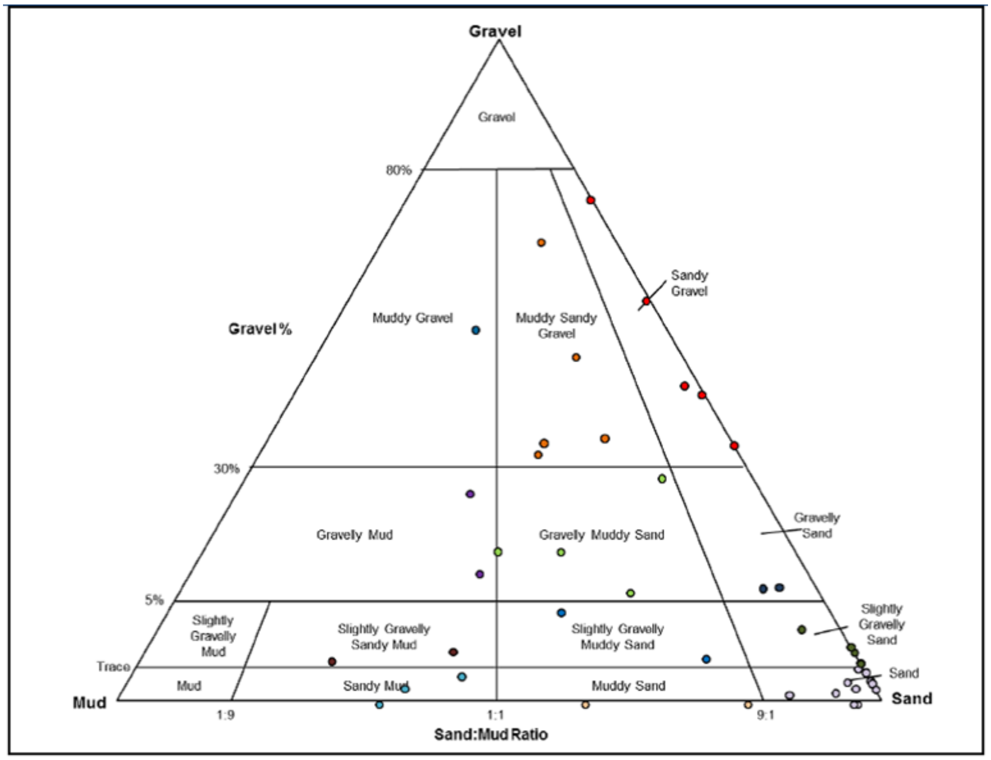


Figure 7.27: The position of the 46 stations sampled within Berkeley Sound within the Folk triangle (BSL, 2015c)

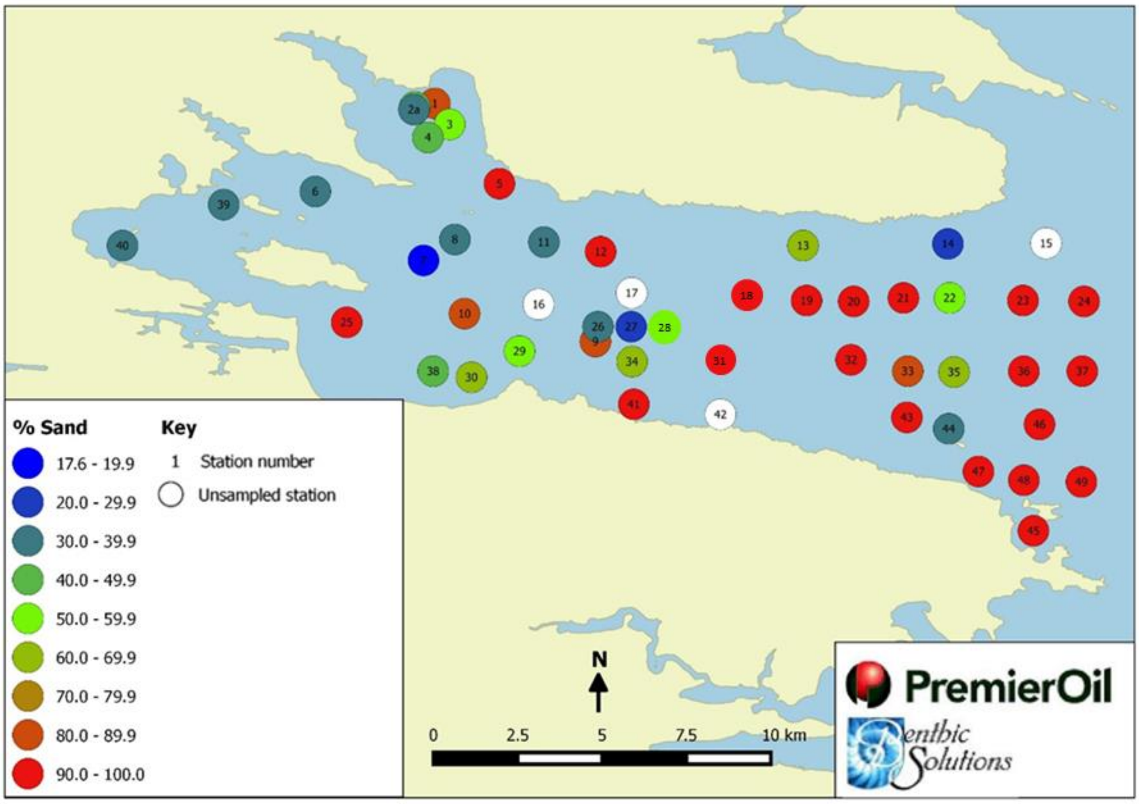


Figure 7.28: Percentage of sand recorded at each of the 46 sites sampled (data from BSL, 2015c)

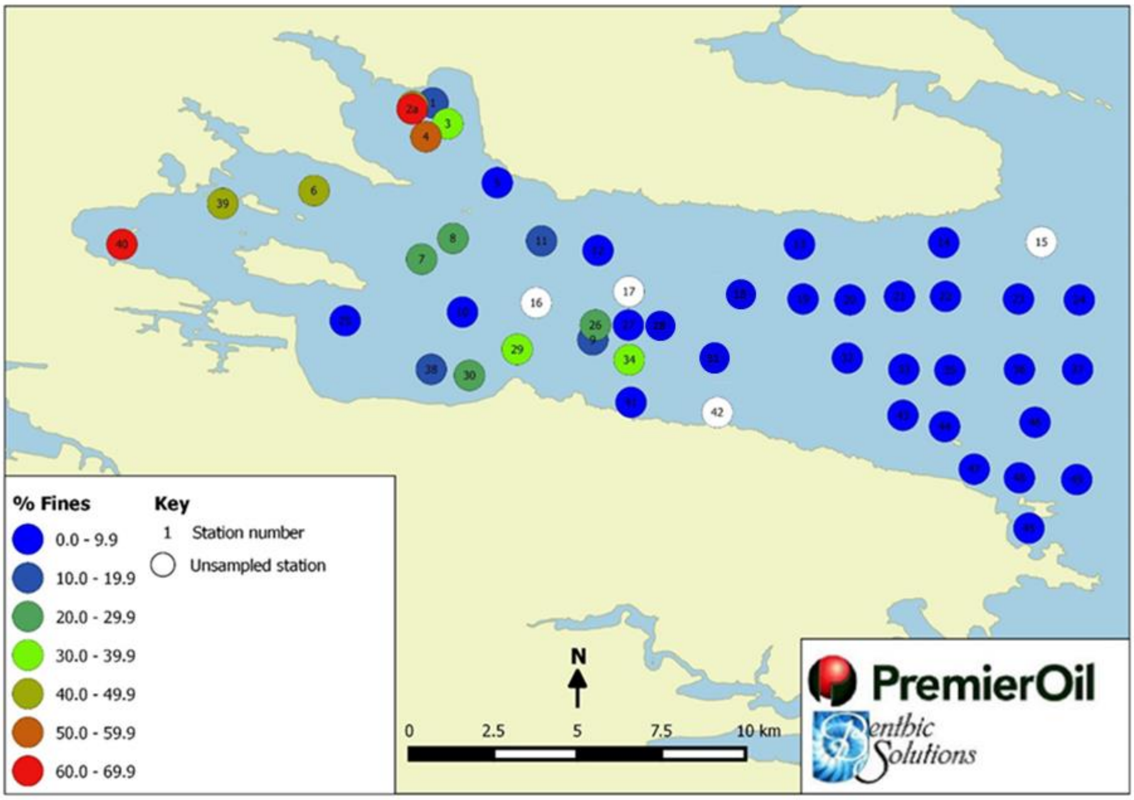


Figure 7.29: Percentage of fines recorded at each of the 46 sites sampled (data from BSL, 2015c

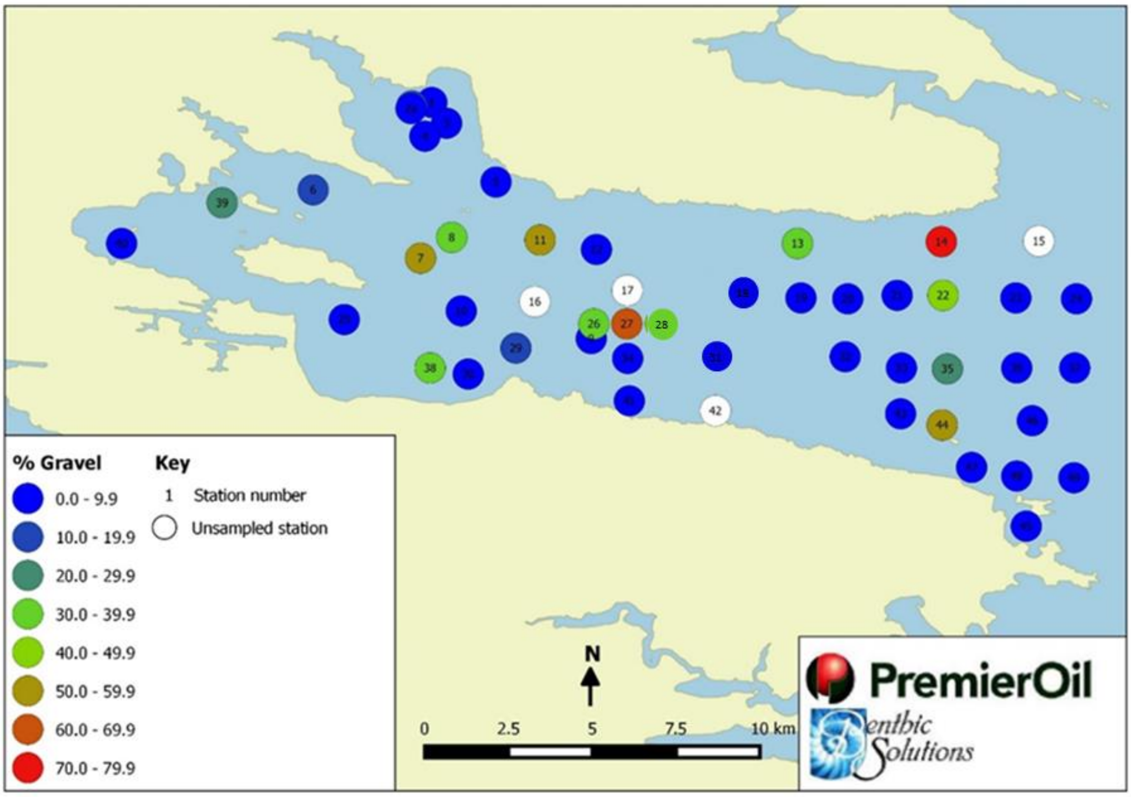


Figure 7.30: Percentage of gravel recorded at each of the 46 sites sampled (data from BSL, 2015c)

7.3.7.2.1.2 Total Organic Matter (TOM),Total Organic Carbon (TOC) and Total Inorganic Carbon (TIC)

Sediments were analysed for Total Organic Carbon (TOC), Total Inorganic Carbon (TIC), Total Organic Matter (TOM) and moisture content.

TOC represents the proportion of biological material and organic detritus within the substrates. In surface sediments, TOC is an important source of food for benthic fauna (Snelgrove and Butman, 1994), although an overabundance may lead to reductions in species richness and abundance due to oxygen depletion.

The TOC levels were variable throughout the survey area, ranging from <0.1 % in the sandy sediments up to 5.92 % at station 34, with a mean of 1.29 % ± 1.46 SD. The distribution generally follows a trend of increased organic enrichment with the percentage of fines. This is illustrated in Figure 7.31, showing an increase in TOC towards the western inshore region of Berkeley Sound, as well as in the large basin feature situated in the area of proposed LTV anchorage (Station 34). These variations are expected to be due to the increased sedimentation in these lower energy environments, compared with the higher energy mobile sands that are considered to be organically poor.

TOC levels could be considered a limiting factor within the substrate, influencing the distribution and abundance of some infaunal species such as deposit feeders. TOC within Berkeley Sound is expected to reflect both autochthonous (originating locally) and allochthonous (originated elsewhere) material. Primary production within Berkeley Sound in both phytoplankton and macroalgae form represent an important component of TOC, especially during summer blooming periods. TOC is expected to be strongly influenced by allochthonous material which includes fluvial transport (limited to small streams) as well as carbon sources entering the Sound from the surrounding sea.

As expected TOM levels followed the same trend as TOC levels which ranged from 0.45 % in sandy sediments (Station 21) to 14.94 % at Station 34, the survey mean was 3.15 % ± 3.73 SD.

TIC is the sum of inorganic carbon compounds such as carbon dioxide, carbonic acid, bicarbonate anions, and carbonate. In contrast to the TOC and TOM, the TIC correlated best with the percentage of gravel. Despite removing shell material from the samples, this correlation is likely due to epifaunal specimens such as bryozoans that contain carbonates in their exoskeletons and have colonised such gravels. Stations predominantly composed of sands and silts exhibited generally low TIC levels. TIC levels were variable and ranged from <0.1 % to 57.40 %, throughout the survey area, with a mean of 11.48% ± 11.96 SD recorded.

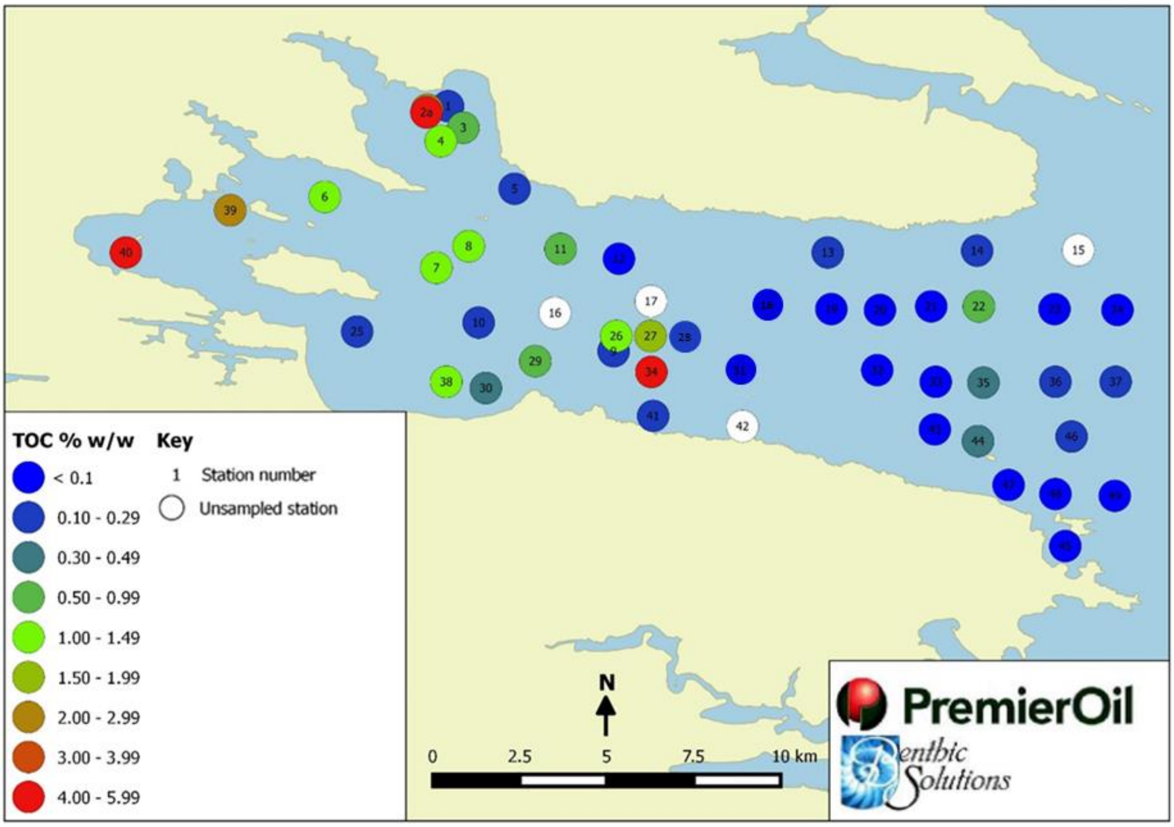


Figure 7.31: Total Organic Carbon (TOC) recorded at each of the 46 sites sampled (data from BSL, 2015c)

7.3.7.2.2 Sediment chemistry

7.3.7.2.2.1 Sediment hydrocarbons

It should be noted that Berkeley Sound cannot be considered a pristine environment with regards to hydrocarbons, with three significant oil spill events documented in the 20 years preceding this survey (SMSG, 2012), along with constant use of the area as an anchorage for large ships and fishing vessels. Understanding of the baseline sediment chemistry is therefore necessary to provide a point of comparison for any future monitoring.

Results for hydrocarbon analyses are summarised and tabulated as total hydrocarbon concentrations, total Polycyclic Aromatic Hydrocarbons (PAH), and total n-alkane and homologue ratios.

Total Hydrocarbon Concentrations

The Total Hydrocarbon Content (THC) of the sediments showed concentrations ranging from 1.03 $\mu g.g^{-1}$ at Station 48 to 159.89 $\mu g.g^{-1}$ at Station 34 (Figure 7.32). The lowest THC values were recorded at the mouth of the Sound in the east, and around Kidney Island in the sandier sediments. Stations located inshore to the west of the Sound showed a general increase in THC, as did the basin feature sampled at station 34 which contained the highest THC (159.89 $\mu g.g^{-1}$), almost four times greater than the next highest value. This can be compared with a central North Sea average of 9.51 $\mu g.g^{-1}$ and a 95th percentile of 40.10 $\mu g.g^{-1}$ (UKOOA, 2001).

THC levels generally correlate with the proportions of fines, TOC and TOM. A general exception to this trend were the stations located to the east and north of Cochon Island, which although generally showing low concentrations, were above those expected for this sediment type. In 2005, a reefer grounded on Cochon Island. Although the vessel was refloated and able to anchor within the Sound, this incident resulted in a small oil spill (approximately 130 tonnes of intermediate fuel oil).

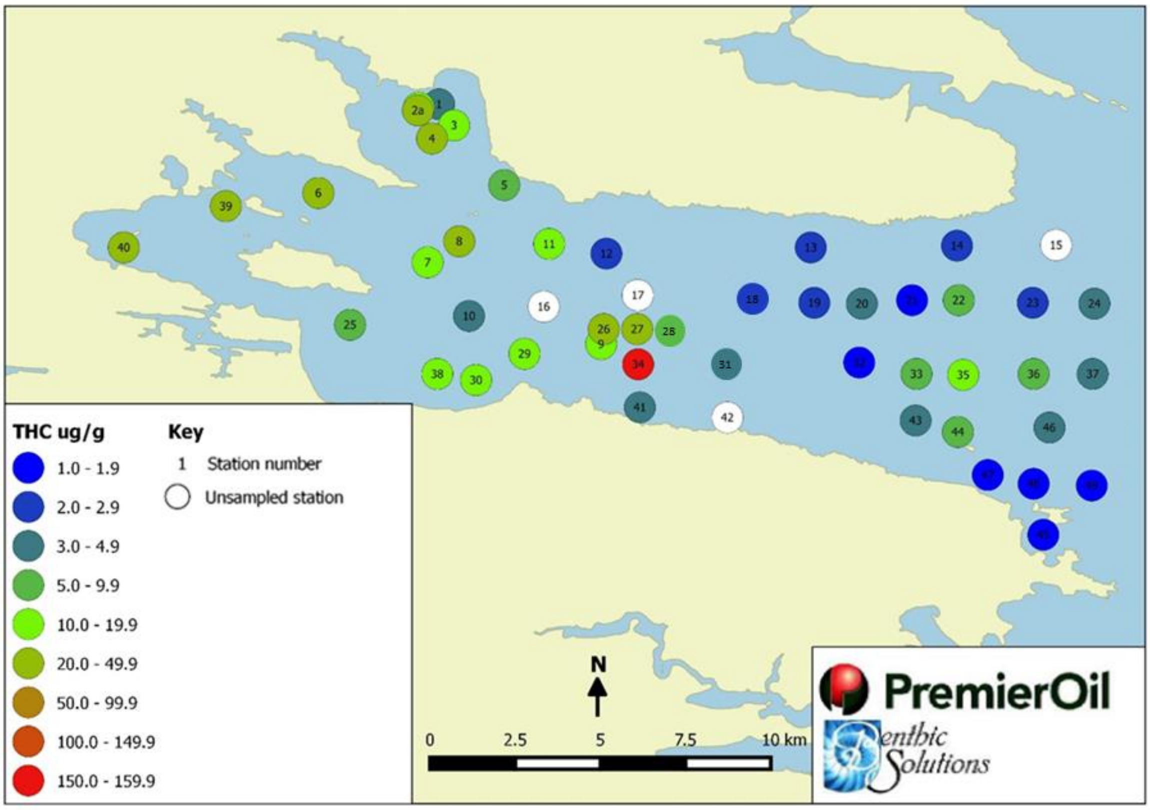


Figure 7.32: Total Hydrocarbon Concentrations (THC) recorded at each of the 46 sites sampled (data from BSL, 2015c)

Saturate / Aliphatic Hydrocarbons

All of the sampling stations were analysed for n-alkanes using Gas Chromatography with Flame Ionisation Detection (GC-FID). The total saturate alkane concentrations are illustrated in Figure 7.33

The total n-alkane concentrations were again highly variable, ranging from 0.03 to 9.99 $\mu g.g^{-1}$ with a mean of 0.72 ± 1.42 SD. The lowest n-alkane concentrations were found at Station 47 and the highest at Station 34, in line with the THC data. This correlates with the results obtained for fines, TOC and TOM.

The overall concentration of alkanes accounted for <10% of the total THC recovered at each station (mean 4.22 ± 1.66 SD). This is quite low, and is expected for uncontaminated marine sediments where background hydrocarbons are continuously replenished by a low but chronic source of alkanes.

Chromatograms were analysed in detail in order to identify the distribution of alkanes. All samples showed a peak at nC_{26} which is thought to be trans-squalene, in addition to this all samples except Stations 34, 37-39, 41 and 44-49, showed a peak at around 9.5 minutes which is thought to be Indole. Squalene is likely to have entered the marine environment through terrigenous plant material, whereas indole occurs due to the breakdown of algal tryptophan by bacteria (Maruyama *et al.,* 1989). This source is likely attributed to the breakdown of phytoplankton from the preceding summer months.

There were large Unresolved Complex Mixture (UCM) humps at Stations 02-04, 05-09, 26, 27, 29, 34, 35 and 38-40 (mainly western inshore stations). The UCM from nC_{10-25} is interpreted to relate to weathered diesel (this range is known as the diesel-range organics; DRO; Geosphere, Inc., 2006); whilst the heavier UCM from nC_{25-37}, peaking at around nC_{33} is likely to represent terrigenous plant materials, which typically comprise the long-chain, odd carbon-number n-alkanes (nC_{25-33}; Eglinton *et al.,* 1962). Given the location of Berkeley Sound, sources of terrigenous plant matter include mosses and grassland from the surrounding hills.

The chromatogram at Station 40 showed numerous peaks throughout the nC_{10-37} range, however, a notable hump peaking around nC_{26} was also observed; this shaped hump was not present at any other station. The station is in close proximity to terrestrial run-off and therefore could be caused by unresolved terrigenous material. Alternatively, this could be resultant from anthropogenic activity at Green Patch Settlement where a livestock farm is located; although the modest TOC and heavy and trace metals concentrations suggests any such influx is not significant.

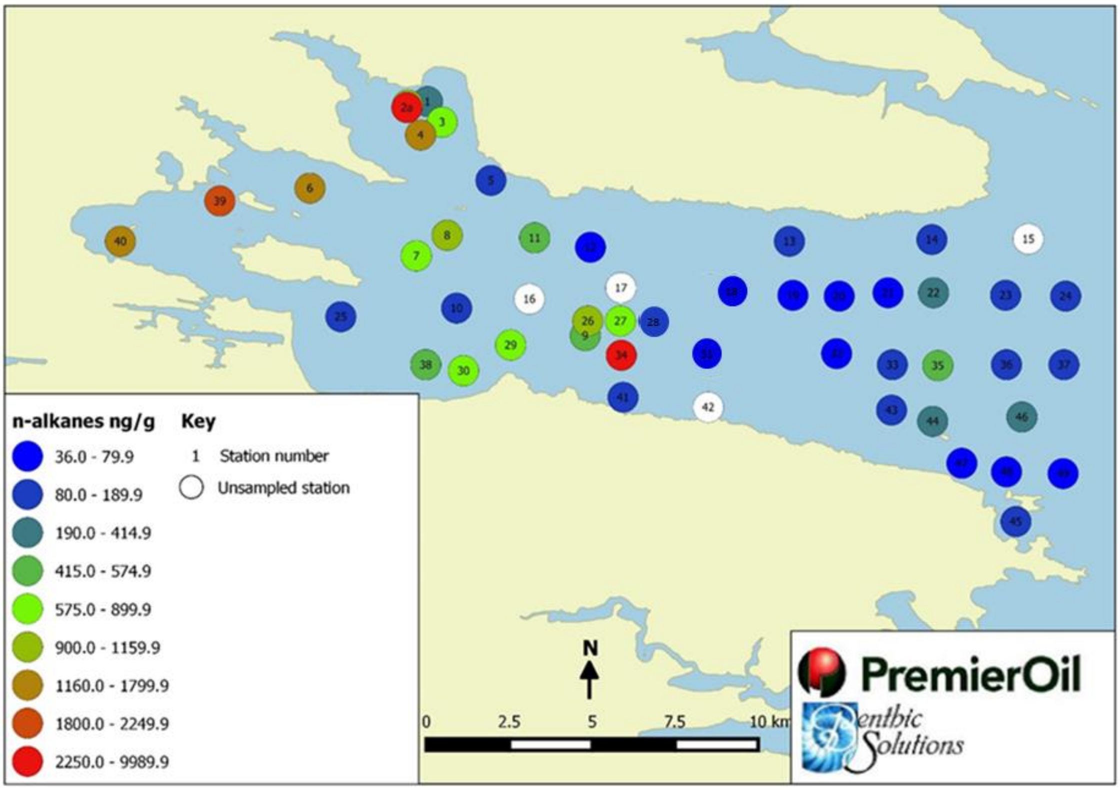


Figure 7.33: Total saturate alkanes recorded at each of the 46 sites sampled (data from BSL, 2015c)

Polycyclic Aromatic Hydrocarbons (PAH)

Polycyclic Aromatic Hydrocarbons (PAHs) and their alkyl derivatives have been recorded in a wide range of marine sediments (Laflamme and Hites, 1978) with the majority of compounds produced from what is thought to be pyrolytic sources. These include the combustion of organic material such as forest fires (Youngblood and Blumer, 1975), the burning of fossil fuels and, in the case of offshore oil fields, flare stacks. The resulting PAHs, rich in the heavier weight 4-6 ring aromatics, are normally transported to the sediments via atmospheric fallout or river runoff. Another PAH source is petroleum hydrocarbon, often associated with localised drilling activities. These are rich in the lighter, more volatile 2 and 3 ring PAHs (NPD; naphthalene (128), phenanthrene, anthracene (178) and dibenzothiophene (DBT) with their alkyl derivatives.

Total PAH concentrations (2 to 6 ring compounds) were highly variable, ranging from <1 to 938.5 $ng.g^{-1}$ (mean 48.48 ± 153.68 SD; Figure 7.34). Total PAHs showed a general increase in concentration with the percentage of fines; as expected, Station 34 contained the highest PAH level in line with results for THC and alkanes.

The naphthalene (NPD) fraction (2 and 3 ring aromatics) followed a very similar trend to total PAH, ranging from <1 to 372.28 $ng.g^{-1}$ with a mean of 23.18 ± 58.91 SD. A higher proportion of NPD at many stations, ranging from 51.7% to 100.0%, suggest a petrogenic influence.

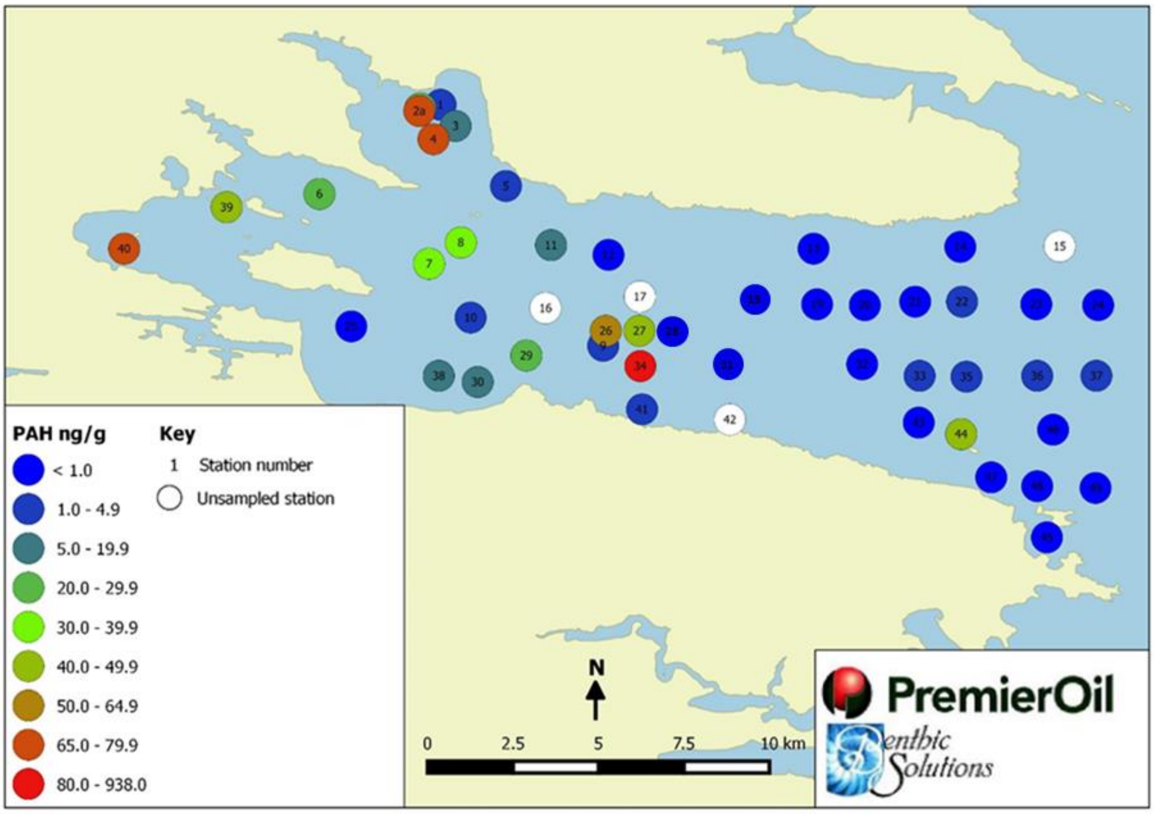


Figure 7.34: Total Polycyclic Aromatic Hydrocarbons (PAH; 2-6 Ring) recorded at each of the 46 sites sampled (data from BSL, 2015c)

7.3.7.2.2.2 Heavy and trace metal concentrations

Metals are generally not harmful to organisms at concentrations normally found in marine sediments and some, like zinc, may be essential for normal metabolism, although it can become toxic above a critical threshold. In order to assign a level of context for toxicity, an approach used by Long *et al.,* (1995) to characterise contamination in sediments will be used here. These researchers reviewed field and laboratory studies and identified metals that were observed to have ecological or biological effects on organisms. They defined 'Effect Range Low' (ERL) values as the lowest concentration of a metal that produced adverse effects in 10 % of the data reviewed, while 'Effect Range Median' (ERM) values designate the level at which half of the studies reported harmful effects. Consequently, metal concentrations recorded below the ERL value are not expected to elicit adverse effects, while levels above the ERL and ERM values are likely to be toxic to some marine life, though with varying likelihood.

The results of heavy and trace metal analysis, with an indication of whether the mean recorded measurements exceeded the ERL are summarised in Table 7.2. Full results can be found in BSL (2015c).

In Berkeley Sound, cadmium (Cd) levels were variable but generally moderate in concentration (above the ERL), and were highest in areas containing a higher proportion of fine sediments. Results suggest a naturally high background concentration of cadmium in these areas. Nickel (Ni) levels exceeded the ERL at Station 47, and arsenic (As) at Stations 07, 13 and 40. Mercury (Hg) remained at trace concentrations at all stations sampled.

Moderate but variable concentrations of lead (Pb) were recorded, however, the highest value recorded at Station 18 fell below the ERL. As with all metals except copper, lead indicated a significant positive correlation with the percentage of fine sediments.

For this survey, natural barium (Ba) levels recorded were variable, reflecting the sediment changes across the Sound with a general positive correlation with the percentage of fines. The majority of barium is typically insoluble in the form of a non-toxic sulphate (Gerrard *et al.,* 1999); this metal is rarely of toxicological concern to the marine fauna.

Of the other metals, chromium (Cr), nickel (Ni), copper (Cu), vanadium (V), tin (Sn) and zinc (Zn) all yielded relatively low concentrations. Vanadium is often associated with the oil and gas industry as it is present in relatively high concentrations in most crude oils (Khalaf *et al.,* 1982). Most vanadium enters seawater in suspension or colloidal form, passing quickly out of the water column and into silt deposition (Cole *et al.,* 1999). Consequently, as the natural background levels in this region were relatively low, possible impacts from anthropogenic activities are likely to be detected from future surveys.

The slight elevation of arsenic at Station 40 as well as containing the highest concentrations of chromium, vanadium and zinc could be due to its close proximity to a livestock farm located at the nearby Green Patch Settlement. However, as high aluminium levels were also recorded here it is most likely a factor of sediment type, which has incurred enrichment of heavy and trace metals. Further to this, based upon the general low concentrations at which heavy and trace metals are recorded at both this station and throughout the survey area, none are considered to be of ecotoxicological concern.

Table 7.2: Summary of heavy and trace metal concentrations in Berkeley Sound (BSL, 2015c)

Measure	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Tin	Vanadium	Zinc	Aluminium	Barium	Iron
Max (St.[a])	14.2 (40)	4.12 (34)	52.1 (40)	7.7 (18)	43.7 (18)	0.08 (44)	21.7 (47)	3.0 (31)	72.9 (40)	50.1 (40)	38,600 (40)	424 (30)	15,400 (39)
Mean	3.43	1.24	18.25	4.53	8.59	0.02	6.89	1.08	28.36	18.7	13,783	204.9	5,972
SD	2.72	1.44	12.33	1.52	6.88	0.02	4.66	0.54	15.18	12.67	9,677	112.4	3,955
Var (%)	79.3	116.0	67.5	33.5	80.1	92.7	67.7	50.09	53.5	67.76	70.21	54.8	66.2
ERL	8.2	1.2	81.0	34.0	47.0	0.15	21.0	n/a	n/a	150.0	n/a	n/a	n/a
Mean > ERL	No	**Yes**	No	No	No	No	No	n/a	n/a	No	n/a	n/a	n/a
ERM	70.0	9.6	370.0	270.0	220.0	0.71	52.0	n/a	n/a	410.0	n/a	n/a	n/a

[a] St = Station number (see Station numbers in Figure 7.34 above)

7.3.8 Summary of physical environment

A summary of the offshore and inshore physical environment is provided in Table 7.3.

Table 7.3: Summary of the offshore and inshore physical environment

Subject	Summary
NFB and the Sea Lion Field	
Meteorology	There is little meteorological data available from the location of the Sea Lion Field. Premier has developed a hindcast weather model, both covering 20 years. The model produced wind and wave data for a wide area around the Falklands. The results were calibrated and verified against satellite and measured data, and confirmed previous wind and wave assumptions.
Oceanography and water quality	There is still a great deal to understand with regards to circulation and hydrodynamics of the Southern Patagonian Shelf. This area has a complex oceanography heavily influenced by the Falkland Current (off shoot of the Antarctic Circumpolar Current), tide and bottom topography. The GAP process has highlighted this area as a priority; and in order to progress this empirical field data will be required to inform, improve and ground truth modelled data.
Bathymetry	The area of the Sea Lion Field is situated on the Continental Shelf Slope in waters approximately 450 m in depth. The seabed in the NFB is characterised by numerous indentations, troughs and trenches. Bathymetric surveys conducted over the NFB indicated the presence of poorly preserved iceberg keel scars.
Sediment types	Sediments across the NFB typically exhibit a south-north gradient of decreasing mean particle size. The proportion of fine material, defined as material with a diameter less than 63 µm, generally increases with increasing depths, and the sediment types ranged from very fine sand in shallower waters (225 m depth) to the southwest, to coarse silt in deeper waters (464 m depths) to the northeast. Sediment types and TOM / TOC levels in the Sea Lion area are generally considered to be homogenous. The sediments are classified as 'medium silt' and, based on post-drilling surveys, appear to be unaffected by previous drilling campaigns. With regard to sediment chemistry, there was no direct evidence of seabed disturbance or elevated concentrations of hydrocarbons and metals associated with historical drilling activity within the Sea Lion area, although some fractions of hydrocarbon may have been derived from contamination associated with the previous drilling activity. Subtle differences between stations were evident that are thought to be associated with natural spatial variation across the area. Hydrocarbon, TOM, TOC and metal concentrations were considered typical of the medium and coarse silty sediments recorded in the Sea Lion survey area (Gardline, 2013b).
Sediment chemistry	With regard to sediment chemistry, there was no direct evidence of seabed disturbance or elevated concentrations of hydrocarbons and metals associated with historical drilling activity within the Sea Lion area, although some fractions of hydrocarbon may have been derived from contamination associated with the previous drilling activity. Subtle differences between stations were evident that are thought to be associated with natural spatial variation across the area. Hydrocarbon, TOM, TOC and metal concentrations were considered typical of the medium and coarse silty sediments recorded in the Sea Lion survey area (Gardline, 2013b).
Berkeley Sound	
Meteorology	Over the course of the year, typical wind speeds vary from 2 m/s to 14 m/s (light breeze to strong breeze) and rarely exceed 18 m/s (gale). Westerly winds are the most common. The air temperature typically varies from 0 C to 15°C and precipitation is most likely in June and least likely in October
Oceanography and water quality	Water quality profiles indicate that the water column within Berkeley Sound is generally well mixed with a significant freshwater influence from the surrounding hills, particularly during the winter months. This is especially evident towards the western extent of the Sound, which is interpreted to have a lower energy hydrodynamic regime. The high wind speeds recorded during the survey, along with the influence from the Falkland Current and the gently shoaling bathymetry within Berkeley Sound are likely to be responsible for the well mixed water column.

Subject	Summary
Bathymetry	Bathymetrically the Sound deepened from the shallow waters in the west to approximately 55 m at the entrance to the Sound in the east. A basin feature dominates the central region of the Sound, around the LTV anchorage location; this depression is approximately 11 m below the level of the surrounding seabed and is expected to act as a sink, with a higher deposition rates of finer sediments.
Sediment types	Environmental ground-truthing confirmed the presence of numerous subtle sediment changes throughout Berkeley Sound with differing proportions of coarse material in the form of fragmented shells, gravel, cobbles and boulders. Generally, the majority of sediments were dominated by sands; however the shallow embayments in the west of Berkeley Sound comprised higher proportions of fine materials, reflecting a weaker hydrodynamic regime. Mega-rippled sand and evidence of current turbulence was present at the eastern end of the survey area. Mobile linear gravel ribbons were recorded throughout the sand habitat to the east of the LTV anchorage location, comprising gravels, cobbles and relic bivalve shells (clams and mussels) heavily encrusted with relic and live barnacles and calcareous mats of pink coralline algae (*Corallina* spp.). Bedrock exposures were recorded in the area of the LTV anchorage location and along the north and south coasts of Berkeley Sound, forming large escarpments in some areas with erosional deposits often present around the base.
Sediment chemistry	Physio-chemical parameters generally showed similar trends throughout the survey area relating to sediment characteristics, and in particular to the proportion of sediment fines; this was the case for total organic content and hydrocarbon concentrations. Station 34, located within the basin feature, showed distinct elevations in organics and hydrocarbons including n-alkanes and PAHs. Despite such elevations, the proportions of n-alkanes and PAHs to total hydrocarbons were similar throughout, suggesting that the area does not reflect any significant variation above that dictated by the sediment type. Consequently, locations that were predominantly sand contained generally low level hydrocarbon concentrations. Where hydrocarbons are present, these were thought to be largely terrigenous in origin, however, evidence for petrogenic sources was also recorded, with weathered diesel signatures observed in most samples within the central part of the Sound. Heavy and trace metals were variable, with general concentrations positively correlating with the percentage of fine sediments. All metals, with the exception of cadmium, were as expected for this region with Station 40 generally showing marginally higher metal concentrations, potentially attributable to its proximity to the Green Patch Settlement, where a livestock farm is present.

7.4 Biological environment

The following sections provide data on the abundance and distribution of the key biological receptors identified within Annex C – Schedule 4 of the FIG Offshore Minerals Ordinance (section 3.1.6.3.1) and listed in section 1.1. Each section is separated into a description of the receptors offshore (the NFB and / or Sea Lion Field) and inshore (Berkeley Sound) and ends with a summary of the key life history characteristics. Where necessary, further details on the life history characteristics are provided within the EIA Chapters (10 and 12) as is relevant to the impact and / or risks being assessed.

7.4.1 Plankton

7.4.1.1 Introduction

The planktonic community is composed of a range of microscopic plants (phytoplankton) and animals (zooplankton) that drift with the oceanic currents. These organisms form the basis of marine ecosystem food chains and many species of larger animals such as fish, seabirds and cetaceans are dependent upon them. The movements of plankton therefore directly influence the movement and distribution of other marine species such that impacts upon plankton may impact upon other receptors. Therefore, it is important to understand the distribution of these organisms.

In general, it can be understood that both the oceanography and topography of the southern Patagonian Shelf (section 7.3.3) create an area of very high plankton productivity immediately to the north of the Islands.

7.4.1.2 Phytoplankton

The distribution and abundance of phytoplankton itself is heavily influenced by salinity, nutrients, water depth, tidal mixing and thermal stratification within the water column (NSTF, 1993). The majority of phytoplankton occur in the photic zone (the upper tens of metres, which receives enough sunlight for photosynthesis to occur) and are unicellular organisms, such as diatoms and dinoflagellates.

7.4.1.2.1 Offshore phytoplankton

There may be as many as 5,000 species of marine phytoplankton with diatoms, cyanobacteria and dinoflagellates amongst the most prominent groups. Historic samples within the vicinity of the Falkland Islands indicate that there are relatively few phytoplankton species with high diatom abundance south of 44°S, whilst the northern waters were comparatively dominated by dinoflagellates and ciliates (Hendley, 1937; Rodhouse *et al.,* 1992).

Shelf waters to the north of the Falklands are particularly rich in phytoplankton (Figure 7.35) in part because of the convergence of the Malvinas and Brazil Currents (section 7.3.3). The turbulent interactions of these currents bring nutrient-rich water to the ocean surface, allowing the phytoplankton to take full advantage of the long days and strong sunlight. The area of the shelf-break between the Falkland Islands and the Phase 1 Development is also an area of high phytoplankton production. It is thought that this the result of upwelling of nutrient rich waters, created by the Falkland Current and seabed topography at the shelf-break.

Although phytoplankton is present year-round, blooms tend to appear in October and can persist throughout the austral spring and summer.

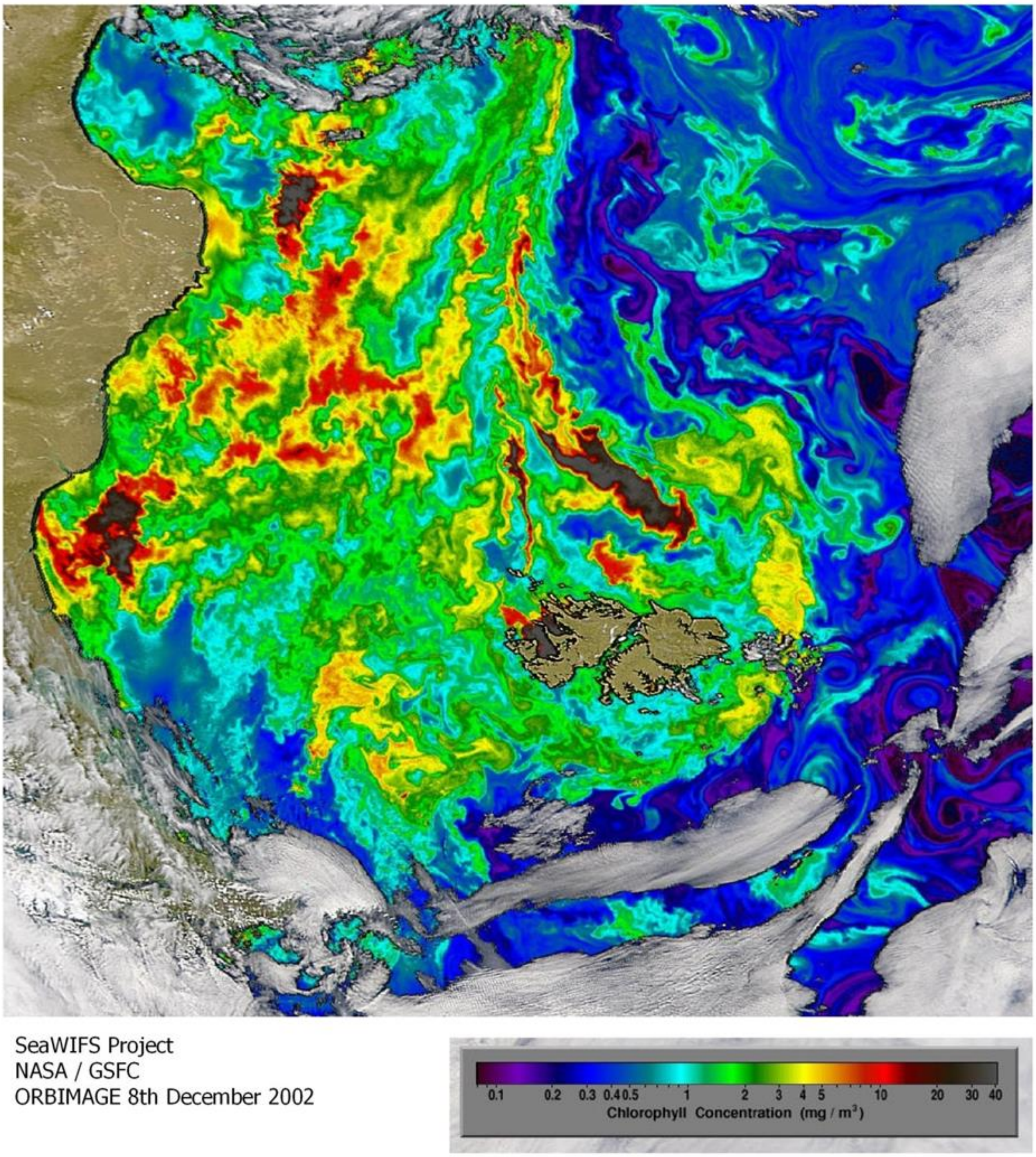


Figure 7.35: Example of Chlorophyll-a concentrations in the southwest Atlantic *(image provided by the SeaWIFS Programme, NASA / Goddard Space Flight Center, and ORBIMAGE)*

7.4.1.2.2 Inshore phytoplankton and Harmful algal blooms

Although Harmful Algal Blooms (HAB) of phytoplankton appear to be rare events in the Falklands, they are a common occurrence off the southern coast of Chile. While HABs have not been recorded in Berkeley Sound, in 2002, one occurred in the inshore waters to the west of the

Falklands. HAB algae contain toxins that accumulate up the food chain poisoning higher predators or rendering filter-feeding organisms toxic. The HAB in 2002 resulted in the death of many penguins (Baylis *et al.,* 2013a & b) and other marine organisms.

7.4.1.3 Zooplankton

7.4.1.3.1 Offshore zooplankton

The high levels of phytoplankton in the NFB supports complex communities of zooplankton (Tarling *et al.,* 1995; Boltovskoy, 2000), which in turn support complex pelagic and demersal ecosystems (Agnew, 2002).

The Falkland Current, an offshoot of the Antarctic Circumpolar Current, brings oxygen and nutrient rich water to the Falklands. The Islands split the Falkland Current into east and west branches, which sweep around the Islands to re-join to the north. This complex system of currents and bathymetry produces areas of upwelling and eddies, where there is little water movement. In turn, this influences primary production and the distribution of zooplankton. In the Falklands, the peak in total zooplankton abundance occurs between January and March, when an area of very high zooplankton density occurs at the shelf-break to the north of the Islands (Agnew, 2002). An area of high zooplankton density also occurs on the shelf-break to the north-east of the Falklands in winter.

A study by Padovani *et al.* (2012) examining the role of the hyperiid amphipod crustacean *Themisto gaudichaudii* on the Patagonian Shelf concluded that this species contributes greatly, both directly and indirectly, to supporting the fish community in the area. The study proposed that this amphipod plays a key role in the sub-Antarctic region, similar to that of Antarctic krill (*Euphausia superba*) in Antarctic waters, channelling the energy flow and enabling a short and efficient food chain.

Gelatinous zooplankton, such as jellyfish, are also considered an important component of the offshore ecosystem, occurring in the diets of at least seven species of fish. For two species in particular, namely the southern rock cod (*Patagonotothen ramsayi)* and spur dogs *(Squalus acanthias),* comb jellies (ctenophores) comprise more than 10 % of the diet (Arkhipkin and Laptikhovsky, 2013).

Other important components of the zooplankton community include the euphausiids *Thysanoessa gregaria*, *Euphausia vallentini* and *E. lucens* (Tarling *et al.,* 1995; Boltovskoy, 2000). Together with *T. gaudichaudii,* these comprise important prey items some of the Falkland Islands most abundant finfish species (e.g. hoki (*Macruronus magellanicus*)) as well as Argentine shortfin squid (*Illex argentinus*) (Mouat *et al.,* 2001; Agnew, 2002; Brickle *et al.,* 2009). Similarly, lobster krill can be found in dense shoals on the shelf where they constitute prey for seabirds, fish and baleen whales (Harrison-Matthews, 1932; Arkhipkin *et al.,* 2001; Arata and Xavier, 2003; Laptikhovsky and Arkhipkin, 2003; Laptikhovsky, 2004; Clausen *et al.,* 2005; Brickle *et al.,* 2009; Michalik *et al.,* 2010; Quillfeldt *et al.,* 2011 and P. Brickle, *pers. obs.*).

7.4.1.3.2 Inshore zooplankton

In inshore waters, lobster krill (*Munida* spp.) is perhaps the most significant component of the zooplankton community and forms dense shoals inshore, but is largely absent from more oceanic waters.

7.4.1.3.2.1 Lobster krill (Munida spp.)

The near-shore environment is dominated by two species of lobster krill:

- Gregarious lobster krill (*Munida gregaria*); and
- Short-eyed lobster krill (*M. subrugosa*).

Post-larval stages of these crustaceans (once thought to be a separate species and sometimes known as *Grimothea*) are pelagic and can form dense shoals, turning the water red. The adults are more commonly found on the seabed but also display shoaling behaviour. Shoals are most frequently encountered between November and May but adult lobster krill can be found throughout the year. These are very abundant species in the Falkland Islands near-shore environment and are critical to this ecosystem (Agnew, 2002). The inshore distribution of this species and its importance as a component of the diets of many higher predators make it an important component of the inshore zooplankton. Evidence from animals examined during the early 20th century whaling, indicate that lobster krill were particularly important prey for sei, humpback and right whales (Harrison-Matthews, 1932). These animals are also important prey for seabirds, (Thompson, 1993; Quillfeldt *et al.,* 2011; Clausen *et al.,* 2005; Michalik *et al.,* 2010; Arata and Xavier, 2003) fish (Arkhipkin *et al.,* 2001; Laptikhovsky and Arkhipkin, 2003; Laptikhovsky, 2004; Brickle *et al.,* 2009).

7.4.2 Marine and Inter-tidal vegetation

7.4.2.1 Introduction

Understanding the marine and inshore vegetation of the Falkland Islands is important as algae are one of the major primary producers in the inshore marine environment. It is necessary to determine whether there are any species present that may be at risk from any oil-related activities or pollution.

7.4.2.2 Seaweeds and algae of the inshore environment

There are 253 seaweed species recorded from around the Falkland Islands (Brodie and Mrowicki, 2019), primarily in inshore waters. Seaweeds within the Falkland Islands, and elsewhere, fall into one of three categories:

- Brown algae (*Phylum: Ochrophyta*);
- Green algae (*Phylum: Chlorophyta*) and
- Red algae (*Phylum: Rhodophyta*).

There have been several collections of seaweeds from around the Islands and samples of 400 and 350 specimens were collected by Vallentin (1909-11) and Clayton (2002-03) respectively (described in Wells, 2010). In 2013, two expeditions were conducted to collect further samples

(c. 500) with the aim of producing the first-ever inventory of the macroalgal species of the Falkland Islands (Mystikou, 2015). Most recently, the Darwin Plus funded project 'Building foundations to monitor and conserve Falklands marine forest habitats' (DPLUS068, 2017-2019) consolidated specimens from herbariums in Falklands Conservation and the Natural History Museum, London. There appear to be many similarities between the Falkland Islands and southern South America (Wells, 2010), with many new species and new records found recently (Brodie and Mrowicki, 2019).

The more conspicuous algal species found in the Falkland Islands are listed in Table 7.4 (Neely and Brickle, 2013).

7.4.2.2.1 Brown algae (Phylum: Phaeophyta)

Of the 58 species of brown algae recorded in the Falklands, the most visually dominant species are the giant kelp (*Macrocystis pyrifera*), the tree kelp (*Lessonia* spp.) and bull kelp (*Durvillaea antarctica*), all of which are classed as brown alga, and are common inshore, between 0.5 m to approximately 40 m depth.

7.4.2.2.1.1 Giant Kelp (Macrocystis pyrifera)

The most characteristic seaweed of the Falkland Islands, and most likely to interact with oil and gas activity in Berkeley Sound, is the giant kelp, *Macrocystis pyrifera*. This species is one of the largest (growing up to 60 m in length) and most abundant of the brown algae found around the coast of the Falkland Islands (Tussenbroek, 1989). Giant kelp forms extensive beds with large floating canopies (known as 'forests') in shallow coastal waters, although relatively sparse within Berkeley Sound when compared with the rest of the east coast of the Islands (section 7.4.3). Giant kelp is a significant species within the shallow marine environment serving as a primary producer and as the foundation to a much more diverse habitat, which supports many species of invertebrate that in turn support higher predators (seabirds and marine mammals, White *et al.,* 2002).

Giant kelp is found in more temperate climates, where sea temperatures are less than 20°C. It is found in areas with rocky, or hard, substrate, which the kelp is anchored to via a holdfast. The stipe grows out of the holdfast and this leads into the leaf-like fronds, which are buoyed by small gas-filled bladders. Research shows that giant kelp may grow at a rate of 60 cm per day (Neely and Brickle, 2013).

The waters of the Falkland Islands are particularly productive and nutrient rich and giant kelp flourishes in the area. Large kelp fronds may become detached from the seabed, as a result of grazing from benthic herbivores or during storm events, to form large rafts that float freely on the sea surface. The distribution of free-floating kelp patches in Falkland Islands waters was reported from the at-sea surveys carried out between February 1998 and January 2001 (White *et al.,* 2002). Floating kelp patches were particularly important foraging habitat for grey-backed storm-petrels (*Garrodia nereis*) with an additional 21 seabird species also recorded as associating with free-floating patches of kelp (Gillon *et al.,* 2001).

7.4.2.2.1.2 Tree Kelp (Lessonia spp.)

Tree kelp is often found intertwined with giant kelp. There are four species of tree kelp that have been identified within Falklands waters: *Lessonia flavicans* (Broad-blade tree kelp; the most common of the four), *L. nigrescens*, *L. frutescens* (although this is suspected to be a local form of *L. nigrescens* (Skottsberg, 1921)) and *L. vadosa* (shallow tree kelp).

Broad blade tree kelp inhabits slightly deeper waters than some of the other tree kelp species, from 2 to 20 m, inhabiting silty sediments and forms dense canopies. Conversely, the shallow tree kelp inhabits depths between 0.5 to 2 m and grows in areas of harder substrate.

Loligo squid, one of the most important marine resources in the Falklands, are known to use kelp beds (primarily *Lessonia* spp.) as spawning sites (Brown *et al.,* 2010).

7.4.2.2.1.3 Bull kelp (Durvillaea antarctica)

Bull kelp (*Durvillaea antarctica*) has a circum-polar distribution in the Southern Ocean. It is extremely robust and found on exposed shores. Unlike many of the other large brown algae, bull kelp does not have air bladders, instead it floats due to a unique honeycomb structure within the alga's blades, which also helps this species to avoid being damaged by the strong waves.

Table 7.4: Conspicuous algae species found within Falkland Islands Waters [a]

Phylum	Common namea	Scientific names [a]
Brown algae (Phaeophyta)	Giant kelp	*Macrocystis pyrifera*
	Shallow tree kelp	*Lessonia vadosa*
	Broad blade tree kelp	*Lessonia flavicans*
	Bull kelp	*Durvillaea antarctica*
	Creeping ring algae	*Herpodiscus durvillaea*
	Bladder algae	*Adenocystis utricularis*
	Sea potato	*Leathesia marine*
	Rope algae	*Desmarestia chordalis*
	Fur algae	*Desmarestia distans*
Green algae (Chlorophyta)	Cushion algae	*Codium effusum*
	Dead man's fingers	*Codium fragile*
	Sponge weed	*Spongomorpha arcta*
	Sea lettuce	*Ulva lactuca*
	Gutweed	*Ulva intestinalis*
	Ruffled sea lettuce	*Ulva linza*
Red algae (Rhodophyta)	Rock-leaf algae	*Lithophyllum falklandicum*
	Encrusting coralline algae	*Corallina spp.*
	Feathered coralline algae	*Corallina officinalis*
	Blood algae	*Hildenbrandia lecannellieri*
	Coiled algae	*Ahnfeltia plicata*
	Iridescent algae	*Iridaea spp.*
	Red sheet algae	*Gigartina skottsbergii*

[a] Source of data and nomenclature for the latin names follows Neely and Brickle (2013)

7.4.2.2.2 Green algae (Phylum: Chlorophyta)

Most of the 45 species of green algae in the Falkland Islands are known from shallow waters and include the sea lettuces *Ulva* spp. and cushion algae such as the *Codium* spp. These are anecdotally highly diverse and will be subject to study on how refugia (like the Falkland Islands) in the last glacial maximum contributed to this diversity, at species and population levels, and indeed how they may have recolonised other glaciated areas as the ice retreated.

7.4.2.2.3 Red algae (Phylum: Rhodophyta)

Red algae are the most diverse group of seaweeds, with 150 species recorded in the Falklands. Along with more typical fleshy species, the red algae include coralline, or encrusting, algae that secrete calcium carbonate. Only red algae are able to live and grow at greater depths than other seaweeds because their red pigmentation means they are able to absorb the blue light available at greater depths (maximum depth for most species is less than 100 m but coralline algae may grow in deeper waters).

7.4.2.3 Mapping of kelp beds

Coastal kelp was mapped utilising Land-Sat satellite imagery with a resolution of 30 m (Premier, 2014b). Imagery relates to kelp on the sea surface and may comprise of giant kelp, tree kelp or bull kelp. Sub-surface tree-kelp and narrow fringes of bull kelp on rocks may not be visible and it was assumed that the greatest area relates to giant kelp and surface tree kelp. Coastal kelp images were taken in August 2013 (East Falkland) and June 2014 (West Falkland), and as such are representative of winter kelp coverage.

As part of the process of assessing the suitability of Berkeley Sound for LTV anchorage, kelp was mapped for the entire Falkland Islands coastline (Premier, 2014b). The spatial extent present within different sections of the coast was compared to the total island-wide coverage of kelp. The coast between MacBride Head and Cape Pembroke (encompassing Berkeley Sound) contained 19.5 km^2 of kelp, equivalent to about 2 % of all Falklands kelp.

Given the importance of kelp beds as an inshore habitat for a wide range of species assemblages and the unknown importance for kelp as a spawning ground for loligo, the distribution of kelp is an important consideration regarding the possible impact and response to potential oil spills. Kelp may have the ability to retain oil and prevent effective oil spill response; however, when compared with the East Falkland coastline as a whole, Berkeley Sound has relatively low kelp coverage (Figure 7.36).

In 2016, further analysis of satellite images was conducted to map terrestrial, inter-tidal and shallow marine habitat types (EnvSys, 2016). Under good conditions, it is possible to map the seabed down to a depth of approximately 15 m. With the aid of the results of dive surveys at known locations it was possible to map kelp below the surface and distinguish between some of the most conspicuous species. Figure 7.37 shows the distribution of giant kelp (*Macrocystis pyrifera*) within Berkeley Sound. The most extensive patches of kelp are located in the relatively shallow, sheltered waters of the Inner Sound, around Cochon Island, Kidney Island and in the vicinity of Volunteer Point.

Through SAERI's Darwin Plus (DPLUS065, 2017-2020) project 'Mapping the Falklands & South Georgia coastal margins for spatial planning' broad-scale coast and terrestrial habitat maps have been produced using Sentinel satellite imagery (10 m resolution) imagery. Although finer resolution, this analysis showed similar patterns of kelp distribution at similar spatial scales around the Falklands compared to the Premier (2014) study. As such, the results of the ongoing SAERI project are not presented here but can be made available by request.

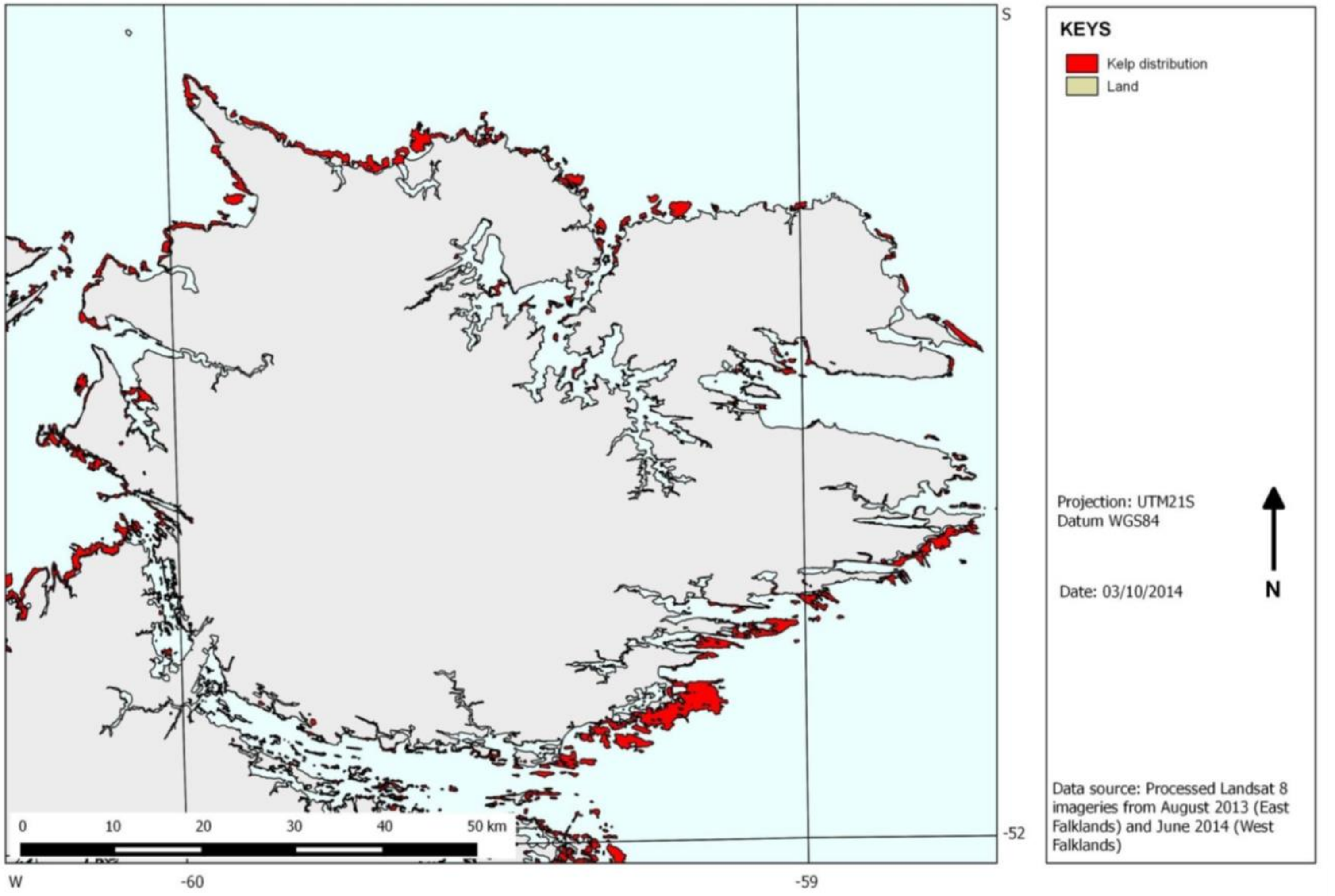


Figure 7.36: Kelp coverage around the East Falkland coastline (from Premier, 2014b)

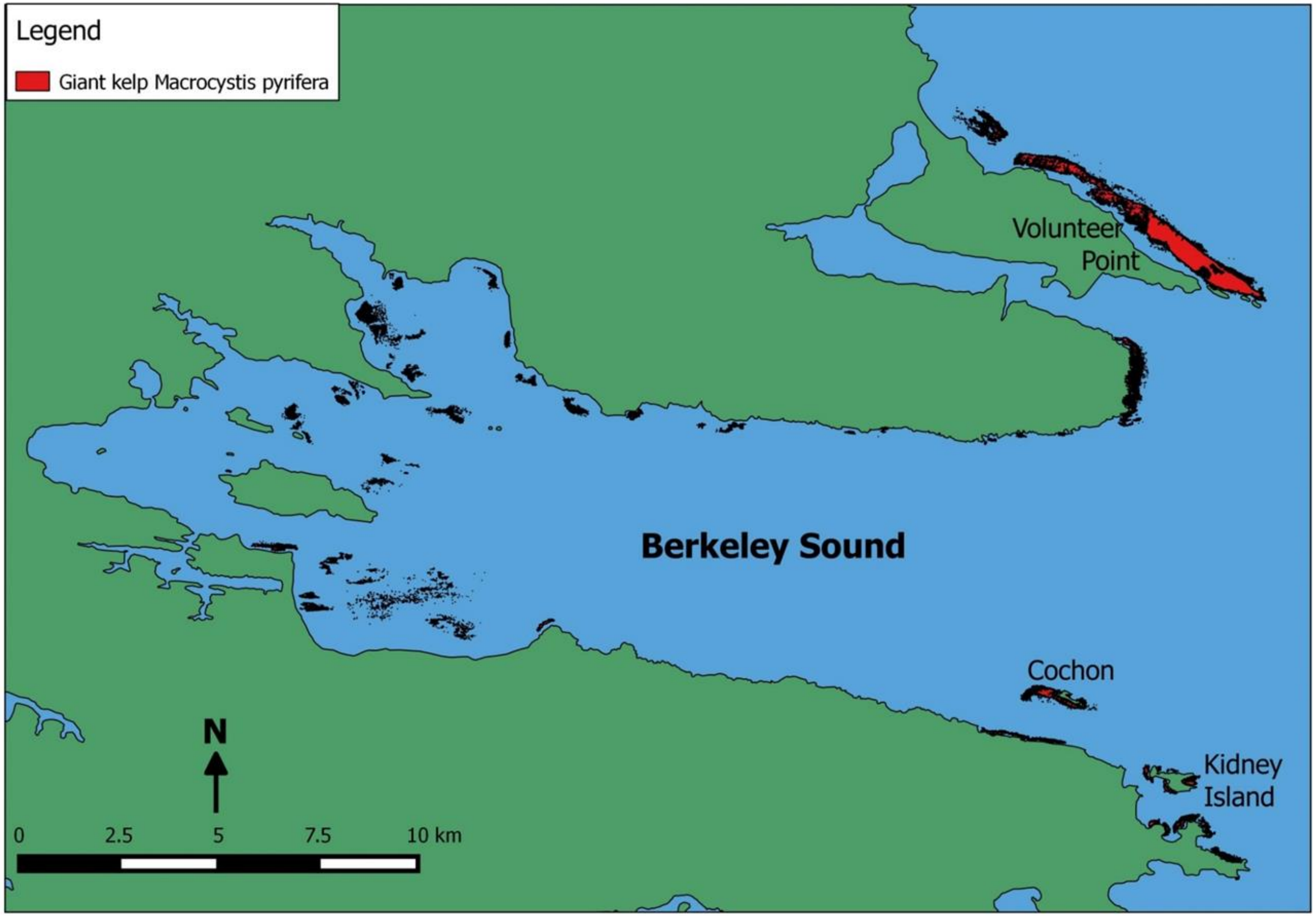


Figure 7.37: Map showing the distribution of giant kelp (*Macrocystis pyrifera*) in Berkeley Sound

7.4.3 Benthic environment

7.4.3.1 Introduction

Benthic organisms (or benthos) are the flora and fauna found on the bottom, or in the bottom sediments, of the sea.

7.4.3.2 NFB and Sea Lion Field (offshore) benthos

A baseline understanding of the offshore benthic environment is required in order to inform the:

- EIA of disturbance to the seabed from the placement of objects; and
- EIA of the discharge of drill cuttings and subsea operational discharges.

Potential impacts of drilling activities would be of particular concern if there are any rare or protected species present within the area likely to be affected by drilling activities.

7.4.3.2.1 Offshore benthic flora and fauna

As described in section 7.2.2, a number of baseline and post-drilling benthic surveys have been conducted in the Falkland Islands since 1998. Although the results from these surveys are useful in a broad sense, it is important to note that there have in many cases, and especially with the older surveys, been significant inaccuracies and inconsistencies with the survey design, sample processing, and species identification. This is an issue that is being addressed by the current GAP project (section 7.2.4.2), which is improving taxonomic resolution and quality control, and the design methodologies for future environmental baseline studies.

The pre-development and post-drilling surveys of the Sea Lion area were conducted in March and April 2012 in Licence Blocks PL032 and PL004 (Gardline, 2013a). In total, 90 stations were sampled: 54 in the environmental baseline survey, 28 (four of which were replicated from the development survey) in areas where drilling had previously taken place, and eight random 'Quality Assurance / Quality Control' stations.

The results and analyses showed that the entire survey area was fairly homogeneous and the benthic community was typical of the sediments in the area (section 7.3.7.1). The community structure was characterised as undisturbed and unpolluted by anthropogenic activity. In terms of the number of taxa present, polychaetes were the most abundant taxonomic group at most stations, making up 53 % of the taxa found throughout the survey area. Crustaceans were the next most abundant group, making up 23 % of the total taxa. Molluscs, echinoderms and 'other' taxonomic groups made up the remainder.

With respect to individual animals, overall crustaceans were the most abundant, making up 38 % of the total number of individuals; polychaetes made up 37 % of the total. There appeared to be a slight degree of spatial differentiation, with slightly more crustacean species found in the southern part of the survey area. The results of the post-drill survey found that the benthic community was typical of those found in undisturbed / unpolluted medium to coarse silt environments, with no evidence of anthropogenic disturbance as a result of drilling activities. Species diversity and abundance was relatively uniform across the survey area.

Although there are inconsistencies in methodology, analyses, and taxonomic resolution, the surveys generally show that the benthic community throughout the survey area can be characterised as a typical silt / mud benthic environment. The consistency in results between pre and post-drilling surveys, both in 1998 and 2012, suggest that the drill operations to date have had little or no effect on the benthic community. The surveys have led to the identification of new species being identified within the Falkland Islands, highlighting the incomplete state of our knowledge on the deep-water benthic environment of the Falkland Islands.

7.4.3.2.2 Offshore benthic habitat assessments

At each station, a habitat assessment was conducted in order to identify:

- Sediment characteristics / benthic species which may indicate an area of environmental interest;
- The presence of any potentially sensitive habitats equivalent to those protected under Annex I of the EC Habitats Directive 92/43/EEC (as enacted by the UK's Offshore Marine Conservation (Natural Habitats) Regulations 2010 (as amended)), such as:
  - Biogenic, stony or bedrock reefs or any other habitats; and / or
  - Submarine structures made by leaking gases.
- Threatened and / or declining species or habitats which are on the OSPAR (2008) list in the UK Biodiversity Action Plan (JNCC, 2016).

Following this assessment, it was concluded that none of the above were within the surveyed area.

7.4.3.3 Berkeley Sound (inshore) benthos

A baseline understanding of the inshore benthic environment is important to:

- Inform the EIA of potential impact of disturbances to the seabed from the placement of objects;
- Inform the EIA of inshore oil spills; and
- Provide a point of comparison for any benthic monitoring.

The inshore marine environment of the Falkland Islands is poorly studied. Prior to the current ongoing studies by SMSG or those commissioned by Premier, few surveys of significance have been conducted. Attempts to survey and categorise the inshore environment and marine habitats of the Falkland Islands are therefore relatively recent and are largely limited to studies undertaken by the SMSG.

There have been a number of SMSG expeditions to Berkeley Sound to describe the benthic communities (SMSG, 2009a; Neely *et al.,* 2010b; SMSG, 2012; Davidson, 2016; EnvSys, 2016), which provide comprehensive coverage of the shallow marine environment, <20 m in depth (see section 7.4.3.3). In the winter of 2015, Benthic Solutions, under contract to Premier, surveyed the deeper waters of the Sound (generally >10 m) using grab samples and underwater photography. section 7.4.3.3.1.2 describes the results of these surveys, further details can be found in (BSL, 2015a, b & c; EnvSys, 2016).

7.4.3.3.1 Berkeley Sound benthic flora and fauna

7.4.3.3.1.1 Inter-tidal and shallow marine benthos

Thus far, SMSG surveys have recorded a total of 530 species in the Falkland Islands intertidal and shallow waters (< 20 m water depth). A few species, particularly sponges, are newly identified and are still undergoing scientific description and naming (e.g. Goodwin *et al.,* 2011; Goodwin *et al.,* 2016).

In February 2016, SMSG were commissioned by Premier to survey the shallow marine habitats within Berkeley Sound. In total, 27 stations were surveyed and results are presented in EnvSys (2016) and SAERI and SMSG (2016). Classifications of the subtidal habitats were based upon the habitat classification system created by SMSG in 2010. The survey showed that the main subtidal habitats within the survey area were *Macrocystis pyrifera* forest, and Sand, both being present at the same number of stations. Other habitats present at varying numbers of sites include: Mixed *Macrocystis* and *Lessonia* forest, Mud, Rock barren, Silty *Lessonia* forest, Fine sand, *Austromegabalanus psittacus* reef, Rock barren and gravel, and Drift algae and Algal litter.

The different habitat types were ranked as follows, according to the number of species found in each:

- *Macrocystis pyrifera* forest, with 94 species found;
- Rock barren habitat, with 47 different species;
- Mixed *Macrocystis pyrifera* and *Lessonia* forest, with 35 different species being present;
- Silty *Lessonia* forest habitat had 33 species present;
- *Austromegabalanus psittacus* reef habitat had 24 species;
- The Sand habitat had nine species;
- Rock barren and gravel habitat had eight species present;
- Mud had six species;
- Fine sand habitat had five species; and
- Drift Algae and algal litter habitat type had two species present.

A total of 139 species were observed and recorded, from the 27 dives, though not all were identified to species or even genus level. By phyla, Echinodermata: sea star (starfish) was the most prevalent grouping (10.04 %), in terms of relative abundance, followed by Chordata: ascidians (9.06 %), Arthropoda: crab (8.25 %), Porifera: sponges (8.16 %) and Echinodermata: sea urchins (7.62 %). Arthropoda: amphipoda and Mollusca: cephalopods were the least abundant representing 0.09 % of the total. By species, the Chilean red sea urchin (*Loxechinus albus*) had the highest overall relative abundance, followed by the blue-spotted rockcod (*Patagonotothen cornucola*), and giant kelp (*Macrocystis pyrifera*).

All of the subtidal habitats recorded are common within the Falkland Islands, and each has varying degrees of associated biodiversity. Berkeley Sound, itself, has different amounts of exposure and openness, going from less exposed / more enclosed at the western end of the Sound, to more exposed / less enclosed towards the eastern end. This will have an impact on the habitat types and species present across the area.

7.4.3.3.1.2 Deeper water benthos

Macrofaunal analysis

Benthic Solutions carried out macrofaunal analysis on 138 grab sample replicates obtained at 46 baseline stations within Berkeley Sound (BSL, 2015c).

The analysis identified a total of 28,369 individuals from 350 taxa in all 138 samples analysed (taxa (singularly referred to as taxon) refers to any taxonomic group; species, genus etc.). Nomenclature follows Neely and Brickle (2013).

Of the 350 taxa recorded, 281 were infaunal (including solitary epifauna), consisting of:

- **Annelids (segmented worms):** 106 taxa (51.4 % of the total individuals);
- **Crustaceans (barnacles, shrimps, crabs etc.):** 79 taxa (34.6 % of total individuals);
- **Molluscs (snails, bivalves and sea slugs):** 56 taxa (7.8 % of total individuals);
- **Echinoderms (sea urchins, starfish, brittle stars etc.):** 16 taxa (1.7 % of total individuals);
- **Solitary epifauna:** 9 taxa (0.3% of total individuals); and
- **Other groups:** (*Nemertea* (ribbon worms), *Nematoda* (round worms), *Sipuncula* (Peanut worms), *Turbellaria* (flatworms), and *Brachiopoda* (lamp shells), *Pycnogonida* (sea spiders), *Pisces* (fish), *Enteropneusta* (acorn worms)), 15 taxa (4.2 % of individuals).

With the exception of species that were intentionally grouped into higher taxonomic levels (e.g. *Nematoda, Nemertea*), the majority of adult specimens were identified to genus level or lower. Approximately 60.7 % of specimens collected during this survey were identified to species level with 88.3 % identified to at least genus level.

Infaunal trends

The macrofauna throughout Berkeley Sound was highly variable in terms of abundance, richness and species composition, as would be expected given the highly variable nature of the sediment and the large scale of survey area. A total of 185 taxa were present with an average density of more than one individual per sample (0.1 m^2), while 58 of the 281 infaunal taxa *recorded* were represented by only a single specimen. *Annelids* (segmented worms) were found to dominate the infaunal community. This dominance is seen by overall rank, with six annelid polychaetes recorded in the top ten ranked taxa. This dominance was followed by *Crustacea* which were also well represented, with four representatives in the top ten ranked taxa.

The results of further analysis generally indicate a wide variation in infaunal community diversity within Berkeley Sound with higher dominance and lower diversity at stations with impoverished fauna. Of particular note, Stations 02A, 04, 34 and 40 had particularly low species richness and diversity. These stations are all close to sites of human activity and also had elevated levels of pollutants (see sections 7.3.7.2.2.1 and 7.3.7.2.2.2; BSL, 2015c for full details). Station 31 is close to the LTV anchorage sites and has been frequently used as an anchoring site by other vessels.

Epifaunal and other biological groups

The results show that 44 of the 46 macrofaunal samples recorded the presence of invertebrate species that are generally considered to be epifaunal and are not statistically assessed within the infauna (discussed above). Analysis of the infaunal and epifaunal communities indicates that generally infauna are numerically dominant, with epifauna making up a small but nevertheless important part of the community. Solitary and colonial epifauna showed a general decrease in richness at stations containing uniform sands. Epifauna were surveyed by a combination of grab and photographic surveys.

Observations on epifauna recovered within the grab samples are as follows.

- ***Coelenterata* (sea anemones, sea pens):** The sessile epifauna was characterised by a scarcity of Coelenterata, with only a few small sea anemones, and a few fragmented specimens, mostly of the hydroid *Sertularella* sp.;
- ***Chordata* (sea squirts):** Tunicates were mostly represented by large specimens of the stalked solitary species, stalked piure (*Pyura legumen*), a few *Ascidia* sp. specimens and encrusting colonial lace tunicate (*Didemnidae* spp.);
- ***Bryozoa* (bryozoan):** The Bryozoa fauna was very rich and diverse within Berkeley Sound. Large numbers were found to inhabit almost any solid surface, including shells, the giant barnacle (*Austromegabalanus psittacus*), and larger species of seaweed. The general knowledge of Cyclopora (e.g. *Tubulipora* spp., *Lichenopora* sp. and *Disporella* sp.) is poor and the latter cannot be identified with certainty as it never been systematically assessed for Antarctic and sub-Antarctic waters. The upright branching genus Cellaria are habitat-forming in Northern Atlantic waters offshore, but does not reach such importance here. Apart from a few species of what were formerly known as Anasca, these species are all encrusting; and
- **Other:** A solitary Entoproct (*Barentsia* sp.) specimen and a few species of *Porifera* (sponges) compose the rest of the epifauna.

It should be noted that grab sampling often fails to recover coarse material, especially larger pebbles and cobbles colonised by epifauna and samples cannot be taken over bedrock, therefore, it is important to not only assess epifauna through physical samples, but also to analyse photographic footage.

Photographic survey operations were carried out using a combined digital video and stills camera system deployed in a drop-down frame. This survey method is especially useful at stations over exposed bedrock where no samples were recovered, in order to determine what species are present. Seabed imagery indicated a wide variety of epifaunal groups and species throughout Berkeley Sound. Conspicuous species included:

- The fan worm *Perkinsiana antarctica*;
- Schythe-edged serolis *Acanthoserolis scythei*;
- Ornamented hermit crab *Pagurus comptus*;
- Lobster krill *Munida gregaria*;
- The spider crabs *Eurypodius spp.*;

- Ribbed mussel *Aulacomya atra*;
- Patagonian scallop *Zygochlamys patagonica*;
- Veined brachipod *Magellania venosa*;
- Snowflake bryozoan *Tubulipora sp.*;
- Beaded sea star *Cosmasterias lurida*;
- Sunstar *Labidiaster radiosus*;
- Chilean sea urchin *Loxechinus albus*; and
- Encrusting sponges:
  - *Tedania* species *Tedania* sp.;
  - Chalk sponge *Grantia* sp.;
  - Boring sponge *Cliona* sp.;
  - Warty tunicate *Asterocarpa humilis*;
  - Stalked piure *Pyura legumen*; and
  - Bubble tunicate *Styela* spp.

Sponges were extremely prevalent in areas of bedrock exposure, cobbles, boulders and other hard contacts. Urchins, brittlestars, sea cucumbers and hermit crabs were also commonly found in these areas. Starfish and tunicates were fairly common throughout, whereas lobster krill (*Munida gregaria*) and isopods dominated sand habitats. Other Crustacea, particularly crabs, were frequently observed at the transition zones between gravel ribbons and sands, and amongst mega-rippled bedforms. Bryozoans and hydroids were often observed attached to and encrusting upon bedrock, hard contacts and algae, and fish such as rockcod (*Patagonotothen* spp.) dominated the free-swimming megafauna. In addition, evidence of cephalopod spawning was recorded at Station 29, where a single egg cluster was found to be attached to a kelp stipe; these are of the commercially important Patagonian long-fin squid (*Doryteuthis gahi*; formerly *Loligo gahi* and referred to as loligo hereafter). It should be noted that the survey was conducted between the two main spawning seasons for the main loligo cohorts (Arkhipkin and Middleton, 2002a; 2002b). Nonetheless, this observation confirms that this species spawns within Berkeley Sound, although it is not possible to infer the intensity of the spawning ground.

Seabed photography confirmed the variable nature of the seabed within Berkeley Sound, as indicated by the bathymetric and side scan sonar datasets (see section 7.3.6.2). Complex gravel ribbons were observed from sites close to the LTV anchorage sites eastwards to the mouth of the Sound, throughout the sand-dominated areas. Sparsely populated epifaunal communities were observed in areas of sand, although the interspersing gravel ribbons (gravels and relic clam shells and barnacles) were colonised by a diverse range of organisms.

7.4.3.3.2 Berkeley Sound inter-tidal and shallow marine habitat mapping and classification

7.4.3.3.2.1 Shallow Marine Surveys undertaken

Since 2006, SMSG have undertaken surveys at nearly 300 sites within several broad geographical areas of the Falkland Islands (Figure 7.38);

- Beauchêne Island (SMSG, 2009b);
- Jason Islands (SMSG, 2008);
- Adventure Sound (SMSG, 2009c);
- Port William;
- Stanley Harbour; and
- Berkeley Sound (SMSG, 2009a; Neely *et al.,* 2010b; SMSG, 2012).
- New Island
- Falkland Sound
- King George Bay

The distribution of these surveys throughout the Falklands archipelago helps to place the significance of the habitats found within Berkeley Sound in context. However, the Falkland Islands have an estimated 7,700 km of coastline and 750 offshore islands (Falklands Conservation, 2006) and thus large sections of the Falklands shorelines remain un-surveyed.

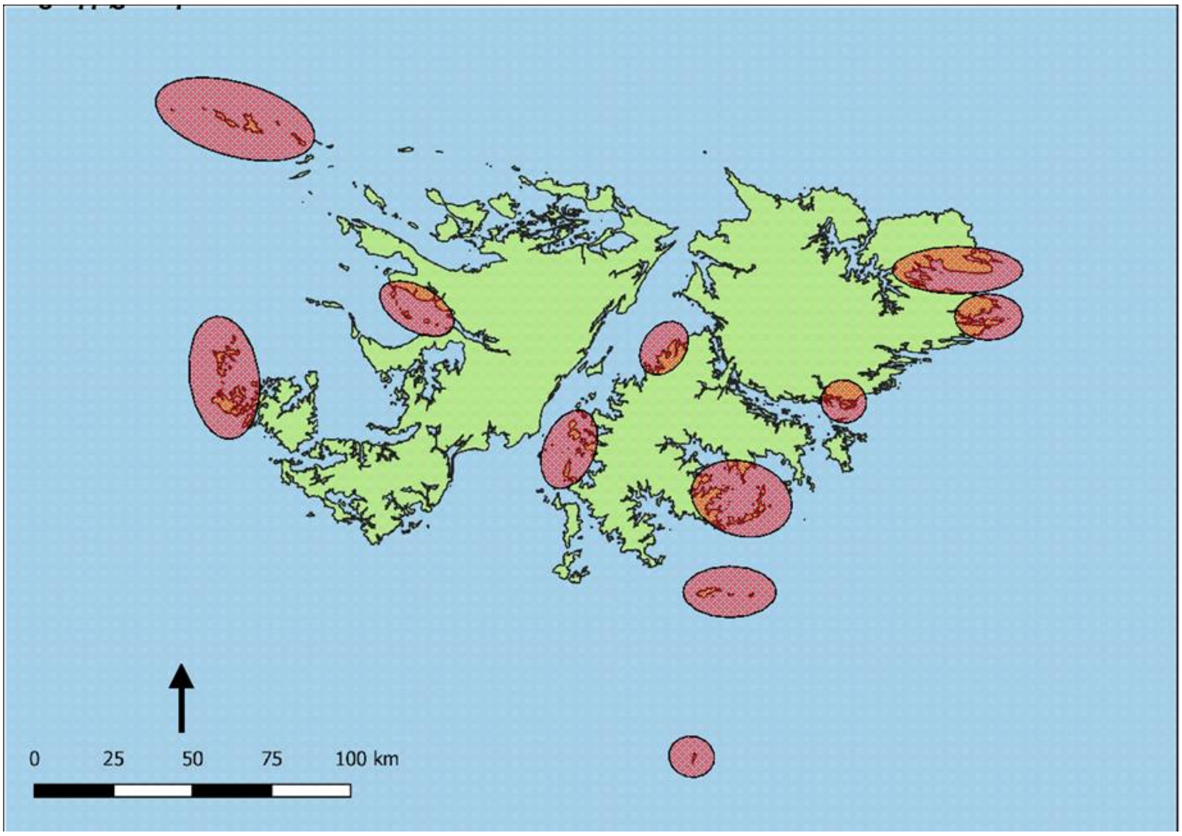


Figure 7.38: Distribution of SMSG dive survey sites across the Falklands archipelago

SMSG dive survey methodology

The survey methodology employed by SMSG consists of three parts:

- Mobile animal surveys;
- Photographic quadrats; and
- JNCC sublittoral habitat classification.

Full details of the methodology and expeditions can be found in Neely (2010).

Island-wide shallow marine survey coverage

The full spatial extent of each marine habitat type is unknown and has not been fully mapped for the Falkland Islands as a whole. Therefore it is not yet possible to define spatially limited, rare or ‘at risk’ marine habitats for the Falkland Islands. While there are some habitats which may be environmentally sensitive, or equivalent to those listed in Annex I of the EC Habitats Directive 92/43/EEC) (section 7.4.3.2.2) and these areas have been subject to greater survey effort, thus far these appear to be ‘rare’ habitat types. Nonetheless, further surveys at other sites may yet identify additional occurrence of these habitats.

Berkeley Sound exhibits a high diversity of marine habitats, including some spatially limited reef habitats. It is likely that due to the range of coastline types and the projecting position to the north-east of the Falklands with oceanic currents close inshore that the area covering Cape Pembroke, Kidney Island and Berkeley Sound has higher diversity than elsewhere on East Falkland; however, due to unequal survey effort between sites it is not possible to be categorical.

Satellite imagery used for refining the habitat maps

In order to assist in comparative assessment of the Berkeley Sound coast, Environment Systems (EnvSys) was commissioned, in partnership with SAERI, to prepare shallow marine, inter-tidal and terrestrial habitat maps. This work builds on previous projects to map habitat types in the LTV anchorage sites. Background information concerning earlier phases of the mapping project can be found in Pike *et al.* (2014) and Marengo (2014a). The results from the preliminary analysis are presented in ‘*North Falklands Coastline Environmental Sensitivity for Oil Spill Response*’ (Premier, 2014b).

Due to the considerable extent of the marine and coastal area that needs to be mapped, a method was developed that combines the use of satellite imagery together with field data, including collection of species presence data, to provide updated detailed habitat maps (EnvSys, 2016).

The satellite imagery used to refine the shallow marine, inter-tidal and terrestrial habitat maps was:

- Three World View images (Figure 7.39) one from November 2011 and two from January 2012 collected in Part 1 of the project. The images were processed for use within a terrestrial and marine environment, as described in EnvSys, (2016); and
- A Sentinel-2 image acquired for this project (Part 2). The Sentinel-2 image used for this study was captured in January 2016. Technical details of this satellite system are described in Env Sys, (2016).

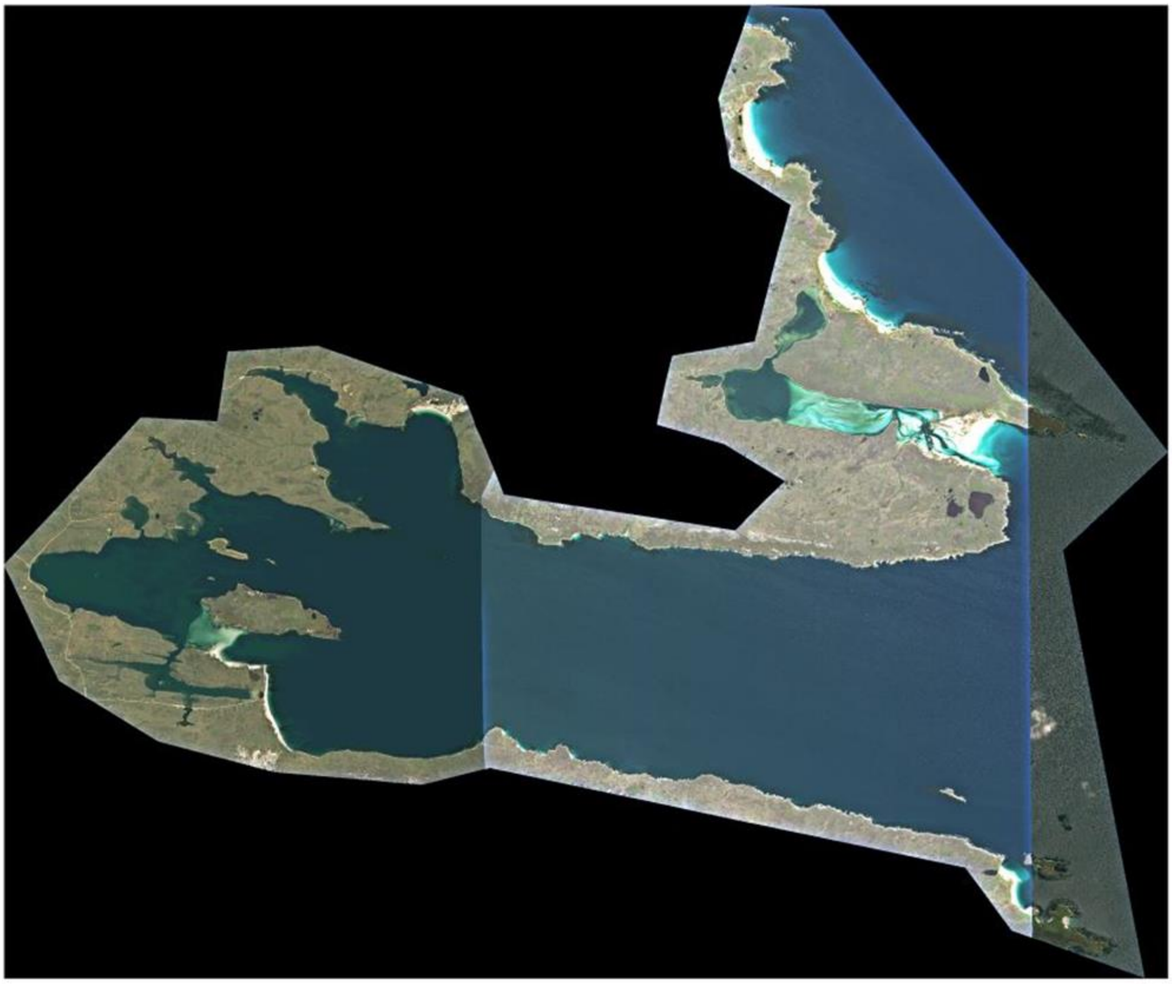


Figure 7.39: Satellite image of Berkeley Sound showing the extent of the three separate images

Using fieldwork to support mapping from satellite data

The fieldwork was undertaken to provide 'ground truth data' to support a detailed understanding of the variability of remote sensing characteristics of particular habitats and to support the selection of an accurate digital elevation model. The species data collected also provided more detailed habitat information on the marine, inter-tidal and terrestrial habitats.

7.4.3.3.2.2 Shallow marine habitat mapping

To date 18 habitats have been identified and full habitat descriptions are provided by Neely *et al.* 2010a and are described briefly below (Table 7.5). It is likely that further study will identify additional habitat types (especially restricted habitats of limited spatial extent that may be missed with low survey effort) and that some hierarchical subdivision of existing habitat types will occur.

The 18 habitat types currently described are:

- *Macrocystis pyrifera* forest;
- *Macrocystis* / *Lessonia* mixed forest;
- Deep *Lessonia* forest;
- Silty *Lessonia* forest;

- Shallow *Lessonia* forest;
- Shallow *Lessonia* forest with high algal cover;
- Fleshy algae-covered substrate;
- *Durvillaea* forest;
- Mussel bed;
- *Austromegabalanus psittacus* reef;
- *Crepidula dilatata* reef;
- *Phragmatopoma virgini* reef;
- Rock barren;
- Cobbles;
- Sand;
- Fine sand;
- Mud; and
- Sheltered artificial structures (Neely *et al*., 2010a).

WorldView 2 satellite has three bands which can penetrate water to between six and 15 metre depth and these bands were used to map the shallow water marine habitats with the aid of dive survey ground-truthing.

From the information gathered so far, there is some zonation of main cover forming species around the Sound. In particular, the western most edge, being the most sheltered, tends to have the finest sediments and overall more *Lessonia* rather than *Macrocyctis* kelp species. The proportion of each habitat mapped is shown in Table 7.6 and mapped in Figure 7.40.

Table 7.5: Habitat descriptions for the Falkland Islands shallow marine environment (Neely *et al.,* 2010a)

Habitat type	Exposure	Substrate	Depth range	Characteristic species
Macrocystis pyrifera forest	Moderate to heavy	Solid bedrock occ. large boulders	3 – 18 m	Giant kelp; coralline algae; common sea star; pink pencil urchin; beaded brittle star.
Macrocystis / Lessonia mixed forest	Moderate to heavy	Solid bedrock occ. large boulders	2 – 20 m	Tree kelp; giant kelp; coralline algae; ornamented hermit crab; pink pencil urchin; common sea star.
Deep *Lessonia* forest	Moderate to heavy	Solid bedrock occ. large boulders	6 – 20+ m	Tree kelp; coralline algae; sponges; Atlantic purple sea urchin; flower-lobed anemone; common sea star.
Silty *Lessonia* forest	Minimal	Solid bedrock or boulders overlaid with a layer of silt	1 – 20 m	Tree kelp; saffron sea cucumber; Patagonian scallop; pink pencil urchin.
Shallow *Lessonia* forest	Moderate to heavy	Solid bedrock occ. large boulders	4 – 17 m	Tree kelp; coralline algae; sponges; common sea star; bryozoans; flower-lobed anemone; Atlantic purple sea urchin.
Shallow *Lessonia* forest with high algal cover	Moderate	Solid bedrock occ. large boulders with fleshy algae	6 – 8 m	Tree kelp; leafy / digitate algae.
Fleshy algae-covered substrate	Moderate	Solid bedrock occ. large boulders with fleshy algae	2 – 11 m	Leafy / digitate algae.
Durvillaea forest	Heavy, surge and swell	Solid bedrock or immobile boulders	0 – 4 m	Bull kelp; coralline algae; Magellanic copper limpet.
Mussel bed	Minimal to heavy	Solid bedrock, often abutting sand, mud or silt	0 – 20 m	Giant mussel; ribbed mussel; blue mussel; ornamented hermit crab; coralline algae.
Austromegabalanus psittacus reef	Moderate	Solid bedrock, often vertical faces	3 – 10 m	Giant barnacle; coralline algae; bubble tunicate; giant tunicate.
Crepidula dilatata reef	Moderate	Solid bedrock	1 – 5 m	Broad slipper limpet; coralline algae; digitate red algae; Chilean sea urchin.
Phragmatopoma virgini reef	Moderate	Solid bedrock or immobile boulders	0 – 7 m	Pink featherduster worm; piure; bryozoans.
Rock barren	Moderate	Solid bedrock or immobile boulders	3 – 10 m	Coralline algae; Chilean sea urchin; ornamented hermit crab.
Cobbles	Heavy, often high surge.	Mobile cobbles, 5 – 20 cm in diameter	5 – 20 m	Flaming limpet.

Habitat type	Exposure	Substrate	Depth range	Characteristic species
Sand	Moderate	Sand	0 – 20 m	Scythe-edged serolis; purple backed crab; tessellated rock cod.
Fine sand	Minimal	Fine sand	0 – 5 m	Filamentous algae; sea lettuce; striped clam; short-spired volutid.
Mud	Minimal	Mud	0 – 15 m	Gregarious lobster krill.
Sheltered artificial structures	Minimal	Boats, pilings etc.	0 – 4 m	Giant tunicate; vase tunicate; parchment worm.

Table 7.6: The area and percentage cover of each of the habitat types mapped in Berkeley Sound (EnvSys, 2016)

Habitat	Area (ha)	Percentage cover
Open water	21.613.9	87.24
Sand cobbles and pebbles medium depth	552.4	2.23
Kelp mosaic / other species	525.2	2.12
Sand with rock platforms, boulders and cobbles	491.4	1.98
Sand occasional mud where sheltered	475.5	1.92
Macrocystis kelp forest	442.1	1.78
Cobbles and rocks (with Algae growth)	140.8	0.57
Lessonia kelp forest	121.6	0.49
Sand rocks and mud at different depths – mud where sheltered	115.5	0.47
Boulders and cobbles with some rock ledges and finer sediments	95.2	0.38
Rocks and boulders – with dense algae	70.8	0.29
Mosaic of rocks, boulders and fine sediments (medium diversity) with algae	70.0	0.28
Rock platforms – occasional mussel beds and finer sediment	60.0	0.24
Total	24,774	100

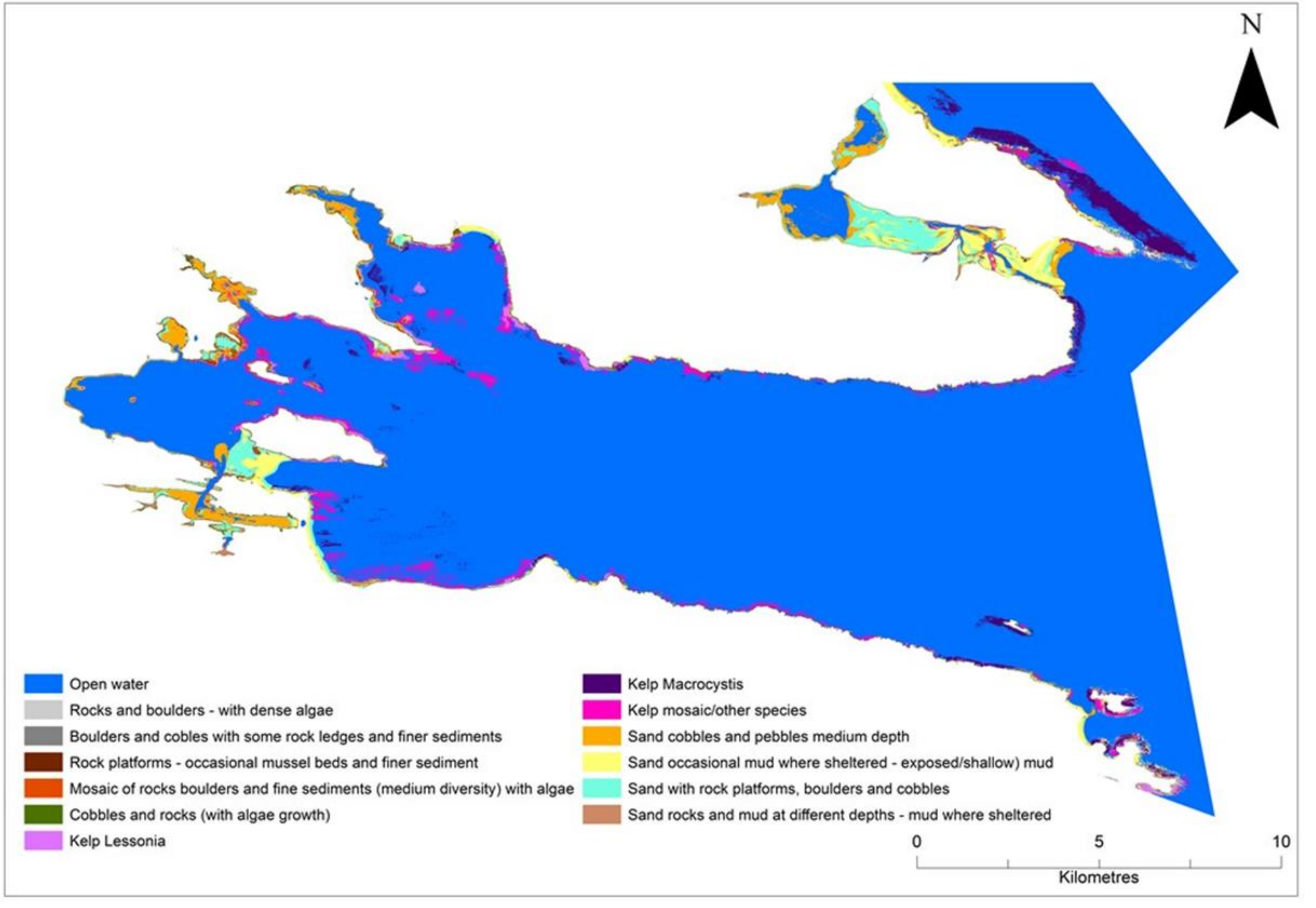


Figure 7.40: Shallow marine and intertidal habit map for Berkeley Sound (EnvSys, 2016)

7.4.3.3.2.3 Inter-tidal habitat mapping

The inter-tidal zone is a very harsh environment and animals living there are exposed to extremes of temperature and salinity as the tides rise and fall. Intertidal habitats are characterised by vertical zonation with characteristic species present within each zone. Therefore, the same substrate type will support very different species assemblages across a relatively small distance. The species groups that are able to dominate each zone are well known from studies elsewhere in the world and reasonably predictable. However, there is currently no recognised habitat classification specifically for the intertidal habitats found in the Falkland Islands. Preliminary fieldwork to describe the inter-tidal habitats of the Falklands was conducted in February 2016, reported in EnvSys (2016). No formal, detailed habitat classification was obtained, as this would require a much more extensive survey and assessment than was afforded in this project; rather a general, qualitative description of type of substratum, species occurrences and degree of diversity has been generated.

The degree of species diversity was estimated based on the number of species occurring at each point of observation / quadrat, and confirmed by visual estimation of the corresponding photos. Classes of species diversity were arbitrarily defined as 'low', 'medium', and 'high'. Anything less than 15 species was classed as 'low' and anything between 15 and 25 was classed as 'medium', while anything above 25 was classed as 'high'.

Following fieldwork the characteristic of each of the intertidal field sites were examined against the spectral signatures of the imagery, in particular based on the sediment type and any algae or other species cover (e.g. mussel beds). Several other factors were considered in the image classification process including depth, the diversity of the communities and the substrates present. From this analysis, a look-up table (Table 7.7) was created to link the main classes from the field survey with features that could be observed in the remote sensing imagery.

Table 7.7: Look-up table linking fieldwork derived inter-tidal habitat classes and classes discernable in the remote sensing imagery

Fieldwork classes	Classes generated in the final map
Boulders	Boulders
Boulders and cobbles	Boulders and cobbles with some rock ledges and finer sediments
Boulders and pebbles	
Boulders and sand	
Cobbles	Cobbles / sparse vegetation
Cobbles and pebbles	Cobbles and rocks (with algae growth)
Gravel mud	Sand rocks and mud at different depths – mud where sheltered
Mosaic of cobbles, pebbles and gravel	Mosaic of rocks boulders and fine sediments (medium diversity) with algae spp.
Mosaic of platforms boulders and sand	
Mosaic of platforms, boulders and cobbles	
Mosaic of platforms, boulders and rocks	
Mosaic of platforms, boulders, cobbles and gravel	
Mosaic of platforms, cobbles and pebbles	

Fieldwork classes	Classes generated in the final map
Mosaic of rocks, boulders and sand	
Mosaic of platforms, rocks, cobbles and sand	Sand with rock platforms, boulders and cobbles
Rock platforms	Rocks and boulders – with dense algae
Rock platforms and boulders	Brown rock platforms – occasional mussel beds and fine sediments
Rock platforms and cobbles	
Rock platforms and sand	
Rocks	
Sand	Sand occasional mud where sheltered
Sand and boulders	Sand rocks and mud at different depths – mud where sheltered
Sand and cobbles	
Sand and dead shells	
Sand and rock escarpment	
Sand cobbles and pebbles	Sand cobbles and pebbles medium depth

Figure 7.41 and Figure 7.42 illustrate how the data collected during fieldwork was translated into the final habitat map. The map covering intertidal and shallow marine habitats for the whole of Berkeley Sound is shown in Figure 7.40 above. Note that Figure 7.42 shows the inter-tidal and shallow marine habitats combined.

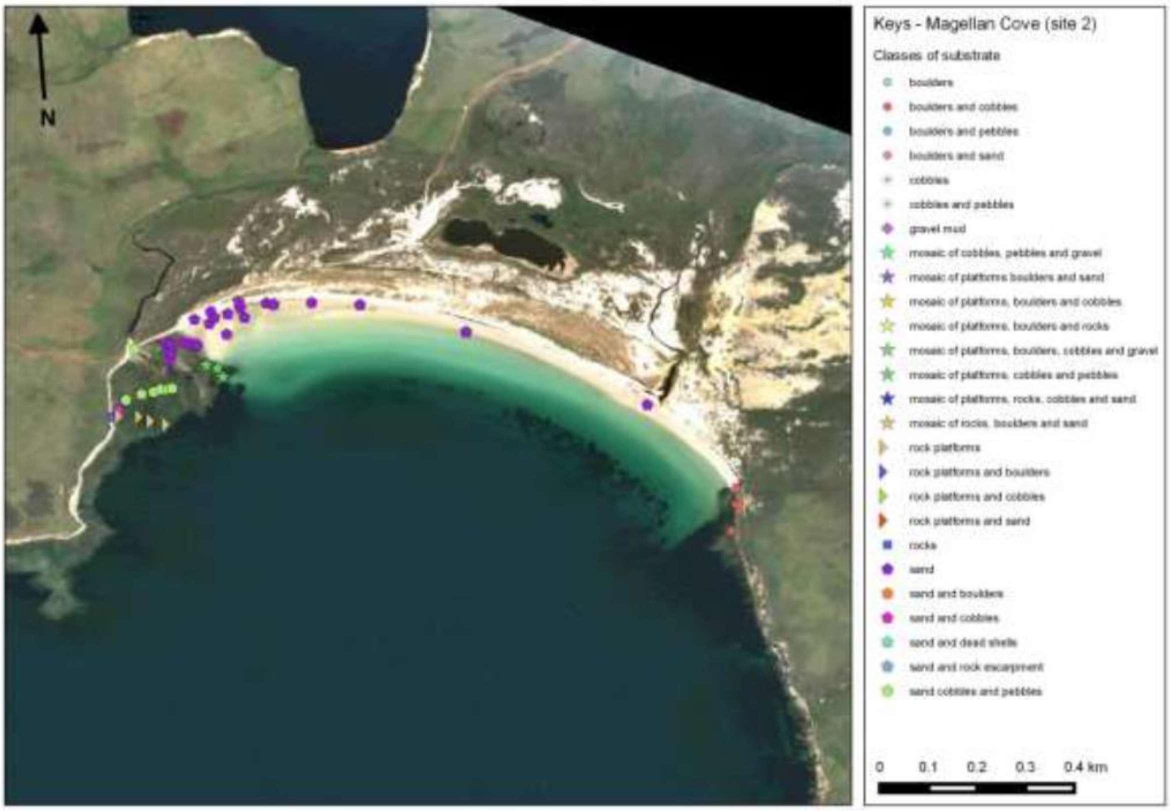


Figure 7.41: Sites and substrate classes recorded at Magellan Cove

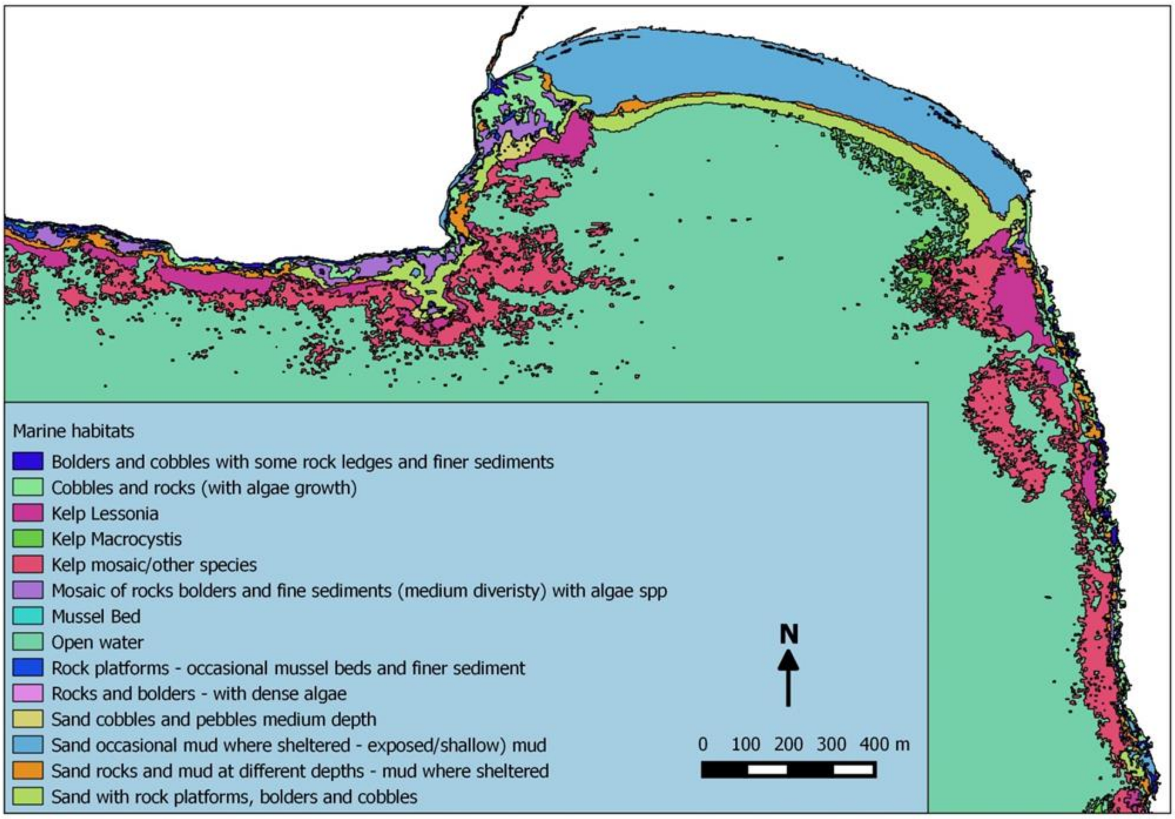


Figure 7.42: Inter-tidal and shallow marine habitats mapped at Magellan Cove

7.4.3.3.3 Berkeley Sound deeper water (> 10m) habitat mapping and classification

The surveys carried out by Benthic Solutions recorded numerous subtle sediment changes throughout Berkeley Sound with differing proportions of coarser materials in the form of fragmented shells, gravel, cobbles and boulders. The distribution of habitat types within Berkeley Sound is shown in Figure 7.43 and Figure 7.44.

Due to differences in the depths surveyed, the habitat classification described by SMSG (Neely *et al.,* 2010a) often only loosely conformed to those encountered by Benthic Solutions.

The six main habitats identified within Berkeley Sound are:

- Rock face and cobbles;
- Mud;
- Sand;
- Kelp forest;
- Mussel beds; and
- Gravels.

The habitat types listed above (and shown in Figure 7.43 and Figure 7.44), and anthropogenic habitats are all discussed in more detail below. Further to the main habitat designations, anthropogenic habitats are also discussed.

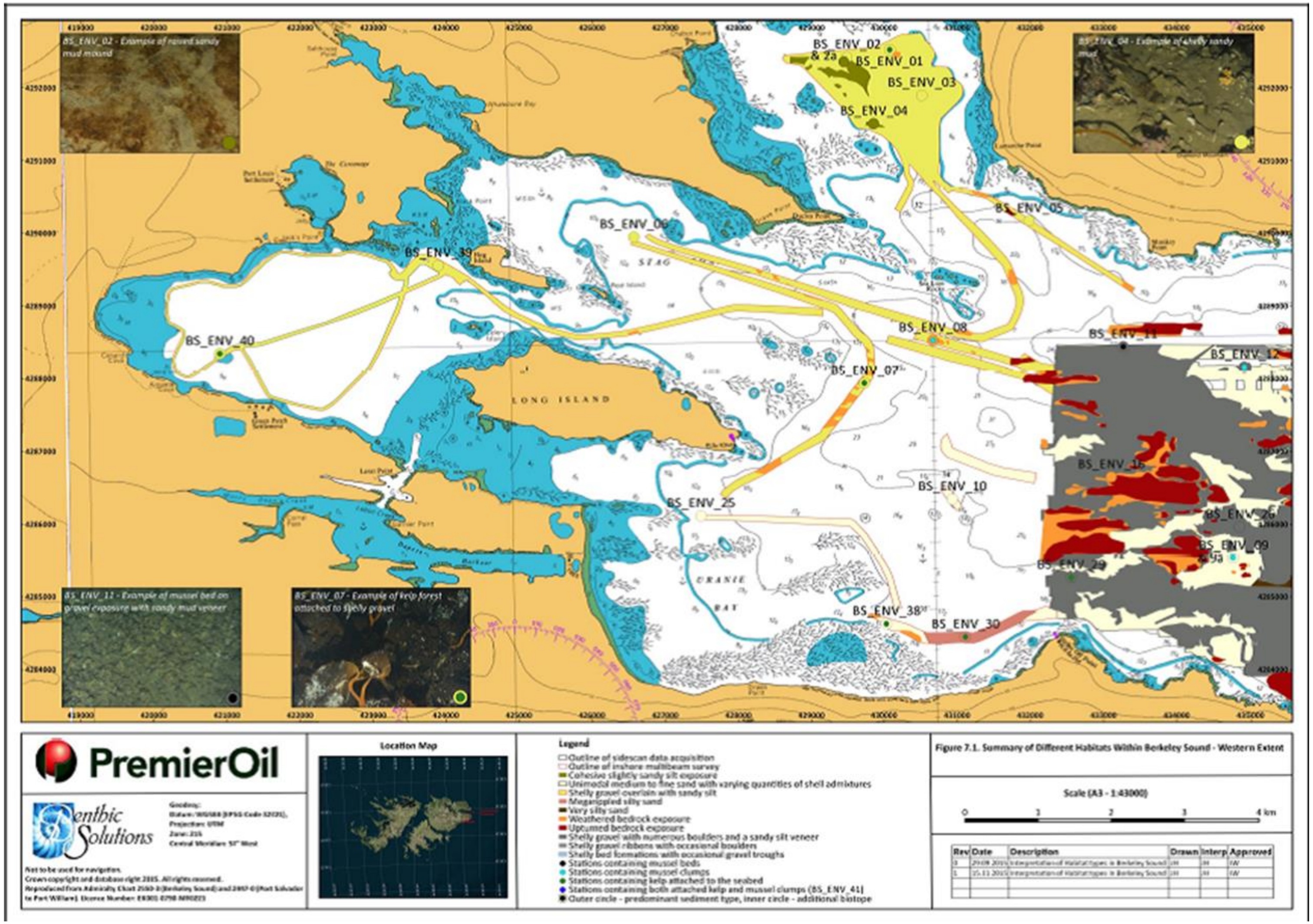


Figure 7.43: Habitats mapped within the inner Berkeley Sound (BSL, 2015b)

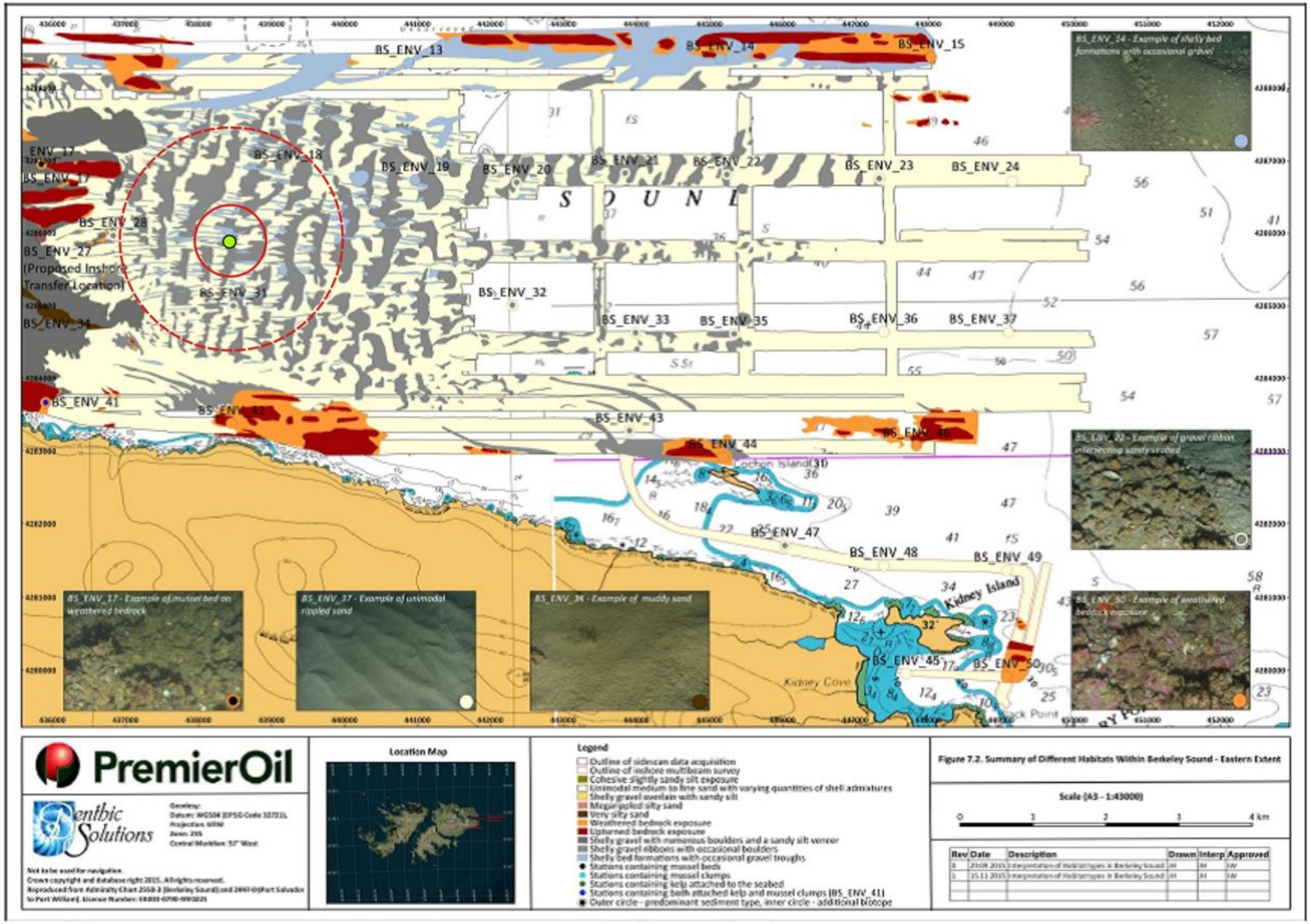


Figure 7.44: Habitats mapped in the outer Berkeley Sound (BSL, 2015b), showing the proposed LTV anchorage and exclusion zones

Rock face and cobbles

Bedrock exposures and escarpments were identified in the area of the LTV anchorage sites, and along the north and south coasts of Berkeley Sound. Around the LTV anchorage sites, the strata generally dipped vertically in a north-south orientation. The size of these exposures varied from localised boulder-sized formations to the most prominent bedrock exposure around site Station 16, which measured over 2 km across by 1 km wide. Erosion of these features often resulted in cobble sized deposits at the base and in the gullies of the formations.

Stations observed to conform to the rock face and cobbles habitat included Stations 42, 44 and 46 in the south of the survey area. Only rock face habitats were observed at Stations Stations 16 and 50, and stations that displayed further variations of this habitat type include station Stations 08, 15, 17 and 41.

Rock features were generally very diverse, characterised by encrusting coralline algae (*Corallina* spp.), numerous sponges (including possibly boring sponge (*Cliona* sp.), lace sponge (*Clathrina* sp.), chalk sponge (*Grantia* sp.) and *Tedania* spp.) and bryozoa (branched bryozoa, *Cellaria malvenensis*, *Reteporella* sp.). Further to this, solitary sessile epifauna included (but was not limited to) barnacles, tunicates (bubble tunicate, *Styela magalhaensis,* stalked piure*, Pyura legume*, warty tunicate, *Asterocarpus humilis* (possibly invasive) and flower tunicate, *Sycozoa gaimardi*), anemones (smooth anemone, *Actinostola chilensis*, flower-lobed anemone, *Antholoba achates*) and the invasive parchment worm, *Chaetopterus variopedatus*.

More mobile species were dominated by large numbers of limpets (often encrusted with coralline algae). Other mobile species included chitons, urchins (Chilean sea urchin), starfish (sunstar, *Labidiaster radiosus*, rough armed sea star, *Ganeria falklandica*, badge starfish, *Diplodontias singularis*), brittlestars (rough brittlestar, *Ophiactus asperula*), rock cod (*Patagonotothen* spp.), and various crustaceans (decorator crab, *Eurypodius latreilli*, Chilean snow crab, *Paralomis granulosa*), amongst numerous others. Detailed site specific conspicuous fauna lists are provided in Appendix III of BSL, 2015b. It is of note that the mottled sea star, *Glabraster antarctica*, which is described as '*a primarily Antarctic and Sub-Antarctic species only rarely seen inshore in the Falklands*' by SMSG (Neely and Brickle, 2013), was identified at Station 42 amongst the coralline algae encrusted bedrock exposures.

Bedrock-associated habitats were visually observed to harbour a huge array of encrusting and free-living biota. The biologically diverse nature of these bedrock exposures could be considered to conform to the designation of a geogenic reef, as per the EC Habitats Directive.

7.4.3.3.3.1 Mud

Muddy habitats, with varying levels of fragmented shell material, were encountered in the western part of the area surveyed, particularly within the Johnson's Harbour and Port Louis embayments. Muds also characterised the base of the depression feature around the LTV anchorage sites. Seabed photography recorded bioturbation in the form of burrows and other 'lebensspuren' (animal tracks and furrows) likely to be produced by echinoderms, gastropods, and isopods, including the scythe-edged serolis (*Acanthoserolis schythei*).

This habitat type showed considerable variation in the form of shell material, sand and cobbles. Ribbed mussel beds and silty *Lessonia* forest were also observed in areas characterised by fines.

Prevalent conspicuous fauna included the scythe-edged serolis isopod, crustaceans (lobster krill, purple backed crab (*Peltarion spinulosum*) and long-nosed spider crab (*Eurypodius longirostris*)), starfish (rough armed sea star, common sea star (*Anasterias antarctica*) and badge starfish), the veined brachiopod (*Magellania venosa*) and gastropods (Gever's trophon (*Trophon geversianus*)) and checkered murex (*Xymenopsis buccineus*)). In most areas, the seabed was generally featureless and absent of current related bedforms, indicating a sedimentary regime with limited hydrodynamic reworking of the sediments. At the edges of the basin feature close to the LTV anchorage sites and at other locations nearby, patches of rippling were observed on the seabed surface, indicative of some level of current turbulence.

7.4.3.3.3.2 Sand

Sandy sediments were widely recorded within the fairway area to the east of the LTV anchorage sites, and around Kidney Island. Within the fairway the sonar data indicated a variable seabed, with linear patches of course materials separating areas of sand; these have been interpreted as mobile gravel ribbons after review of the seabed imagery and video footage.

Bioturbation and 'lebensspuren' in the form of crustacean tracks was observed at a number of stations, particularly those with less shell material or fewer cobbles present, with burrows also occasionally recorded.

Sand megaripples with wavelengths of 0.5 m to 1.5 m (crest to crest) were observed at stations closest to the mouth of the Sound, indicative of current turbulence, with the orientation suggesting that the localised currents flow east / west in line with expectations based upon the tides flowing in and out of the Sound. Megarippled shelly bedforms were also identified along the north coast at Stations 13 and 14, and also at Stations 19 and 43 within the fairway and along the south coast, respectively. These were composed of very coarse materials, and are indicative of current turbulence with little deposition from fine materials.

Lobster krill (*M. gregaria*) represented the most abundant epifauna inhabiting sandy substrates. Other crustaceans (Chilean snow crab, long-nosed spider crab), starfish (beaded sea star, sunstar, rough armed sea star) and rock cod (*Patagonotothen* spp.) were also noted in these areas, along with numerous relic polychaete tubes.

7.4.3.3.3.3 Kelp forest

Kelp forests were encountered along the coast, and in shallow areas with exposed or shallow-buried bedrock (section 7.4.2.2). Two kelp habitats were observed in the seabed video and photography: silty *Lessonia* forest and mixed *Lessonia* / *Macrocystis pyrifera* forest. In addition, during transits, large areas of giant kelp (*M. pyrifera*) were encountered frequently along the coast of the Sound, and around Cochon and Kidney Islands.

Large clusters of storm-rafted giant kelp were present at the surface throughout much of the Sound, with kelp debris also present on the seabed at a number of stations.

Conspicuous fauna included; Patagonian scallop (*Zygochlamys patagonica*), starfish (rough armed sea star, common sea star), tunicates (piure species., warty tunicate (*Asterocarpa humilis*; possibly invasive), bubble tunicate (*Styela* sp.)), ornamented hermit crab, ribbed mussel, nudibranchs, fur algae (*Desmarestia distans*), urchins and various encrusting sponges. Encrusting pink coralline algae (*Corallina* sp.) was recorded in low quantities at nine stations, and in addition, at Station 41 ribbed mussel densely populated the *Lessonia* holdfasts. It should be noted that this example of a silty *Lessonia* forest was composed of comparatively less silt than other examples further to the west of the site.

At Station 29, sparse kelp coverage was encountered, with fur algae attached to the shells of bivalves and other hard contacts. One cluster of squid eggs was photographed at this station; these eggs are thought to belong to the commercially exploited loligo squid.

7.4.3.3.3.4 Mussel beds

Mussel beds, mostly thought to comprise the ribbed mussel, were identified at two stations within the environmental survey area (Stations 17 and 11), with smaller patchy aggregations noted at a further four stations. Three species of mussel are known to form the majority of extensive beds in the Falkland Islands: blue mussel, giant mussel (*Choromytilus chorus*) and ribbed mussel (Neely *et al.,* 2010a). Blue mussel is thought to inhabit shallower waters, whereas both giant and ribbed mussels tend to be found in deeper areas. The majority of mussel beds were observed at stations characterised by silty sediments, and located on slope faces, and all mussel beds observed were found to be located in the western half of the survey area, where the silt content was visually interpreted to be higher.

Mussel beds provide a complex structure which creates a habitat within which small organisms are able to shelter, and a substrate for encrusting organisms to colonise. Mussel beds are included in the OSPAR List of threatened habitats (specifically horse mussel, *Modiolus modiolus*), and are recognised for creating biogenic reef structures, and are therefore included in the Annex I Reefs list in the EC Habitats Directive. The two large beds identified at Stations 11 and 17 could therefore be construed as biogenic reefs.

Ribbed mussel individuals were often found to be encrusted with calcareous coralline and other algae, barnacles, sponges and small tunicates, such as *Styela magalhaensis*. Starfish; such as rough armed sea star and beaded sea star, were common amongst the mussel beds, along with crustaceans (Chilean snow crab, ornamented hermit crab), veined brachiopods and various gastropods.

7.4.3.3.3.5 Gravel patches and ribbons, shell material, cobbles and occasional boulders

Gravel ribbons encompassed differing proportions of sand, silt, shell material, gravels and cobbles, and include the complex gravel ribbons and megarippled shelly bedforms mentioned previously. The presence of ribbed mussel beds and silty *Lessonia* forest were noted at Station 41 along the southern coast of Berkeley Sound.

Gravel ribbons comprised large patches of relic bivalve shells (likely the striped clam, *Eurhomalea exalbida*), gravels and cobbles. These materials were heavily encrusted with both relic and live barnacles and calcareous mats of *Corallina* spp.

Gravel ribbons were also found to support a diverse range of organisms, including numerous crustaceans (ornamented hermit crab, long-nosed spider crab and Chilean snow crab), the naked urchin and the white feather-duster worm (*Perkinsiana antarctica*), along with various sponges, tunicates, hydroids and bryozoans colonising the hard contacts. Relatively few conspicuous fauna were recorded in areas of shelly bedforms, with the mobile sunstar most frequently observed, followed by the long-nosed spider crab and the Chilean snow crab.

7.4.3.3.3.6 Anthropogenic habitat

Examples of anthropogenic structures were prevalent throughout the Berkeley Sound (see section 7.7.6.2), and were mostly present in the form of localised sonar contacts. The shipwrecks of the *Ocean 8* and *Blakeney* were also identified in the analogue data; however, no seabed photography was acquired at these locations. The introduction of anthropogenic structures such as wrecks into the marine environment can often be seen as a long-term benefit, providing a hard surface that is often an alternative substrate to natural rock. This can therefore benefit epifaunal species that are otherwise only present on rocky reefs (Hiscock *et al.,* 2010).

While the addition of these vertical and horizontal hard surfaces could be considered to be ecologically beneficial to the region, other anthropogenic activities can have the opposite effect. Anchor scars were identified throughout the survey area. The physical dragging of the anchors disturbs benthic communities, stripping hard surfaces and overturning soft sediments.

Evidence of shipping activities in the region were observed at Station 09; these ranged from uncolonised aluminium cans, to a heavily colonised steel structure, as well as the aforementioned anchor scars. The presence of shipping debris throughout the area relates to Berkeley Sound's long history as an anchorage.

The steel structure at Station 09A was investigated using seabed photography (Figure 7.120) and is thought to be an arm from a jigger. The structure was found to be densely populated, with bivalves (possibly mussels), gastropods (broad slipper limpet, Gever's trophon and checkered murex), decorator crab, giant tunicates (*Paramolgula gregaria*), starfish (common sea star, possibly badge starfish), naked urchin, painted shrimp (*Campylonotus vagans*), and encrusting sponge recorded.

Numerous rock cod (*Patagonotothen* spp.) were also present around the structure, likely belonging to more than one species. Sheltered structures are often used by mobile species as a nursery area; this is supported by the presence of numerous fish in the subsea video.

Seabed imagery indicated the possible presence of the filamentous bacteria *Beggiatoa* sp. within the anchor scars, visible as a white mat on the seabed. This bacteria is generally only found in areas that interface aerobic and anaerobic conditions and is often found in areas of organic enrichment.

7.4.3.3.4 Berkeley Sound environmentally sensitive habitats

The classification of intertidal habitats is still in development, however, to date it appears that the range of intertidal habitats found are widespread and therefore not considered to be environmentally sensitive.

However, during the Benthic Solutions' field programme (BSL, 2015b), several potentially environmentally sensitive habitats, or those of conservation significance recognised under the UK's Offshore Marine Conservation Regulations 2010 (which implements the EU Habitats Directive 92/43/EEC) were identified within Berkeley Sound. These include:

- Geogenic Reefs (rock faces and cobbles);
- Biogenic Reefs (mussel beds); and
- Kelp Forests.

7.4.3.3.4.1 Geogenic reefs

Geogenic reefs were interpreted to occur in areas of bedrock exposure (section 7.4.3.3.3). The biological diversity observed at these sites was considered to conform to the EC Habitats Directive designation of geogenic reefs. These areas were found to be colonised by a diverse array of biota, with numerous associated free-living species present too. Bedrock exposure was observed in the form of escarpment outcrops in the centre of the Sound and along the north and south coast.

7.4.3.3.4.2 Biogenic reefs

Biogenic reefs took the form of mussel beds and were predominantly thought to comprise the ribbed mussel (*Aulacomya atra*). Although examples of the small ridged mussel (*Brachidontes blakeanus*) were also recorded, this species is not known to form the dense aggregations observed during the survey. Three further species of mussel are known to inhabit the Falkland Islands: purple shore mussel (*Perumytilus purpuratus*), giant mussel (*Choromytilus chorus*) and the blue mussel (*Mytilus edulis*); the latter two of which are capable of aggregating to form extensive subtidal beds, as observed with *A. atra*. Mussel beds were identified at two stations: 11 and 17, with patchy aggregations observed at four further stations although these are not thought to constitute the dense aggregations that define this habitat type. Mussel beds (specifically horse mussel, *Modiolus modiolus* and intertidal blue mussel beds) are included in the OSPAR List of threatened habitats and are recognised for creating biogenic reef structures; they are also included in the Annex I Reefs list in the EC Habitats Directive. However, blue mussel beds are an extremely common feature in the Falklands coastal waters and it is questionable whether blue mussel beds represent a threatened habitat in the Falkland Islands.

Further biogenic reefs have been previously identified locally by the SMSG (Neely *et al.,* 2010a) but were not recorded during this programme. The full spatial extent of each habitat type is unknown and has not been fully mapped. Therefore it is not yet possible to define spatially limited, rare or at risk marine habitats for the Falkland Islands. There are no designated species or habitats equivalent to those of conservation significance recognised under the UK's Offshore Marine Conservation Regulations 2010 (which implements the EC Habitats Directive 92/43/EEC), or listed as a priority habitat within the *Natura 2000* marine network.

The habitat types most likely to meet such criteria that have been recorded in the Falklands shallow marine environment are the following cold water reef forming species:

- Giant barnacle (*Austromegabalanus psittacus*) reef;

- Broad slipper limpet (*Crepipatella dilatata*) reef; and
- Purple-crowned feather duster worm (*Phragmatopoma virgini*) reef.

Giant barnacle reefs and broad-slipper limpet reefs have only been encountered within Berkeley Sound (in the region of Strike-off Point; Neely *et al.,* 2010a) and a feather duster tubeworm reef has been observed at only one site within Port William, near to Cape Pembroke, these are likely to be rare and spatially limited habitat types. However, Berkeley Sound and Cape Pembroke have also been subject to the greatest survey effort and the identified species / habitat accumulation curve is more advanced. Further survey at other sites may yet identify additional occurrence of these habitats.

7.4.3.3.4.3 Kelp forests

Kelp forests are known to provide shelter for sometimes hundreds of species within their holdfasts (Chile; Ríos *et al.,* 2007), illustrating their importance within biological communities. The sensitivities of kelp forests have been recognised elsewhere in the world, with an extensive *M. pyrifera* forest in Alaska currently undergoing consideration for red list status (Endangered to Critically Endangered; Keith *et al.,* 2013), however, no legislative protection is currently in place for this habitat type globally.

Marine algae and especially the species of kelp (Giant Kelp - *Macrocystis pyrifera*, Tree Kelp - *Lessonia* spp. and Bull Kelp - *Durvillaea antarctica*) form a significant component within 7 of the 18 coastal habitat types described by SMSG (Neely *et al.,* 2010a) and dominate much of the coastline of the Falklands. While no index of diversity is available, it is likely that kelp forest forms the most diverse habitat with greatest range of faunal associations of the Falkland Islands marine habitat types. *Macrocystis* and *Lessonia* kelp in particular form a complex stratified 3-dimensional habitat matrix through the water column.

Kelp although relatively resistant to low-level oil accumulations, due to the protecting mucilaginous exudate on foliage, may be impacted by heavier accumulations due to:

- Reduced photosynthetic output;
- Breakage from increased foliar loading; and
- Inhibition of settlement and growth of new young plants due to sedimentation.

Furthermore, indirect impacts may result if faunal assemblages are impacted with a resultant increase in grazing fauna leading to defoliation. Kelp may also limit oil dispersal and retain oil in the near-shore environment.

Understanding the marine and inshore vegetation of the Falkland Islands is important as algae are one of the major primary producers in the marine environment. As with other components of the inshore marine environment the marine algal habitats and floral and faunal associations that exist within Falklands waters are poorly described and understood. See also section 7.4.2 for detail on the mapping of kelp forest.

7.4.3.3.5 Marine non-native / invasive species

The introduction of marine invasive species has had environmental, and in many cases economic, impact across the globe. It is likely that the first vessels to arrive in the Falklands (in the 18th Century) were carrying non-native species and this continues to the present day. The Falklands, like many other parts of the world, are perceived to be relatively pristine but may have already been significantly altered by invasive marine species. One of the major issues regarding the detection of marine invasives is the lack of baseline data regarding the native fauna. The surveys of SMSG are beginning to fill some of these gaps by conducting baseline surveys to record the species and habitat types present in the Islands (see Neely *et al.,* 2010a; Neely, 2010). These surveys have identified two non-native species that are present; the vase tunicate (C*iona intestinalis*) and the parchment worm (*Chaetopterus variopedatus*). These species are known to be problematic in other parts of the world, which sparked dedicated surveys to map the distribution of these species in Stanley and Mare Harbours (SMSG, 2011), the primary ports in the Falklands.

Vase tunicates are very competitive and can rapidly cover nearly 100 % of the available substrate, excluding almost all of the native species in that area. The results of surveys thus far indicate that this species is restricted to Stanley and Mare Harbour (i.e. not in Berkeley Sound), hinting at a relatively recent introduction (SMSG, 2011). This also highlights the risk of vessels visiting these Harbours having the potential to translocate this organism to other parts of the Falklands.

The parchment worm is more widespread throughout the Falklands and it is likely that it was introduced some time ago, possibly during the era of wooden sailing vessels (SMSG, 2011).

In addition to the species above, several non-native species have been found recently that are considered to be invasive elsewhere, but seem to be having little impact on the naïve Falklands floral and faunal assemblage at this time. These include;

- The cnidarian *Metridium* sp. (plumose anemone, SMSG, 2013);
- The ascidian *Asterocarpa humilis;* and
- Nine species of algae (Brodie and Mrowicki, 2019).

There is potential for other non-native species to be present but are yet to be discovered. The surveys of BSL (2015c) found several species within Berkeley Sound that were previously only known from the North Atlantic. As many of the vessels visiting the Falklands originate in Europe, it is plausible that these arrived in ballast water or as biofouling organisms.

To further address the lack of baseline, Premier commissioned (in partnership with SMSG, SAERI, University of Aberdeen, and FIG-Biosecurity) a multi-year (2015-2018) monitoring program to test the effectiveness of methods for the monitoring and early detection of marine invasives in the Falklands (Premier 2019). Monitoring sites were located in Stanley Harbour at the Temporary Dock Facility, and at York Bay in Port William. Monthly visual inspections of species recruitment onto settlement plates was carried out, and periodic analysis of the whole settlement plate assemblage was done using metagenomic analyses (see Figure 7.45).

Results showed; 1) natural species recruitment on settlement plates can vary significantly within and between sites, and temporally within and between years; 2) whilst metagemonic methods can detect the total species present including cryptic and newly settled species, traditional taxonomic analysis of plate assemblages are required to confirm species' identity; 3) comparing gene sequences to GenBank showed that of the 51 unique species detected throughout the study, eight were confirmed to 100% likelihood of a named identity, and 21 were confirmed to ~90% likelihood of a named identity, suggesting that ~ 50% of species found require formal identification and genetic bar-coding for detection in the future.

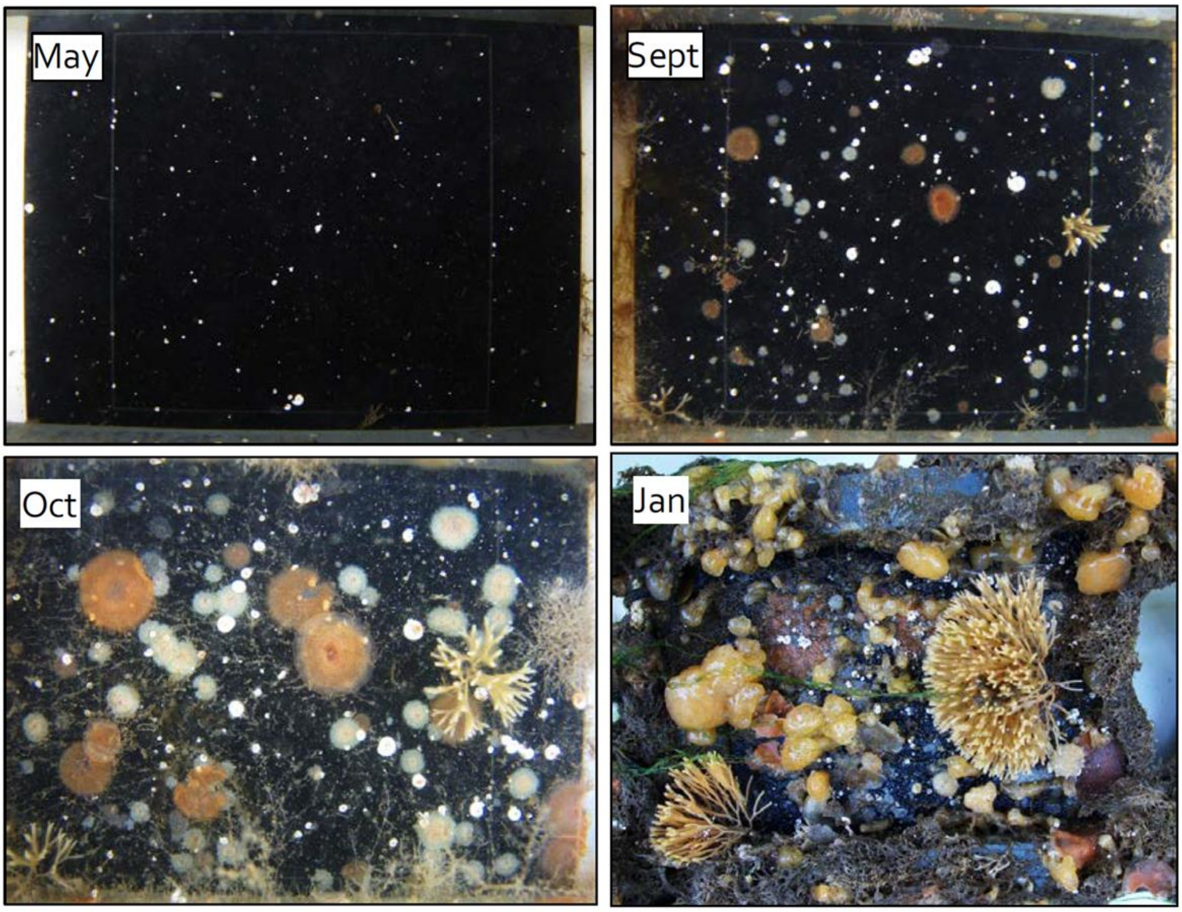


Figure 7.45: Example of progress in colonisation and growth of organisms on settlement plate over time (TDF site, May 2016 – Jan 2017)

This study will inform a marine invasives species monitoring program, as recommended at the EMMP workshop. This will likely involve firstly, the establishment of a more comprehensive baseline of a species bar-coding library, as well as deploying settlement plates in Berkeley Sound and Stanley Harbour for monitoring pre-construction phase in advance of the first vessels arriving to the Falklands. Recommendations regarding new, highly portable technology to be potentially used in the Falklands were also made.

7.4.3.4 Marine flora and fauna in Stanley Harbour and surrounding areas

The mud habitats in and around Stanley Harbour have been described as having a relatively high abundance of the saffron sea cucumber (*Cladodactyla crocea*), the tessellated rock cod (*Patagonotothen tessellatae*), the invasive sea squirt, vase truncate (*Ciona intestinalis*), the pencil urchin (*Austrocidaris canaliculata*) and the common starfish (*Anasterias antarctica*). Approximately 30 commonly occurring species were recorded during a broad survey of the wider extent of Stanley Harbour conducted in 2011 by the Shallow Marine Surveys Group (SMSG;

Brickle *et al.,* 2011). These are all considered to be common and widespread species and are not considered to be restricted in distribution or of great ecological concern.

In 2013, a more detailed benthic grid survey of the immediate development area to the east of The Narrows was carried out by SMSG (SMSG, 2013). Findings of the 2013 survey were broadly similar to the 2011 SMSG study with the most common and widespread species being the saffron sea cucumber. The species assemblages suggested that the area was not rich in biodiversity, and showed little variation between sites surveyed. The area in and around Stanley Harbour, and specifically the TDF development, has relatively low biological significance with similar habitats widely represented within the Falkland Islands.

7.4.3.5 Summary of the offshore and inshore benthic environment

Table 7.8 provides a summary of the offshore and inshore benthic environments.

Table 7.8: Summary of the offshore and inshore benthic environments

Subject	Summary
NFB and the Sea Lion Field	
Offshore benthic flora and fauna	The macrofauna communities were dominated by Polychaeta (bristle worms) and Crustacea (shrimps), and reflected the very diverse habitats recorded throughout Berkeley Sound. A total of 281 infaunal taxa and 69 epifaunal species were identified during the seabed sampling campaign. The results were analysed using multivariate techniques which showed the community forming one main cluster with subtle variations within, generally separating out based on sediment type. Three statistically significant sub-clusters were evident, grouping together stations characterised by mud, gravel and sand sediments. A diverse epifaunal community was recorded throughout the Sound, constituting an important element of the ecosystem in this area. These conspicuous groups were represented by Porifera, Bryozoa, Cnidaria, Crustacea, Echinodermata, Mollusca and Tunicata. Sponges were prevalent in areas of bedrock exposure, mainly in encrusting form but with some solitary specimens also identified.
Offshore habitats	The habitat encountered in the NFB is relatively uniform in character due to the lack in diversity in substrate type. In places, erratic rocks are present a hard substrate for encrusting organisms such as sponges and deepwater corals. However, these features have not been encountered in the area of the Phase 1 Sea Lion Development.
Berkeley Sound	
Shallow marine and inter-tidal flora and fauna	The results of dive surveys show that the shallow marine environment of Berkeley Sound is numerically dominated by the phyla, Echinodermata: sea star (starfish) (10.04 %), followed by Chordata: ascidians (9.06 %), Arthropoda: crab (8.25 %), Porifera: sponges (8.16 %) and Echinodermata: sea urchins (7.62 %) Arthropoda: amphipoda and Mollusca: cephalopods were the least abundant representing 0.09 % of the total. By species, the Chilean red sea urchin (*Loxechinus albus*) had the highest overall relative abundance, followed by the blue-spotted rockcod (*Patagonotothen cornucola*), and giant kelp (*Macrocystis pyrifera*).
Deeper water flora and fauna	The macrofauna communities were dominated by Polychaeta (bristle worms) and Crustacea (shrimps), and reflected the very diverse habitats recorded throughout Berkeley Sound. A total of 281 infaunal taxa and 69 epifaunal species were identified during the seabed sampling campaign. The results were analysed using multivariate techniques which showed the community forming one main cluster with subtle variations within, generally separating out based on sediment type. Three statistically significant sub-clusters were evident, grouping together stations characterised by mud, gravel and sand sediments. A diverse epifaunal community was recorded throughout the Sound, constituting an important element of the ecosystem in this area. These conspicuous groups were represented by Porifera, Bryozoa, Cnidaria, Crustacea, Echinodermata, Mollusca and Tunicata. Sponges were prevalent in areas of bedrock exposure, mainly in encrusting form but with some solitary specimens also identified.
Shallow marine and inter-tidal habitats	Shallow marine habitats within Berkeley Sound are very diverse. Of note are; kelp forests (which support a wide range of benthic organisms and are utilised by foraging higher predators) and biogenic reefs. Surveys near Strike-off Point have found reefs composed of slipper limpets and giant barnacles.
Deeper water habitats	The benthic communities in the deeper waters of Berkeley Sound are closely linked to the sediment type. Of note were, exposed areas of bedrock, which supported large numbers of encrusting epifaunal organisms (such as sponges). These were classified as meet the criteria necessary for geogenic reefs.

7.4.4 Fish and invertebrate ecology

7.4.4.1 Introduction

This section provides a summary of the most abundant fish and squid species within Falkland Islands waters, describes their seasonal abundance in relation to the Sea Lion Field, their seasonal spawning migrations and their principal diet. Note that, to inform the EIA of impacts to others users of the sea, indication is made as to which species are of commercial importance with catch statistics provided in section 7.7.3.1.1.

7.4.4.2 NFB and Sea Lion Field (offshore) fish and invertebrate ecology

The wider area of continental shelf and slope in the vicinity of the Sea Lion Field provides important feeding grounds for a number of species throughout all seasons of the year, with a slight decrease in the number of species present during the spring months. Whilst a number of these fish and squid species spawn within the Falkland Islands inner shelf and deep slope waters, none of the commercial species are known to have spawning grounds within the area of the Sea Lion Field and many species migrate outside of Falkland Islands waters to spawn (Arkhipkin *et al.,* 2012a). A number of skate species are known to spawn in this area based on the evidence from the occurrence of hatchlings and reproductively active females (Pompert, 2011).

7.4.4.2.1 Patagonian Shelf habitats

The Patagonian Shelf and Slope are amongst the two most biologically productive areas in the southwest Atlantic. As the Falkland Current meets the continental slope it results in an area of strong upwelling of Sub-Antarctic Surface Water (SASW) that forms a highly productive frontal zone as it mixes with shelf waters (section 7.3.3). Due to its high primary productivity, the Patagonian Shelf ecosystem is characterised by abundant pelagic and demersal organisms that support rich squid and fish resources. Many species of fish and squid within the Patagonian ecosystem, such as Argentine shortfin squid, common hake (*Merluccius hubbsi*) and hoki, migrate seasonally to the productive frontal zones to feed, and return to non-frontal zones during spawning periods, resulting in seasonal changes in the fish assemblages across the ecosystem. The convergence of the SASW and Patagonian Shelf waters at the Falkland Islands shelf break forms the transition between the temperate and sub-Antarctic ecosystems (section 7.3.3), and consequently species belonging to both temperate and sub-Antarctic taxa are found within the area.

7.4.4.2.1.1 Conservation and Management Zones

The Falkland Islands Conservation and Management Zones (FICZ and FOCZ) delineate the extent of the Falkland Islands EEZ, and six main habitat zones have been identified within this area characterised by bottom topography, bathymetry, water structure and hydrodynamics (Arkhipkin *et al.,* 2012a). These zones are represented by:

- The Inner Shelf (IS);
- The outer shelf (OS) is subdivided into two habitats:

  - North-Western Outer Shelf (NWOS); and
  - South-Eastern Outer Shelf (SEOS).
- The upper continental slope is partitioned at latitude 51° S into two habitats:
  - Northern Slope (NS);
  - Southern Slope (SS); and
  - Deepwater Slope (DS) at depths between 600 and 1,200 m.

The Sea Lion Field sits in the Northern Slope area in the FICZ (Figure 7.46).

The NS covers an area of 50,686 km^2, with an average depth of greater than 400 m. This ecoregion was identified by bottom topography (most representative), bathymetry, water structure and hydrodynamics, however, the bottom topography is not homogeneous. The shallow-water area (250–350 m) of NS is mainly flat with sandy or muddy bottom topography and parts are heavily trawled throughout the year for finfish and skates. The deep-water area to the northeast of the NS has rough bottom topography and is covered with corals to the north and is therefore difficult to work by trawlers.

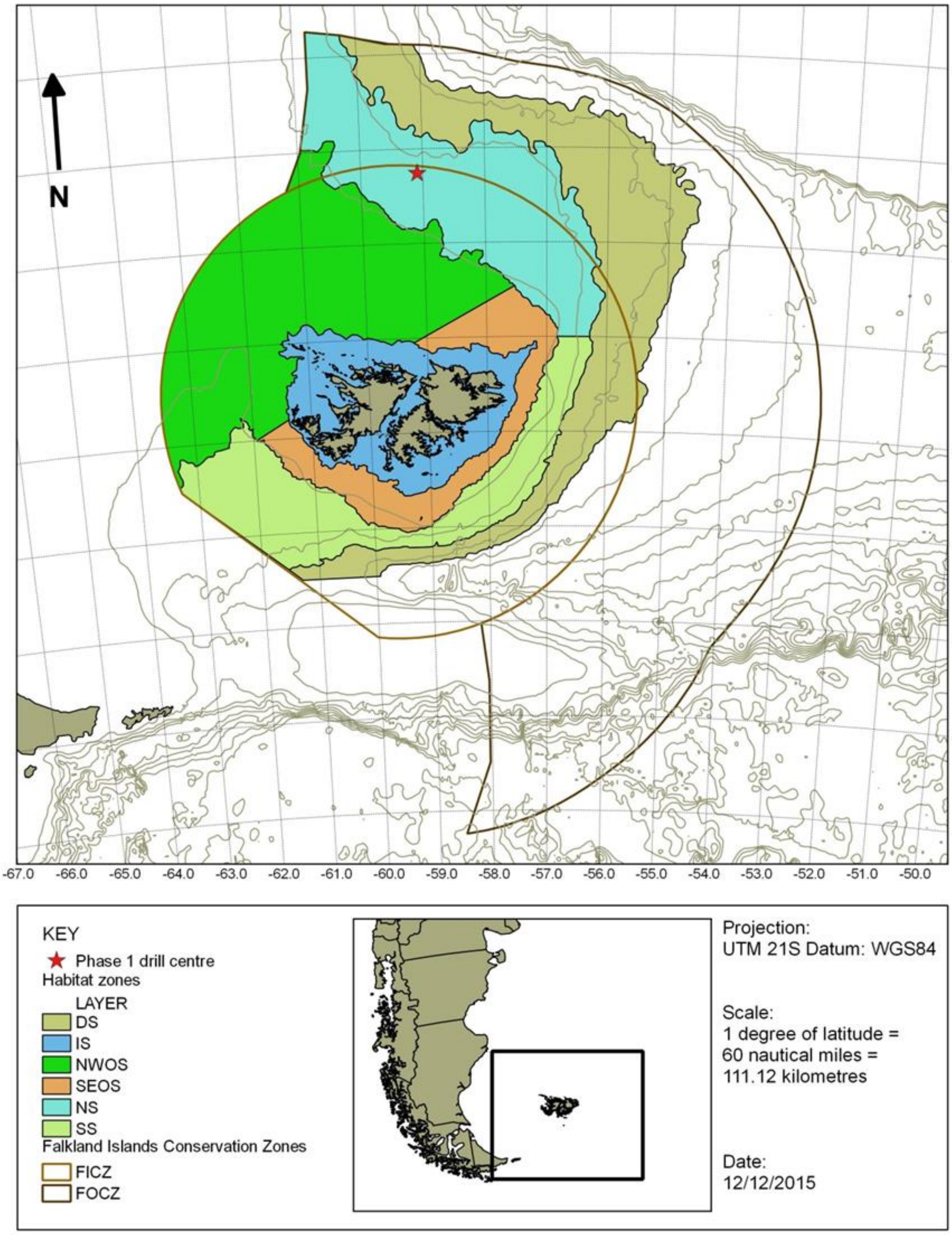


Figure 7.46: Map delineating habitat zones within Falkland Islands waters (Source: Arkhipkin *et al*. 2012a. Inner shelf (IS), north-western outer shelf (NWOS), south-eastern outer shelf (SEOS), northern (NS) and southern slope (SS) and deep water slope (DS))

7.4.4.2.2 Seasonal abundances around the Falkland Islands

Despite the biological productivity of the Falkland Islands waters only a small number of predators (fish and squid) spend all year around the eastern Patagonian Shelf and only consume a relatively small proportion of this bounty. Most of the productivity is exploited by non-resident migrating species that move to the area from distant spawning grounds to take advantage of the highly productive waters (Arkhipkin *et al.,* 2012b). Sharks, skates, squid, tunas and gadoids migrate to the area at different times of the year to feed. A number of deep water species of fish and squid feed within the area as juveniles and move to deeper waters as they mature and become adults.

7.4.4.2.2.1 Seasonal abundances on the Northern Slope

The six sub-Antarctic and seven temperate fish and squid species found in abundance in Falkland Islands waters primarily utilise these areas as productive feeding grounds, migrating within and out of these waters as food availability changes and to follow seasonal spawning migrations. The Northern Slope (NS) area, where the Sea Lion Field is located, is an important feeding area for a number of species, whose abundance in the NS varies seasonally. Table 7.9 summarises the relative abundance of the main fish species throughout the six main habitat zones over the four 'seasons'. Within the table, high abundances are highlighted in turquoise, moderate abundance is highlighted in light blue and low abundance is white. Note however that cell highlights relate only to the relative abundance within the NS.

The NS provides an important foraging area for some species throughout the year, with the spring season showing lowest species abundance with only hoki and yellownose skate found in higher abundances (Table 7.9 below). Most species have relatively wide distributions being present in several habitat areas within each season, suggesting that no species is solely reliant on the NS area as a feeding ground. However, during the autumn and spring more than 50% of the hoki population inhabit the NS over other areas (Arkhipkin *et al.,* 2012b).

Although the productive waters of the Falkland Islands support the foraging of a diverse and abundant assemblage of fish and squid, an unusual aspect of Falklands fish ecology is the migration of the majority of higher trophic species, such as southern and common hake, hoki and kingclip, to spawn elsewhere. Only a few large predators such as red cod (SEOS), several skates, loligo (IS) and greater hooked squid (DS), spend their entire life cycle in the shelf ecosystem (Arkhipkin *et al.,* 2012b).

7.4.4.2.2.2 Other commercial and non-commercial fish species on the Northern Slope

Although not currently commercially harvested, grenadiers, particularly the Ridge scaled rattail (*Macrourus carinatus*), are abundant in the NS and may be subject to a future fishery (Payá, 2009). Other species not mentioned above include a number of skate species, morid cods and psychrolutid fish. Lantern fishes (Myctophidae), black smelts (bathylagids) and other bentho-pelagic fish also contribute to the fish community on the NS. Little is known about their biology and life history in the Falkland Islands but they likely play a significant role in the ecology, through the consumption of primary consumers and vertical migrations, which could play a major role in exporting carbon from the surface layers to deeper water. These are important features of the ecosystem on the North Slope (P. Brickle *pers. obs*), that were evident in many of the drop down camera surveys undertaken in the Sea Lion area (Gardline, 2013a).

Table 7.9: Summary of seasonal abundance of fish species in the six FOCZ/FOCZ habitat zones, indicating abundance on the Northern Slope habitat zone (which contains the Sea Lion Field) [a]

Species	Spring (Oct – Dec) [b]	Summer (Jan – Mar) [b]	Autumn (Apr – Jun) [b]	Winter (Jul – Sept) [b]
Sub-Antarctic species				
Southern blue whiting [c]	SEOS / SS / NWOS	**NS**/ SS/ NWOS/ SEOS	**NS** / SS / DS	SEOS / SS / NWOS
Southern hake [c]	SS/ NWOS/ **NS**/ DS	NWOS / SS / DS	SS / NWOS	SS / NWOS / **NS**
Hoki (whiptail hake) [c]	**NS**/ NWOS/ SS/ SEOS			SS / NS / NWOS
Patagonian toothfish [c]	DS/ SS / SEOS/ **NS**/ NWOS	NWOS/ **NS**/ DS/ SS	**NS**/ DS/ SS/ NWOS	DS/ SS/ **NS**/ NWOS/ SEOS
Greater hooked squid	DS / **NS** / SS	DS/ NWOS/ **NS**/ SS/ SEOS	DS/ SS/ NWOS/ SEOS/ **NS**	DS / SS / **NS**
Loligo squid [c]	IS / SS	IS / SEOS / SS	SEOS / IS	SS / SEOS / **NS**
Temperate species				
Common hake [c]	NWOS / **NS**	NWOS / **NS**	NWOS / **NS**	NWOS / **NS**
Kingclip [c]	NWOS/ SS/ **NS**/ SEOS	NWOS / SS / **NS**	NWOS / SS / **NS**	NWOS / **NS** / SS
Southern rock cod [c]	NWOS / SEOS / **NS**	NWOS/ **NS**/ SS/ SEOS	NWOS / **NS** / SS	NWOS/ SS/ **NS**/ SEOS
Argentine shortfin squid [c]	Absent	NWOS / **NS**	NWOS / **NS**	Absent
Yellownose skate	**NS**/ NWOS/ SS/ SEOS	NWOS	**NS** / SS / NWOS	**NS** / NWOS / SS
Spur dog	NWOS / **NS** / IS	NWOS	NWOS	NWOS / **NS**
Slender tuna	Absent	IS / SEOS / NWOS	**NS** / NWOS / SEOS	Absent

[a] The habitats are identified in order of abundance for each species, and cell highlights relate only to the relative abundance within the NS. Habitat Zones: IS - inner shelf, NWOS - north-western outer shelf, SEOS - south-eastern outer shelf, NS - northern slope, SS - southern slope and DS - deepwater slope.

[b] Turquoise = High abundances in the NS. Light blue = Moderate abundances in NS White = Low abundances.

[c] Commercially important species

(Source: based on data from Arkhipkin et al. (2012b))

7.4.4.2.3 Species-specific summary of fish migration patterns, diet and life-cycle characteristics around the Falkland Islands

Information on the migration patterns of fish around the Falkland Islands has been summarised from Arkhipkin *et al.* (2012b), based on data collected from 13,044 commercial bottom and pelagic trawls between 2000 and 2010 and from 1,272 research trawls between 1999 and 2011. See Table 7.10 below for a summary of the data below and life history and behavioural characteristic. Unless specifically stated, the International Union for the Conservation of Nature (IUCN) status of the species listed below has not been evaluated.

7.4.4.2.3.1 Sub-Antarctic fish and squid

Southern blue whiting

Southern blue whiting (*Micromesistius australis*) was until recently an abundant pelagic migratory species associated with southwest Atlantic waters. In the past ten years, catches within Falklands waters have dropped to approximately 10 % of their 2007 catch (2,790 tonnes in 2015), although the most recent data show signs of stronger recruitment to the stock (FIG, 2016c). It is unclear what caused the decline but over-fishing is likely to be a contributing factor. Its spawning grounds are to the southwest of the Falkland Islands where it congregates during the spring. Once spawning is complete, the Southern blue whiting migrate onto the South-Eastern Outer Shelf (SEOS), and to a lesser extent in the Southern Slope (SS), where they feed on the abundant plankton resources (Brickle *et al.,* 2009). During the summer (Dec-Feb), the main proportion of southern blue whiting migrates to the NS, and then further north with the Falkland Current beyond the southern Patagonian Shelf.

Southern hake

Southern hake (*Merluccius australis*) is a large bentho-pelagic predator consuming prey both in the water column and near the seabed, particularly smaller fish. Its greatest abundance observed in Falkland Islands waters is found during the austral summer when it migrates to forage in the SEOS, NWOS and SS. In autumn they almost disappear from the NWOS but remain abundant in the SS. The lowest biomass is observed during winter when they migrate into Chilean waters to spawn (Arkhipkin *et al.,* 2003; Payá and Ehrhardt, 2005; Bustos *et al.,* 2007; Brickle *et al.,* 2016).

Hoki (whiptail hake)

Hoki or whiptail hake (*Macruronus magellanicus)* is one of the most abundant fish in the seas around southern South America. Spawning typically occurs during the winter months in areas outside of southern Patagonian Shelf waters. During spring hoki migrate to their feeding areas on the Falklands continental slope where it occurs in significant numbers in the NS and also in the SS and NWOS. Hoki is an opportunistic predator primarily consuming zooplankton, small fish and squid (Brickle *et al.,* 2009). It has been suggested that approximately 20-25 % of the population migrate to the warm waters of the NWOS during the spring and summer. During autumn, the majority of hoki return to the upper slope and are found in large numbers over the NS. In winter, most of the population migrates outside the southern Patagonian Shelf to spawn with low numbers remaining on the SS. Unlike southern blue whiting, hoki appear both in shallow waters of IS and deep waters of the slope (DS); especially in autumn.

Patagonian toothfish

Patagonian toothfish (*Dissostichus eleginoides*) is a near bottom predator that has a wide distribution around the sub-Antarctic. The overall seasonal distribution of toothfish does not change significantly between the various habitat zones. In winter toothfish stay mainly in deepwater (DS) and slope region (NS), and start to migrate to shallower waters of the NWOS, SS and SEOS in spring. In summer, toothfish migrate to the warmer waters of NWOS and NS to forage on southern rock cod, moving back to the slope regions (mainly NS) in autumn (Arkhipkin *et al.,* 2012a).

Greater hooked squid

The greater hooked squid (*Onykia ingens*) is an abundant species throughout the Southern Ocean and feeds predominantly on fish species (Arkhipkin *et al.,* 2012b). The IUCN status of this species has been assessed as 'Least Concern' (Barratt and Allcock, 2014a). It is a relatively large squid (maximum reported mantle (body/tube) length of 61 cm) found from the surface to the deep waters (at 1,100 m; Jackson, 1993). Although abundant, this species is not commercial due to the high concentrations of ammonia in its flesh. However, it is one of the main prey items for shelf and slope cetaceans (Clarke, 1980). Following the winter spawning period the adults die, and in spring the juveniles move from the deep-water spawning area to shallower waters on the NS and SS. In summer, the maturing juveniles forage mainly on the NWOS, NS and SS to depredate on southern rock cod. By autumn, the now fully mature greater hooked squid make their migration back to deep waters to spawn, gradually disappearing from shelf and upper slope areas, and reaching their highest abundance in DS (Arkhipkin *et al.,* 2012a).

Red cod

Red cod (*Salilota australis*) is a relatively large demersal fish. On the Falkland Islands Shelf red cod's abundance is highest in spring in the SEOS, SS and NWOS, during their spawning and post spawning period. In the summer they disperse mostly over the NWOS to feed (Arkhipkin *et al.,* 2001). In autumn they are mainly dispersed across the shelf and then in winter adult fish start to migrate back to the SEOS to spawn (Arkhipkin *et al.,* 2010 and 2012b; Brickle *et al.,* 2011).

Patagonian long-finned squid

Patagonian long-finned squid, known locally as loligo, is an important domestic commercial species that spends its whole life cycle in the waters of the Falkland Islands (Arkhipkin *et al.,* 2012b). The loligo population comprises two different spawning groups, the first spawning during spring and the second spawning during the autumn season. Their abundance on the NFB is high in winter, when pre-spawning animals forage for zooplankton in SS, SEOS and less significantly on the NS. During the spring the abundance is very low as many animals move to inshore areas to spawn and die (section 7.4.4.3.2.1). The population increases again during summer as the newly hatched juveniles move from inshore waters to the SEOS and SS to feed on the abundant zooplankton, whilst avoiding depredation pressure from the larger fish (Arkhipkin *et al.,* 2012b). During August the second spawning group migrates into inshore waters to spawn, whilst the maturing juveniles from the spring spawning group replace them on the SEOS feeding grounds.

7.4.4.2.3.2 Temperate fish and squid

Common hake

Common hake (*Merluccius hubbsi*), like the austral hake, is a near bottom predator that inhabits the temperate waters of the Patagonian Shelf and slope (Cohen *et al.,* 1990). During autumn and winter, common hake migrate to their main foraging grounds in the NWOS, and to a lesser extent to the NS, to feed on southern rock cod. During spring and summer common hake abundance decreases significantly in the FICZ as they migrate northwest to their spawning grounds on the northern Patagonian Shelf (Arkhipkin *et al.,* 2003; Arkhipkin *et al.,* 2012a).

Kingclip

Kingclip, also known as the pink cusk eel (*Genypterus blacodes*), is a large eel-like benthic predator that occurs in the temperate shelf and slope waters of southern South America (Renzi, 1986). The greatest abundances are found in the NWOS, SS and SEOS, which are the main foraging areas for this species. During the summer approximately 60% of the adult population migrate to their spawning grounds in the northern Patagonian Shelf outside Falkland Islands waters. In autumn, their abundance is at a minimum with remaining individuals possibly skipping spawning in the NWOS and SS. In winter, kingclip migrates back to the Falkland Islands to forage primarily on southern rock cod with increased abundances in NWOS, NS and SS. They then move from the NS further south to SS to continue feeding during spring (Arkhipkin *et al.,* 2012b).

Southern rock cod

The southern rock cod (*Patagonotothen ramsayi*) is a bentho-pelagic species consuming prey both in the water column and near the seabed on the shelf and upper slope (50-500 m depths). The abundance of southern rock cod has increased several-fold in recent years and it is currently the most abundant finfish on the Falkland Islands shelf and has become one of the most important finfish fisheries in the Falkland Islands (FIG, 2013c). It is hypothesised that the regional decline in southern blue whiting is a factor in rock cod's increased abundance (Laptikhovsky *et al.,* 2013). Southern rock cod is itself an important prey species for all predatory fish (Laptikhovsky *et al.,* 2013) and juvenile phases of loligo squid. This temperate species has a flexible diet with the ability to switch between main food sources as their abundance varies with the seasons (Arkhipkin and Laptikhovsky, 2013). During the spring and summer months, rock cod feed primarily on zooplankton crustaceans and benthic organisms in the NWOS and NS coinciding with peak zooplankton production during these months (Arkhipkin *et al.,* 2012b). During the late summer and autumn months gelatinous plankton form an important part of their diet reflecting their overall seasonal abundance in the oceans (Arkhipkin and Laptikhovsky, 2013). The abundance of rock cod decreases particularly in the upper slope areas (NS and SS) during autumn, due to a migration out of Falkland Islands waters in preparation for the winter spawning period. A small proportion of the stock remains on the SS during the winter months.

Argentine shortfin squid

The Argentine shortfin squid has an annual life cycle (Hatanaka, 1986) and is the most abundant squid species in the southwest Atlantic, IUCN status 'Least Concern' (Barratt and Allcock, 2014b). It is closely associated with the temperate waters of the Patagonian Shelf and highest abundances are recorded on the NWOS and NS during summer where it migrates to the southern part of its range to forage on zooplankton, in particular krill (e.g. *Thysanoessa gregaria, Euphausia vallentini and E. lucens*) and pelagic amphipods (such as *Themisto gaudichaudii*). In autumn, they make their way north along the slope as part of their pre-spawning migration and abundances in the NWOS and NS decreases. During the rest of the year this species is absent from the Patagonian Shelf and slope (Arkhipkin *et al.,* 2012b).

Yellownose skate

The yellownose skate (*Zearaja chilensis*) is a relatively large skate that is moderately abundant in water depths between 100 and 300 m on the temperate shelves around southern South America (Nakamura *et al.,* 1986) but rarely found in depths >500 m. A migratory species, the yellownose skate makes long spawning migrations out of Falkland Islands waters to warmer waters in the summer (Arkhipkin *et al.,* 2013). The skate returns in autumn during their feeding migration to prey on other fish and squid, which are abundant in Falkland Islands waters. The yellownose skate reaches maximum abundance around the Falkland Islands in austral winter (July to September) primarily on the NWOS (Arkhipkin *et al.,* 2013). Throughout the spring, their abundance gradually decreases in the northern regions with some movement likely to the southern slope. This species has been assessed as 'Vulnerable' on the IUCN Red List and the population is thought to be in decline and subject to commercial fishing pressure (Kyne *et al*., 2007). The yellownose skate is one of the four species dominating the multispecies skate fishery in the Falkland Islands, which is currently managed by limiting the fishing effort and numbers of licences. The late maturation of females at 14 years old and low reproductive capacity makes this species vulnerable to overfishing and other factors that contribute to mortality.

Spur dog

The spur dog (*Squalus acanthias*) is a small shark that is associated with temperate waters of the Patagonian Shelf (Nakamura *et al.,* 1986). It reaches its maximum abundance in Falkland Islands waters in the NWOS during spring, with smaller aggregations in the NS. In summer through to autumn this species migrates out of Falkland Islands waters onto the Argentine Shelf and into international waters (Arkhipkin *et al.,* 2012b). This species has been assessed as 'Vulnerable' on the IUCN Red List and the population is thought to be in decline (Fordham *et al*., 2016). Although naturally abundant, it is vulnerable to over-exploitation by fisheries due to its late maturity, low reproductive capacity, longevity, long generation time (25 to 40 years) and hence a very low rate of population increase (2-7% per year).

Slender tuna

The slender tuna (*Allothunnus fallai*) is a medium sized tuna growing to a maximum total length of approximately 100 cm. This species is widespread and locally abundant in the Southern Ocean and is assessed as Least Concern by IUCN (Collette *et al*., 2011). Slender tuna has the most southerly distribution of tunas in the South Atlantic, and feeds predominantly on zooplankton and is recorded in the IS in summer with the greatest abundance appearing in autumn in the NS. During the winter and spring months the slender tuna is completely absent from the Falkland Islands waters (Arkhipkin *et al.,* 2012b).

7.4.4.2.4 Summary of offshore fish and invertebrate ecology

A summary of the abundance and behaviour of offshore fish and invertebrate species in provided in Table 7.10.

Table 7.10: Summary of offshore fish and invertebrate species around the Falkland Islands

Species	Domain	Migratory [a]	High abundance on NS	Behaviour on NS	Diet	Commercially targeted
Sub-Antarctic species						
Southern blue whiting	Pelagic	✓	Summer	Feeding	Zooplankton	✓
Southern hake	Bentho-pelagic	✓	-	n/a	Fish, squid	✓
Hoki (whiptail hake)	Pelagic	✓	Spring - Autumn	Feeding	Zooplankton fish and squid	✓
Patagonian toothfish	Demersal	X	Summer & Autumn	Feeding	Fish, squid, crustaceans	✓
Greater hooked squid	Pelagic	X	Summer	Feeding	Zooplankton, squid, fish	X
Loligo squid	Pelagic	X	Winter	Feeding	Zooplankton, squid, fish	✓
Temperate species						
Common hake	Bentho-pelagic	✓	Summer	Feeding	Fish, squid	✓
Kingclip	Demersal	X	Winter	Feeding	Fish, Squid crustaceans	✓
Southern rock cod	Demersal	X	Summer	Feeding	Zooplankton, benthic invertebrates and gelatinous plankton	✓
Argentine shortfin squid	Pelagic	✓	Summer	Feeding	Zooplankton, squid, fish	✓
Yellownose skate	Demersal	✓	Spring	Feeding	Fish, crustaceans	✓
Spur dog	Demersal	✓	-	Feeding	Fish, squid and benthic invertebrates	X
Slender tuna	Pelagic	✓	Autumn	Feeding	Zooplankton, squid	X

[a] In and out of the Falkland Islands EEZ

7.4.4.3 Berkeley Sound (inshore) fish and invertebrate ecology

Commercial fishing is not permitted within coastal waters around the Falkland Islands (within three miles of the coastline section 7.5.1.2). Nonetheless, commercial species may utilise inshore waters for feeding or spawning. Additionally, there are numerous inshore species (20 species, mostly crustaceans and molluscs) that, although currently not heavily exploited in the Falklands, have the potential for commercial exploitation (Neely *et al.,* 2010b; Davidson, 2016). All species contribute to the diverse inshore community however.

This section provides a description of the most abundant species of fish and invertebrates off the east coast of the Falkland Islands and in Berkeley Sound. For each, a summary of their ecology is provided in terms of;

- Their seasonal abundances in relation to the Berkeley Sound area;
- Their seasonal spawning migrations; and
- Their principal diet.

7.4.4.3.1 Fish species

There are relatively few fish species found within inshore waters in and around Berkeley Sound. The exceptions being, rock cod, mullet, smelt and sprat.

7.4.4.3.1.1 Southern rock cod

Detail on the offshore distribution and abundance of this species is provided in section 7.4.4.2.3.2.

The genus *Patagonotothen* contains 14 species in the waters off southern South America of which *P. ramsayi* is the most abundant (Ekau, 1982; Norman, 1937; Hart, 1946; Brickle 2005a). Little is known about the biology and ecology of these species. Bargelloni *et al.* (2000) estimated that the divergence time of Subantarctic *P. tessellata* from Antarctic *Lepidonotothen nudifrons* at 9 million years. Stankovic *et al.* (2002) added *P. brevicauda* to their analysis and estimated that the divergence time of *Patagonotothen* from its Antarctic sister is approximately seven million years well after the formation of the Antarctic Polar Front, which formed 20 – 25 million years ago.

Inshore eight species of rock cod (*Patagonotothen*) have been recorded (Neely and Brickle, 2013). The have very different niches and include the abundant *Patagonotothen tessellata* which inhabit open water outside of the kelp line. Within the kelp *P. cornucola* inhabit the benthos particularly in algal litter, *P. squamiceps* inhabits the kelp canopy and *P. sima* inhabits the intertidal. The inshore species range in size from 5 to 6 cm (*P. sima*) to 40 cm (*P. wiltoni*) (P. Brickle *pers. obs.*). These species are important prey for a number of inshore predators. In late summer huge shoals of post larval *P. tessallata* are prey for sei whales, dolphins, seals and slender tuna (P. Brickle *pers. obs.*). See Brickle (2005) for more information.

7.4.4.3.1.2 Falklands' mullet

The Falkland Islands' mullet (*Eleginops maclovinus*) belongs to the primitive monotypic notothenioid family Eleginopidae (Balushkin, 1992). Unlike most other notothenioids, *Eleginops* never became associated with the margins of the Antarctic plate (Eastman, 1993). It is the only notothenioid fish (apart from the Australian freshwater Pseudaphritidae), in which its entire evolution occurred in temperate nearshore environments (Balushkin, 1994) away from Antarctic waters.

The Falklands mullet is one of the most unusual notothenioids, only one of two euryhaline species (adapted to live in a range of salinities) in the entire suborder. The fish lives in coastal waters around the Falkland Islands (Boulenger, 1900; Hart, 1946) and in estuaries and rivers along the South American coast as far north as Uruguay on the east coast and Talcahuano, Chile on the west coast (Regan, 1913; Norman, 1937; Andriashev, 1964). DeWitt *et al.* (1990) reported that a specimen had also been recorded from Tristan da Cunha in the Atlantic Ocean.

The Falkland mullet is an important component of Falkland Islands inshore ichthyofauna and preys on smelt, larval notothenioids, echiurid worms, polychaetes and crustaceans including *Munida* spp. Mullet are prey to sea lions and inshore dolphins (see Brickle *et al.,* 2003; 2005a; 2005b; Brickle and MacKenzie, 2007 for more detail on mullet biology and ecology in the Falkland Islands).

The local mullet has been subject to a small inshore fishery in the Falkland Islands which continues. Catches vary and have been up to 15 tonnes per year (Brickle *et al.,* 2003).

7.4.4.3.1.3 Smelt

There are two species of smelt or silversides (family Atherinopsidae) *Odontesthes smitti* and *Odontesthes nigicans* that inhabit the coastal waters of the Falkland Islands. Their biology and ecology are not well known and are taken occasionally as bycatch in beach seine nets for mullet (P. Brickle *pers. comm.*).

7.4.4.3.1.4 Falklands sprat

Sprattus fuegensis is an abundant near shore and shelf herring like fish in the family Clupeidae. Falkland sprat was subject to a trawl fishery in the late 90s and is an important prey item for inshore predators and migrating predatory fish, mammals and seabirds in the Falklands Islands (P. Brickle, *pers. obs.*). This is particularly the case in mid to late summer when young fish of the year are plentiful and preyed upon by many species of higher predator including large baleen whales.

7.4.4.3.2 Invertebrate species

7.4.4.3.2.1 Loligo (Patagonian long-finned squid Doryteuthis gahi)

Loligo is a demersal cold-water squid, which forms the basis of a substantial fishery on the Patagonian Shelf to the south, east and northeast of the Falkland Islands, with highest catches concentrated on the shelf break in waters between 150 and 200 m in depth.

A small squid species (typical mantle length of 13–17 cm), loligo is an important domestic commercial species that spends its whole life cycle in Falkland Islands waters (Arkhipkin *et al.,* 2012b) staying offshore to feed and coming inshore to spawn and die. The loligo population comprises two different spawning cohorts, the first spawning during spring and the second spawning during the autumn. Detail on the loligo distribution and abundance in the NFB is provided in section 7.4.4.2.3.1 above. During August the second spawning group migrates into inshore waters to spawn, while the maturing juveniles from the spring spawning group replace them on the feeding grounds.

Despite being of great commercial significance, little is known about the breeding behaviour of Falklands' loligo. However, it was believed that unlike other loliginid squid they do not lay their eggs directly on the substrate, instead the eggs are attached to kelp stipes and likely on rocky outcrops. This is believed to be an adaptation to reduce the predatory pressure from benthic invertebrates. Also curious is the observation that although egg masses can be encountered anywhere in the kelp year-round (Tingley *et al.,* 1996), they are never seen in great numbers at a single site. It is believed that each female lays clusters of eggs in many different locations. This appears to be an adaptation to the unpredictable inshore marine environment and may also reduce the predatory pressure from the abundant populations of seabirds and marine mammals in the region (Brown *et al.,* 2010). It is acknowledged that the distribution of loligo spawning grounds are poorly known in the Falkland Islands. Despite regular observations of *D. gahi* egg masses among kelp forests around the Falkland Islands (Arkhipkin *et al.,* 2000; P. Brickle *pers. obs*.), they have never been found in numbers required to support the large fishery that currently exists for this species around the Falklands. This fishery is one of the most important loliginid fisheries in the world and yields some 82 -99% of the catch of the species in Atlantic Ocean (Arkhipkin *et al.,* 2006).

Therefore, the question remains: are kelp forests the only spawning grounds for this species? First doubts appeared when a loligo egg mass was found attached to the tube of the polychaete *Chaetopterus variegatus* collected by bottom trawl at the depth range 68-71 m (Laptikhovsky, 2007). Investigation of *Loligo* sp. egg masses in Argentinean waters revealed the existence of two types of clusters; those allocated to *D. gahi* (based on egg size) were found attached to the ropes with artificial egg clusters to attract females (demonstrating possible confusion with kelp stipes), and also a few were found attached to (artificial) hard substrata (Barón *et al.,* 2001). Although spawning in this species on rocky ground is plausible, the prevalence of these bottom–attached masses remains unclear. On 11 January 2011 during a benthic SCUBA survey, undertaken by SMSG, off Tussoc Island, Port William (54°40'496 S 057°43'689 W, depth 9.8 m) a loligo egg mass was observed attached to the bedrock. It is likely that loligo spawn on rocky outcrops in deeper water outside of the kelp zone. Further surveys are required to establish the distribution of these spawning grounds. The loligo fishery is particularly important to the Falkland Islands economy, it is significant that this species and its fishery are present year-round and would therefore be vulnerable to inshore oil-based pollution for almost the whole year.

7.4.4.3.2.2 Other commercially exploitable invertebrates

The Inshore Fisheries Research Project was initiated to investigate the distribution and abundance of 20 potentially exploitable inshore invertebrate species (Neely *et al.,* 2010b). As part of this collaborative project between SAERI, the Falkland Islands Fisheries Department and SMSG, dive surveys have been conducted within the eastern half of Berkeley Sound (Davidson, 2016).

Of the potentially commercial species, only the Chilean sea urchin, ribbed mussel (*Aulacomya atra*), blue mussel (*Mytilus edulis*), keyhole limpets (*Fissurella* species), and piure (*Pyura chilensis*) were found in any appreciable numbers and in several locations.

Chilean sea urchin

Chilean sea urchins (*Loxechinus albus*) were found at all 10 of the dive sites. The recorded density ranged between 36 and 940 urchins per 60 m^2. The higher densities were found in the eastern half of the survey area, with lower densities in the west.

Ribbed mussel

The ribbed mussel (*Aulacomya atra*) was present at eight of the 10 dive sites. The recorded density ranged between 6 and 1,350 mussels / 60 m^2. The densities were higher further towards the west of the survey area, with lower abundances in the east.

Blue mussel

Blue mussels (*Mytlius edulis chilensis*) were only found at three of the 10 dive sites. The density, at the sites where they were found, ranged from 12 to 280 mussels per 60 m^2.

Keyhole limpet

Keyhole limpet species (*Fissurella* species) were found at three of the 10 sites. The density, at the sites where they were found, ranged from 5 to 29 limpets per 60 m^2. The distribution of keyhole limpets was skewed to the east of the area surveyed.

Piure

Piure (*Pyura chilensis)* were found at four stations, but was not found in high densities anywhere. The highest density recorded was 20 piure per 60 m^2.

7.4.4.3.3 Summary of inshore fish and invertebrate ecology

A summary of the abundance and behaviour of inshore invertebrate and fish species in provided in Table 7.11.

Table 7.11: Summary of inshore fish and invertebrate species around the Falkland Islands

Species	Domain	Migratory	High abundance in BS	Behaviour in BS	Diet	Commercially targeted
Invertebrate species						
Loligo	Demersal	✓	✓	Spawning	Zooplankton, squid, fish	✓
Ribbed mussel	Benthic	x	✓	Resident	Filter feeder	x
Chilean sea urchin	Benthic	x	✓	Resident	Algae	x
Blue mussel	Benthic	x	✓	Resident	Filter feeder	x
Keyhole limpet	Benthic	x	x	Resident	Algae	x
Piure	Benthic	x	x	Resident	Filter feeder	x
Fish species						
Mullet	Demersal	x	✓	Resident	Zooplankton, benthic invertebrates	x
Rock cod	Demersal	x	✓	Resident	Zooplankton, benthic invertebrates and gelatinous plankton	✓
Sprat	Pelagic	x	✓	Resident	Zooplankton	x
Smelt	Pelagic	x	✓	Resident	Zooplankton	x

7.4.4.4 Fish and squid in Stanley Harbour and surrounding areas

Five fish species were recorded during recent surveys (Brickle *et al.,* 2011; SMSG, 2013); the tessellated rock cod (*Patagonotothen tessellata*) was the most common with blue-spotted rock cod (*P. cornucola*), kelp rock cod (*P. squamiceps*), humped rock cod (*P. sima*), and orange fin rock cod (*P. brevicauda*) occurring less frequently. Mullet (*Eleginops maclovinus*) is also caught by recreational fishers at the western end of Stanley Harbour.

Commercial fishing is an important industry within the Falkland Islands and a number of commercial species of fish and squid are exploited. In general, it is considered that commercial species are not found in Stanley Harbour in significant numbers, although there is the potential for them to be present in low numbers.

A number of inshore non-commercial cephalopod species are potentially present with *Enteroctupus megalocyathus* and *Muusoctopus eureka* occurring in similar environments to the TDF development such as Mare Harbour (Brickle *et al.,* 2011). Spawning of Patagonian Longfin Squid or loligo (*Doryteuthis gahi*), the main cold water commercial squid species in the Falkland Islands is known to occur within relatively shallow near-shore waters. Egg masses are known to occur in algal beds (Arkhipkin *et al.,* 2000). However, there is no evidence to suggest that there are spawning grounds within the area of the proposed TDF development.

7.4.5 Seabirds and seabird vulnerability

7.4.5.1 Introduction

The productive waters around the Falkland Islands provide globally important feeding areas for significant aggregations of seabirds (White *et al.,* 2002). The Islands themselves hold internationally important breeding populations of a number of seabird species, and coastal and offshore waters support numerous species of non-breeding visitors (BirdLife International, 2014a). Of the 82 seabird species recorded in the Falkland Islands, 22 / 23 breed in the archipelago, 24 are annual non-breeding visitors and the remainder rare visitors or vagrants. (White *et al.,* 2002; Woods and Woods, 2006).

Over 70 % of the global population of the near threatened black-browed albatross (*Thalassarche melanophris*) breed on the Islands (Wolfaardt, 2012). After New Zealand, the Falkland Islands support more penguin species than any other region in the world. For most of these species, the populations breeding in the Falkland Islands represent a significant proportion of the global total. Approximately 34 % and 36 % of the global populations of gentoo (*Pygoscelis papua*) and rockhopper penguins (*Eudyptes chrysocome*), respectively, breed in the Falkland Islands (Baylis *et al.,* 2013a & b). Furthermore, a significant proportion (possibly 10 %) of the global population of Magellanic penguins (*Spheniscus magellanicus*) breed on the Islands (Woods and Woods, 1997). The small breeding population of king penguins (*Aptenodytes patagonicus*) in the Falkland Islands, at the north-western limit of the species' range, is almost entirely concentrated at Volunteer Point, on the east coast of East Falkland, adjacent to Berkeley Sound.

In addition to the large number of seabirds that breed on the Islands, many non-breeding seabirds have been observed (White *et al.,* 2002) or tracked migrating into the waters of the

Falkland Islands from elsewhere, particularly South Georgia (Croxall and Woods, 2002; Phillips *et al.,* 2006).

The avifauna of the Patagonian Shelf region is well studied and documented, and seabird distribution, breeding and foraging patterns are relatively well understood in comparison to other species (Croxall *et al.,* 1984, Woods 1988, Woods and Woods 1997, Strange, 1992, White *et al.,* 2001 & 2002, FIG, 2008a, BirdLife International, 2015). However, it is acknowledged that there are data gaps.

This section provides a summary of the seabird species found in the Falkland Islands, their abundance, distribution, feeding and breeding ecology, conservation status and sensitivities.

7.4.5.2 Seabirds in the NFB and Sea Lion Field (offshore)

7.4.5.2.1 Seabird abundance and distribution

Numerous surveys have been conducted over the years in efforts to determine the distribution and abundance of seabirds in the Falkland Islands. In particular, the JNCC Seabirds At Sea Team (SAST) was commissioned to conduct seabird and marine mammal surveys in advance of the first exploratory round of drilling for oil within Falkland Islands waters. In addition to the JNCC surveys, seabird abundance and distribution within the Sea Lion area has been informed by at-sea surveys conducted by Rockhopper Exploration and Desire Petroleum during seismic survey campaigns in the PL001 licence area (Geomotive and MRAG, 2011) and the wider NFB licence blocks (Polarcus, 2011) and numerous satellite tracking projects.

7.4.5.2.1.1 JNCC Seabirds At Sea Team (SAST) surveys

In advance of the first exploratory round of drilling for oil within Falkland Islands waters, the JNCC were commissioned to conduct seabird and marine mammal surveys. Surveys commenced in 1998 and continued for three years, with three dedicated observers employed throughout the period. The surveys covered an area of over 20,900 km^2 and recorded over 399,700 individual birds of 57 species. These data were published in the form of distribution maps; to display the seasonal dispersion of all species recorded (White *et al.,* 2002). This work represents the most comprehensive survey of the at-sea distributions of seabirds within Falkland Islands waters and is considered here as the baseline to which additional information has been added, and should continue to be in the future. It is acknowledged that the age of the Seabirds-at-Sea dataset (collected between 21 and 14 years ago, as of 2019), and inherent limitations of the survey method, mean that there are some questions regarding how representative the data are of present day populations. Consequently, information relating to each species described below has been supplemented by more recent references on a species by species basis.

The SAST distribution atlas (White *et al*., 2002) and associated database remain the most useful description of seabird distributions within Falkland Islands waters, in terms of broad scale spatial and temporal patterns of distribution of breeding and non-breeding birds. There remain gaps in the SAST coverage but it is possible to infer the species assemblages that are likely to be found in these areas with the data available, therefore, White *et al*., (2002) has been used as a primary reference in the EIS. Questions have been raised about the age of the SAST data. In order to ensure that the JNCC Seabirds At Sea data provided an appropriate dataset on which to base the environmental impact assessment, Premier commissioned Genesis to undertake a review of the data.

The review assesses the adequacy of the existing seabird data presented in the EIS for the purposes of impact assessment, i.e. is the quality and quantity of seabird data presented in the EIS fit for purpose?

The review concluded that the survey methods used, the coverage and the age of the data are comparable with existing datasets used to inform similar impact assessments undertaken in the UK. As a whole, the volume of data collected in the waters off the Falkland Islands is significantly smaller than the equivalent European Seabirds At-Sea (ESAS) data set, being based on three years of survey effort as opposed to over 30 years for the ESAS data. However, the survey effort is not dissimilar to the level of effort from the Atlantic Frontier waters located off the north and west coast of Scotland, where O&G exploration is also relatively new and developing. It is therefore concluded that the existing offshore seabird data within the Falklands is adequate for the purposes of undertaking an impact assessment.

The review can be read in its entirety in Genesis (2017) '*Review of seabird data at Sea Lion (Document No. J74462B-A-RT-00001/A1). Report prepared by Genesis for Premier Oil Exploration and Production Ltd, July 2017.'*

With permission from Falklands Conservation (FC) and JNCC, the SAST survey data was re-examined to highlight the species recorded in the vicinity of the Sea Lion area. An imaginary 'box' (between 49-50˚S and 58.5-59.5˚W) was used for this purpose. The number of birds recorded per kilometre of survey track, on a seasonal basis, was calculated to indicate relative abundance and is presented in Table 7.12 (the highlights in shades of blue indicate relatively High, Medium and Low abundance). For the purposes of this analysis, the months of March, April and May are considered to be autumn, June, July and August are winter, September, October and November are spring and December, January and February are summer. As in White *et al.* (2002), clear seasonal patterns of abundance, and therefore risk from oil and gas related activity, were identified for most species recorded in the region.

In total, over 2,050 km of survey track were observed over Sea Lion Field waters. Effort was spread across all months with a high of 504 km achieved in July and a low of 41 km in May.

Over 4,880 seabirds were recorded within the area adjacent to Berkeley Sound, monthly counts for all the species recorded are shown in Table 7.12.

Table 7.12: Relative seasonal abundance of seabird species recorded in the vicinity of the Sea Lion Field during JNCC surveys (JNCC data) [a, b]

Rank	Autumn (M,A,M)		Winter (J,J,A)		Spring (S,O,N)		Summer (D,J,F)	
	Species [c]	Birds/km	Species [c]	Birds/km	Species [c]	Birds/km	Species [c]	Birds/km
1	BBA	1.172	Pr	1.417	BBA	0.415	Pr	0.940
2	GS	0.576	BBA	0.315	Pr	0.252	GS	0.440
3	WCP	0.342	AF	0.239	SS	0.126	BBA	0.379
4	CP	0.168	CP	0.124	CP	0.098	WP	0.124
5	WP	0.108	SRA	0.031	R/M	0.059	WCP	0.083

6	AF	0.054	GHA	0.030	WP	0.054	MP	0.079
7	GBsp	0.045	SGP	0.019	WCP	0.049	GBsp	0.077
8	SPP	0.045	NGP	0.013	GBsp	0.031	SS	0.053
9	SS	0.042	NRA	0.011	AF	0.031	SGP	0.022
10	Pr	0.039	KP	0.011	SGP	0.018	LTS	0.020
11	SRA	0.033	DP	0.010	DP	0.018	SRA	0.010
12	SGP	0.030	WP	0.008	MP	0.013	SPP	0.010
13	MP	0.030	KG	0.008	NGP	0.013	WA	0.008
14	GHA	0.027	GPsp	0.007	GPsp	0.010	GPsp	0.008
15	LTS	0.024	MDP	0.002	AS	0.010	AS	0.008
16	WA	0.018	SS	0.002	NRA	0.005	DP	0.006
17	AS	0.018	Dio Alb	0.001	WA	0.003	NRA	0.002
18	NRA	0.009	WCP	0.001	SRA	0.003	CP	0.002
19	AtP	0.009			KG	0.003	RP	0.002
20	GPsp	0.009					BBSP	0.002
21	DP	0.009						
22	R/M	0.009						
23	MDP	0.006						
24	NGP	0.006						
25	LS	0.003						
26	RP	0.003						
27	BBSP	0.003						

[a] Survey effort: Autumn 333.5 km, Winter 829.7 km, Spring 388.1 km, Summer 508.6 km

[b] Highlights in shades of blue indicate relatively Very High, High, Medium and Low abundance

[c] The species names relating to the species codes are found in the species accounts (section 7.4.5.2.3 below).

GPsp = giant petrel species, Dio Alb = *Diomedea* albatross species.

Data limitations with seabird distribution and vulnerability information

There are a number of limitations associated with the SAST surveys which are described by White *et al.,* (2001 and 2002) and must be taken into consideration when interpreting the data. The SAST surveys were conducted opportunistically; therefore distribution of survey effort was closely linked to the activity of patrol vessels. Occasionally, some vessel time was dedicated to covering the NFB but there remain some gaps in coverage. As a result, coverage within some of the key Licence Blocks was not as high as had been hoped at the outset of the project (White *et al.,* 2001 and 2002). In particular, the Drilling Campaign Area was not covered during April, May and September.

The detection and identification of cryptic species, such as penguins and diving-petrels (*Pelecanoides* spp), at-sea was highlighted as one of the most significant challenges for observers, as these birds can be difficult to spot from vessels (White *et al.,* 2002). However, simultaneous projects to satellite track penguins were conducted, to complement at-sea observations and fill any gaps. The recorded distribution of penguins during SAST surveys are supported by satellite tracking data (for example Pütz *et al.,* 2000; 2002a and b). Additional tracking has been carried out in subsequent years, but these data have yet to be collated and analysed to derive composite distribution and vulnerability maps. This is an issue that is currently being addressed by the GAP project (section 7.2.4.2).

Visual surveys also rely on good conditions for observing. When conditions are too rough or dark to continue, surveys stop. Therefore, the activity of birds at night is not recorded. Some species are known to return to colonies at dusk, this behaviour is well known from observations from land and can be observed at sea when close to land late in the day. With sufficient survey effort, the movements of birds to and from colonies will be captured in the data.

The SAST data were collected over ten years ago. Whether this influences the validity of the data is a matter for debate. During the three years of the project major inter-annual variations in species distribution were not identified, perhaps because the study covered a relatively short time frame.

One of the great advantages of at-sea surveys is that all species are recorded. Therefore, it is possible to assess the risk to species that have not been tracked. None of the smaller species of petrel have been tracked, yet they are vulnerable to oiling and light induced bird strikes.

Recent studies suggest that there may be significant inter-annual and spatial variation in foraging and migration patterns, for individuals of the same species breeding on the same island (Masello *et al.,* 2010) and on island breeding sites that are in close proximity (Granadeiro *et al.,* 2011; Catry *et al.,* 2013). This is likely to be the case for individual birds but whether this is reflected in the foraging ranges of populations as a whole remains to be seen. The three years of SAST surveys did detect some inter-annual variation but most of these concerned non-breeding visitors to Falkland Islands waters. Species such as great shearwater and soft-plumaged petrel are likely to show greater inter-annual variation than those breeding at the Falklands. A combination of satellite tracking and at-sea observations is likely to provide the best overview of seabird distribution within the waters of the Falklands Islands and will be investigated as part of the GAP project.

7.4.5.2.1.2 Seabird surveys from seismic vessels in the NFB during 2011

A total of 242 seabird surveys were conducted from January until May 2011 during a 3D seismic survey in the licence area PL001, which is adjacent to block containing the Sea Lion Field (Geomotive and MRAG, 2011). In addition, 226 individual seabird surveys were conducted over a larger area covering many of the NFB licence blocks from the end of November 2010 to May 2011 (Polarcus, 2011). Survey methods were based on standardised protocols developed by the JNCC and used by SAST in the Falklands. Additionally, a mixture of line transect and point surveys were conducted in March and April 2012 as part of the Sea Lion Field environmental baseline survey (Gardline, 2013a). The objective of these surveys was to add to the knowledge of seabird abundance and distribution within the PL001 licence area during the summer season. However, it is difficult to compare the data presented in Geomotive and MRAG (2011) and Polarcus (2011) with that in White *et al.* (2002) as it is presented in a different format. Nonetheless, there are similarities in the ranks of species abundance from all three datasets. Table 7.13 lists the 20 most abundant seabird species recorded during the PL001 and NFB surveys, the corresponding rank of abundance of those species, and their IUCN Red Data List threat status.

The most abundant families of seabirds recorded during the surveys were albatrosses, shearwaters, petrels, skuas and fulmars (Table 7.13). Three species of penguin (Magellanic, gentoo and rockhopper) were recorded in low numbers during both surveys. However, it must be noted that penguins are more difficult to detect because of their diving behaviour. Great shearwaters, soft-plumaged petrels, white-chinned petrels and giant petrel species were also frequently encountered, and are all known to follow and be attracted to vessels (Polarcus, 2011).

Table 7.13: Number of seabird sightings during the PL001 and NFB Surveys

Bird species common name	PL001 [a]		NFB [b]	
	Rank	No. of birds	Rank	No. of birds
Black-browed albatross	1	3,118	1	5,043
Great shearwater	2	2,106	3	1,004
Soft-plumaged petrel	3	1,257	6	318
White-chinned petrel	4	1,100	2	1,633
Prion spp. (inc. Blue petrel)	5	552	5	488
Giant petrel species	6	411	4	574
Sooty shearwater	7	338	11	17
Wilson's storm-petrel	8	229	7	262
Atlantic petrel	9	173	23	2
Southern royal albatross	10	172	12	16
Cape petrel	11	170	20	4
Manx shearwater	12	158	NR [c]	NR
Southern giant petrel	13	132	NR	NR
Northern giant petrel	14	125	NR	NR
Falkland Islands skua	15	78	NR	NR
Large albatross species	16	65	13	14
Large skua	17	64	16	7
Wandering albatross	18	59	10	20
Antarctic fulmar	19	52	9	22
Grey-backed storm petrel	20	44	NR	NR
Magellanic penguin	21	42	8	70
Diving-petrel species	26	6	13	14
Rockhopper penguin	30	2	15	11
Black-bellied storm-petrel	NR[c]	NR	19	3
Northern royal albatross	23	14	20	2
Gentoo penguin	30	2	20	2
'Shy' type albatross	NR	NR	23	1

[a] Geomotive and MRAG 2011. 11/01/11 - 02/05/11.

[b] Polarcus 2011. 25/11/10 - 05/05/11.

[c] NR = not recorded.

7.4.5.2.1.3 Satellite tracking studies

At about the same time that the SAST surveys were being initiated in the Falklands, a number of satellite tracking studies of seabirds commenced. These focussed on a range of species, including black-browed albatross (Huin, 2002), Magellanic (Pütz *et al.,* 2000 and 2002a), rockhopper (Pütz *et al.,* 2002b) and gentoo penguins (Clausen and Pütz, 2003). In subsequent years, tracking projects have continued on a number of species at various sites around the Islands (see Blockley and Tierney, 2016). Tracking studies have formed a major part of the GAP Programme (see section 7.2.4.2). The initial results of tracking are presented in Blockley and Tierney (2016), however, work is ongoing to interpret this data with the aim of producing distribution maps. In addition, some species that breed elsewhere, particularly on South Georgia, have been tracked to Falkland Islands waters (e.g. Berrow *et al.,* 2000; Phillips *et al.,* 2006; Ratcliffe *et al.,* 2014).

The main limitation of the tracking data is the comparatively small sample sizes that are currently available. This applies to priority taxa, age-classes, breeding stages and sites, but is particularly the case for immature / juvenile birds, periods outside of the breeding season and species that breed elsewhere (most of the Endangered, Vulnerable and Near Threatened species encountered within Falklands waters do not breed in the Islands). So, although there has been a considerable and increasing focus on tracking seabirds in recent years, there remain substantial data gaps. Generally, small sample sizes and data gaps limit the ability to obtain statistically significant and biologically relevant results. Work is currently underway to address priority tracking data gaps in the Falklands (section 7.2.4.2), so that these data can be used in future assessments.

BirdLife International manages the Global Procellariiform Tracking Database (BirdLife International, 2004), which serves as a central repository for albatross and petrel tracking data from all over the world. The Global Procellariiform Tracking Database model has recently been extended to penguins (and other seabirds). Work is currently underway in the Falklands to collate, and determine how best to use, the tracking data available for seabirds breeding and visiting the Falkland Islands (section 7.2.4).

Where possible the published accounts of tracking projects have been used to describe the distribution of species and their foraging ecology, however, there is little information in the published literature that adequately describes the distribution of the populations involved.

7.4.5.2.1.4 GAP project overview and data availability

The recommendations of the GAP analyses group were to initiate further tracking work to fill the obvious and highest priority taxon gaps. Briefly, the main priority gaps were:

- Seabirds: those species most susceptible to oil contamination, such as penguins, should be afforded the highest priority, particularly Gentoo, Magellanic and Rockhopper penguins;
- Pinnipeds: fur seals and sea lions were considered a priority for immediate tracking work given their breeding distribution in the north of the Falklands and given that little was known about their at-sea distribution; and
- Collate existing tracking data.

The GAP analysis integrated data from four types of biologging tags - geolocator tags (GLS), satellite tags (PTT), Fastloc-GPS tags and GPS tags. The type of biologging tag selected was a compromise between tag size, battery life, cost, and location accuracy. A detailed description of differences between biologging tags are described in the GAP Phase I report (Blockley and Tierney 2016). However, in brief:

GLS tags record light levels and time. Light levels allow sunrise and sunset to be estimated, which can be used to calculate longitude. Time provides a measure of day length, which can be used to calculate latitude. Locations derived from GLS tags have errors of hundreds of kilometres. However, their small size makes them ideal to track migratory movements of seabirds.

Satellite tags (PTTs) are one of the most widely used tags because they provide real-time location data remotely via Argos satellites anywhere in the world. Locations are estimated using the Doppler-shift in frequencies between the tag and polar-orbiting satellites. Satellite tags transmit data when the animal is at the surface. The number of satellite links influences the error associated with the estimated position (error ranges from hundreds of meters to kilometres). For species that do not spend a long time at the surface, location quality can be consistently poor.

Fastloc-GPS tags are a compromise between satellite tags and GPS tags. Fastloc-GPS tags (Wildtrack Telemetry System Limited, Leeds, UK) require only seconds at the surface to take a snapshot of the radio signals produced by GPS satellites. Fastloc GPS tags process these signals onboard the tag (identifies satellites and their pseudo-ranges), and then transmits data via the Argos satellite system and final locations are post-processed. The location accuracy of Fastloc-GPS tags is typically less than 100 m (Costa *et al*., 2010).

GPS tags utilise a constellation of satellites that orbit the earth and transmit navigational data. Due to the time required for a GPS tag to be at the surface to obtain a satellite fix and maintain the almanac, they are typically best suited to flying seabirds. The location accuracy of GPS tags is typically less than 50 m.

Data processing steps varied depending on the type of tag used, but in general involved three main steps: (1) Identify foraging trips, (2) use a speed filter to remove obviously erroneous locations, and (3) implement a movement model to account for location error and produce a best-fit/most likely track. Given GLS tags are associated with a very large location error (> 150 km), here we focus on data derived from other tags (satellite tags, Fastloc-GPS tags and GPS tags). For a detailed overview of how telemetry data was analysed, please refer to Baylis *et al.*, 2019.

Results - Telemetry data (all species)

To summarise the observed distribution of individuals at-sea, telemetry data was split into groups according to species, sex, season and breeding status / stage. Table 7.15 and Figure 7.47 provide an overview of the data available from satellite tags, Fastloc-GPS tags and GPS tags, and the various groups that were defined.

In total, 687 individuals were tracked, with 1,891 foraging trips identified, from 21 colonies (listed in Table 7.14). Individual species maps, showing the animal's tracks, are presented in Figures

7.48, 7.49 and 7.50. Maximum foraging trip distance ranged from 79 km for chick-rearing gentoo penguins to 1,325 km for incubating black-browed albatross (Table 7.15). Over 60 % of sampled colonies (13 of 21) were in the north-east of the Falkland Islands (Figure 7.47). The proportion of colonies from which animals were tracked for each species ranged from < 10 % for South American sea lions and gentoo penguins (4 of 71 and 6 of 81 colonies, respectively) to 30 % for black-browed albatross (4 of 12 colonies).

Figure 7.47 represents the core foraging areas (50 % utilization distributions) for the animals tracked (refer to Table 7.15). Core foraging areas extended as far north as 42°S, 1,000 km to the north of the Falkland Islands, and as far south as 56°S, 360 km to the south. Foraging trips were, however, predominantly confined to the Patagonian Shelf, including the Burdwood Bank (Figure 7.47).

The highest overlap of core areas, both among groups and species was on the Patagonian Shelf to the north of the Falkland Islands (Figure Figure 7.47). In total, 83 % of locations (species range was 67 – 99 % of locations) were associated with bathymetric depths less than 400 m, which highlighted a preference for the Patagonian Shelf and Burdwood Bank for most species. The exceptions were southern elephant seals, where 68 % of foraging trip locations were associated with water depths between 400 m and 800 m (i.e., shelf-slope waters; Figure 7.50), and rockhopper penguins, which foraged beyond the Patagonian Shelf and slope during incubation, in water > 600 m deep (Figure 7.48). Most foraging trip locations (74 %) were within the Falkland Islands Conservation Zones. The remaining locations were within the Argentine Exclusive Economic Zone (23 %), and the high seas (3 %).

Predictive models

Tracking data was not available for all breeding colonies at the Falkland Islands. For example, gentoo penguins and South American sea lions breed at over 70 sites around the Falkland Islands, but were tracked from only six and three sites, respectively. It is unlikely that the existing telemetry data accurately depicts the space use of animals from other colonies, especially distant colonies; however, it is impractical to track all breeding colonies. To predict the space use from colonies not tracked, Baylis *et al*. (2019) modelled habitat selection using Generalized Additive Models (GAMs).

In brief, space use was modelled as a function of dynamic and static environmental indices that described habitat. The seven environmental indices used were sea surface temperature, sea level anomaly, eddy kinetic energy, bathymetry, slope and distance from colony. Predicting from these models, the predicted distribution of animals was mapped from both sampled and unsampled colonies. Note that male fur seals and sea lions roam widely and use multiple colonies. Therefore, predictive models were not developed for male seals. For a detailed overview of how models were developed and the environmental indices used, please refer to Baylis *et al*. (2019).

Model results are presented in the species accounts in section 7.4.5.2.2 for seabirds and section 7.4.6.2.2.1 for pinnipeds. The results depict the probability of occurrence, proportional to the likelihood of absences – perhaps best interpreted simply as predicted presence and absence. Results from both tracking data and predictive models demonstrated that the shelf area around the Falkland Islands (which includes parts of the North Falkland Basin) was important habitat for marine higher predators breeding at the Falkland Islands. The large area of shelf used by marine predators reflects the ubiquitous breeding distribution of some species, combined with the long-distance movements of most species tracked.

Limitations of telemetry data

Telemetry data were collected over different years, and for some species and some breeding colonies, available telemetry data was unlikely to fully represent core areas used based on the representativeness analysis detailed in Baylis *et al*. (2019). Given data collection was opportunistic rather than systematic, inconsistencies in the temporal coverage of data between species could obscure potentially important areas of use. Ultimately, it would be ideal to track species at the same time, stratifying data collection across colonies within species, such that good geographical coverage was achieved, with more data collected from larger colonies. However, the resources required to undertake simultaneous tag deployments on multiple predator species from multiple colonies is typically not feasible.

Limitations of predictive models

Although the predictive models generally performed well (see Baylis *et al.* 2019) , caveats and constraints exist with the predictive modelling approach. For example, the models developed by Baylis *et al.* 2019 could have been extended by including additional terms to account for correlation structures inherent in telemetry data, including (1) individual and colony-level slopes (random effects); (2) a term to model temporal / serial autocorrelation and (3) terms to describe spatial autocorrelation. However, including these terms has so far proved impracticable in studies that have analysed datasets of similar size due to computational constraints and lack of convergence (Raymond *et al*., 2015; Arthur *et al*., 2017; Trathan *et al*., 2018; Warwick-Evans *et al*., 2018).

Table 7.14: Colony location abbreviations used in the Table 7.15 and Figure 7.47

Colony	Abbreviation	Colony	Abbreviation
Bird Island	BIRD	Volunteer Point	VPT
New Island	NEW	Volunteer Rocks	VRK
Steeple Jason	SJI	Rugged Hill	RHL
North Fur Island	NFUR	Diamond Cove	DC
Saunders Island	SAU	Kidney Island	KDI
Pebble Island	PBI	Kelp Island	KELP
Cape Dolphin	CD	Bertha’s Beach	BB
Cape Bouganville	CBG	Bleaker Island	BLK
Big Shag Island	BSI	Sea Lion Island	SLI
Seal Bay	SEALB	Beauchêne Island	BCI
Cow Bay	CB		

Table 7.15: Data derived from tags other than GLS tags, includes six seabird and three pinniped species.

Species	Migra-tory	Season	Breeding stage (group)	Colonies tracked [% tracked]	Individuals	Foraging trips	Trip distance (km) max [mean ± SD]
Seabirds							
Gentoo penguin *Pygoscelis papua*	N	Winter	Non-breeding	BB, BLK, CB, CD, PBI [6 %]	25	155	479 [109 ± 80]
		Summer	Incubation / Chick rearing	NEW, CB [2 %]	45	74	79 [21 ± 16]
Magellanic penguin *Spheniscus magellanicus*	Y	Summer	Incubation / Chick rearing	BLK, CB, CD, PBI, SEALB, NEW [7 %]	63	140	1,115 [298 ± 298]
King penguin *Aptenodytes patagonicus*	N	Winter	Chick rearing	VPT	8	32	971 [295 ± 215]
Rockhopper penguin[a] *Eudyptes chrysocome*	Y	Summer	Incubation	CBG, PBI, SEALB, SOP [11 %]	27	27	514 [216 ± 127]
		Summer	Chick rearing	BIRD, NEW, PBI, SEALB [11 %]	116	185	540 [139 ± 109]
Black-browed albatross[b] *Thalassarche melanophris*	Y	Summer	Incubation	NEW, SJI, BCI, SAU [33 %]	70	92	1,325 [507 ± 339]
		Summer	Chick rearing	NEW, SJI, BCI, SAU [33 %]	256	699	1,235 [131 ± 147]
Sooty shearwater *Ardenna grisea*	Y	Summer	Incubation	KDI	20	43	438 [185 ± 87]
Pinnipeds							
South American fur seal[c] *Arctocephalus australis*	N	Winter - female	Lactation	NFUR, VRK [20 %]	9	108	674 [310 ± 216]
		Spring - female	Lactation	NFUR, VRK [20 %]		42	940 [425 ± 295]
		Winter - male	Non-breeding	NFUR [10 %]	4	34	992 [229 ± 206]
South American sea lion *Otaria flavescens*	N	Summer - female	Lactation	CD, BSI, KELP [4 %]	25	93	173 [63 ± 34]
		Winter- male	Non-breeding	CD, BSI [3 %]	21	157	157 [88 ± 36]
Southern Elephant seal *Mirounga leonina*	Y	Summer - female	Post-breeding	SLI	10	10	497 [120 ± 42]

[a]Total number of rockhopper penguins tracked was 137, but some birds were tracked over both incubation and chick rearing periods.
[b]Total number of black-browed albatross tracked was 319, but some birds were tracked over both incubation and chick rearing periods

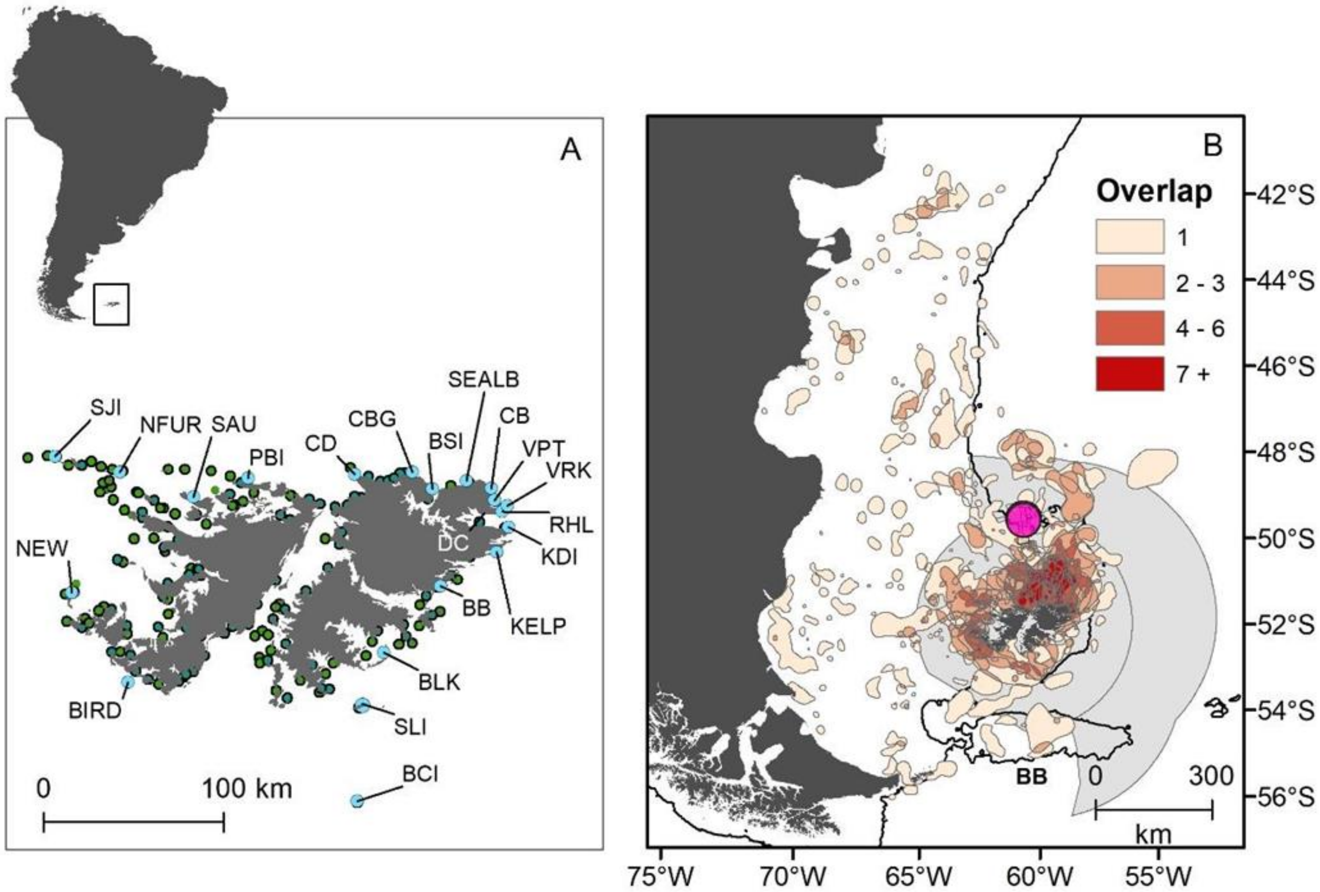


Figure 7.47: Panel A = locations of the 21 tracked breeding colonies (blue dots) and untracked colonies (green dots). Panel B = important areas identified by overlap of 50 % utilization distributions, derived from the tracking data presented in . Thin black line is the 400 m isobath that marks the edge of the Patagonian Shelf, as well as the Burdwood Bank (BB). Grey shading is the Falkland Islands Interim and Outer Conservation Zones. The pink dot represents the drill centre. Adapted from Baylis *et al*. (2019).

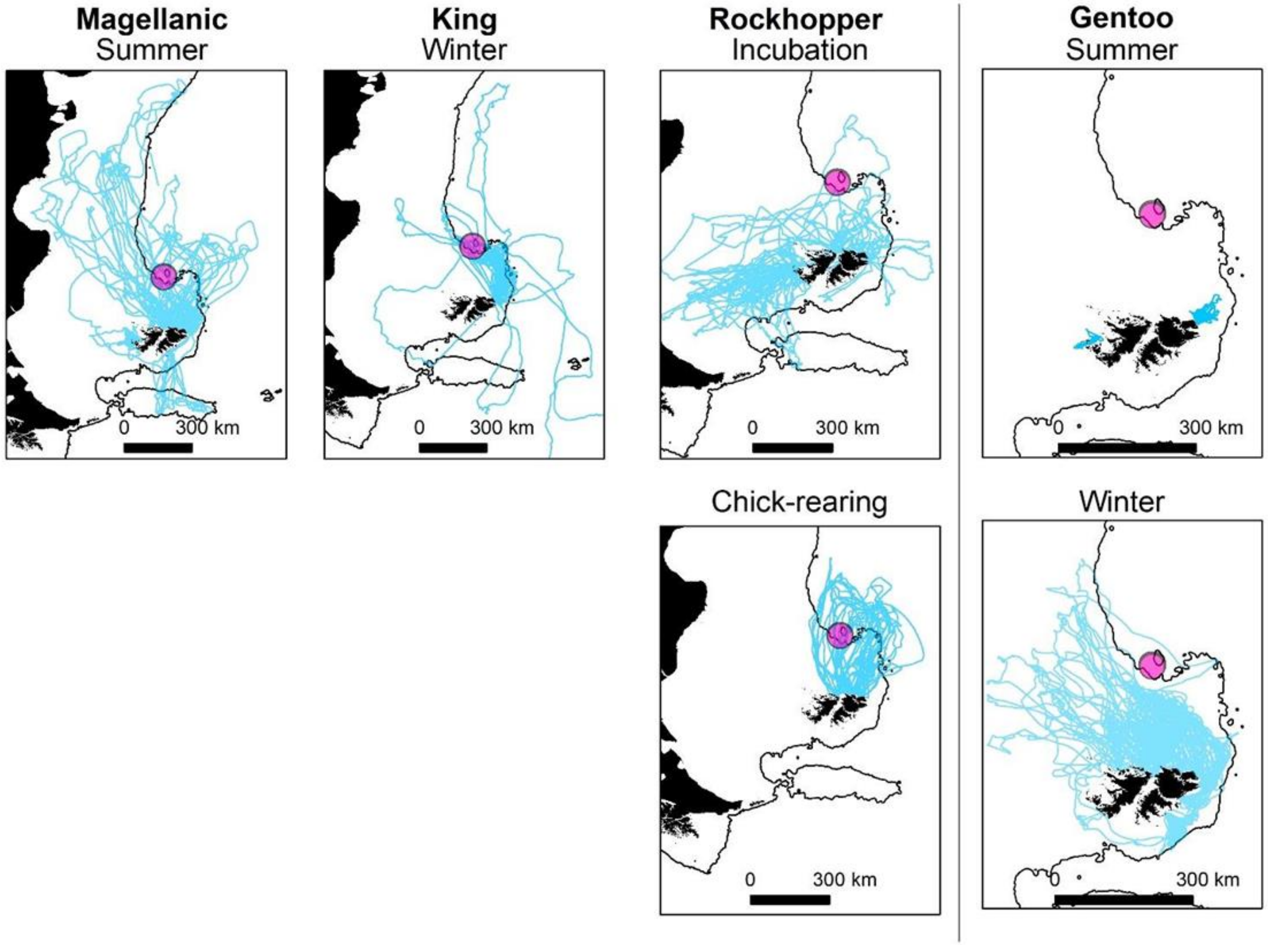


Figure 7.48: Penguin telemetry data, by species and where available, season or breeding stage. The pink dot represents the drill centre.

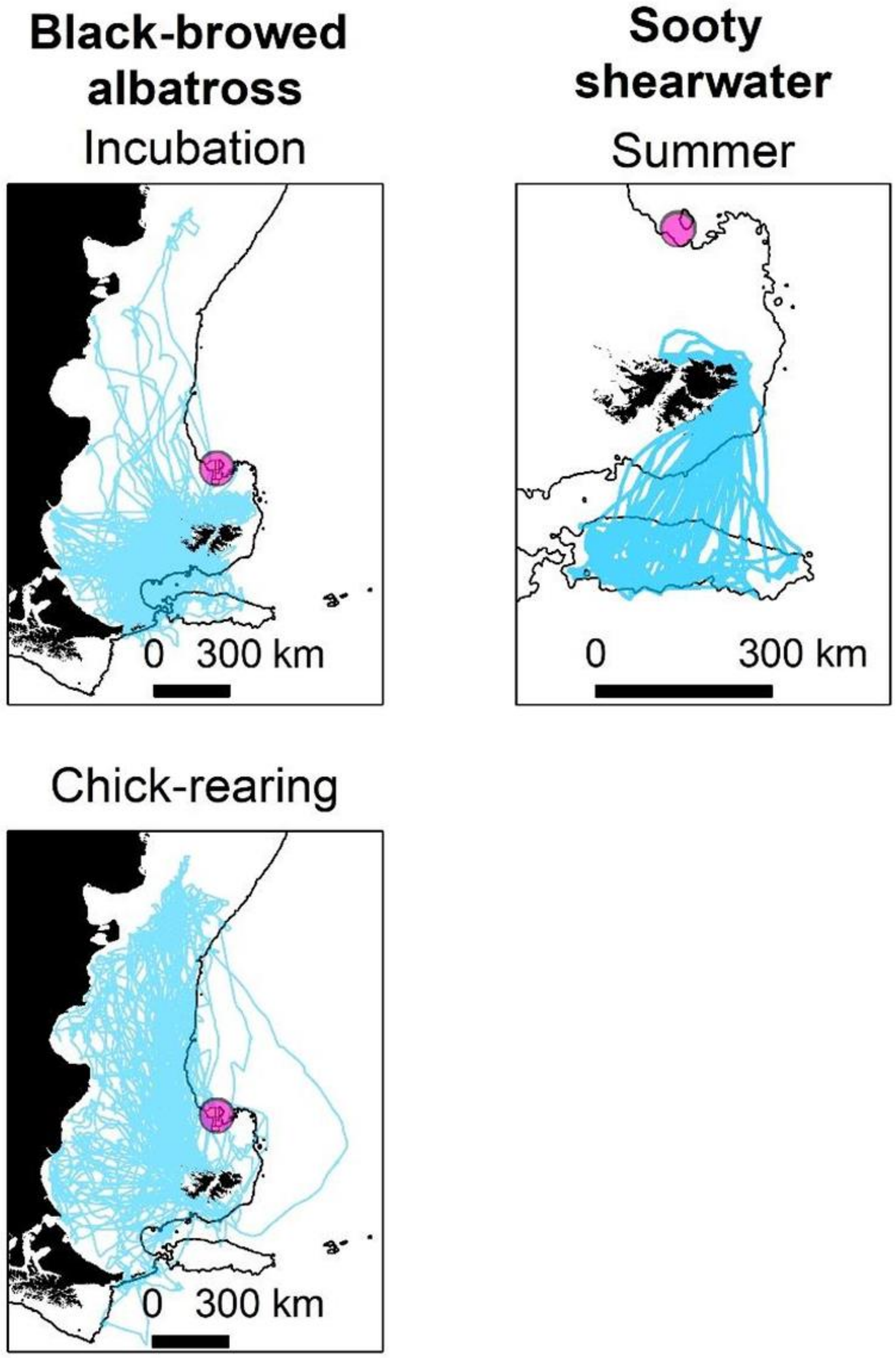


Figure 7.49: Flying seabird telemetry data, by species and where available, breeding stage. The pink dot represents the drill centre.

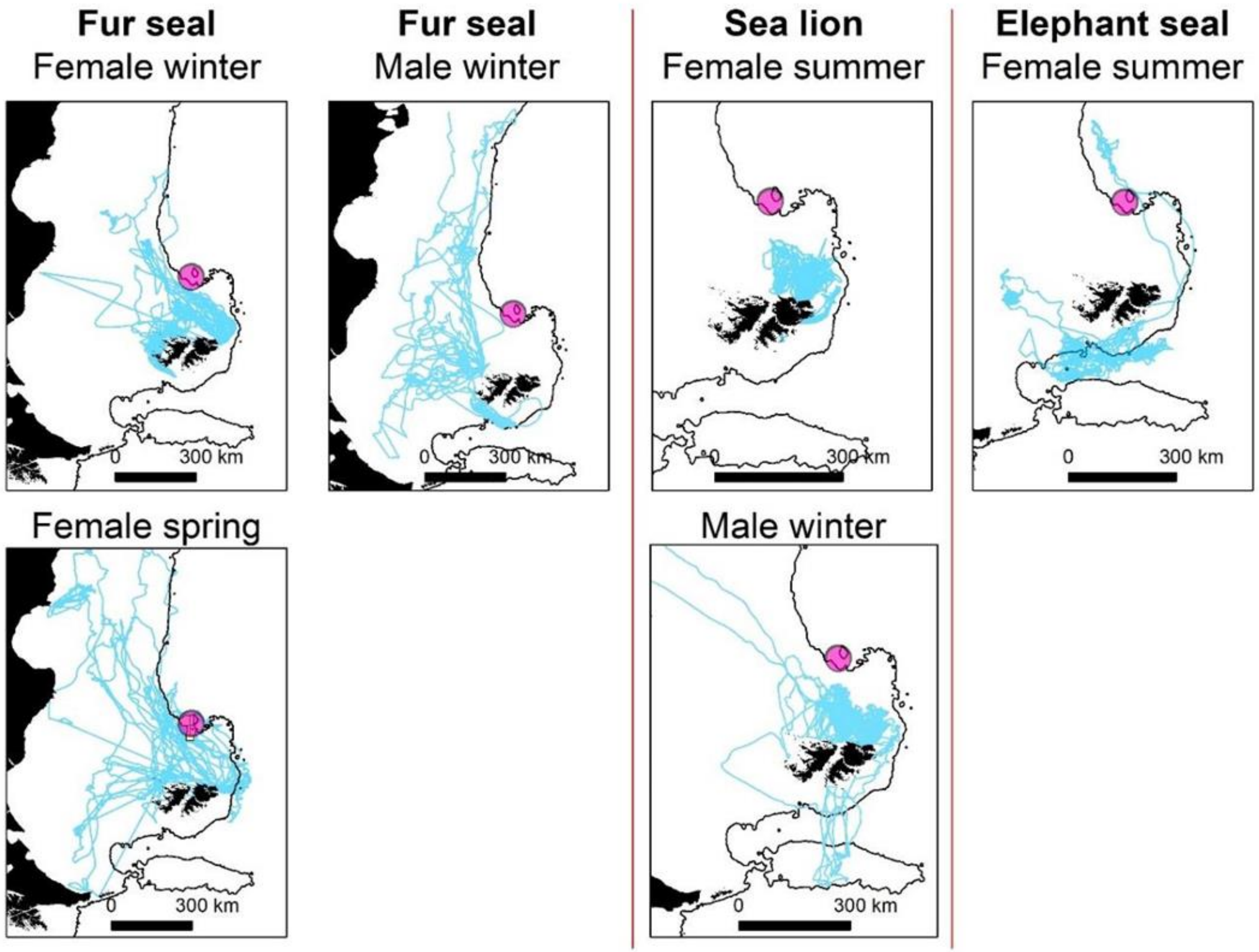


Figure 7.50: Pinniped telemetry data, by species and where available, sex and season. The pink dot represents the drill centre.

7.4.5.2.2 Species-specific distribution and abundance

In this section, a brief account is provided of the abundance and distribution for each species, listed in order of autumn abundance (Table 7.12 above). This information is based primarily on the results of the SAST surveys (White *et al.,* 2002), but is also informed by additional at-sea surveys and tracking data.

Table 7.16 provides a summary of the key ecological characteristics of the most noteworthy seabird species within the NFB and particularly the Sea Lion area to help understand how O&G operations may pose a threat to these species, and how the potential impacts may be avoided or mitigated.

Black-browed albatross (BBA)

The Falkland Islands are home to the world's largest breeding population of black-browed albatrosses (*Thalassarche melanophris*). The most recent census, in 2010, estimated the breeding population to comprise approximately 500,000 breeding pairs, which represents approximately 74 % of the global population (Wolfaardt, 2012).

During SAST surveys, black-browed albatross were regularly recorded throughout the year in the vicinity of the Sea Lion area (Table 7.12) and were ranked in the top three species recorded in all seasons. In the autumn (March to May), the number of birds recorded per kilometre travelled was substantially greater than in other seasons.

Black-browed albatrosses were tracked from four Falklands colonies. The results were used to produce the predicted distribution shown in Figure 7.51. The data indicates that birds forage predominantly over the Patagonian Shelf. During chick rearing the range of adult birds is more restricted than during the incubation period, when birds are likely to be away from the colonies for longer periods of time. SAST surveys recorded a similar distribution but recorded differences in the abundance of black-browed albatrosses across the Patagonian Shelf.

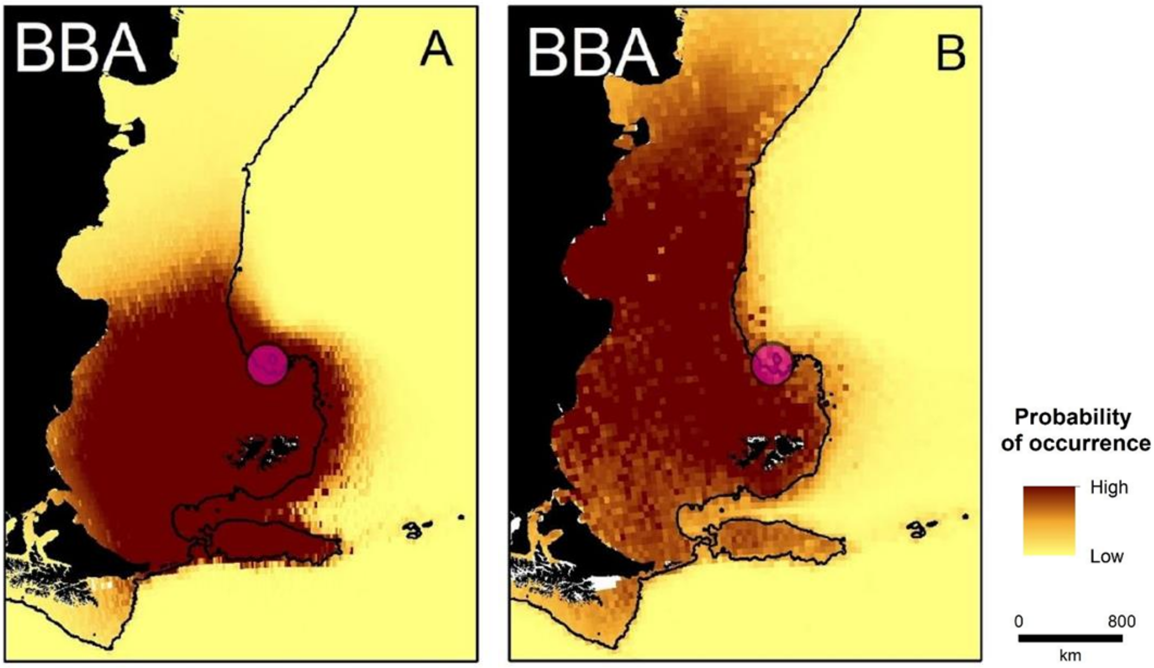


Figure 7.51: Black-browed albatross predicted habitat use (predicted presence) for birds breeding on the Falklands from the available biotelemetry and biologging data (A = chick rearing, B = incubation). Adapted from Baylis *et al.* (2019). The pink dot represents the drill centre.

Great shearwater (GS)

Great shearwaters (*Puffinus gravis*) are largely non-breeding visitors to Falkland Islands waters, although there is a very small local breeding population (50-100 pairs, Woods and Woods, 1997). Virtually the entire global population of five million pairs breed on the Tristan da Cunha group of islands (BirdLife International, 2016). After breeding, the population embarks on a clockwise circum-Atlantic migration.

Great shearwater was the second most numerous species recorded in the summer and autumn (Table 7.12). The seasonal presence of this species within Falklands waters was consistent from year-to-year, although the number of birds can vary inter-annually (White *et al*., 2002).

White-chinned petrel (WCP)

There is a very small breeding population of white-chinned petrels (*Procellaria aequinoctialis*) in the Falkland Islands, estimated at 55-100 pairs (Reid *et al*., 2007). Most of the birds present within Falkland Islands waters come from the much larger breeding population at South Georgia (Berrow *et al*., 2000; Phillips *et al*., 2006), which is estimated to comprise approximately 900,000 pairs, and to be in decline (Martin *et al*., 2009).

White-chinned petrels were one of the most regularly recorded species throughout most of the year in the vicinity of the Sea Lion area, except for the winter months when their numbers are considerably reduced (Table 7.12).

Cape petrel (CP)

Cape petrels (*Daption capense*) are non-breeding visitors to Falkland Islands waters from their Antarctic breeding grounds. Although recorded in every season, Cape petrels do not arrive in large numbers until May. Numbers start to decline in September and are virtually absent during the summer months (Table 7.12; White *et al*., 2002).

Wilson's storm-petrel (WP)

Wilson's storm-petrels (*Oceanites oceanicus*) are extremely widespread and abundant in the southern hemisphere. The Falklands are thought to support a modest breeding population of something in excess of 5,000 pairs (Woods and Woods, 1997).

Although present throughout the year, numbers of Wilson's storm petrels were greatly reduced during the winter months. In the summer months, high densities of Wilson's storm-petrel were found over the Patagonian Shelf to the northeast of East Falkland, close to the Sea Lion area (White *et al*., 2002).

Antarctic fulmar (AF)

Like Cape petrels, Antarctic fulmars (*Fulmarus glacialoides*) are non-breeding visitors to Falkland Islands waters from their Antarctic breeding grounds. Antarctic fulmars were one of the most common species recorded during the winter months, but were almost entirely absent during the summer (Table 7.12).

Grey-backed storm-petrel (GBSP)

Like Wilson's storm-petrel, the Falklands support what is thought to be a small breeding population (1,000-5,000 pairs) of grey-backed storm-petrels (*Garrodia nereis*) (Woods and Woods, 1997). During the summer months, high densities of this species were encountered over the shelf break to the northeast of the Islands, which extends close to the Sea Lion area. Although recorded in all seasons, fewer grey-backed storm-petrels were recorded in the winter (Table 7.12).

Grey-backed storm-petrels were the most frequently recorded species feeding in association with patches of free floating kelp (Gillon *et al*., 2001).

Soft-plumaged petrel (SPP)

Soft-plumaged petrels (*Pterodroma mollis*) are regarded as summer and early autumn visitors to Falklands waters (Table 7.12). The nearest breeding location of this species to the Falklands is on the Tristan da Cunha group. Soft-plumaged petrels were one of the few species recorded by White *et al*. (2002) that showed inter-annual variation in the number of birds recorded within Falklands waters. Like several other species with breeding populations in the Tristan da Cunha group, the majority of soft-plumaged petrels recorded were encountered over oceanic waters to the north east of the Falklands.

Sooty shearwaters (SS)

Sooty shearwaters (*Puffinus griseus*) have an estimated breeding population within the Falkland Islands ranging between 10,000-20,000 pairs (Woods and Woods, 1997) and >100,000 pairs (Falklands Conservation, 2006). Although present throughout the year, the majority of the breeding population are absent from Falklands waters from April to August (Table 7.12; White *et al*., 2002). Generally, the highest densities of sooty shearwaters were recorded over inshore waters, where large flocks raft on waters adjacent to breeding colonies.

Twenty sooty shearwaters were tracked from Kidney Island during the summer months. Results indicate that the birds were largely restricted to the east coast of the Falklands and Burdwood Bank (Figure 7.49 and Figure 7.52). SAST surveys recorded highest densities of sooty shearwaters over inshore waters off the east coast of the Islands, but encountered sooty shearwaters throughout the inshore waters around the Falklands. Sooty shearwaters were present in lower number over the wider Patagonian Shelf (White *et al*., 2002).

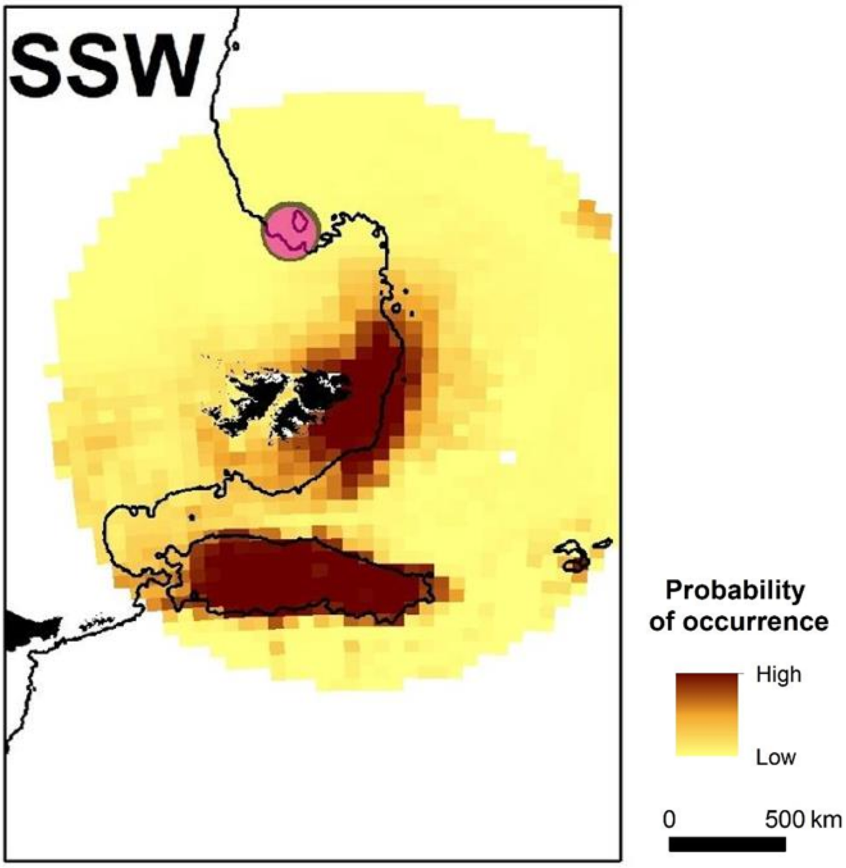


Figure 7.52: Sooty shearwater predicted habitat use (predicted presence) for birds breeding on Kidney Island from the available biotelemetry and biologging data. Adapted from Baylis *et al*. (2019). The pink dot represents the drill centre.

Prion species (Pr)

Several species of prion (*Pachyptila species*) are known to frequent Falkland Islands waters. However, they are difficult to identify to species level at-sea and therefore most prions were recorded as 'prion species'. Throughout most of the year, prions are one of the most numerous 'species' encountered within Falklands waters; however, there is a distinct decline in numbers during the autumn (Table 7.12).

Two species of prion breed within the Falkland Islands: thin-billed (*P. belcheri*) and fairy prions (*P. turtur*). The population of thin-billed prions is estimated to comprise approximately two million pairs on New Island alone (*Catry et al*., 2003) with other smaller colonies elsewhere in the Islands, making thin-billed prion the most numerous breeding seabird in the Falklands. Fairy prions have a far smaller breeding population at one confirmed breeding site, on Beauchêne

Island (Woods and Woods, 1997). In addition, Antarctic prions (*P. desolata*) are likely to visit Falkland Islands waters.

Locally high densities of prions can be found close to the Sea Lion area in the summer months but densities of this 'species' are generally much higher elsewhere within Falklands waters, to the west and southwest of the Islands (*White et al.*, 2002).

Southern (SRA) and Northern royal albatrosses (NRA)

Southern and northern royal albatrosses (*Diomedea epomophora* and *D. sanfordi*) are both non-breeding visitors to the southwest Atlantic from their breeding sites in New Zealand. They are classified as Vulnerable and Endangered, respectively, under the IUCN Red List framework. Both species are recorded throughout the year in Falklands waters, with the largest numbers of birds recorded between March and June (Table 7.12; *White et al*., 2002). However, southern royal albatross are considerably more numerous than the northern species (White *et al*., 2002). During this period, royal albatrosses were found in highest densities over Patagonian Shelf waters to the west of the Falklands. At other times, royal albatrosses appear to disperse throughout Falklands waters.

Southern giant petrels (SGP)

The Falklands support the largest breeding population of southern giant petrels (*Macronectes giganteus*) in the world, with approximately 19,500 breeding pairs (Reid and Huin, 2005) or approximately 33% of the global population. The presence of white morph birds (white plumaged birds) during the winter months indicates that some birds that breed in higher latitudes move to Falklands waters during the winter (White *et al*., 2002).

Southern giant petrels were recorded in all seasons (Table 7.12) and were noted for being extremely persistent followers of vessels. The true density of birds within Falklands waters is likely to have been underestimated as birds in close attendance to fishing vessels were not recorded (White *et al*., 2002). This species was not recorded in high numbers in the vicinity of the Sea Lion area but the presence of an oil rig, platform or supply vessels may attract these scavenging birds, and consequently increase their presence in the area.

Magellanic penguin (MP)

Magellanic penguins (*Spheniscus magellanicus*) are regarded as summer breeding visitors to the Falkland Islands, which support approximately 10% of the global population (Woods and Woods, 1997). During their breeding season, highest densities of Magellanic penguins were recorded in inshore waters but patches of locally high density were also encountered over Patagonian Shelf and shelf-break waters. Following the post-breeding moult, Magellanic penguins migrate northwards in the autumn to over-winter on the northern Patagonian Shelf (Pütz *et al*., 2000). They do not start to return to the Falklands until September. It is during these migrations that many birds will pass through the NFB.

Sixty-three Magellanic penguins were tracked from six locations during the summer months. The results of the predictive model indicate the presence of this species throughout Patagonian Shelf waters but also an area of relatively high probability of occurrence in shelf-slope waters to the north of the Sea Lion Field Figure 7.53. This reflects the data collected during SAST surveys (White *et al*., 2002).

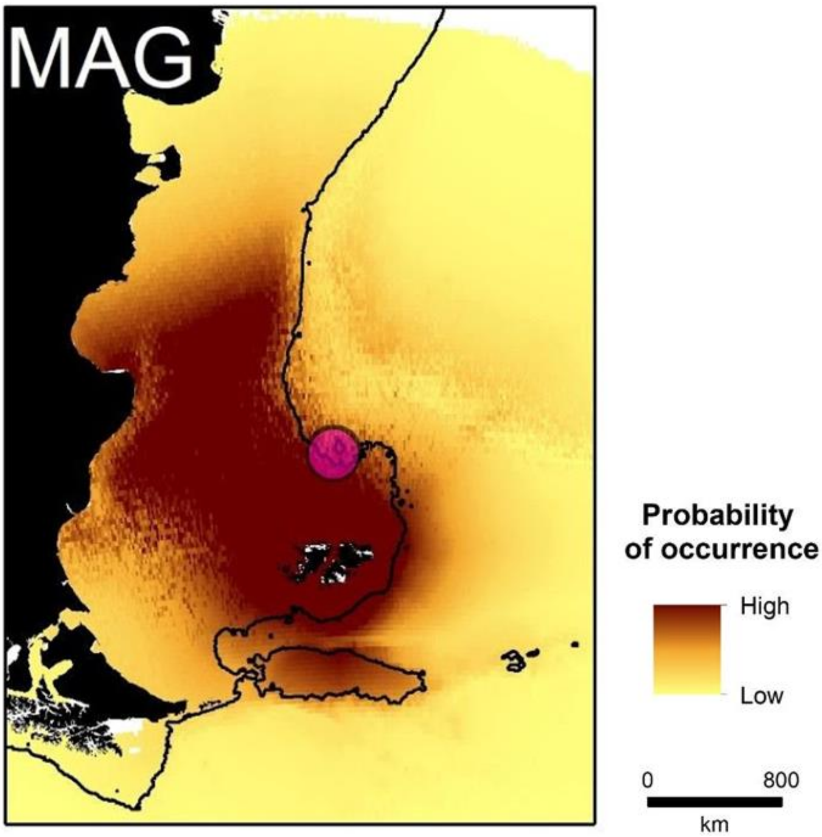


Figure 7.53: Magellanic penguin, predicted habitat use (predicted presence) for birds breeding on the Falklands from the available biotelemetry and biologging data. Adapted from Baylis *et al.* (2019). The pink dot represents the drill centre.

Grey-headed albatross (GHA)

Grey-headed albatrosses (*Thalassarche chrysostoma*) are non-breeding visitors to Falkland Islands waters. The closest breeding populations are on islands off the southern coast of Chile and South Georgia, with approximately 50% of the global population of this Endangered species breeding on the latter (ACAP, 2014).

The presence of this species within Falklands waters is highly seasonal, with the majority of birds recorded between May and September (White *et al*., 2002). During this period, most of the birds recorded were encountered over the shelf-break to the south and east of the Islands (White *et al*., 2002).

Long-tailed skua (LTS)

Long-tailed skuas (*Stercorarius longicaudus*) breed in the Arctic during the boreal summer and spend the non-breeding season in the South Atlantic and South Pacific. The vast majority of birds observed in the vicinity of the Falklands were recorded between December and March (Table 7.12). The Falklands lie towards the southern limit of this species' range, and the majority of sightings were recorded over oceanic and shelf-break waters to the north of the Islands. Like several other non-breeding summer visitors to the Falkland Islands, considerable inter-annual variations in the number of this species were recorded (White *et al*., 2002).

Wandering albatross (WA)

Wandering albatrosses (*Diomedea exulans*) are classified as Vulnerable under the IUCN Red List, and are non-breeding visitors to Falkland Islands waters. The closest breeding site is at South Georgia where approximately 1,400 pairs breed per annum (Poncet *et al*., 2006), and where the population continues to decline. Observations of banded individuals at-sea indicate that a large proportion of the South Georgia population utilise Falklands waters at some point during the year (Croxall *et al*., 1999; Otley *et al*., 2007).

Wandering albatrosses are found in low numbers throughout the year, primarily over the shelf-break waters surrounding the Falkland Islands. Few birds were recorded in the vicinity of the Sea Lion area (Table 7.12) but it is likely that many birds pass through this area during the course of a year.

Antarctic skua (AS)

The presence of Antarctic skuas (*Stercorarius antarctica*) within the study area is highly seasonal, with the vast majority of birds recorded between November and April (Table 7.12). The density of birds recorded was highest over inshore waters, close to breeding sites. However, locally high densities were encountered at-sea throughout the remainder of the Falklands Conservation Zones (White *et al*., 2002).

Atlantic petrel (AtP)

The large breeding population of Atlantic petrels (*Pterodroma incerta*) is restricted almost entirely to Gough Island, in the Tristan da Cunha group, where the population of 1.8 million pairs is in decline due to mouse depredation (BirdLife International, 2015). Atlantic petrel is currently classified as Endangered according to the IUCN Red List.

Although not recorded in the vicinity of the Sea Lion Field, this species will be infrequently present in the area. Atlantic petrels have been recorded in every month but there was a distinct peak in numbers during spring, which corresponds with the post-breeding period of this winter breeding species. Most Atlantic petrels were recorded in oceanic waters to the north east of the Falklands (White *et al*., 2002).

Diving-petrel species (DP)

Two species of diving-petrel (*Pelecanoides* species) are regularly encountered within Falkland Islands waters: common diving-petrel *Pelecanoides urinatrix* and Magellan diving-petrel *P. magellanicus*; Georgian diving-petrel *P. georgicus* has also been recorded. Given reasonable views, Magellan diving-petrels can be readily identified at-sea but the other species are difficult to separate and therefore most birds were recorded as ‘diving-petrel species’.

In general, far more diving-petrels are recorded during the spring and summer than during the autumn and winter months. The highest densities of birds were recorded to the west and south of the Falklands (White *et al*., 2002). Diving-petrels were only recorded in low numbers in the vicinity of the Sea Lion area (Table 7.12).

Southern rockhopper (RP) and Macaroni penguins (MAC) (R/M)

The Falklands support approximately 40% of the global population of southern rockhopper penguins (*Eudyptes chrysocome*) (Baylis *et al*., 2013b). Outside the breeding and moulting periods, between May and August, these birds were only encountered in low numbers within Falklands waters. During the spring, rockhopper penguins were dispersed throughout Falklands waters (White *et al*., 2002), during which time the highest number of birds were recorded in the vicinity of the Sea Lion area (Table 7.12). During the austral summer months, the distribution of rockhopper penguins was linked to the shallower waters of the Patagonian Shelf.

Tracking of rockhopper penguins at several sites around the Falklands during incubation and chick-rearing indicates distinctive patterns of distribution in these two periods. During incubation, birds disperse more widely and are present in the relatively deep waters of the shelf-slope. During chick-rearing, the model predicts that the area of high probability of occurrence is concentrated over the Patagonian Shelf (Figure 7.54). The distribution predicted from the tracking data reflects the distribution pattern recorded during SAST surveys (White *et al*., 2002).

During the austral winter months, some macaroni penguins (*E. chrysolophus*) from the breeding population on South Georgia move into the oceanic waters of the Falklands Conservation Zones (White *et al*., 2002). These observations are supported by satellite tracking of birds from South Georgia (Ratcliffe *et al*., 2014). It was not always possible to be certain of the identity of Eudyptes penguins when encountered at-sea and therefore many birds were recorded as rockhopper / macaroni penguins. It is likely that some of these birds were in fact macaroni penguins.

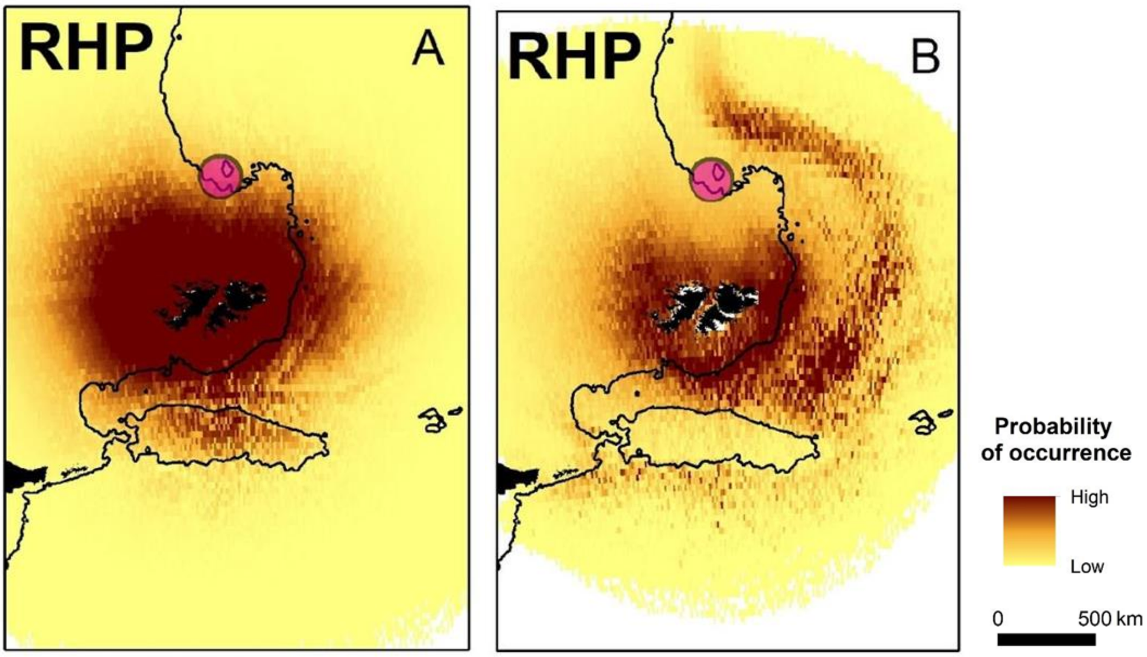


Figure 7.54: Rockhopper penguins, predicted habitat use (predicted presence) for birds breeding on the Falklands from the available biotelemetry and biologging data (A = Chick rearing, B = Incubation). Adapted from Baylis *et al.* (2019). The pink dot represents the drill centre.

Northern giant petrel (NGP)

Northern giant petrels (*Macronectes halli*) are non-breeding visitors to Falkland Islands waters. The closest breeding sites are found on South Georgia, which supports the world's largest breeding population of this species. Satellite tracking during the breeding season indicates that these birds visit the Patagonian Shelf on foraging trips (Gonzáles-Solís *et al*., 2000). Like southern giant petrels, this species was recorded in all months but in lower numbers. During the autumn and winter months, highest densities of this species were recorded over the Patagonian Shelf. In the spring and summer, birds were dispersed throughout the waters surveyed (White *et al*., 2002).

Little shearwater (LS)

Little shearwaters (*Puffinus assimilis*) are rare non-breeding visitors to Falkland Islands waters, the nearest breeding population being found on the Tristan da Cunha group. White *et al*. (2002) only recorded this species during the summer and autumn months with a peak in sightings during March. The majority of records were of birds in the waters to the north of the Islands.

Black-bellied storm-petrel (BBSP)

Black-bellied storm-petrels (*Fregetta tropica*) are non-breeding visitors to Falklands waters. The presence of this species is almost entirely restricted to the summer months, when they are most frequently sighted over oceanic waters to the north of the Islands (White *et al*., 2002). Very few birds were recorded in the vicinity of the Sea Lion area (Table 7.12).

Two additional species were recorded during austral winter and spring surveys but not during the austral autumn.

King penguin (KP)

Although there is a small resident breeding population of king penguins (*Aptenodytes patagonicus*) in the Falkland Islands, encounters with king penguins at-sea were highly seasonal. Virtually all of the birds recorded were seen between June and September (White *et al*., 2002). The timing of these sightings and the number of birds encountered suggest that many of the king penguins present within Falklands waters originated from South Georgia. This is supported by data from birds tracked from South Georgia in the winter.

Most of the king penguins records within Falklands waters come from oceanic and shelf-break waters to the north of the Islands (White *et al*., 2002).

Eight king penguins from Volunteer Point were tracked during the winter. The tracks indicate that for most of the time the birds' activity was concentrated over the shelf-break to the north of the Falklands with some birds travelling further afield, mostly into deep, oceanic waters (Figure 7.48). The predictive model suggests high probability of occurrence over a wider area of the Patagonian Shelf (Figure 7.55).

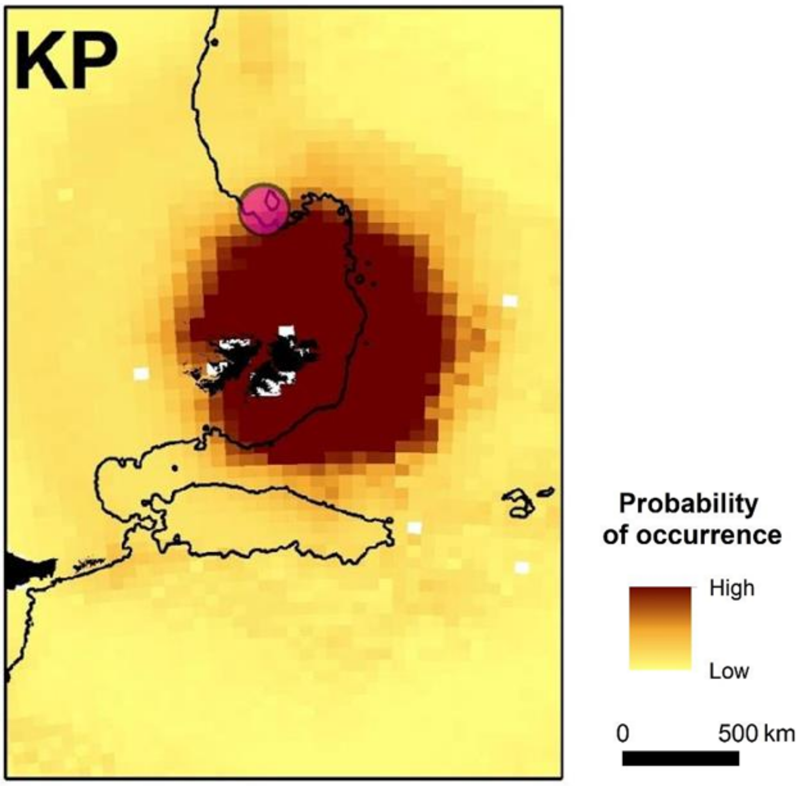


Figure 7.55: King penguin, predicted habitat use (predicted presence) for birds breeding at Volunteer Point from the available biotelemetry and biologging data. Adapted from Baylis *et al.* (2019). The pink dot represents the drill centre.

Kelp gull (KG)

Kelp gulls (*Larus dominicanus*) are resident breeders in the Falkland Islands. During the austral summer (November to April), kelp gulls are confined to inshore waters. In the austral winter (May to October), kelp gulls were recorded in far higher numbers but the majority of sightings still occur over inshore waters. However, birds also range much further offshore; it is at this time that they are recorded in the vicinity of the Sea Lion area (Table 7.12).

Gentoo penguin

Although not recorded near the Sea Lion Field, the Falkland Islands are home to a globally important population of gentoo penguins (*Pygoscelis papua*). Although present throughout the year, returning to shore regularly during the winter, JNCC surveys recorded clear seasonal trends in the distribution of this species. Between December and March, all records were within 100 km of the nearest land, while between April and November gentoo penguins were recorded at greater distance, up to 316 km, from land. However, despite their wider distribution, gentoo penguins were rarely observed in waters greater than 200 m in depth (White *et al*., 2002).

Kerguelen petrel

Kerguelen petrels (*Aphrodroma brevirostris*) are non-breeding visitors to the waters of the Falkland Islands, with the majority of sightings occurring between May and November (White *et al*., 2002). A small population was recently discovered breeding on South Georgia (Black *et al*.,

2012) but the nearest substantial population is found on Gough Island in the Tristan da Cunha group. Kerguelen petrels can be encountered throughout Falklands waters during the winter months but they are more frequently seen over offshore / oceanic waters.

Blue petrel

Like Kerguelen petrels, blue petrels (*Halobeana caerulea*) are seasonal non-breeding visitors to Falklands waters, with the majority of sightings between May and November (White *et al*., 2002). This species is rarely encountered over Patagonian Shelf waters, most records come from oceanic waters to the east and southeast of the Islands. The nearest breeding colonies of blue petrels are found on islands off the southern coast of Chile and South Georgia, the origin of birds seen in the Falklands is unknown.

7.4.5.2.3 Summary of offshore bird abundance, distribution, life-cycle and behavioural characteristics

Table 7.16 provides a summary of bird abundance, distribution, life-cycle and behavioural characteristics in the NFB and around the Sea Lion Field.

Table 7.16: Summary of offshore bird abundance, distribution, life-cycle and behavioural characteristics

Species	IUCN status	ACAP species [a]	FI priority species	Seasonal occurrence and distribution	Breeding cycle	Feeding mode	Persistent ship associate	Breeding sites	Falklands population	Global population and trend
Black-browed albatross (*Thalassarche melanophris*)	LC	✓	✓	Present year-round in high numbers across the Patagonian Shelf, less numerous over deeper waters. Spring / Summer / Autumn / Winter	Annual breeder; First breeding at 7 yrs; 1 egg laid mid Oct; Chicks fledge Apr/May.	Surface seizing and shallow dives (to c. 10 m) from the surface	✓	In the Falklands, 17 breeding sites, very large colonies on Jason Islands and Beauchêne Island.	c. 500,000 pairs. 76% global population	700,000 pairs Stable
Great shearwater (*Puffinus gravis*)	LC	X	X	Widespread over waters to the north of the Falklands between Dec – Apr, absent in the winter and spring. Vast majority of birds observed are non-breeders. Spring / Summer / Autumn / Winter	Adults return Sept; 1 egg laid end Oct; Chicks and adults depart late April.	Surface seizing and pursuit diving (to c. 20 m)	✓	Kidney Island only known site in the Falklands	20 pairs <0.1% global population	5 million pairs Stable
White-chinned petrel (*Procellaria aequinoctialis*)	VU	✓	✓	Widespread over shelf and oceanic waters in winter, shallower waters in spring summer. Most birds present are non-breeding visitors. Spring / Summer / Autumn / Winter	Adults return Sept; 1 egg laid Oct/Nov; Chicks and adults depart Apr/May.	Surface seizing and pursuit diving (to c. 20 m)	✓	Kidney Island, New Island, Bottom Island	55-100 pairs <0.1% global population	1.2 million pairs Decreasing
Cape petrel (*Daption capense*)	LC	X	X	Common winter visitor to Falklands waters, few present in the summer months. Spring / Summer / Autumn / Winter	Single egg laid Nov/Dec; Fledge Feb/Mar.	Surface seizing and	✓	Antarctica	Non-breeder	2 million individuals Stable

Species	IUCN status	ACAP species [a]	FI priority species	Seasonal occurrence and distribution	Breeding cycle	Feeding mode	Persistent ship associate	Breeding sites	Falklands population	Global population and trend
						shallow dives				
Wilson's storm-petrel (*Oceanites oceanicus*)	LC	X	X	Present throughout the year but abundance far higher during the summer months. Spring / Summer / Autumn / Winter	Adults return Nov; 1 egg laid Nov-Jan; Chicks fledge Feb/Mar.	Foot paddling (surface seizing)	✓	Rat free tussock islands e.g. Beauchêne and Jason Islands	5,000+ pairs	4 – 10 million pairs Stable
Antarctic fulmar (*Fulmarus glacialoides*)	LC	X	X	Common autumn and winter visitor. Highest densities found over Patagonian Shelf waters but found throughout Falklands waters. Spring / Summer / Autumn / Winter	Single egg laid Nov/Dec; Fledge Mar/Apr.	Surface seizing	✓	Antarctica	Non-breeder	4 million individuals Stable
Grey-backed storm-petrel (*Garrodia nereis*)	LC	X	X	Present throughout the year but abundance highest between Sep – Mar. Spring / Summer / Autumn / Winter	Adults return Oct/Nov; Egg dates Nov/Dec; Fledging Feb/Apr.	Foot paddling (surface seizing)	X	Rat free tussock islands; e.g. Beauchêne and Kidney Islands	1-5,000 pairs	200,000 individuals Decreasing
Soft-plumaged petrel (*Pterodroma mollis*)	LC	X	X	Primarily in deep waters north of the Falkland Islands (Nov–Apr, peak Jan). Spring / Summer / Autumn / Winter	Egg laid Nov/Dec; Fledge May.	Surface seizing and shallow dives	X	Tristan da Cunha, Gough Island	Non-breeder	5 million individuals Stable

Species	IUCN status	ACAP species [a]	FI priority species	Seasonal occurrence and distribution	Breeding cycle	Feeding mode	Persistent ship associate	Breeding sites	Falklands population	Global population and trend
Sooty shearwater (*Puffinus griseus*)	NT	X	✓	Present throughout the year but most of the population depart between Apr – Aug. Spring / Summer / Autumn / Winter	Start breeding at 4 yrs; Adults return Sept; 1 egg laid late Nov; Adults depart Mar; Chicks fledge April.	Surface seizing and pursuit diving (to c. 50 m)	X	Tussock islands notably Kidney Island	100,000 pairs 0.1% global population	20 million pairs Decreasing
Prion species (*Pachyptila spp.*)	LC	X	X	Most numerous 'species' of seabird in Falklands waters, recorded throughout the year. Spring / Summer / Autumn / Winter	Return Sept; Egg dates Oct/Nov; Fledge Feb/Mar.	Picking at the surface on the wing and shallow dives	X	e.g. New Island, Jason Islands	2 million + pairs of thin-billed prion	20+ million pairs Stable
Southern royal albatross (*Diomedea epomophora*)	VU	✓	X	Present throughout the year. Highest density found over Patagonian Shelf northwest of Islands between March and June. Spring / Summer / Autumn / Winter	Biennial breeder; Age at first breeding 6-12 years; Single egg laid Nov/Dec; Fledge Oct to Dec.	Surface seizing	✓	New Zealand	Non-breeder	7,900 pairs Stable
Northern royal albatross (*Diomedea sanfordi*)	EN	✓	X	Present throughout the year. Highest density found over Patagonian Shelf northwest of Islands between March and June. Spring / Summer / Autumn / Winter	Biennial breeder; Mean age at first breeding 8 years;	Surface seizing	✓	New Zealand	Non-breeder	17,000 individuals Decreasing

Species	IUCN status	ACAP species [a]	FI priority species	Seasonal occurrence and distribution	Breeding cycle	Feeding mode	Persistent ship associate	Breeding sites	Falklands population	Global population and trend
					Single egg laid in Nov; Fledging Sept / Oct.					
Southern giant petrel (*Macronectes giganteus)*	LC	✓	✓	Recorded in all months, highest densities March-June over Patagonian Shelf waters, west and south of Falkland Islands. Spring | Summer | Autumn | Winter	Annual breeder; Age at first breeding 5-11 years; Adults return Sept; 1 egg laid Oct/Nov; Chicks fledge Mar.	Surface seizing	✓	38 locations, primarily islands in Falkland Sound	19,810 breeding pairs 41% global population	46,800 pairs Increasing
Magellanic penguin (*Spheniscus magellanicus*)	NT	X	✓	Majority recorded between Nov and Mar, absent during winter, feeding Patagonian Shelf and shelf break, Argentine coast. Spring | Summer | Autumn | Winter	Adults arrive Sept; 2 eggs laid Oct; Chicks fledge Mar; Adults depart Apr.	Dive to depths of 140 m	X	Over 90 locations on the Falkland Islands	c.140,000 pairs 10% global population	1.3 million pairs Decreasing
Grey-headed albatross (*Thalassarche chrysostoma*)	EN	✓	X	Present year-round but highest abundance from May to Sept, when found over the shelf edge and deeper waters. Spring | Summer | Autumn | Winter	Biennial breeder; Age at first breeding 12 yrs on SouthGeorgia; Single egg laid in Oct; Fledge Apr/May.	Plunge diving, Surface seizing and surface dives	✓	Southern Chile and South Georgia	Non-breeder	250,000 individuals Decreasing

Species	IUCN status	ACAP species [a]	FI priority species	Seasonal occurrence and distribution	Breeding cycle	Feeding mode	Persistent ship associate	Breeding sites	Falklands population	Global population and trend
Wandering albatross (*Diomedea exulans*)	VU	✓	X	Non-breeding visitor present throughout, mostly over waters >200 m in depth. A high proportion of the South Georgia population are recorded within Falklands waters during the course of the year. Spring | Summer | Autumn | Winter	Biennial breeder; Age at first breeding 8+ years; Single egg laid Dec/Jan; Fledge following Dec.	Surface seizing	✓	South Georgia	Non-breeder	6,100 pairs Decreasing
Atlantic petrel (*Pterodroma incerta*)	EN	X	X	Recorded in all months, majority Oct to Mar during post-breeding dispersal. Most numerous over deep waters to northeast, and southeast. Spring | Summer | Autumn | Winter	Single egg laid Jun/Jul.	Surface seizing and shallow dives	X	Tristan da Cunha, Gough Island	Non-breeder	1.8 million pairs Decreasing
Diving-petrel species (*Pelecanoides spp.*)	LC	X	X	Present in all months, greater number between Sept and Feb to the west of the Falklands. Spring | Summer | Autumn | Winter	Returns Sept; Egg date Oct;	Pursuit diving to c. 60 m	X	Tussock Islands; e.g. Beauchêne Kidney and Jason Islands	5-10,000 pairs	16 + million individuals
Northern giant petrel (*Macronectes halli*)	LC	✓	X	Recorded in all months with slightly higher density recorded from March to August, over Patagonian Shelf waters. Spring | Summer | Autumn | Winter	Annual breeder; Age at first breeding 4-11 years; Single egg laid Aug to Oct; Fledge Mar/Apr.	Surface seizing Persistent ship associate	✓	South Georgia	Non-breeder	11 – 14,000 pairs Increasing

Species	IUCN status	ACAP species [a]	FI priority species	Seasonal occurrence and distribution	Breeding cycle	Feeding mode	Persistent ship associate	Breeding sites	Falklands population	Global population and trend
Rockhopper penguin (*Eudyptes chrysocome*)	VU	X	✓	Winter foraging between Straits of Magellan and 39°N (1,400km). Spring / Summer / Autumn / Winter	Mating Oct 2 eggs laid mid Nov Chicks fledge Mar Adults depart April	Pursuit diving to c. 100 m	X	Primarily outer islands of West Falkland	320,000 pairs 36% global population	1.23 million pairs Decreasing
King penguin (*Aptenodytes patagonicus*)	LC	X	X	May-June migrate south of Polar Front. Spring / Summer / Autumn / Winter	12 mo - Mating Oct 1 egg laid Nov-Mar 55 day incubation	Pursuit diving to c. 350 m	X	Primarily Volunteer Point in the Falklands	<1,000 pairs 0.04% global population	2 million pairs Increasing
Gentoo penguin (*Pygoscelis papua*)	LC	X	✓	Resident, primarily within 10 km up to 300 km in winter. Spring / Summer / Autumn / Winter	Nest building Sept 1-2 eggs laid late Oct 34 day incubation	Pursuit diving to c. 100 m	X	79 locations throughout the Falklands	121,500 pairs, 34% global population	387,000 pairs Stable

a See section 7.4.5.5.2

Key: Relative abundance of seabirds within Falklands waters

Not recorded	Low	Moderate	High	Very High

(Source: BirdLife International, 2015; FIG, 2008a; White *et al*., 2002; Woods, 1988; Reid *et al*., 2007; Reid and Huin, 2005; Wolfaardt, 2012; Baylis, 2012)

7.4.5.3 Birdlife of Berkeley Sound (inshore)

Although the largest seabird colonies in the Falklands are found on offshore islands in the south and west of the Falklands archipelago, the area of Berkeley Sound does support some significant colonies of seabirds; particularly sooty shearwater (*Puffinus griseus*), white-chinned petrel (*Procellaria aequinoctialis*), rockhopper, gentoo and king penguins (see section 7.5.2.3.1.1).

Total island-wide censuses have been undertaken by Falklands Conservation for a number of seabird species including gentoo (Baylis *et al.,* 2013a), rockhopper (Baylis *et al.,* 2013b), macaroni and king penguins (Pistorius *et al.,* 2012), black-browed albatross (*Thalassarche melanophris*; Baylis, 2012), southern giant petrel (*Macronectes giganteus*; Reid and Huin, 2005), and white-chinned petrel (Reid *et al.,* 2007). A small number of colonies are monitored annually as part of Falklands Conservation's Seabird Monitoring Programme (e.g. Crofts and Stanworth, 2017). The results of this work provide vital baseline data and help to put the importance of Berkeley Sound colonies into the context of the wider Falkland Islands.

This section provides a summary of the distribution of birds in Berkeley Sound (and adjacent waters), their abundance, distribution, feeding and breeding ecology and sensitivities.

7.4.5.3.1 Seabird distribution and abundance surveys

Data from numerous surveys and studies have been used to identify the distribution of birds in Berkeley Sound. The surveys include:

- Four seasonal coastal bird surveys carried out between 2016 and 2019 by SAERI;
- The JNCC SAST which commenced each survey trip from Stanley;
- Satellite tracking of penguin species; and
- Annual seabird monitoring programme carried out by Falklands Conservation.

The relevant results from the above are summarised below with the data collated into species-specific summaries in section 7.4.5.3.2.

7.4.5.3.1.1 Berkeley Sound coastal bird survey, summer 2016

Under contract to Premier, the South Atlantic Environmental Research Institute (SAERI), conducted a series of seasonal coastal bird surveys summer 2016, winter 2017, spring 2018 and autumn 2019 to determine the distribution of potentially sensitive receptors around the Berkeley Sound coast. The methodology used during the 2016 coastal bird survey was adapted from that described in Tabak *et al.* (2015) and Neely (2010). The aim of the survey was to record the distribution of birds and marine mammals along the entire coastline of Berkeley Sound. In order to achieve this, two approaches were taken: one land-based and one boat-based. These two approaches were required to obtain the best available coverage given issues of boat access and steep terrain (as cliffs are difficult to survey from land). Land and boat surveys both recorded all birds and marine mammals sighted within a strip transect, which extended 100 m seaward and 25 m landward of the high tide line. The distribution of survey effort achieved in each survey is shown in Figure 7.56.

Berkeley Sound contains a wide range of habitat types; from rat free tussock islands, exposed rocky coasts, cliffs, gently sloping farmland, sheltered bays and mud flats. As is supported by this survey, each habitat type is expected to support a distinct assemblage of birds. The distribution of all birds recorded in each survey is shown in Figure 7.57. The results of these surveys indicate that there are clear differences in the species and abundance of birds found along the coasts of the outer and inner Sounds. The outer Sound is numerically dominated by imperial shag, rock shag, rockhopper and gentoo penguins in the spring and summer. During the winter and autumn surveys the coasts of the outer Sound supported relatively few birds. The inner Sound supported lower numbers of birds but a greater diversity of species, which was numerically dominated by Falkland steamer duck, rock shag, kelp gull, Magellanic penguin and upland goose. The distribution of individual species are described in section 7.4.5.3.2.

The species and number of individuals recorded during the survey are shown in Table 7.17

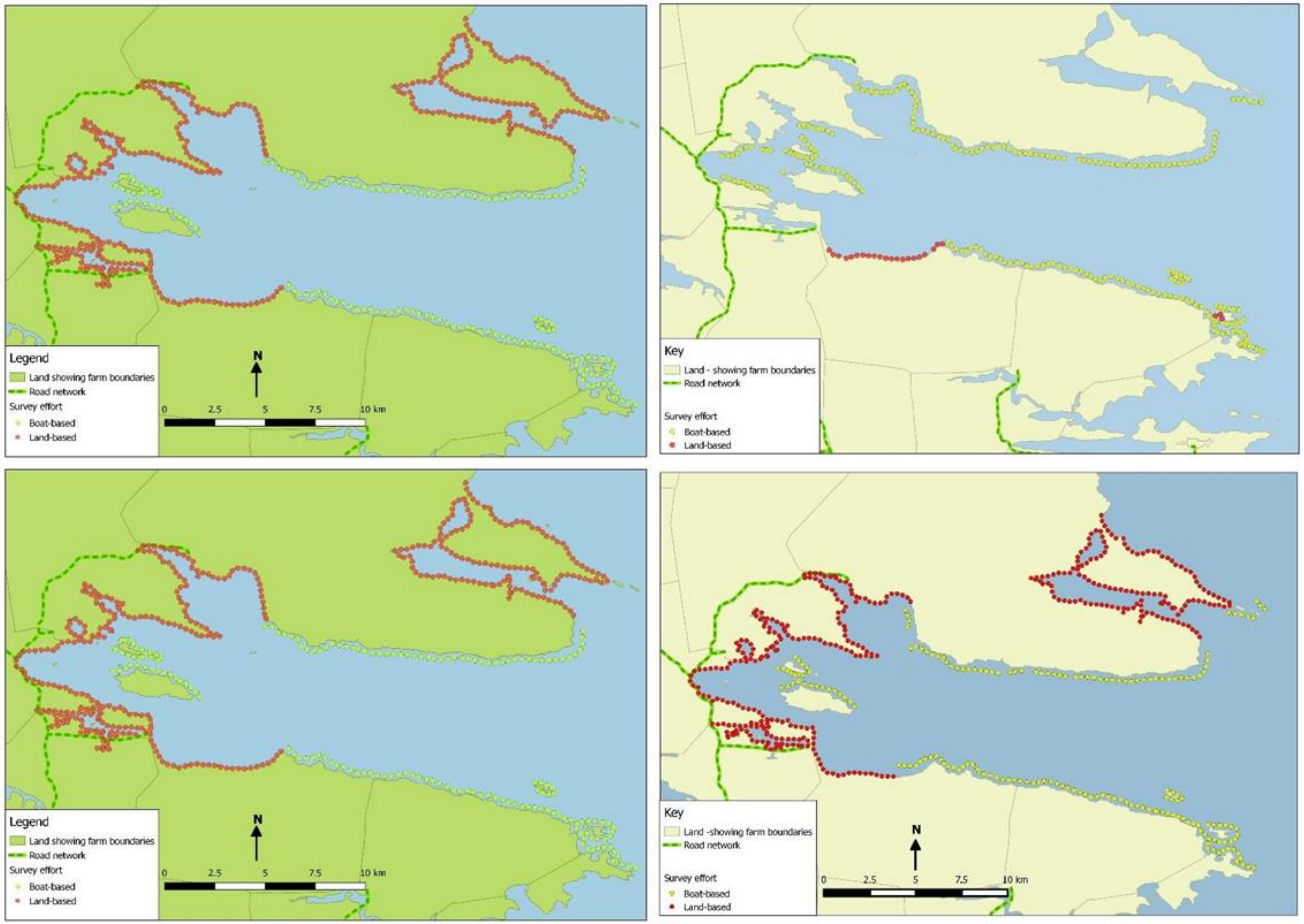


Figure 7.56: Distribution of coastal bird survey effort

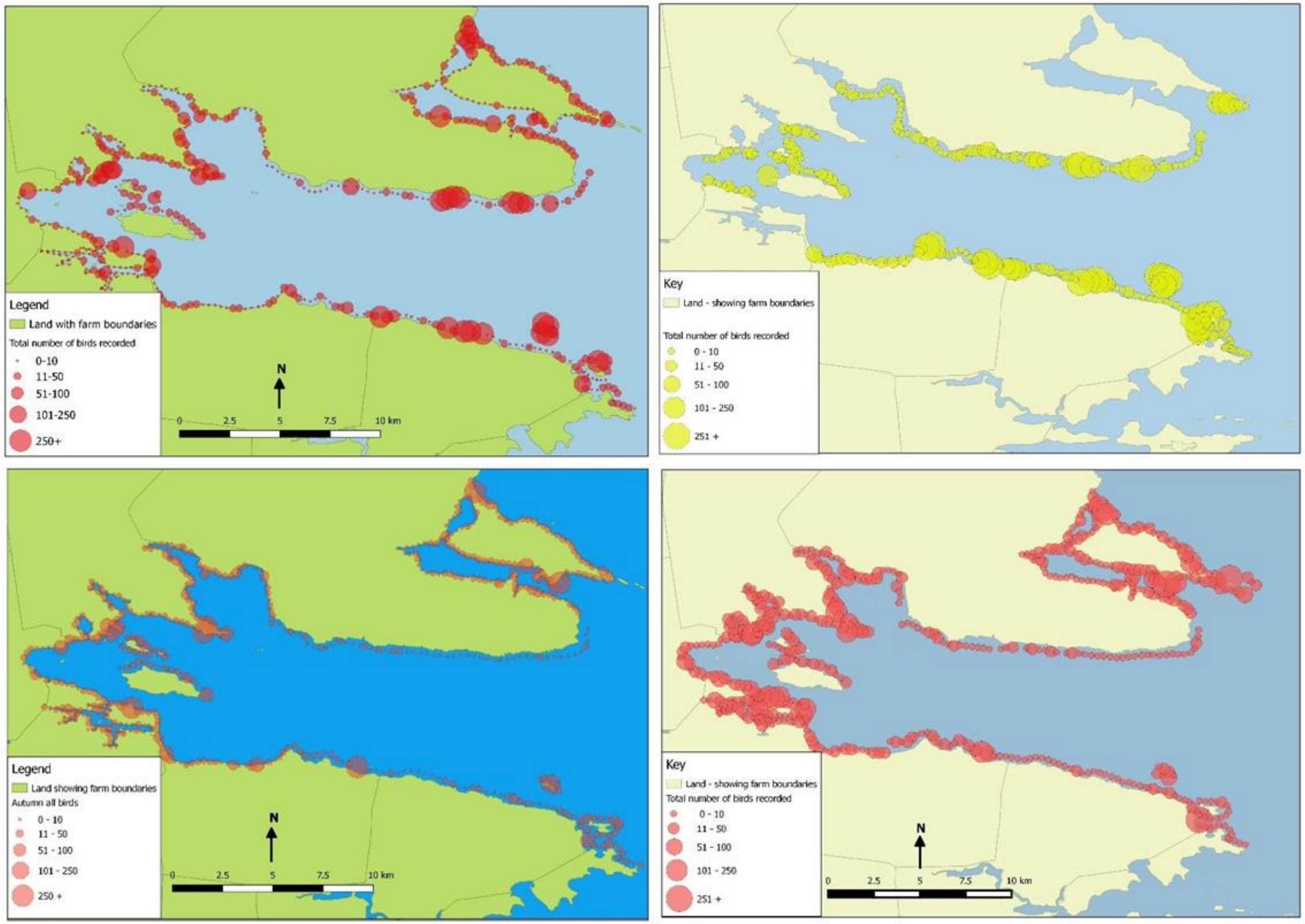


Figure 7.57: The distribution of all bird records in each survey

Table 7.17: Summary of bird species recorded during each survey

Common name	Scientific name	Spring	Summer	Autumn	Winter	Total
Rockhopper penguin	*Eudyptes chrysocome*	6,018	2,773	2	0	8,793
Rock shag	*Phalacrocorax magellanicus*	1,523	1,670	2,720	1,695	7,608
Imperial shag	*Phalacrocorax atriceps*	1,350	4,457	567	396	6,770
Falkland steamer duck	*Tachyeres brachydactyla*	1,583	485	1,700	2,006	5,774
Gentoo penguin	*Pygoscelis papua*	417	1,700	1,005	939	4,061
Kelp gull	*Larus dominicanus*	934	342	1,829	776	3,881
Upland goose	*Chloephaga picta*	496	109	794	603	2,002
Two-banded plover	*Charadrius falklandicus*	214	0	769	995	1,978
Kelp goose	*Chloephaga hybrida*	568	142	668	528	1,906
Patagonian crested duck	*Lophonetta specularoides*	500	21	701	555	1,777
Magellanic oystercatcher	*Haematopus leucopodus*	368	7	603	359	1,337
Magellanic penguin	*Spheniscus magellanicus*	733	465	3	0	1,201
White-rumped sandpiper	*Calidris fuscicollis*	1,030	0	0	0	1,030
Sheathbill	*Chionis albus*	185	0	364	425	974
Giant petrel species	*Macronectes* spp.	153	32	474	152	811
Dolphin gull	*Larus scoresbii*	227	20	267	223	737
King penguin	*Aptenodytes patagonicus*	511	0	29	150	690
Brown-hooded gull	*Larus maculipennis*	425	0	70	50	545
Speckled teal	*Anas flavirostris*	39	0	350	131	520
Dark-faced ground-tyrant	*Muscisaxicola macloviana*	54	7	323	133	517
Blackish oystercatcher	*Haematopus ater*	103	21	162	99	385
Turkey vulture	*Cathartes aura*	90	14	176	52	332
Long-tailed meadow lark	*Sturnella loyca*	66	2	150	103	321
Black-throated finch	*Melanodera melanodera*	31	0	216	67	314
Falklands thrush	*Turdus falklandii*	75	5	117	74	271
Ruddy-headed goose	*Chloephaga rubidiceps*	52	12	86	117	267

Common name	Scientific name	Spring	Summer	Autumn	Winter	Total
South American tern	*Sterna hirundinacea*	219	0	0	0	219
Rufous-chested dotterel	*Charadrius modestus*	0	0	45	59	104
Falkland pipit	*Anthus correndera*	33	0	31	23	87
White-tufted grebe	*Rollandia rolland*	8	0	51	21	80
South American tern	*Sterna hirundinacea*	0	76	0	0	76
Dark-crowned night heron	*Nycticorax nycticorax*	26	5	29	8	68
Tussac bird	*Cinclodes antarcticus*	4	30	1	5	40
Sooty shearwater	*Puffinus griseus*	27[a]	1[a]	0	0	28
Crested caracara	*Caracara plancus*	2	0	24	0	26
Black-chinned siskin	*Spinus barbatus*	6	0	13	0	19
Antarctic skua	*Stercorarius antarctica*	3	12	0	0	15
Silver teal	*Anas versicolor*	0	0	12	1	13
Red-backed hawk	*Buteo polyosoma*	1	0	3	4	8
Grass wren	*Cistothorus platensis*	1	0	0	5	6
Cobb's wren	*Troglodytes aedon*	0	4	0	0	4
Yellow-billed pintail	*Anas georgica*	0	0	4	0	4
Chiloe widgeon	*Anas silbilatrix*	3	0	0	0	3
Peregrine falcon	*Falco peregrinus*	3	0	0	0	3
Least seed snipe	*Thinocorus rumicivorus*	0	0	2	0	2
Wilson’s storm-petrel	*Oceanites oceanicus*	0	0	2	0	2
White-chinned petrel	*Procellaria aequinoctialis*	0	0	1	1	2
Antarctic fulmar	*Glacialoides antarctica*	0	0	0	1	1
House sparrow	*Passer domesticus*	1	0	0	0	1
Magellanic snipe	*Gallinago magellanica*	0	0	1	0	1
Sanderling	*Calidris alba*	0	0	1	0	1

[a] Note: Sooty shearwater were not targeted with dusk surveys

7.4.5.3.1.2 JNCC Seabirds At Sea Team (SAST) surveys

JNCC SAST surveys started and ended in Stanley and therefore contribute to our knowledge of seabird and marine mammal distributions over inshore waters near Berkeley Sound.

In total, over 2,688 km of survey track were observed, within the area shown in Figure 7.58, over the seven year life of SAST surveys. Each observation made is linked to one of the point locations shown in Figure 7.58, which each represent approximately 3 km of survey track. Effort was spread across all months with a high of 329 km achieved in July and a low of 152 km in May.

Over 26,800 seabirds were recorded within the area adjacent to Berkeley Sound, seasonal relative abundance for all the species recorded is shown in Table 7.18.

Many of the species recorded displayed clear temporal and spatial patterns of distribution, which are described below.

The majority of the most numerous species shown in Table 7.18 are Falkland Islands breeding species but some abundant visiting species; include great shearwaters (*Puffinus gravis*), Antarctic fulmars and Cape petrel, also feature. From a conservation perspective, some of the most significant species are those covered under the Agreement for the Conservation of Albatrosses and Petrels (ACAP) (section 7.4.5.3.2). Eight ACAP species were recorded; black-browed albatross, southern giant petrel, white-chinned petrel, northern giant petrel (*Macronectes halli*), southern royal albatross (*Diomedea epomophora*), grey-headed albatross (*Thalassarche chrysostoma*), wandering albatross (*Diomedea exulans*) and northern royal albatross (*Diomedea sanfordi*).

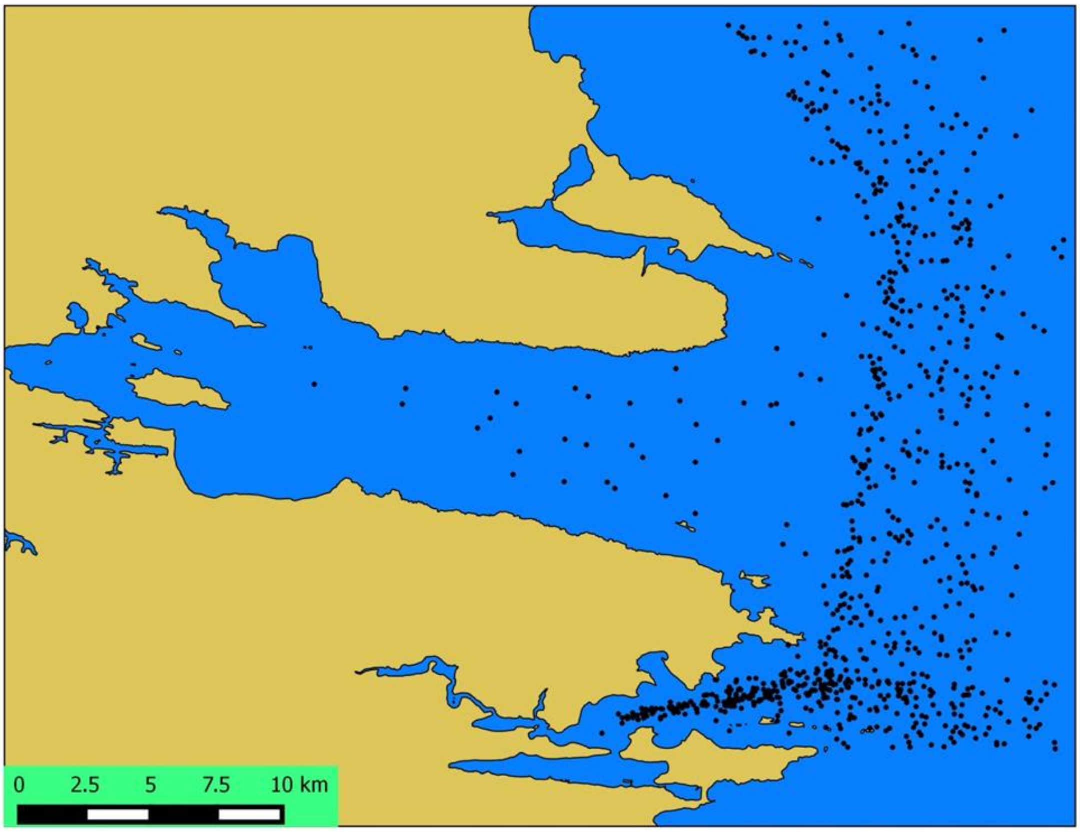


Figure 7.58: Total survey effort achieved during JNCC surveys in coastal waters near Berkeley Sound, each point represents a 10-minute observation period (or approximately three km of survey track)

Table 7.18: Relative seasonal abundance of seabirds recorded in the waters adjacent to and within Berkeley Sound during JNCC surveys (JNCC data) [a, b]

Rank	Autumn (M,A,M)		Winter (J,J,A)		Spring (S,O,N)		Summer (D,J,F)	
	Species [c]	Birds/ km	Species [c]	Birds/ km	Species [c]	Birds/ km	Species [c]	Birds/ km
1	IS	2.994	IS	2.220	SS	10.177	MP	4.131
2	SS	2.482	BBA	0.294	IS	2.830	SS	3.936
3	BBA	0.968	AF	0.234	MP	0.870	IS	1.419
4	MP	0.691	KG	0.221	BBA	0.536	BBA	1.279
5	GS	0.665	RS	0.184	AF	0.184	RP	0.424
6	FFSD	0.554	GP	0.102	WP	0.174	WP	0.265
7	GP	0.458	SGP	0.099	KG	0.148	SAT	0.255
8	AF	0.194	FFSD	0.085	SAT	0.095	KG	0.247
9	WCP	0.151	SS	0.045	GP	0.071	WCP	0.242
10	KG	0.146	CP	0.038	SGP	0.068	FFSD	0.236
11	SGP	0.128	NGP	0.011	CP	0.053	GS	0.219
12	SAT	0.118	MP	0.010	DP	0.052	GP	0.159
13	CP	0.050	DG	0.009	RS	0.050	SGP	0.098
14	RP	0.036	BHG	0.008	WCP	0.044	Pr	0.092
15	AS	0.036	GHA	0.003	RP	0.029	AS	0.038
16	RS	0.029	KeP	0.003	AS	0.014	SRA	0.033
17	NGP	0.014	Pr	0.002	DG	0.012	RS	0.031
18	DP	0.012	MDP	0.002	NGP	0.010	DP	0.015
19	GHA	0.009	WP	0.001	FFSD	0.005	NGP	0.013
20	Pr	0.007	RP	0.001	GS	0.005	BHG	0.013
21	DG	0.005	DP	0.001	BHG	0.004	AF	0.012
22	BHG	0.005	SRA	0.001	MDP	0.004	CP	0.006
23	SRA	0.004	WA	0.001	GBSP	0.004	DG	0.002
24	LTS	0.004	BP	0.001	SRA	0.001	MDP	0.002
25	KeP	0.002			NRA	0.001	WA	0.002
26	WA	0.002			BP	0.001	SPP	0.002
27	NRA	0.002						
28	SPP	0.002						

[a] Survey effort: Autumn 561.2 km, Winter 870.7 km, Spring 735.4 km, Summer 521.4 km
[b] Highlights in shades of blue indicate relatively Very High, High, Medium and Low abundance
[c] The species names relating to the species codes are found in the species accounts (section 7.4.5.3.2).

7.4.5.3.1.3 Satellite tracking studies

At about the same time as SAST surveys were starting in the Falklands, satellite tracking projects on a number of species; black-browed albatross (Huin, 2002), Magellanic (Pütz *et al.,* 2000 and 2002a), rockhopper (Pütz *et al.,* 2002b) and gentoo penguins (Clausen and Pütz, 2003) commenced. In subsequent years, tracking projects have continued on a number of species at various sites around the Islands through the GAP programme (section 7.4.5.2.1.4). Additionally, some species that breed elsewhere, particularly on South Georgia, have been tracked to Falkland Islands waters (for instance, Berrow *et al.,* 2000; Phillips *et al.,* 2006; Ratcliffe *et al.,* 2014).

7.4.5.3.1.4 Falklands Conservation annual monitoring programme

Falklands Conservation undertake an annual seabird monitoring programme across the Falkland Islands and currently monitor gentoo penguins at 11 breeding sites (16 colonies), Magellanic penguins at one site (single colony) and rockhopper penguins at five sites (13 colonies). King penguins and black-browed albatross are monitored at single but key sites in terms of colony size, in relation to the Falklands population, southern giant petrels are monitored at one site (three colonies), imperial shag at three sites and brown skua at one site (Crofts and Stanworth, 2018). Data from these monitoring sites give information on the breeding success and population trends over a number of years, indicating the current status of the populations.

Within Berkeley Sound, three rockhopper colonies on the north coast of the Sound (Diamond Cove, Rugged Hill and Eagle Hill; Figure 7.59) are monitored annually (Crofts and Stanworth, 2018) and all colonies are counted during the island –wide census, which takes place approximately every five years. Gentoo and king penguins are monitored annually at Volunteer Point (Figure 7.59). In recent years, monitoring has commenced at the imperial shag colony at Rugged Hill.

The number of pairs of seabirds breeding at each of these colonies is compared with the Falkland Islands population as a whole in Table 7.20. Annual monitoring at selected sites by Falklands Conservation has recorded high variability in the number of breeding pairs and breeding success in gentoo and rockhopper penguins between and within monitored sites (Crofts and Stanworth, 2017). However, monitoring during the 2016 / 17 breeding season recorded dramatic reductions in the number of breeding pairs of gentoo and rockhopper penguins recorded across virtually all sites (declines of 35 % and 31 % respectively since 2015), including those in Berkeley Sound. There is some evidence that food availability has been poor in the 2015/16 season, evident from below average breeding success and starvation in moulting adult penguins (Crofts and Stanworth, 2017). Seabirds in poor physical condition are likely to defer breeding, which may account for the apparent crash in the breeding populations. However, adult mortality may also be a contributing factor. Local factors such as food supply or stochastic events, such as toxic algal blooms, can have dramatic influence at a regional level within the Falklands archipelago. However, the archipelago wide decline in the number of breeding birds hints at a more significant environmental perturbation. There is evidence that the seawater temperature around the Falklands was lower than usual in 2016 (Crofts and Stanworth, 2017), which may have resulted in reduced food availability to adults preparing to moult in early 2016 and breed in 2016 / 17.

Monitoring during the 2017 / 18 season recorded an overall increase of 17 % in the number of Gentoo penguin breeding pairs at monitored colonies (Crofts and Stanworth, 2018). However, this trend was not reflected in the colonies at Volunteer Sands and Volunteer Green, which showed little change from the previous year.

Overall, the number of rockhopper penguin breeding pairs remained the same as the previous year (Crofts and Stanworth, 2018). However, the number of breeding pairs at monitored sites in Berkeley Sound showed a small (c. 3 %) decline.

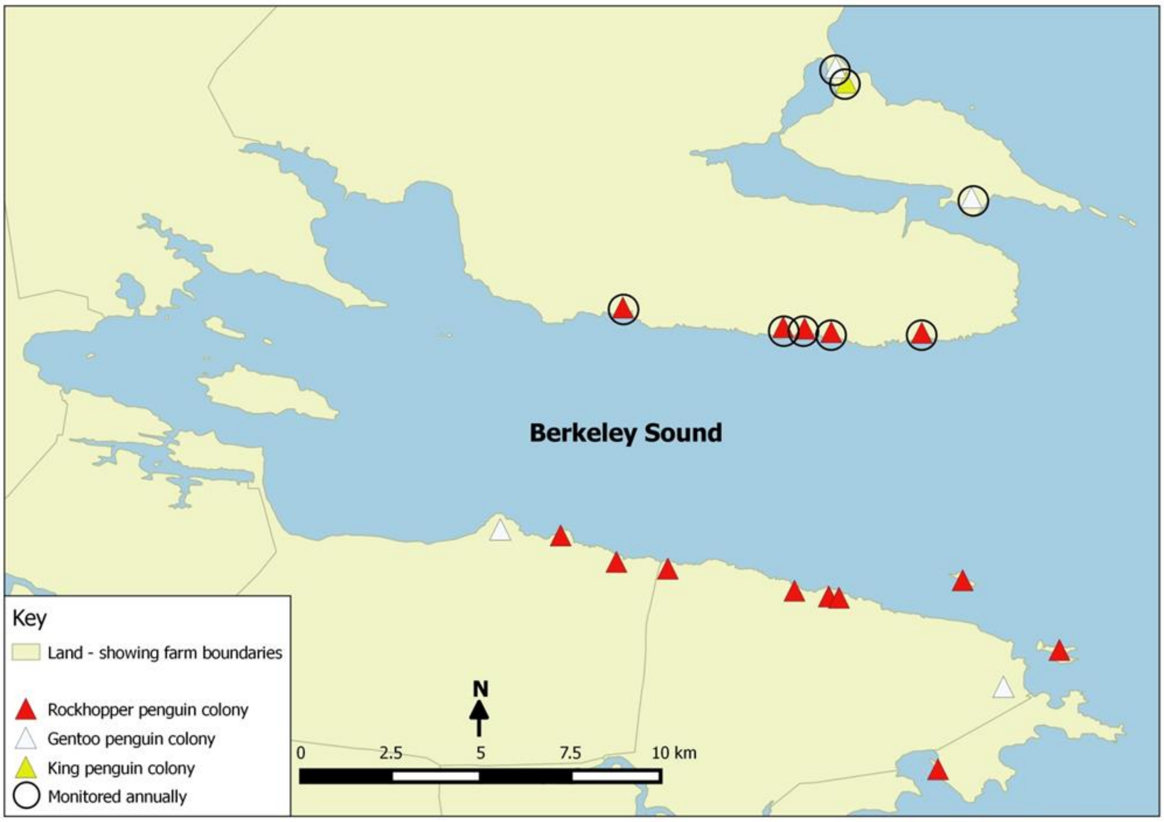


Figure 7.59: Locations of penguin colonies within Berkeley Sound

Table 7.19: The size of seabird colonies within Berkeley Sound

Colony	Annual monitoring site	2010 count (pairs)	2010 FI population (pairs)	2010 % of FI population	Long-term population trend (since 1995)	Short-term population trend (since 2010)
Gentoo penguin [b]						
Cow Bay	✓	1,599		1.21	↑	↓[a]
Volunteer Point	✓	3,529		2.67	↔	↓[a]
Strike-off Point	x	146	132,321 ± 2,015	0.11	↔	Unknown
Kidney Cove	x	1,227		0.93	↓	Unknown
BS Gentoo total	-	6,501		4.9	↑	Unknown
Rockhopper penguin [b]						

Colony	Annual monitoring site	2010 count (pairs)	2010 FI population (pairs)	2010 % of FI population	Long-term population trend (since 1995)	Short-term population trend (since 2010)
BS north coast	✓	2,648	319,163 ± 18,503	0.83	↔	↔
Diamond Cove	✓	167		0.05	↔	↔
BS south coast	x	2,131		0.67	↔	Unknown
Cochon Island	x	552		0.17	↑	Unknown
Kidney Island	x	297		0.09	↑	Unknown
BS Rockhopper total	-	5,795		1.8	↔	Unknown
King penguin [c]						
Volunteer Point	✓	c. 720 chicks	c. 720 chicks	c.100 %	↑	↔
Imperial shag [c]						
Eagle Hill	✓	283 nests	Unknown	Unknown	Unknown	Unknown
Southern giant petrel [d]						
Volunteer Lagoon	x	9 (2004 count)	19,810 (2004 count)	0.045	Unknown	Unknown

Note: [a] Short-term decline due to a dramatic crash in the number of breeding pairs since 2015 (Crofts and Stanworth, 2018), prior to 2015 the number of breeding pairs was increasing

Sources: [b] Baylis, 2012; [c] Stanworth, 2014; [d] Reid and Huin, 2005

7.4.5.3.1.5 Bird distribution data gaps and limitations

As described above, the area of Volunteer Lagoon has not been surveyed to date and this represents the greatest spatial gap in knowledge regarding bird distributions in Berkeley Sound. Additionally, coastal bird surveys are required throughout the year to determine seasonal differences in bird abundance and distribution.

There are a number of advantages and disadvantages associated with each of the survey methods described above. However, when interest is focussed on a relatively small area; such as Berkeley Sound, it is likely that visual surveys along fixed transects will provide the most useful data for future monitoring. Nonetheless, further survey work is required to better understand baseline bird distributions within the Sound.

7.4.5.3.2 Species-specific distribution and abundance

The following collates the data from the surveys above to provide a species-specific summary of the distribution and abundance of the most significant bird species encountered within Berkeley Sound. A summary of the abundance, distribution, life-cycle and behavioral characteristics is provided in section section 7.4.5.3.3.

Rockhopper penguin (RP)

In total, 8,793 rockhopper penguins were recorded during the course of all four coastal bird surveys, making this the most numerous species recorded during the project. Points of high density were associated with known colonies on the coasts of the outer Sound, Cochon and Kidney Islands. Few rockhopper penguins were recorded in the inner Sound (Figure 7.60).

During the spring, far more rockhopper penguins were recorded than at any other time (Table 7.17). The summer survey coincided with the start of the moult period in this species and adult birds were congregating in colonies ashore but it was thought that many were still at-sea.

Very few rockhopper penguins were recorded during the autumn survey and none was recorded in the winter survey.

Satellite tags have been deployed on rockhopper penguins breeding at a number of colonies around the Falklands, including two on the south side of Berkeley Sound. The tracks obtained indicate that birds breeding in Berkeley Sound tend to forage over the shelf and shelf-slope to the north of the Falklands (Pütz *et al*., 2003). However, trip length (and range) may vary throughout the breeding season, depending on the energy demands of chicks and adults. Nevertheless, rockhopper penguins breeding within Berkeley Sound will be departing from and returning to their colonies throughout the breeding season and are therefore potentially at risk over this entire period.

The GAP project fitted rockhopper penguins from Berkeley Sound with geolocators over the winter period. The results indicate that these birds depart from Falklands waters and overwinter off the coast of South America.

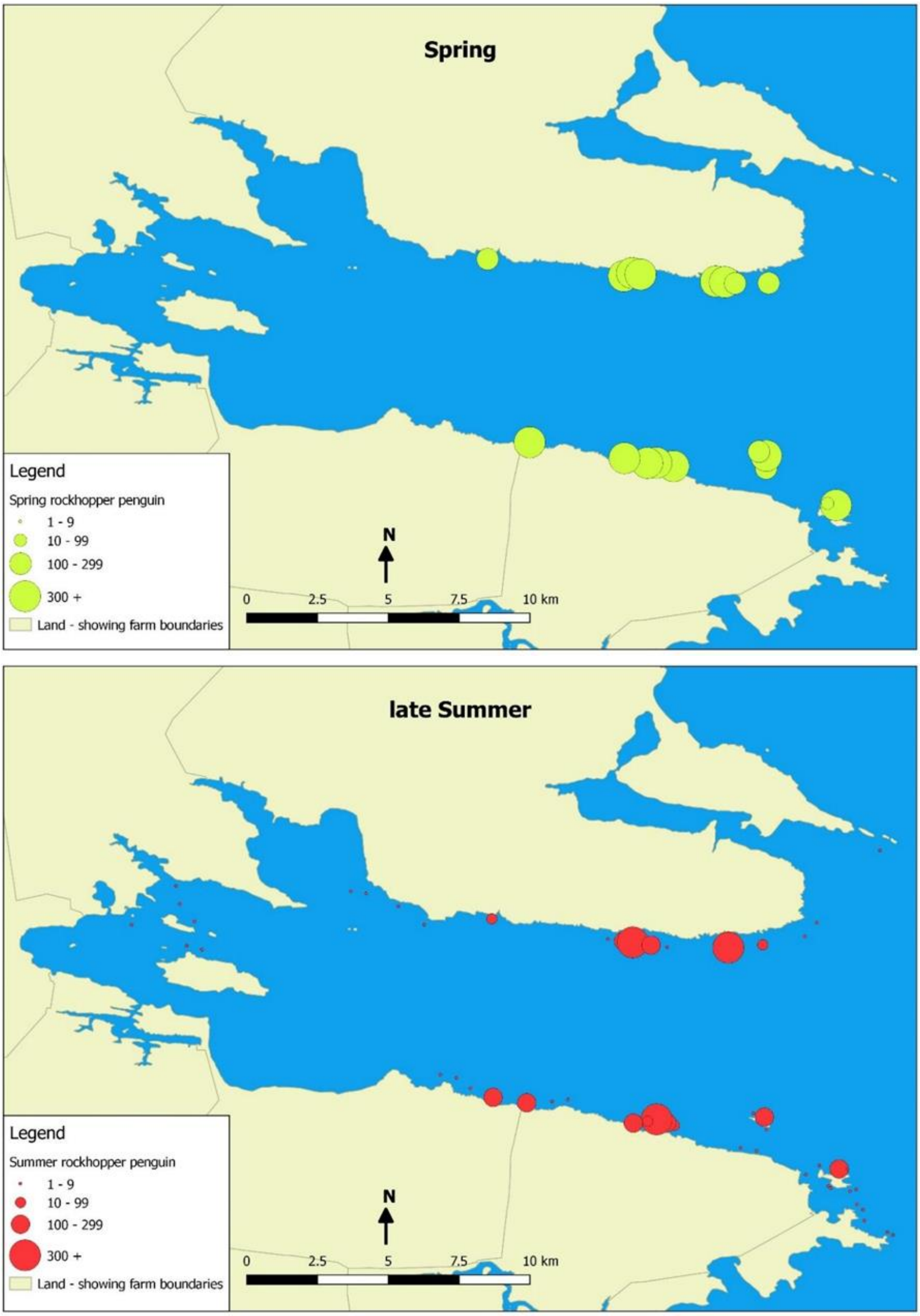


Figure 7.60: Distribution of rockhopper penguins recorded during coastal bird surveys

Rock shag (RS)

Rock shags were the second most numerous species recorded during the coastal bird survey project, with 7,608 birds recorded (Table 7.17). The distribution of rock shag records from each survey is illustrated in Figure 7.61. Although recorded throughout the areas surveyed, rock shags show seasonal shifts in distribution. In spring and summer, more rock shags were recorded in the outer than the inner Sound. In the autumn, rock shags apparently disperse and relatively fewer were recorded in the outer Sound. During the winter, the number of rock shags present in the outer Sound was greatly reduced. Of note, a stretch of cliff on the south coast of the outer Sound supported higher numbers than elsewhere (Figure 7.61).

Rock shags have a coastal distribution and were infrequently recorded during JNCC surveys, which were rarely conducted within this species' range. The limited rock shag tracking data that is available from areas outside of Berkley Sound indicates maximum travel distances of < 4 km from land.

Imperial shag (IS)

Imperial shag was the most numerous species recorded during the series of coastal bird surveys, with 6,770 birds recorded (Table 7.17). During the spring and summer, Cochon Island supports a large population of this species and the highest density was observed on the cliffs of the north coast of this island. Other smaller colonies were recorded on the north coast of Kidney Island, Volunteer Point and the north and south coasts of the outer Sound (east of Strike-off Point). Elsewhere, imperial shags were only recorded as single birds or small groups (Figure 7.62). During the survey, large groups of imperial shags (likely to be feeding aggregations) were observed on the waters of the outer Sound. These birds were not recorded as they fell outwith the coastal survey transect.

By contrast, during the autumn and winter, imperial shags were only recorded in low numbers within Berkeley Sound (Figure 7.62). The only large group observed was seen roosting on the north coast of Volunteer Rocks, however these birds fell outwith the survey transect.

Perhaps surprisingly, imperial shag was the second most numerous species of seabird recorded by the SAST in the vicinity of Berkeley Sound (section 7.4.5.3.1.1) and were consistently recorded as one of the most numerous species present in all months of the year (Table 7.19). Further, they were by far the most abundant species recorded during the winter months. So although imperial shags were not observed on the coast in the winter they are still abundant within inshore waters during the winter months. Like several other species distributions described here, large groups of imperial shags were recorded in the waters off Mengeary and Volunteer Points, which suggests that these are important foraging areas for numerous species of seabirds.

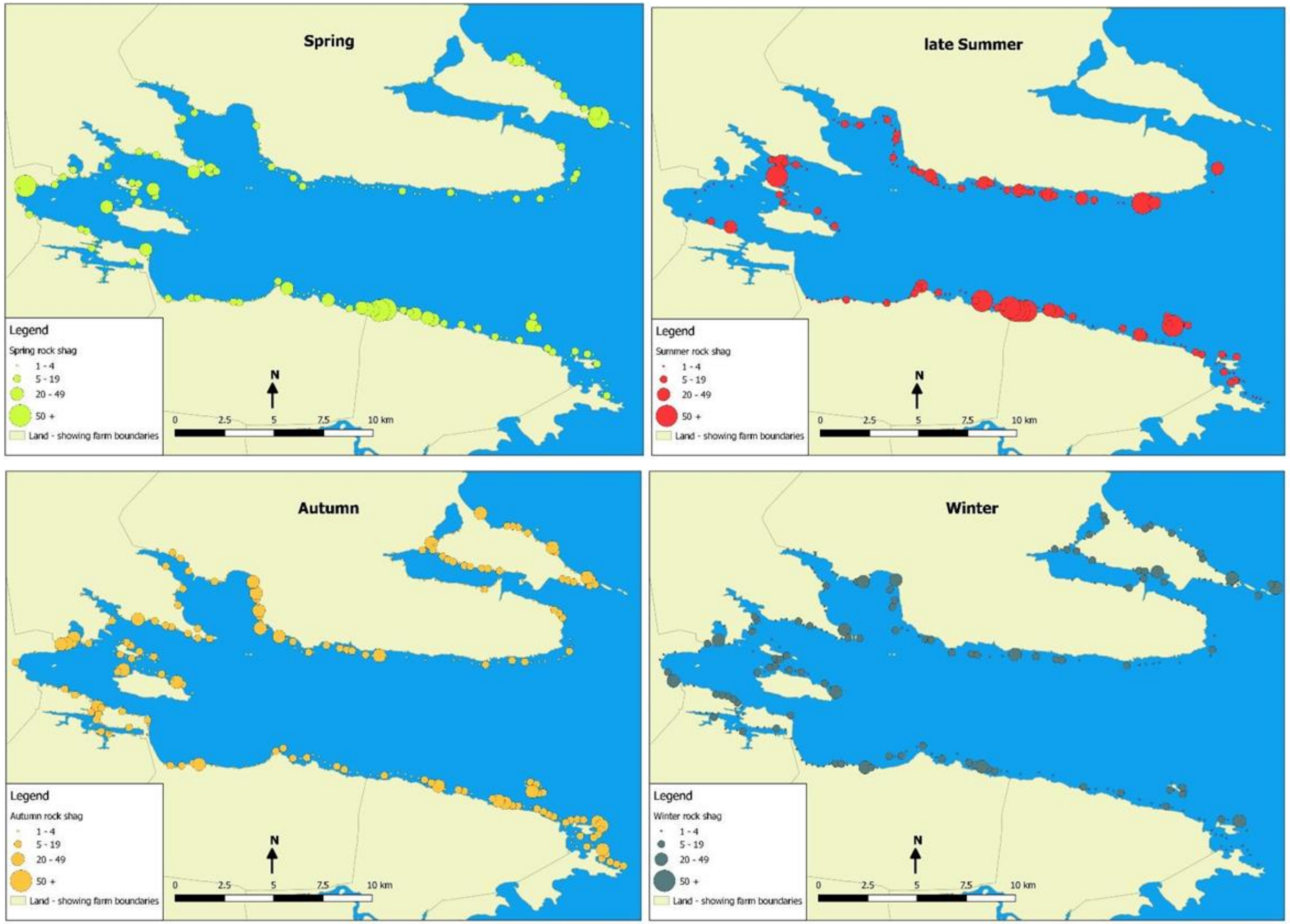


Figure 7.61: Distribution of rock shags recorded in March 2016 (left) and July 2017 (right)

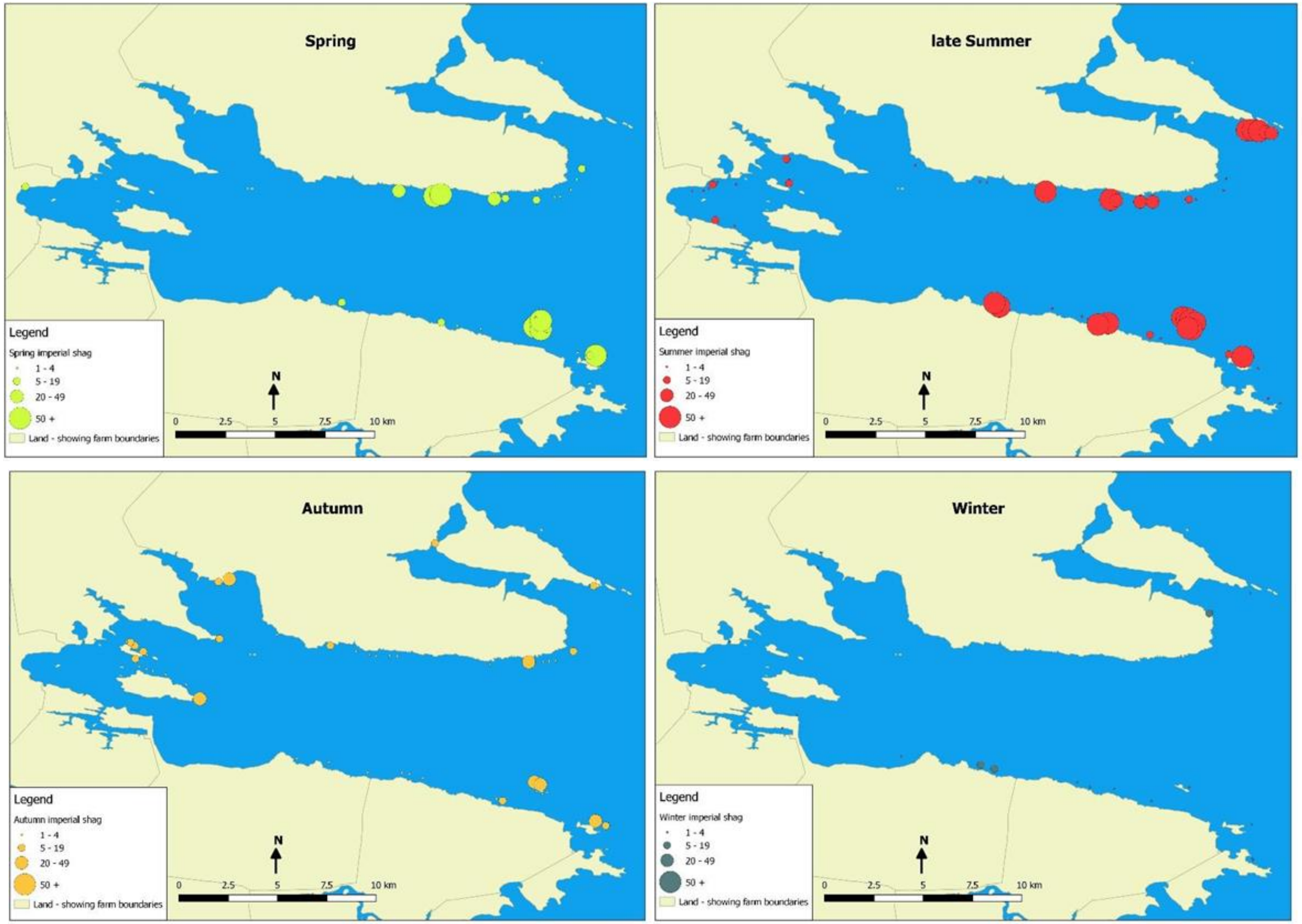


Figure 7.62: The distribution of all imperial shag recorded in March 2016 (2016 (left) and July 2017 (right)

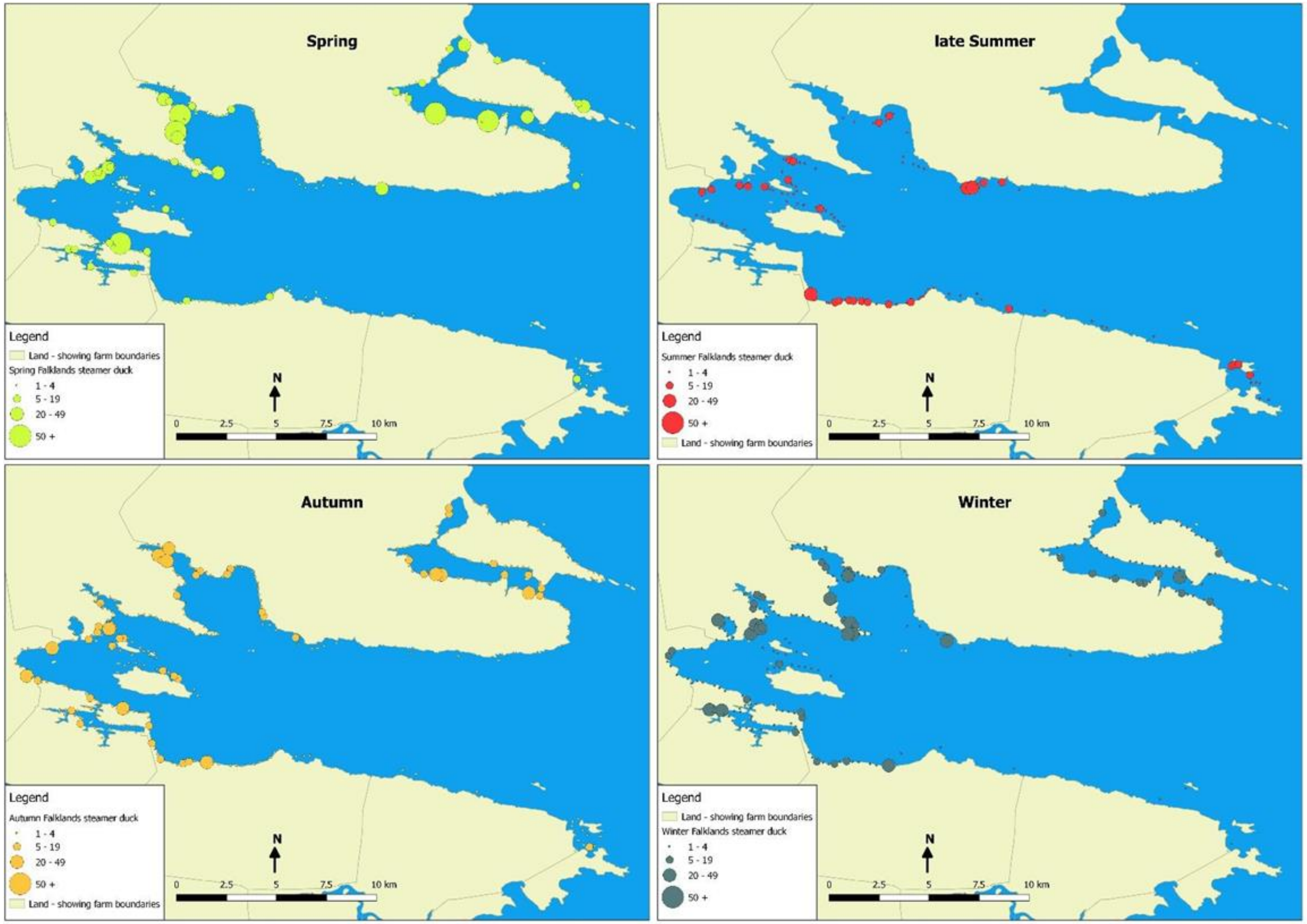


Figure 7.63: The distribution of all Falklands steamer duck records in the vicinity of Berkeley Sounds

Falkland steamer duck (FSD)

The Falkland steamer duck is one of only three endemic bird species in the Falklands (the others being Cobb's wren and Tussock bird). Overall, Falkland steamer duck was the fourth most numerous species recorded during the coastal bird surveys (Table 7.17: Summary of bird species recorded during each survey). Throughout the year, steamer ducks were the most numerous species recorded in the inner Sound during the coastal bird surveys, and were also recorded around the coast of Kidney Island, but appeared to be largely absent from the more exposed coasts of the outer Sound (Figure 7.63). Adult steamer ducks occupy territories throughout the year and pairs are recorded at regular intervals around the entire coast of the inner Sound and Volunteer Lagoon. Larger aggregations of young or non-breeding birds were encountered in all seasons but the group size recorded was larger in the spring than at other times.

This species was the fifth most numerous species recorded by the SAST although the distribution of records was restricted exclusively to the inshore waters of Port William. The lack of records in Berkeley Sound however, reflects the distribution of survey effort which was rarely within 2 km of the coast.

Gentoo penguin (GP)

Gentoo penguins are resident in the Falklands and regularly return to shore throughout the year. Gentoo penguin were consistently one of the most numerous species in each survey (Table 7.17). However, they were only recorded in association with known breeding sites; primarily Kidney Cove and Lagoon Sands.

Satellite tags have been deployed on gentoo penguins breeding at a number of colonies around the Falklands, including Kidney Cove. It is generally regarded that during the breeding period (September to February) gentoo penguins forage inshore and return to colonies on a daily basis. Although not derived from tracking, detailed observations of birds breeding at Volunteer Point recorded mean minimum and maximum foraging trip lengths were between 2.0-3.0 days and 0.7-1.8 days during the incubation and brood periods respectively (Otley *et al*., 2005). Comparable foraging trips were longer at other sites studied in the South Atlantic (Otley *et al*., 2005).

During the winter, tracking from Kidney Cove has shown that birds may disperse away from the breeding colony but still return regularly to land elsewhere in the Falklands (Clausen and Pütz, 2003). Foraging trips were more variable in length and range during the winter, when compared with the breeding birds. Although gentoo penguins are present at Berkeley Sound colonies throughout the winter, they may not be the same birds that breed there during the summer.

Magellanic penguin (MP)

Generally, Magellanic penguins favour relatively sheltered vegetated areas that have access to the open sea. During coastal bird surveys, the area with the highest density of breeding Magellanic penguins recorded was on the greens behind Volunteer Beach. Magellanic penguins were apparently absent from the study area during the autumn and winter surveys (Table 7.17).

Magellanic penguins were recorded in low numbers throughout the waters surveyed by the SAST; however, large groups were encountered within Port William and across the entrance of Berkeley Sound (Figure 7.64). Tracking and at-sea observations indicate that the majority of Magellanic penguins migrate northwards following moulting and overwinter outwith the waters of the Falkland Islands (Pütz *et al*., 2000). This is reflected in the number of birds recorded in each season (Table 7.18 above), which indicates that very few Magellanic penguins are present between May and September.

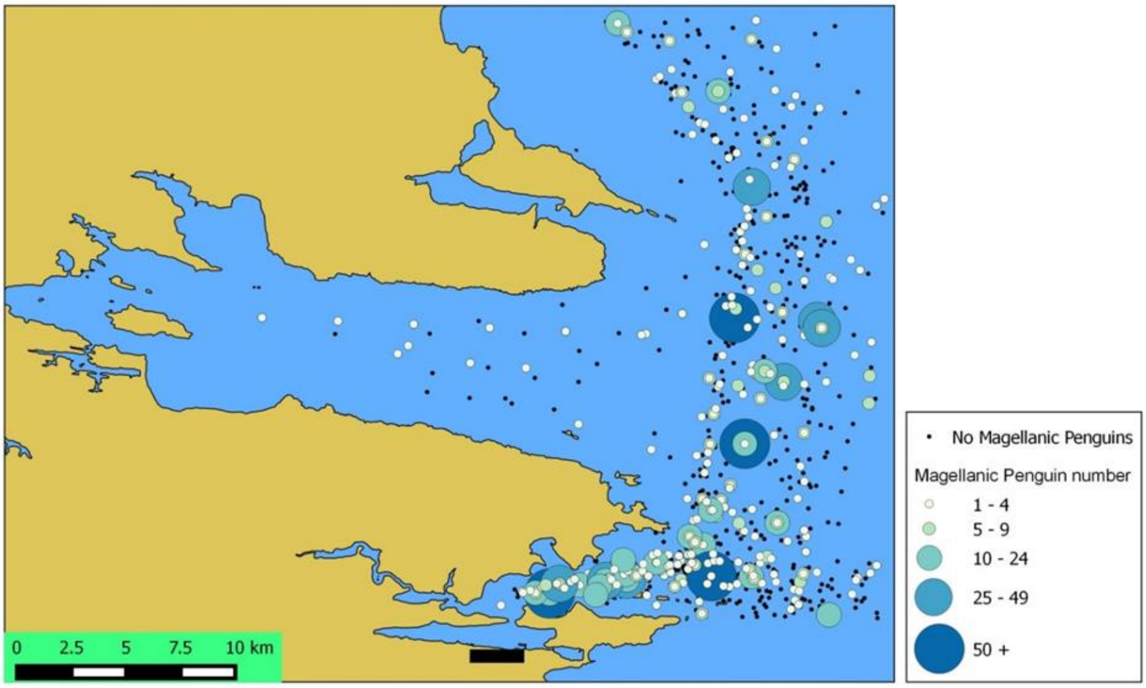


Figure 7.64: The distribution of all Magellanic penguin records in the vicinity of Berkeley Sound

King penguin (KP)

Unlike the other species of penguin breeding in the Falklands, king penguins raise chicks throughout the year, therefore, colonies are occupied throughout the year. The largest king penguin colony in the Falklands is located close to Berkeley Sound, behind Volunteer Beach. The majority of the king penguins recorded during coastal bird surveys were recorded close to this site or the far smaller colony at Volunteer Sands. The fact that no king penguins were observed during the summer coastal survey (Table 7.17) was due to the lack of survey effort near these colonies (Figure 7.56).

Several tracking studies have been conducted on king penguins (*Aptenodytes patagonicus*) breeding at Volunteer Point, which have identified seasonal shifts in distribution associated with phases of the breeding cycle (Pütz, 2002; Pütz and Cherel, 2005; Baylis *et al*., 2014; summarised in Table 7.20. Although the distribution may change during the course of the year (Pütz, 2002), king penguins are generally found offshore over the continental slope. The recorded distribution is thought to be closely linked to the distribution of the primary prey species, *myctophids* or lantern fish (Cherel *et al*., 2002). While these offshore foraging areas are likely to be beyond the influence of activities within Berkeley Sound, breeding birds return regularly to shore and it is here (in inshore waters) that they are at greatest risk. It is likely that the length of foraging trips and therefore the frequency of visits to the colony are of greater interest when assessing the impact of inshore activity than the location of feeding grounds.

Table 7.20: Summary of king penguin foraging trips from Volunteer Point

Season	Months	Duration (days)			Min distance travelled (km)			Maximum distance from colony (km)		
		Mean	SD	Median	Mean	SD	Median	Mean	SD	Median
Early winter [a]	Mar, Apr, May	19.8	15.5	15	2014.5	1279	1370	664.6	419.7	485
Late winter [a]	Jun, Jul, Aug	28.1	29	33.5	2787.7	3081.9	3419	510.2	392.8	778
Early summer [a]	Oct	5.2	3.9	15	595.1	554.5	1685	158.5	150.4	352
Early summer [b]	Nov	15.1	5.5	-	861.7	785.3	-	257.5	124.9	-
Early winter [c]	Apr	7.6	2.1	-	191	16	-	-	-	-
	May	16.4	14.7	-	277	222	-	-	-	-
	Jun	29.0	22.7	-	393	329	-	-	-	-

Sources: [a]Pütz, 2002; [b]Pütz and Cherel, 2005; [c]Baylis et al., 2014

Black-browed albatross

Although seen throughout the year by the SAST, the number of black-browed albatrosses recorded was generally lower during the winter months (Table 7.18 above). Usually recorded individually or in small numbers, larger groups were occasionally encountered (Figure 7.65).

Black-browed albatrosses have been tracked from a number of colonies in the Falklands; Beauchêne, Saunders Island, New Island and Steeple Jason (BirdLife International, 2004). Results have confirmed that this species forage primarily over Patagonian Shelf waters. Birds tracked from Beauchêne are of especial interest as this is the second largest colony in the Islands and the closest to Berkeley Sound. To date, tracking indicates that the east coast of the Falklands is not a core foraging area for this species (BirdLife International, 2004).

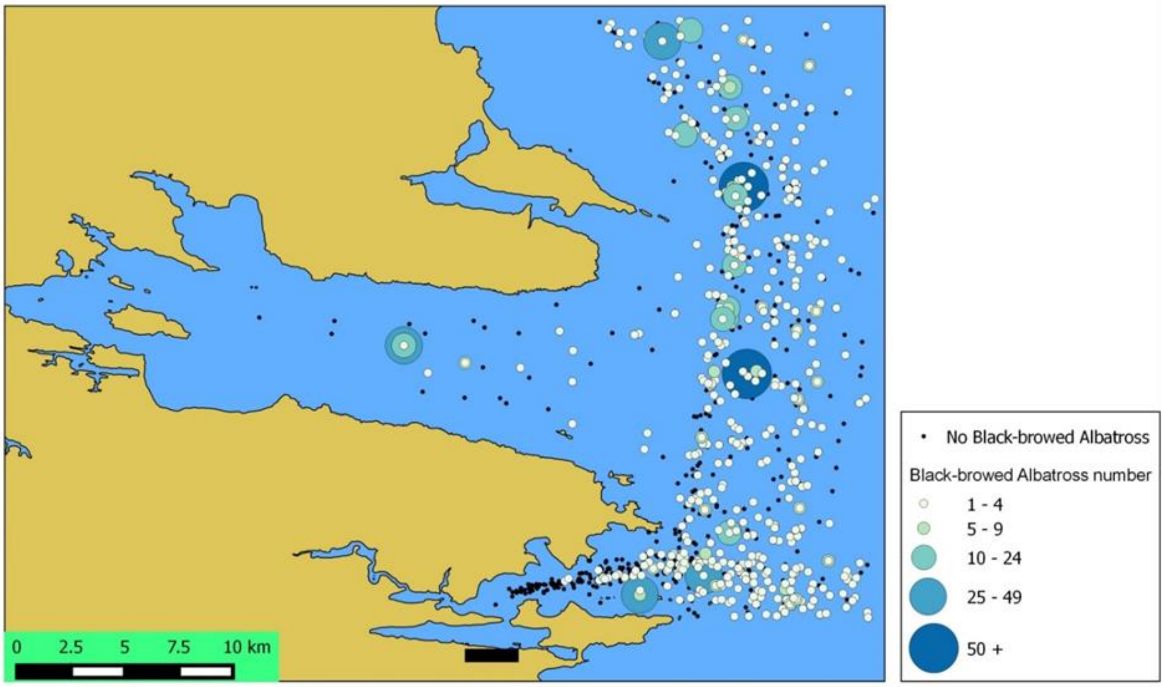


Figure 7.65: The distribution of all black-browed albatross records in the vicinity of Berkeley Sound

Southern giant petrel (SGP)

Southern giant petrels were present throughout Berkeley Sound in low numbers. Most sightings were of single birds flying along the coast but several larger aggregations (mostly associated with Kidney Island) and breeding colonies were recorded. The presence of a small breeding colony near the entrance to Volunteer Lagoon was confirmed and a potentially 'new' breeding site was identified on Peat Island, to the east of Hog Island (Figure 7.3). The first site is close to a known breeding site at Black Rincon within Volunteer Lagoon, this colony consisted of nine nests in the 2004 / 05 season (Reid and Huin, 2005). However, the present colony appears to have moved to the opposite side of the Lagoon and is on the point to the west of Lagoon Sands. At the second site, birds were seen on nests but the presence of eggs was not confirmed.

White-chinned petrel (WCP)

Although only two white-chinned petrels were recorded during the coastal bird surveys, the Falkland Islands largest known colony of this species is found on Kidney Island (Reid *et al.,* 2007). Breeding takes place between September and May and this is when the number of white-chinned petrels visiting the Island will be highest. JNCC surveys in inshore waters adjacent to Berkeley Sound recorded white-chinned petrels at moderate to high densities from spring to autumn with fewer observed during the winter. Like many other species of petrel, rafts of white-chinned petrels congregate in inshore waters near breeding colonies.

White-chinned petrels are classed as 'Vulnerable' by the IUCN and therefore represent one of the most sensitive of the Falklands breeding species.

Sooty shearwater (SS)

As was evident during the SAST surveys (section 7.4.5.3.1.3), the sooty shearwater is the most numerous breeding seabird species in the vicinity of Berkeley Sound with population estimates ranging between 10-20,000 (Woods and Woods, 1997) and >100,000 pairs (Falklands Conservation, 2006; Clark *et al*. 2019) breeding on Kidney Island. Although the behaviour was never recorded during SAST surveys, huge rafts of sooty shearwaters gather off Kidney Island at the entrance to Berkeley Sound during the breeding season, where they wait until dusk before returning to their nesting burrows ashore. This behaviour makes sooty shearwaters vulnerable to the effects of any surface pollutants and / or the effects of artificial light.

Figure 7.66 shows the distribution of all sooty shearwater records in the vicinity of Berkeley Sound during JNCC surveys with very high abundance recorded at the entrance to Port William. This reflects the proximity to the breeding site on Kidney Island but also, to some extent, reflects the route taken by the SAST survey vessels. Despite this species' diurnal habit of dispersing to feed during the day before returning to breeding colonies in the evening, very high densities of sooty shearwaters were recorded throughout the day in waters adjacent to Berkeley Sound, within Berkeley Sound and off Volunteer Point.

Between May and August, the number of sooty shearwaters recorded is greatly reduced (Table 7.17 above) as many birds migrate to the northern hemisphere at this time (Hedd *et al.,* 2014).

Contrary to the SAST surveys, very few sooty shearwaters were recorded during the coastal bird surveys. Although sooty shearwater was the most numerous species observed, virtually all of the birds seen were outwith the transect. For instance, while surveying the coast of Kidney Island (known to be an important breeding site) on 26th October a raft of approximately 15,000 sooty shearwaters was observed to the north of the island. A large number of sooty shearwaters was also observed passing off the coast of Johnsons Rincon on 22nd October. The presence of these birds deep within the Sound may have been related to the wind direction on the day (south-easterly), as they were not present in the same area on the 26th.

In 2007, 44 sooty shearwaters from Kidney Island were fitted with geolocator tags (Hedd *et al.,* 2014) (section 7.4.5.3.1.4). The results allow information regarding at-sea distribution, foraging trip length and activity (time spent on the water) to be collected. For instance, differences in the foraging strategies of male and female birds were found. The greatest differences between the sexes occur in the early stages of breeding, before the egg is laid (in late November). At this time, males forage closer to, and spend significantly more time at, the breeding sites than females. Key results of the tracking studies are summarised in Table 7.21.

The results of further tracking of sooty shearwaters from Kidney Island during the GAP programme are shown in Figure 7.66.

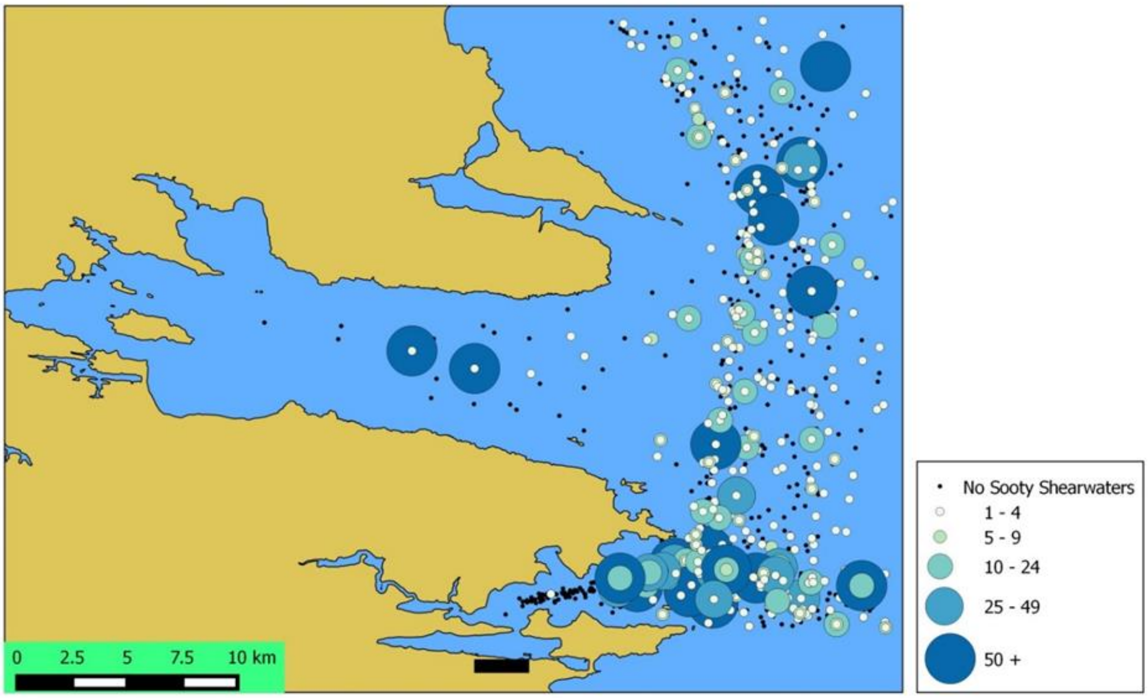


Figure 7.66: The distribution of sooty shearwater records in the vicinity of Berkeley Sound (held on the SAST database)

Table 7.21: Sooty shearwater behaviour derived from geolocator tags (data from Hedd *et al.,* 2014)

Period	Date	Trip length		Range / distance		Overlap in distribution
		Male	Female	Male	Female	
Pre-Breeding	Return late Sept	Daily	Variable	-	-	Low
Pre-laying exodus	Leave early Nov	12 ± 8.7 days	22.4 ± 3.5 days	2,830 ± 1.997 km	5,906 ± 1,412 km	Low
Incubation	Lay 22 Nov	7.6 ± 2.7 days		Range 491 ± 273 km		High
Chick rearing	Hatch 18 Jan	1.4 ± 1.3 days		Max. 410 km		High

Kelp gull (KGu)

Kelp gulls were recorded throughout the areas covered by all of the coastal bird surveys; however, highest numbers were recorded in the inner Sound. Several notable concentrations were recorded in the summer on Long Island or the adjacent mainland. During the winter, kelp gulls appeared to be more dispersed.

Dolphin gull (DG)

Dolphin gulls were recorded in low numbers during all of the coastal surveys, always associated with groups of shags or penguins. The Falklands are the global stronghold of this species with approximately 85% of the world's population breeding in the Islands.

Brown-hooded gull

Brown-hooded gulls were infrequently encountered; however, when sighted they were usually in groups. Brown-hooded gulls were most frequently encountered in the inner Sound.

South American tern (SAT)

All of the South American terns recorded during the summer 2016 coastal survey were sighted close to Kidney Island. It appeared that there may be a colony of this species on a small island off the northwest tip of Kidney Island. South American terns were not recorded during the winter 2017 survey.

South American terns were recorded at moderate to high densities in coastal waters near Berkeley Sound from the spring to autumn.

Antarctic skua (AS)

Antarctic skuas were occasionally observed during the summer 2016 coastal survey (section 7.4.5.3.1.1) but there was no discernible pattern to the distribution of this species. This species was absent during the winter of 2017.

Tussock bird (TB)

Tussock bird was recently given endemic status, having been split from the blackish cincloides found on mainland South America. During the coastal surveys, tussock birds were recorded around three islands within the Sound; Cochon, Kidney and Hog Islands. Tussock birds only thrive on islands without rats, although they can be seen in adjacent rat infested areas. Cochon and Kidney Islands are known to be rat-free, however, the status of Hog Island is unknown.

Cobb’s wren (CW)

Although rarely recorded during the summer 2016 coastal survey, Cobb’s wren is one of the most sensitive species found in the Berkeley Sound area. This species is endemic to the Falkland Islands and has restricted distribution within the Islands due to being extremely vulnerable to predation by introduced rats and cats. The distribution of these birds is therefore extremely patchy and largely restricted to small rat free tussock islands, such as Cochon and Kidney Islands. The small range and susceptibility to rat invasions means that the species is classified as Vulnerable by the International Union for the Conservation of Nature (IUCN). A species action plan has been written for Cobb’s wren by Falklands Conservation and FIG (2008d).

The behaviour of Cobb’s wrens, favouring dense coastal tussock backing boulder beaches, not only makes them susceptible to rats but also to any events that could result in shoreline oiling (Cobb’s wrens regularly forage for invertebrates along the strandline and beneath boulders in the intertidal zone). The small size and habitat preferences of these birds also make them impossible to survey accurately from a moving boat.

Eggs are laid between early October and December, and there are probably two broods per season (Woods, 1988; Woods and Woods, 1997).

Although Cobb's wrens were not recorded during the winter 2017 survey, they are known to be present on Cochon and Kidney Islands at this time.

Kelp goose (KGo)

Kelp geese were recorded throughout the areas surveyed during the summer 2016 coastal survey. This species is territorial and therefore was only recorded in pairs, or small family groups. During the winter 2017 survey, kelp geese were recorded more frequently in the sheltered waters of the inner Sound.

All other species

A number of other species of duck, shorebirds and land birds were recorded opportunistically during both coastal surveys (Table 7.17 above). However, due to difficulties in seeing these species from a moving boat, the results of this survey are not reliable enough to map the distribution of these species.

7.4.5.3.3 Summary of inshore bird abundance, distribution, life-cycle and behavioural characteristics

Table 7.22 provides a summary of inshore bird abundance, distribution, life-cycle and behavioural characteristics.

Table 7.22: Summary of inshore bird abundance, distribution, life-cycle and behavioural characteristics

Species	IUCN status	ACAP species [a]	FI priority species	Seasonal occurrence and distribution[a]	Breeding cycle	Feeding mode	Persistent ship associate[b]	Berkeley Sound breeding sites	Falklands population	Global population and trend
Sooty shearwater (*Puffinus griseus*)	NT	X	X	Present throughout the year but most of the population depart between Apr – Aug. Spring / Summer / Autumn / Winter	Start breeding at 4 yrs; Adults return Sept; 1 egg laid late Nov; Adults depart Mar; Chicks fledge April.	Surface seizing and pursuit diving (to c. 50 m)	X	Kidney Island	100,000 pairs 0.5% global population	20 million pairs Decreasing
Imperial shag (*Phalacrocorax atriceps*)	LC	X	X	Present throughout the year in high numbers, distribution restricted to inshore waters. Spring / Summer / Autumn / Winter	2-4 eggs laid Nov; Chicks fledge mid-Feb.	Pursuit diving	X	Cochon and Kidney Islands Outer Sound cliffs	c. 45,000 – 84,000 pairs	Unknown
Rockhopper penguin (*Eudyptes chrysocome*)	VU	X	✓	Winter foraging between Straits of Magellan and 39°N (1,400km). Spring / Summer / Autumn / Winter	Mating Oct 2 eggs laid mid Nov; Chicks fledge Mar; Adults depart April.	Pursuit diving to c. 100 m	X	Cochon and Kidney Islands Outer Sound cliffs	320,000 pairs 36% global population	1.23 million pairs Decreasing
Gentoo penguin (*Pygoscelis papua*)	LC	X	✓	Resident, primarily within 10 km up to 300 km in winter. Spring / Summer / Autumn / Winter	Nest building Sept; 1-2 eggs laid late Oct; 34 day incubation.	Pursuit diving to c. 100 m	X	Strike-off Point, Kidney Cove and Volunteer Point	121,500 pairs, 34% global population	387,000 pairs Stable
Magellanic penguin (*Spheniscus magellanicus*)	NT	X	✓	Majority recorded between Nov and Mar, absent during winter, feeding Patagonian Shelf and shelf break, Argentine coast Spring / Summer / Autumn / Winter	Adults arrive Sept; 2 eggs laid Oct; Chicks fledge Mar; Adults depart Apr.	Dive to depths of 140 m	X	Relatively sheltered low lying coasts; e.g. Kidney, Long Island and Volunteer Point	c.140,000 pairs 10% global population	1.3 million pairs Decreasing

Species	IUCN status	ACAP species [a]	FI priority species	Seasonal occurrence and distribution[a]	Breeding cycle	Feeding mode	Persistent ship associate[b]	Berkeley Sound breeding sites	Falklands population	Global population and trend
Rock shag (*Phalacrocorax magellanicus*)	LC	**X**	**X**	Present year-round, forages in coastal waters, often amongst kelp forests, returning to shore to roost on a daily basis. Spring / Summer / Autumn / Winter	2-5 eggs laid in Nov to mid Dec; Chicks fledge mid-Jan to late Feb.	Pursuit diver	**X**	Rocky coastlines throughout;	c. 32,000 – 59,000 pairs	Unknown
Falkland steamer duck (*Tachyeres brachydactyla*)	LC	**X**	**X**	Endemic to the Falklands, maintain territories year-round. Forage in coastal waters, regularly returning to land to rest. Spring / Summer / Autumn / Winter	5-10 eggs laid mid-Sept to Dec; Chicks fledge at 15-16 weeks old.	Upending and diving for molluscs and crustaceans	**X**	Relatively sheltered coast of the inner Sound	c. 9,000 – 16,000 pairs, common and widespread endemic	Unknown
Black-browed albatross (*Thalassarche melanophris*)	LC	✓	✓	Present year-round in high numbers across the Patagonian Shelf, less numerous over deeper waters. Spring / Summer / Autumn / Winter	Annual breeder; First breeding at 7 yrs; 1 egg laid mid Oct; Chicks fledge Apr/May.	Surface seizing and shallow dives (to c. 10 m) from the surface	✓	In the Falklands, 17 breeding sites, very large colonies on Jason Islands and Beauchêne Island.	c. 500,000 pairs. 76% global population	700,000 pairs Stable
Kelp gull (*Larus dominicanus*)	LC	**X**	**X**	Resident species, disperse in the winter to exploit foraging opportunities. Spring / Summer / Autumn / Winter	2-3 eggs laid Dec; Chicks fledge Mar.	Predators of young birds and eggs, marine inverts but also scavengers	✓	Long Island	c.24,000 – 44,000 pairs	3.3 to 4.3 million individuals

Species	IUCN status	ACAP species[a]	FI priority species	Seasonal occurrence and distribution[a]	Breeding cycle	Feeding mode	Persistent ship associate[b]	Berkeley Sound breeding sites	Falklands population	Global population and trend
Great shearwater (*Puffinus gravis*)	LC	X	X	Widespread over waters to the north of the Falklands between Dec – Apr, absent in the winter and spring. Vast majority observed are non-breeders. Spring Summer Autumn Winter	Adults return Sept; 1 egg laid end Oct; Chicks and adults depart late April.	Surface seizing and pursuit diving (to c. 20 m)	✓	Kidney Island only known site in the Falklands	20 pairs <0.1% global population	5 million pairs Stable
White-chinned petrel (*Procellaria aequinoctialis*)	VU	✓	✓	Widespread over shelf and oceanic waters in winter, shallower waters in spring summer. Most birds present are non-breeding visitors. Spring Summer Autumn Winter	Adults return Sept; 1 egg laid Oct/Nov; Chicks and adults depart Apr/May.	Surface seizing and pursuit diving (to c. 20 m)	✓	Kidney Island, New Island, Bottom Island	55-100 pairs <0.1% global population	1.2 million pairs Decreasing
Antarctic fulmar (*Fulmarus glacialoides*)	LC	X	X	Common autumn and winter visitor. Highest densities found over Patagonian Shelf waters but found throughout Falklands waters. Spring Summer Autumn Winter	Single egg laid Nov/Dec; Fledge Mar/Apr.	Surface seizing	✓	None	Non-breeder	4 million individuals Stable
King penguin (*Aptenodytes patagonicus*)	LC	X	X	Breeding cycle takes an entire year; therefore, adults visit colonies throughout the year. Spring Summer Autumn Winter	Mating Oct; 1 egg laid Nov-Mar 55 day incubation	Pursuit diving to c. 350 m	X	Volunteer Point	<1,000 pairs 0.04% global population	2 million pairs Increasing
Kelp goose (*Chloephaga hybrida*)	LC	X	X	Common resident species throughout the Falklands on rocky coasts. May move to overwinter in more sheltered areas between April and September. Spring Summer Autumn Winter	4-6 eggs laid Oct / Nov;	Grazes algae in the intertidal zone and coastal grasses	X	Breeds in the areas including exposed outer Sound	c. 10,000 – 18,000 pairs	Unknown

Species	IUCN status	ACAP species [a]	FI priority species	Seasonal occurrence and distribution[a]				Breeding cycle	Feeding mode	Persistent ship associate[b]	Berkeley Sound breeding sites	Falklands population	Global population and trend
Cobb's wren (*Troglodytes cobbi*)	VU	X	✓	Widespread but fragmented population, only found on predator (rat and cat) free tussock islands.				3-4 eggs laid Oct – Dec; May have two broods per year.	Invertebrates often forages in the beach	X	Cochon and Kidney Islands	Endemic, 6,000 breeding pairs	6,000 breeding pairs
				Spring	Summer	Autumn	Winter						
				Moderate	Moderate	Moderate	Moderate						
Tussock bird (*Cinclodes antarcticus*)	NT	X	X	Widespread but fragmented population, only breeds on predator (rat and cat) free islands.				1-3 eggs laid Oct-Dec; May have two broods per year.	Invertebrates often forages in the beach	X	Cochon and Kidney Islands	c. 15,000 – 28,000 pairs	Unknown
				Spring	Summer	Autumn	Winter						
				Moderate	Moderate	Moderate	Moderate						

[a] See section 7.4.5.5.2

[b] Indicates species that are attracted to vessels, as a potential source of food, and can form large flocks in the wake of ships.

Key: Relative abundance of seabirds within Falklands waters

• Not recorded	• Low	• Moderate	• High	• Very High

Source: BirdLife International, 2019; FIG, 2008a; White et al., 2002; Woods, 1988; Reid et al., 2007; Reid and Huin, 2005; Wolfaardt, 2012; Baylis, 2012; Woods and Woods, 1997.

7.4.5.4 Birds in Stanley Harbour and surrounding areas

Many of the common species of land birds of the Falklands can be found breeding around the coast of Stanley Harbour. Of these, species of duck (such as Patagonian crested ducks; *Lophonetta specularoides*) and kelp geese (*Chloephaga hybrida*) rely on the marine environment for food and are therefore susceptible to marine pollution. There are relatively few seabirds found within the Harbour, when compared with other inshore waters of the Falkland Islands. However, there is a small breeding population of Falkland steamer ducks (*Tachyeres brachydactyla*) and Magellanic penguins (*Spheniscus magellanicus*), and rock shags (*Phalacrocorax magellanicus*) are regularly seen in the Harbour.

In 2013, two coastal bird surveys, one in the winter (August) and the other in the summer (December), were conducted along the entire coastline of Stanley Harbour (Poncet, 2014). The results of these surveys form the basis of this baseline description of birdlife within Stanley Harbour.

The coastline of the harbour was split into seven transects (Figure 7.67). All birds within 100 m to seaward and 25 m inland of the coast were recorded as surveyors walked each transect. The results of the surveys are summarised in Table 7.23.

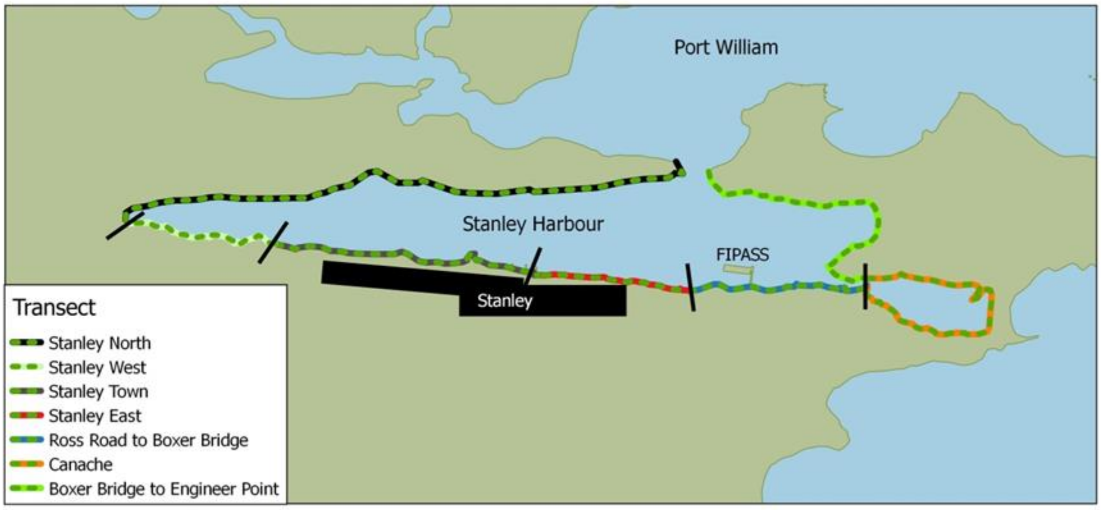


Figure 7.67: The Stanley Harbour coastline showing the coastal bird survey transects

7.4.5.4.1 Falklands steamer duck

The summer survey recorded steamer duck breeding territories at regular intervals around much of the Stanley Harbour coastline, with the exception of the coastline along the Stanley waterfront and the Canache where this species was relatively scarce. Breeding territories are occupied by the same pair throughout the year. In addition, aggregations of non-breeding steamer ducks were recorded at 'traditional' sites around the coast, mostly in the western end of the Harbour but also near the entrance to the Canache.

Table 7.23: A summary of the results of the Stanley Harbour coastal bird survey (from Poncet, 2014)

Transect	Length (km)	No. of species		Total No. of birds		Birds / km	
		Winter	Summer	Winter	Summer	Winter	Summer
Stanley North	6.46	18	18	291	315	45	49
Stanley West	1.7	16	12	131	123	77	72
Stanley Town	3.17	11	13	156	219	49	69
Stanley East	1.6	10	14	96	84	60	53
Ross Road to Boxer Bridge	2.05	18	15	199	140	97	68
The Canache	3.8	20	15	250	172	66	45
Boxer to Engineer Point	3.4	15	13	118	111	35	33
Total for Stanley Harbour	**22.18**	**-**	**-**	**1,241**	**1,164**	**56**	**52**

7.4.5.4.2 Kelp goose

Very few kelp geese breed within Stanley Harbour and the number of birds present during the summer is relatively low. However, during the winter kelp geese disperse and more birds can be found feeding in the sheltered waters of Stanley Harbour.

7.4.5.4.3 Passerines

Seven species of passerine (perching birds such as; Falkland thrush, black-chinned siskin, black-throated finch, long-tailed meadowlark, grass wren, Falkland pipit and house sparrow) were recorded along all coastlines. The town of Stanley with its trees, shrubs and buildings provide good habitat for passerine birds.

7.4.5.4.4 Waders

Although found in low numbers elsewhere, The Canache proved to be a local hot-spot for waders. This shallow embayment reveals inter-tidal mudflats at low tide, which attracts feeding waders. Although present year-round, the number of waders within The Canache is higher during the winter than the summer.

7.4.5.5 Seabird population and conservation status

Most seabird species are highly mobile, travelling thousands of kilometres across international waters and multiple Exclusive Economic Zones and generally only return to land to breed and moult. They face many serious conservation challenges throughout their migratory range and across all phases of the lifecycle, and are currently considered the most threatened group of birds (BirdLife International, 2014b). The species accounts in the previous section include the IUCN Red List threat categories for each species. It is important to note that these threat categories refer to the status of the global population, and not specifically the Falklands population. It is also useful to note that there are often regional differences in population trends. For example, on the basis of the most recent archipelago-wide census, the population trend for the black-browed albatross population in the Falklands is positive (Wolfaardt, 2012), whereas the South Georgia population continues to decline (Poncet *et al.,* 2006).

The population status of many of the abundant breeding seabirds in the Falkland Islands is relatively well understood thanks to a number of long-term monitoring projects conducted by Falklands Conservation and other research institutions, especially those conducting research at New Island. On the basis of the most recent archipelago-wide surveys of seabirds breeding in the Falkland Islands (in 2010), black-browed albatrosses, rockhopper and gentoo penguins were all found to be increasing in number. These archipelago-wide censuses are complemented by a number of annual monitoring studies, which highlight a high degree of inter-annual and inter-site variability in population numbers and breeding productivity. The king penguin population in the Falkland Islands, which is arguably insignificant in global terms, but is one of the islands' most important tourist attractions, has also been increasing since annual monitoring began in 1991 (Pistorius *et al.,* 2012, Crofts and Stanworth, 2018). However, these increases should not be taken to mean that the seabird populations in question are not susceptible and vulnerable to current and future threats, and indeed to the effects of multiple threats.

7.4.5.5.1 Threats to seabirds

Seabirds face threats both at sea and on land, at their breeding sites. Arguably one of the greatest threats to seabirds, particularly albatrosses and petrels, is the incidental mortality associated with fisheries (bycatch). Fisheries bycatch has been recognised as a critical threat to seabirds in the waters of the Falkland Islands (Sullivan *et al.,* 2003; Reid *et al.,* 2004). Following the introduction of effective mitigation measures and the adoption of a National Plan of Action for Reducing Incidental Catch of Seabirds in Capture Fisheries (NPOA-S, Longline), seabird bycatch associated with longline fishing in the Falkland Islands has been significantly reduced. Since 2007, there have been no reported seabird mortalities in the longline fishery (FIG, 2013c).

Significant levels of seabird mortality have also been recorded in the finfish trawl fishery in the Falkland Islands (Sullivan *et al.,* 2003). Although mitigation measures, and a NPOA-S (Trawl), have been adopted, and have contributed to a substantial reduction in mortality, seabirds are still killed incidentally in the trawl fisheries of the Falklands Islands. The estimated number of birds killed in the trawl fishery (mostly black-browed albatrosses) varies considerably from year-to-year (Figure 7.68; FIG, 2018). Inter-annual differences in estimated mortality are due to fluctuations in the recorded mortality rate rather than fishing effort (FIG, 2015n).

Other potential threats to seabirds include competition with commercial fisheries for food, habitat modification, introduced predators, disease and contamination from various forms of pollution. Research conducted in the early years of commercial fisheries in the Falklands found that although a number of seabirds utilise species that are commercially harvested, there was no conclusive evidence that competition with fisheries was having a negative impact on seabird populations (Thompson, 1992; Thompson and Riddy, 1995). Incidents of disease and harmful algal blooms have been recorded for several seabirds in the Falklands, but these tend to be isolated, rather than persistent factors. Although a number of seabird species have been found oiled in the Falkland Islands, to date, the numbers recorded have been relatively low, especially in relation to possible population level impacts.

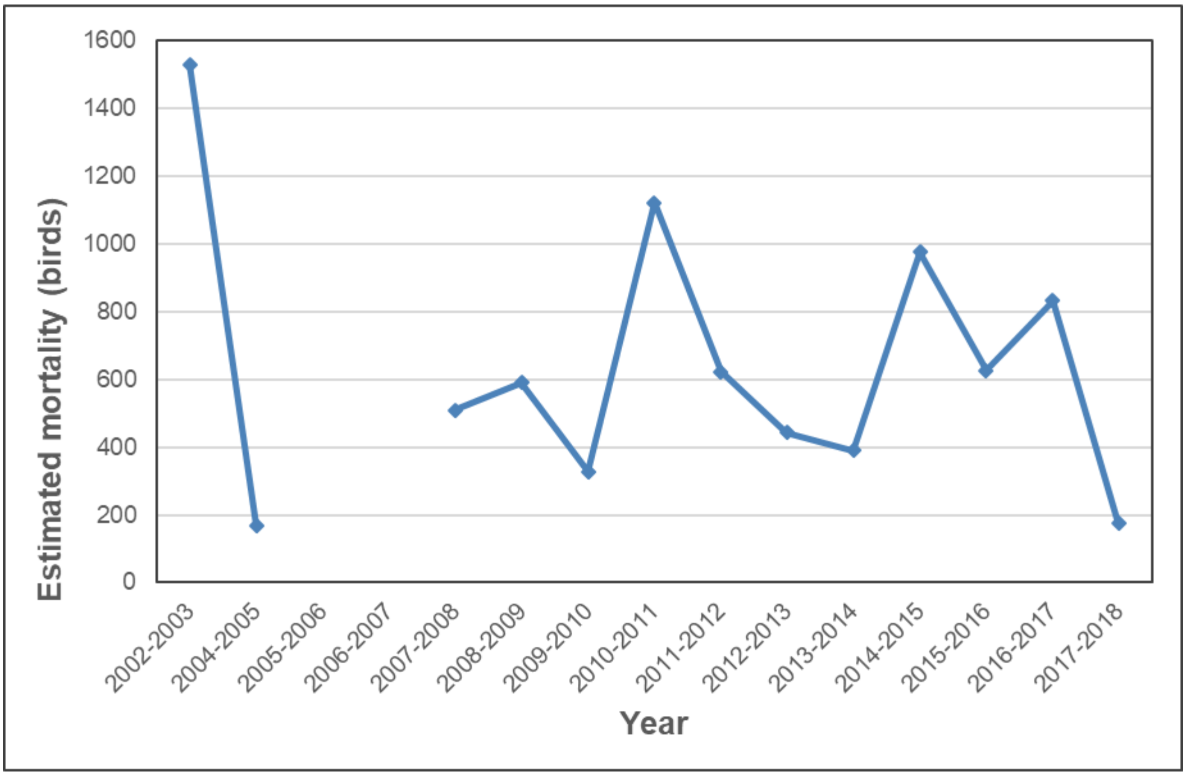


Figure 7.68: Annual estimates of seabird bycatch in the Falkland Islands trawl fishery (FIG, 2018)

7.4.5.5.2 Agreement for the Conservation of Albatrosses and Petrels (ACAP)

In recognition of the threat of fisheries related mortality and land-based threats at breeding sites a multilateral Agreement for the Conservation of Albatrosses and Petrels (ACAP) was established in 2004, which seeks to conserve albatrosses and petrels by coordinating international activity to mitigate known threats to their populations. ACAP is a daughter agreement to the Convention on the Conservation of Migratory Species of Wild Animals (CMS), which the Falkland Islands are signatories to. CMS's objective is to conserve migratory birds throughout their range; it identifies migratory species threatened with extinction (CMS, Appendix I) and strives to strictly protect these species. CMS also acts as a framework Convention for other regional agreements for migratory species that need international co-operation (CMS, Appendix II) to conserve them over their entire range, such as ACAP.

ACAP aims to stop or reverse population declines by co-ordinating action between States within migratory ranges to mitigate known threats to albatross and petrel populations. To achieve this ACAP promotes an Action Plan which describes a number of conservation measures including research and monitoring, reducing incidental mortality in fisheries, eradicating non-native species at breeding sites and reducing disturbances, habitat loss and pollution.

Currently, ACAP covers 30 species, which comprise 22 albatrosses, seven petrels and one shearwater. Of these species, eight were recorded over the waters within or adjacent to Berkeley Sound during JNCC surveys (White *et al.,* 2002; Black, 2005b). Two of these eight species have breeding populations within Berkeley Sound; a small but nationally important breeding population of white-chinned petrels on Kidney Island and two small colonies of southern giant petrels, one at the entrance to Volunteer Lagoon and the other on Peat Island. Table 7.24 shows the species listed under ACAP that occur within Berkeley Sound waters.

Table 7.24: ACAP species (ACAP, 2016) that have been recorded within the waters of the Falkland Islands

Common name	Scientific name	Local status	IUCN status
Black-browed albatross	*Thalassarche melanophris*	Common breeder	LC
Grey-headed albatross	*Thalassarche chrysostoma*	Regular visitor	EN
Grey petrel	*Procellaria cinerea*	Regular seasonal visitor	NT
Light-mantled sooty albatross	*Phoebetria palpebrata*	Regular visitor	NT
Northern giant petrel	*Macronectes halli*	Common visitor	LC
Northern royal albatross	*Diomedea sanfordi*	Regular visitor	EN
Sooty albatross	*Phoebetria fusca*	Rare visitor	EN
Southern giant petrel	*Macronectes giganteus*	Common breeder	LC
Southern royal albatross	*Diomedea epomophora*	Common visitor	VU
Wandering albatross	*Diomedea exulans*	Common visitor	VU
White-capped albatross	*Thalassarche steadii*	Rare seasonal visitor	NT
White-chinned petrel	*Procellaria aequinoctialis*	Rare breeder/Common visitor	VU

7.4.5.6 Seabird vulnerability to oil spill

One of the potential threats that need to be considered in relation to hydrocarbon developments is the impact of oil pollution. To date, reports of oiled seabirds in the Falkland Islands concern a small number of birds. However millions of seabirds have been killed globally by oil pollution (García-Borboroglu *et al.,* 2006 and 2008; Wolfaardt *et al.,* 2009). With the development of the O&G industry in the Falkland Islands, the risk posed to seabirds is an important consideration, especially given the global importance of this area for seabirds and the logistical challenges associated with responding to oil spill events.

Birds are vulnerable to oiling from surface oil pollution, which can cause direct toxicity through ingestion, and hypothermia as a result of a bird's inability to waterproof its feathers. Oil pollution can also impact birds indirectly through contamination of their prey (NRC, 2003). Seabird species vary greatly in their responses and vulnerability to surface pollution, therefore in assessing their vulnerability it is important to consider species-specific aspects of their feeding, breeding and population ecology (White *et al.,* 2001). Species that spend a greater proportion of their time on the sea surface are considered to be at greatest risk from the effects of surface pollution. Penguins are therefore more likely to be affected than the highly aerial petrels. Species that are wholly dependent on the marine environment for feeding and resting are considered more vulnerable to the effects of surface pollution than species that use offshore areas only seasonally or move offshore only to rest or roost. In addition, the potential reproductive rate of a species will influence the time taken for a population to recover following impacts. Other factors such as natural mortality rate, migratory behaviour, species abundance and conservation status (e.g. IUCN global Red List status) will also determine the effects of an oil spill on seabird populations.

7.4.5.6.1 JNCC Oil Vulnerability Index (OVI)

To assess the relative risk to different species, the JNCC developed an index to assess the vulnerability of bird species to the threat of oil pollution (Williams *et al.,* 1994). One of the main outputs of the SAST surveys in the Falkland Islands was the production of an Oil Vulnerability Atlas (White *et al.,* 2001). This analysis scored each species on four factors to produce an Oil Vulnerability Index (OVI). Recently, JNCC have updated the OVI to include recent survey data and using a new method, which has been named the Seabird Oil Sensitivity Index (SOSI). The OVI method is described below as this is the one that has been applied here. The OVI was applied to the density of that species recorded within each ¼ ICES square (an area measuring approximately 15 x 17 nautical miles), this data is summed to give the Area Vulnerability Score (AVS) for each ¼ ICES square. The AVS's for each square were plotted on a monthly basis to highlight areas that support vulnerable assemblages of seabirds throughout the Falklands Conservation Zones (White *et al.,* 2001).The results of the original analysis were published in White *et al.* (2001) and the vulnerability maps for each month are presented in Figure 7.69 to Figure 7.72. These maps place the Sea Lion Field and Berkeley Sound into the wider context of Falkland Islands waters and generally, seabird density and consequently AVSs decreased with increasing water depth.

7.4.5.6.1.1 AVS in the Sea Lion Field (offshore)

During the austral summer (December to February; Figure 7.69), the vulnerability of the area in the immediate vicinity of the Sea Lion Field increased, from low in December to high in February. The species contributing most to this relatively high score were prion species, black-browed albatrosses, Magellanic penguins, Wilson's and grey-backed storm-petrels and great shearwaters. Areas to the north and west of the Field were low and moderate respectively. However, an area of very high vulnerability was identified to the south-east in January.

In the austral autumn (March to May; Figure 7.70), the immediate area around the Sea Lion Field received relatively low survey effort. In March, the area was regarded as moderate to high vulnerability, due to the presence of high densities of black-browed albatrosses, Magellanic penguins and great shearwaters with lower densities of rockhopper penguins, Wilson's and grey-backed storm-petrels and white-chinned petrels. In April and May, the area received lower survey coverage. At this time, low to moderate densities of Cape petrels and black-browed albatrosses were recorded with lower numbers of grey-headed albatrosses, Antarctic fulmars and prions also present.

During the austral winter months (June to August; Figure 7.71), the area of the Sea Lion Field is classed as an area of moderate vulnerability, at which time a patchy distribution of species typical of the Patagonian Shelf in winter, was recorded. The most numerous species in this area at this time were; prion species, black-browed albatross, Antarctic fulmar and Cape petrel.

Surveys during the austral spring (September to November; Figure 7.72) recorded relatively lower densities of seabirds than at other times of the year. The area of the Sea Lion Field is therefore classed as moderately vulnerable. The seabirds present during this period include; rockhopper/macaroni penguins, prion species, Wilson's storm-petrels, black-browed albatrosses and Magellanic penguins.

7.4.5.6.1.2 AVS in Berkeley Sound (inshore)

The JNCC analysis has not been performed specifically for coastal waters due to the lack of dedicated survey effort close inshore. Vulnerable areas within Berkeley Sound, for seabirds, are linked to the location of colonies and aggregations associated with these colonies. This information has been used to indicate the areas of greatest concern regarding seabird interactions with Oil and Gas activity within the Sound and Figure 7.69 to Figure 7.72 show high or very high vulnerability throughout the year. The data available regarding known breeding populations allows some inferences regarding seasonal oil spill vulnerability within Berkeley Sound. High densities of resident species, such as gentoo penguin, rock and imperial shags (*Phalacrocorax magellanicus* and *P. atriceps*) and black-browed albatrosses are found in coastal waters year-round. During the summer, these are joined by large breeding populations of seabirds that spend the winter elsewhere, which results in the very high vulnerabilities.

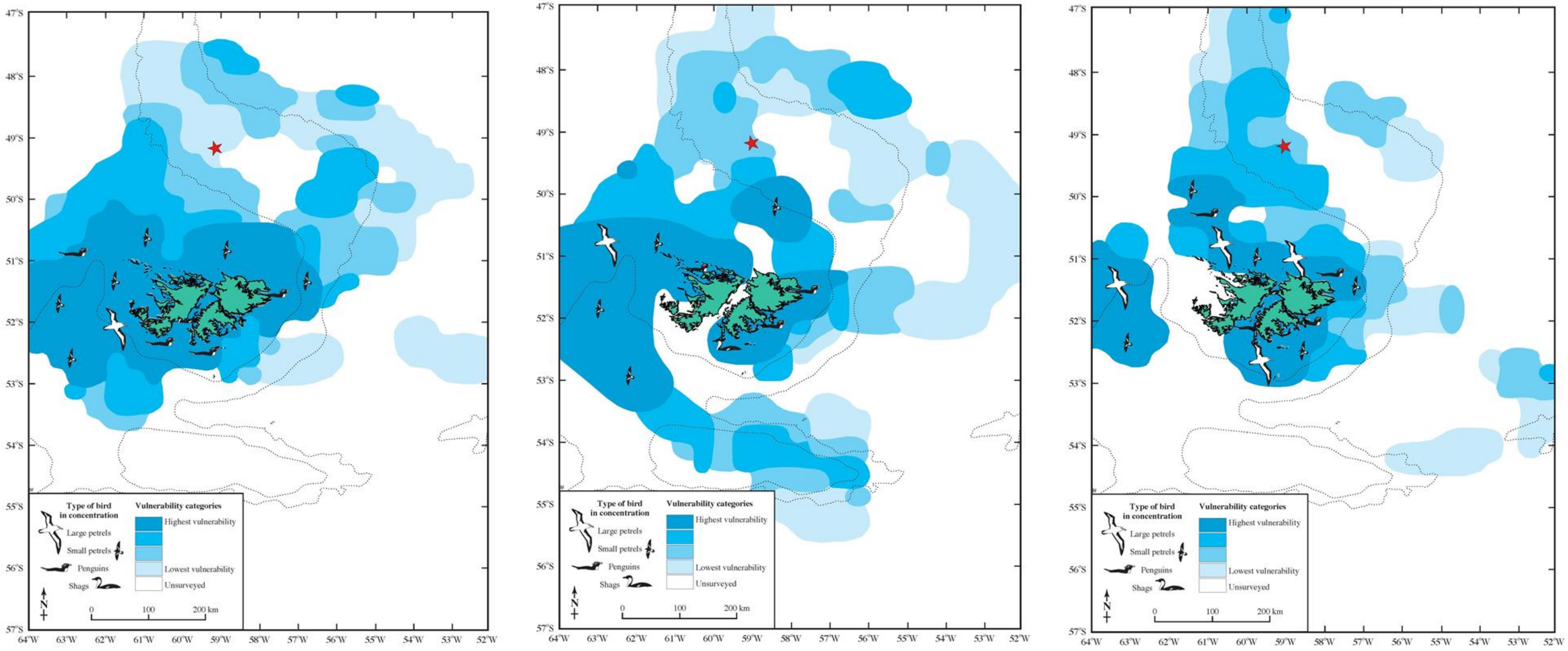


Figure 7.69: Seabird Vulnerability Maps for summer months; December (left), January (centre) and February (right) (the red star indicates the location of the Sea Lion Development) *(source: White et al. (2001))*

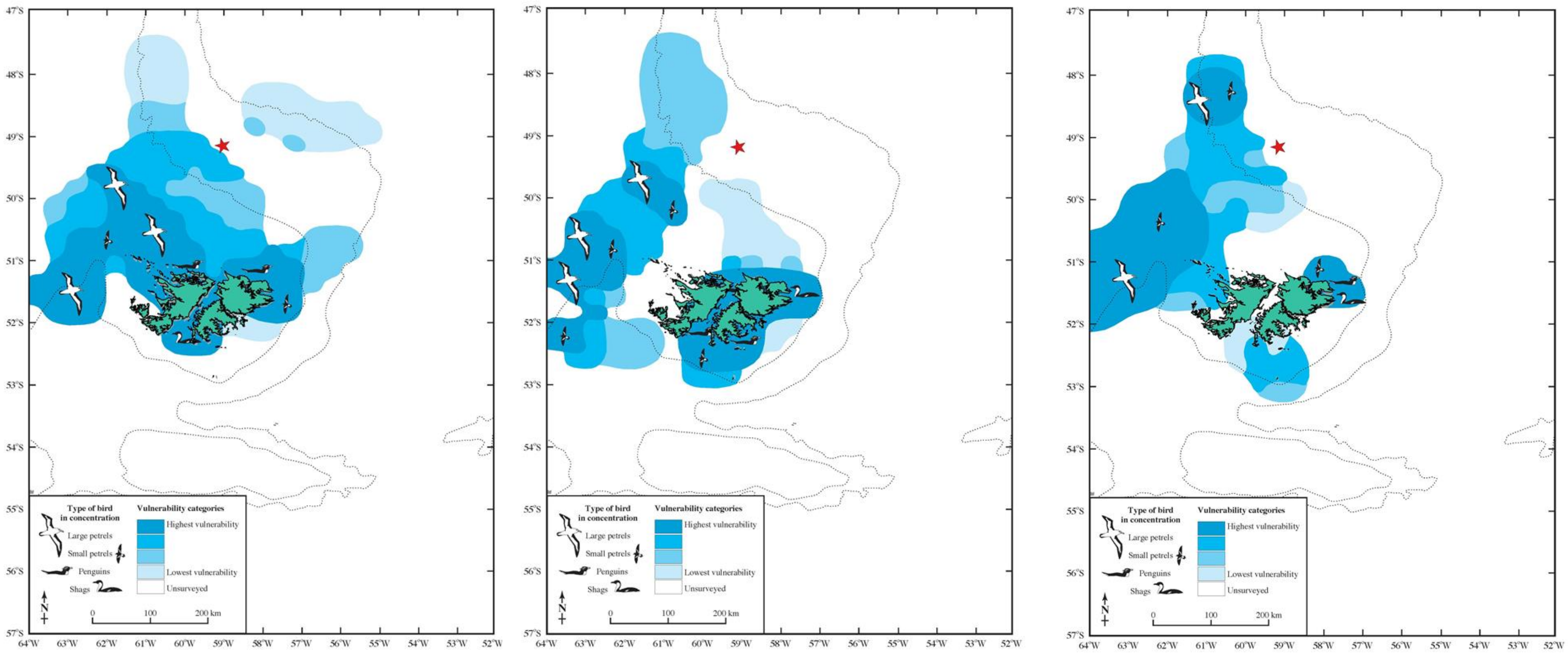


Figure 7.70: Seabird Vulnerability Maps for autumn months; March (left), April (centre) and May (right) (the red star indicates the location of the Sea Lion Development) *(source: White et al. (2001))*

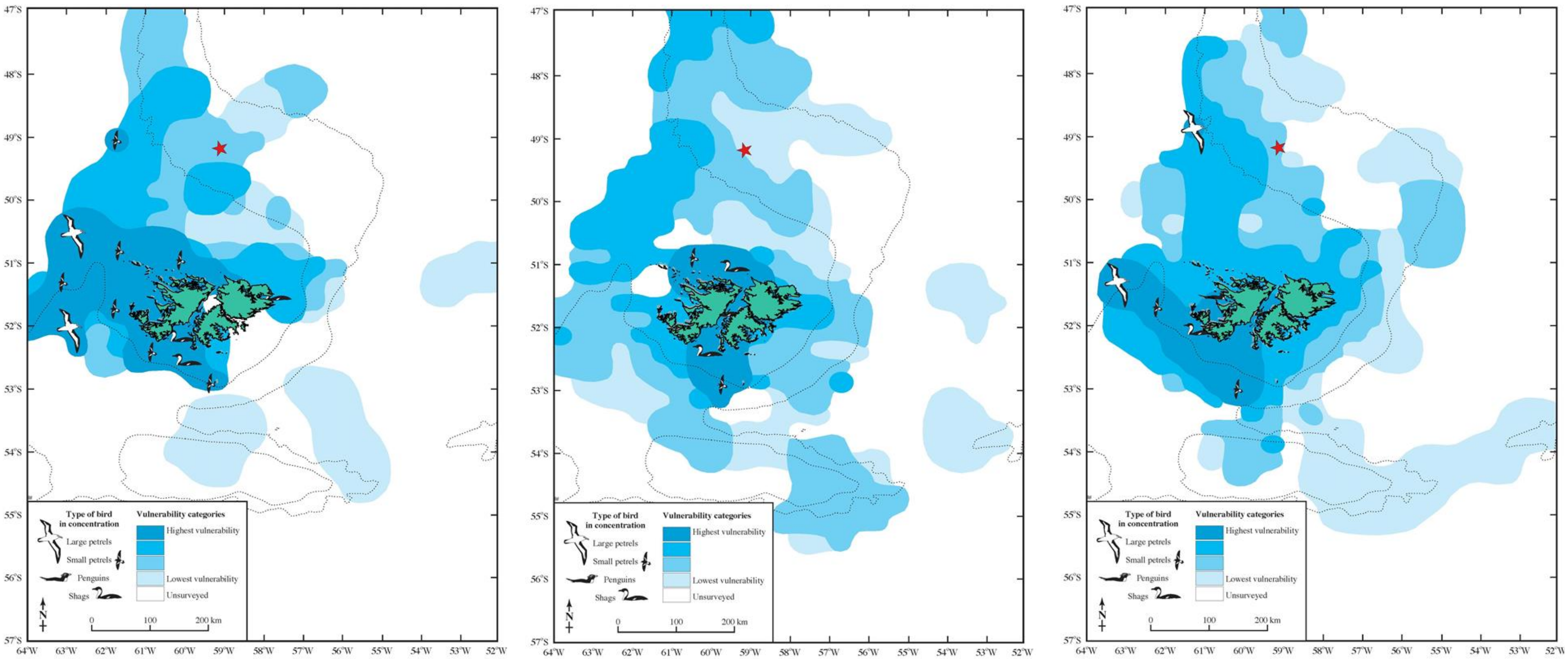


Figure 7.71: Seabird Vulnerability Maps for winter months; June (left), July (centre) and August (right) (the red star indicates the location of the Sea Lion Development) *(source: White et al. (2001))*

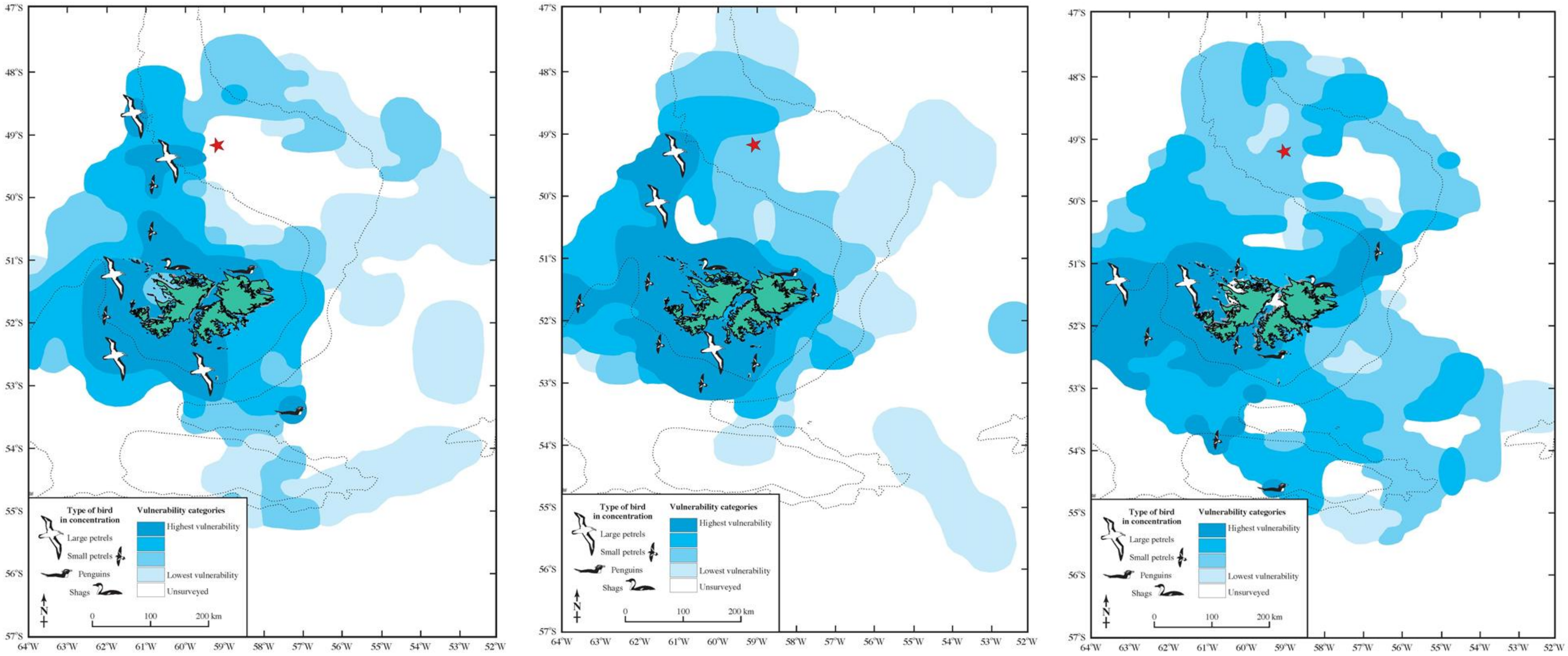


Figure 7.72: Seabird Vulnerability Maps for spring months; September (left), October (centre) and November (right) (the red star indicates the location of the Sea Lion Development) *(source: White et al. (2001))*

7.4.6 Marine mammals

7.4.6.1 Introduction

Marine mammals can be divided into two main categories:

- Cetaceans (whales, dolphins and porpoises) which can be further divided into:
  - Baleen whales (Mysticeti) such as the humpback whale, sei whale and right whale, which feed by extruding plankton from seawater which is filtered through baleen plates; and
  - Toothed whales and dolphins (Odontoceti) such as killer whales, sperm whales, dolphins and porpoises which all have teeth for prey capture.
- Pinnipeds (seals, sea lions and furseals):
  - Fin-footed, semi-aquatic marine mammals that spend part of their time hauled out on land to rest, moult and breed.

The following describes the cetacea and pinnipeds known to be present in the NFB and in, and around, Berkeley Sound.

7.4.6.1.1 Cetaceans

Although cetaceans are not tied to land to breed, many species return to specific areas to calve, reproduce or feed each year. During the non-breeding period, many of the larger species make ocean-wide migrations to exploit specific feeding grounds, often at high latitudes. It is believed that many of the baleen whales recorded offshore within Falkland Islands waters are on passage through the area to and from these feeding / breeding grounds.

The abundance and availability of prey, including plankton, fish and squid, can, therefore, be of prime importance in determining the number and distribution of marine mammals and it is thought that the productive inshore waters around the Falkland Islands (including Berkeley Sound) are of importance as feeding areas for visiting and resident species.

Confirmed sightings and stranding records indicate that at least 25 species of cetacean occur within Falkland Islands waters. Many of these species are locally rare and / or inconspicuous with some only known from stranded animals (Otley, 2012). It is generally considered that there are insufficient data available to describe the foraging and breeding areas, seasonal distribution and abundance, and diet of most marine mammal species in the Falklands (FIG, 2008a). Therefore, the dispersion of marine mammals within Berkeley Sound, and more widely around the Falkland Islands, remains poorly understood. Nonetheless, the available data suggest that several species are present in the area, some on a seasonal basis. Both the visual and acoustic survey methods described below have recognised limitations which need to be acknowledged. However, the datasets have been used in a complementary manner to provide a better overall picture.

7.4.6.1.2 Pinnipeds

At least, six pinniped species have been recorded in the Falkland Islands in recent years, three of which are known to breed on the islands. These are the:

- South American fur seal (*Arctocephalus australis*);
- South American sea lion (*Otaria flavescens*); and
- Southern elephant seal (*Mirounga leonina*).

Two of the species listed above, the fur seal and the sea lion, are known to breed within Berkeley Sound (Thompson *et al.,* 2005; Strange, 1992).

In addition to this, seasonal and vagrant visitors include:

- The Antarctic fur seal (*Arctocephalus gazella*) - seasonal visitor;
- The leopard seal (*Hydrurga leptonyx*) - occasional visitor; and
- The Ross seal (*Ommatophoca rossii*) -vagrant.

It is possible that other species from the Antarctic or sub-tropics occur as rare visitors or vagrants also, for instance sub-Antarctic fur seal, (*Arctocephalus tropicalis*).

Fur seals and sea lion are eared seals (Otariidae), while the elephant, leopard and Ross seals are earless or 'true seals' (Phocids), which are less agile on land than eared seals, due to their less flexible hind limbs.

7.4.6.2 Marine Mammals in the NFB and Sea Lion Field (offshore)

7.4.6.2.1 Cetacean abundance and distribution surveys in the NFB and the Sea Lion Field (offshore)

The Falkland Islands support a diverse range of marine mammal species. Much of the information regarding the status of marine mammals in the Falklands comes from anecdotal reports and records of stranded animals (Otley, 2012; Augé *et al.,* 2016). However, there have also been a number of at-sea surveys that have collected information on the abundance and distribution of marine mammals. From February 1998 to January 2001, a team of Joint Nature Conservation Committee (JNCC) observers systematically conducted at-sea surveys of seabirds in the waters of the Falkland Islands (White *et al.,* 2002). Although these surveys and the methodology used were designed specifically to map seabird distribution, all marine mammals observed were recorded.

The results of these surveys have been used to map and describe the distribution of marine mammals in the Falkland Islands. White *et al.* (2002) remains the most comprehensive account of the at-sea distribution of marine mammals within the waters of the Falkland Islands waters. However, the age of the dataset, and inherent limitations associated with at-sea surveys, raise uncertainty as to how representative it is of present day populations. In recent years, the collection of data by marine mammal observers on seismic vessels (Polarcus, 2011; Geomotive and MRAG, 2011) and the deployment of acoustic monitoring devices (Hipsey *et al.,* 2013) have added to our knowledge of the distribution and abundance of marine mammals in the region.

Key outcomes from the following surveys are described below:

- Marine mammals recorded during JNCC seabirds at-sea team (SAST) surveys
- Acoustic monitoring survey of marine mammals in the vicinity of the Sea Lion Field (including a description of the acoustic baseline determined during the survey)

- Marine mammal observations during seismic surveys in the NFB

7.4.6.2.1.1 Marine mammals recorded during JNCC seabirds at-sea team (SAST) surveys

Visual surveys were conducted during 91 cruises covering a total area of 20,907 km^2. Figure 7.73 shows the area covered and the total survey effort between 1998 and 2001 in relation to the Sea Lion Development area. Since the end of the JNCC supported project, some additional seabird and marine mammal surveys have been conducted within Falkland Islands waters, using the same methodology. However, these datasets have yet to be collated and analysed as a whole. There is evidence that the number of large cetaceans present around the Falkland Islands has increased since the time of the JNCC surveys (Augé *et al.,* 2016).

The JNCC surveys documented 6,550 individuals, comprising 17 species of marine mammal, including 14 species of cetacean and three pinniped 'species'.

Survey effort was generally greatest during the summer months due to longer daylight hours. Survey effort was lowest during the autumn months when the survey bases (Fishery Patrol Vessels, FPVs) were required elsewhere. Figure 7.74 shows the relative occurrence of sightings for each species throughout the year. These data are adjusted to account for the differences in monthly survey effort. Although several species appear to be present throughout the year (for example, sperm whales and Peale's dolphins), others exhibited a marked seasonality (for instance, hourglass dolphin *Lagenorhynchus cruciger* and southern bottlenose whale *Hyperoodon planifrons*). Baleen whale sightings were relatively infrequent between May and September, which is likely due to the migratory behaviour of these species.

It is possible to broadly describe the seasonal occurrence and general distribution of most species of cetacean. Combined with more recent survey data, a better understanding of Falkland Islands cetacean populations is developing but much remains to be learnt regarding the rarer species.

The three commonest species recorded during the JNCC surveys were all dolphins and accounted for 68.4 % of all cetacean records. The most commonly recorded species was Peale's (644 sightings) with hourglass (150 sightings) and Commerson's dolphins *Cephalorhynchus commersonii* (84 sightings) also regularly recorded. Southern right whale dolphins *Lissodelphis peronii* were only observed on five occasions. The three most frequently recorded dolphin species each exhibited a distinct spatial pattern of dispersion with very restricted overlap in their ranges (see species accounts below). However, there was evidence of seasonal variation in the dispersion pattern of hourglass dolphin.

The JNCC surveys did not record all cetacean species that are known or believed to occur around the Falkland Islands. A number of species have been found stranded in the Falkland Islands (Otley *et al.,* 2012; Otley, 2012; Augé *et al.,* 2016) but were not observed during the JNCC surveys (White *et al.,* 2002). In addition to seven beaked whale species (Otley *et al.,* 2012), dusky (*Lagenorhynchus obscurus*) and bottlenose dolphins (*Tursiops truncatus*), spectacled porpoise (*Phocoena dioptrica*), and pigmy right whale (*Caperea marginata*) each have between 1-4 stranding records in the Islands (Otley *et al.,* 2012). The majority of the stranded species that were not recorded during JNCC surveys were beaked whales which are notoriously difficult to observe at-sea and even more difficult to identify to species level. Apart from southern bottlenose whale, which is reasonably easy to identify, the majority of beaked whales sighted were recorded as 'beaked whale species'. None-the-less, Gray's (*Mesoplodon grayi*) and strap-toothed beaked whales (*M. layardii*) have been positively identified during at-sea surveys in the southwest Atlantic, outside Falkland Islands waters. All 17 of the 'unidentified beaked whales' recorded within Falkland Islands waters during the JNCC surveys were encountered in waters greater than 1,000 m deep to the east of the Islands.

There are a number of limitations of visual surveys, which should be considered whenever using these data. Experienced and skilled observers are required and many species spend considerable periods of time below the surface, where they are undetectable. Sea state and visibility will also affect the reliability of visual surveys. The use of multiple observers and distance sampling survey techniques can increase the reliability of the data collected during dedicated marine mammal surveys but these techniques were not applied during JNCC surveys. Acoustic methods may help to quantify the abundance of marine mammals but these methods also have limitations. The vocal range of many of the species encountered within Falkland Islands waters is unknown. The combination of visual and static acoustic monitoring can provide a more rigorous survey methodology through amalgamation of both datasets.

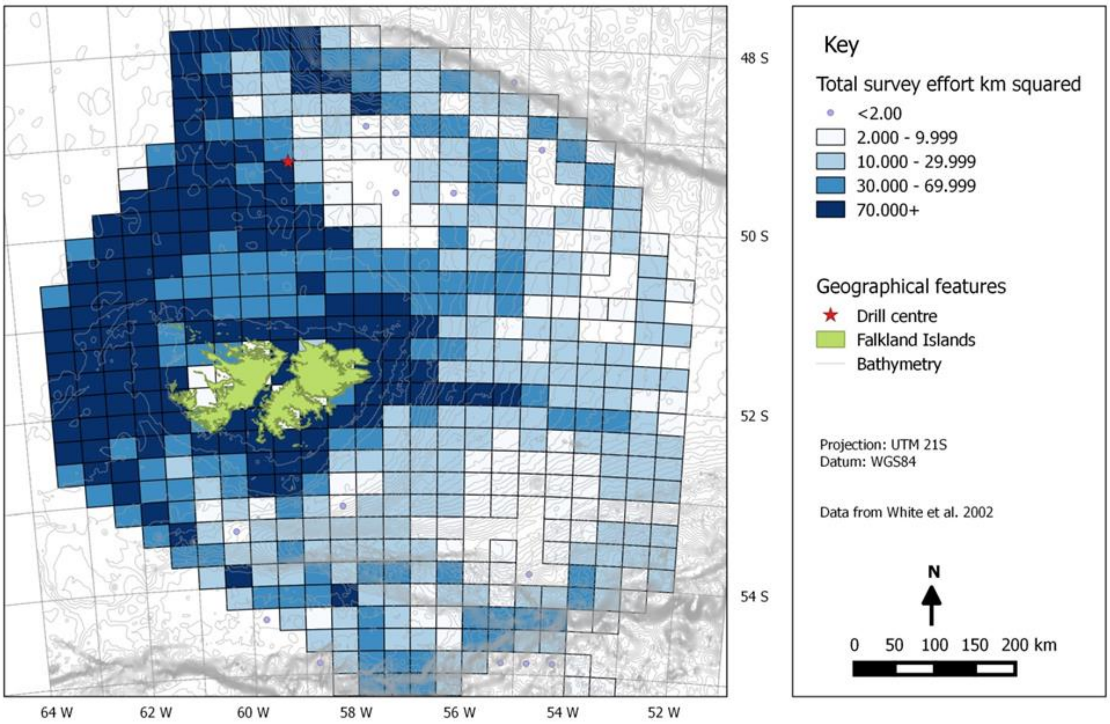


Figure 7.73: Total survey effort achieved during JNCC surveys between February 1998 and January 2001 (White *et al.,* 2002)

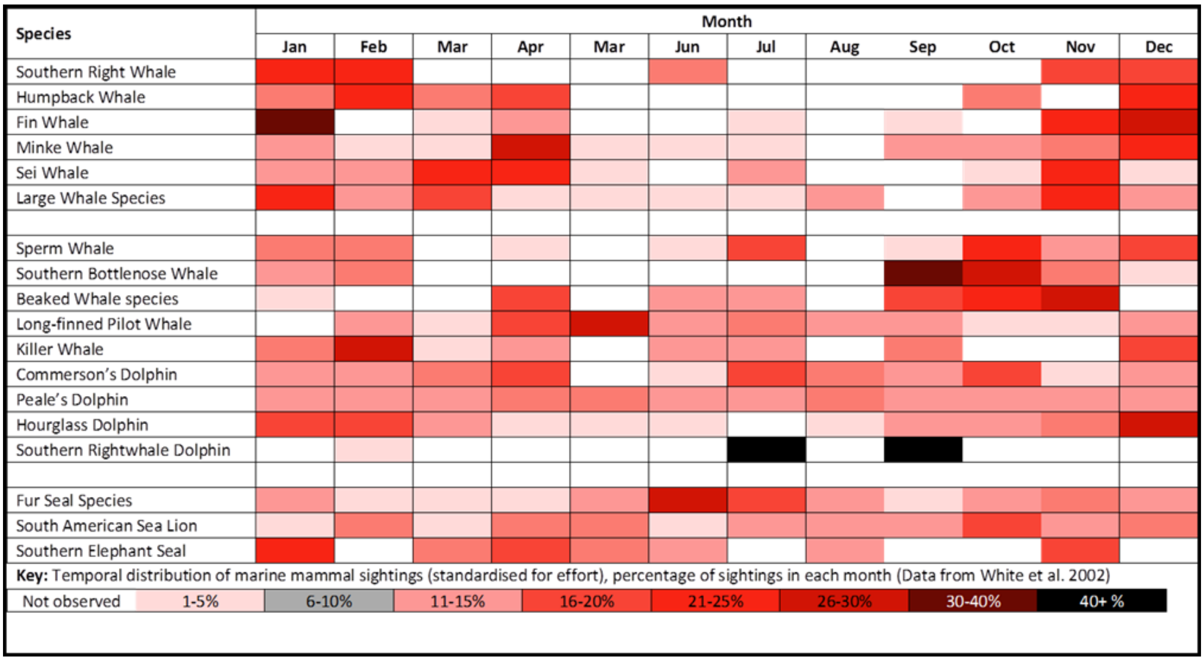


Figure 7.74: Relative incidence of marine mammal sightings, by species, adjusted for monthly survey effort *(Adapted from: White et al. 2002).*

7.4.6.2.1.2 Acoustic monitoring survey of marine mammals in the vicinity of the Sea Lion Field

From 2012 to 2013, Rockhopper Exploration conducted a one-year static acoustic monitoring programme in the Sea Lion Field, using wideband acoustic recordings to examine the spatial and temporal distribution of resident and transitory marine mammal populations from their vocalisations (Hipsey *et al.,* 2013). Full details of the monitoring survey and results are described in Hipsey *et al.* (2013). The aim of the acoustic survey was to enhance the existing marine mammal dataset collected during the three-year JNCC SAST surveys and more recent seismic surveys, to provide a more comprehensive dataset for assessing potential impacts from future hydrocarbon related development of the area. A persistent, autonomous passive acoustic monitoring programme was selected as it provides an almost continuous survey methodology, which is not hampered by factors restricting the effectiveness of visual surveys, (such as, nightfall, poor visibility due to rain and fog, and long mammal dive periods) and the approach does not require the permanent presence of vessels with trained human observers. Additionally, since sound can travel significant distances underwater, the spatial coverage of a static recording programme typically extends much further than the visual horizon. Acoustic detection ranges vary by species but low-frequency cetaceans (mostly baleen whales) can be detected tens to hundreds of kilometres away from a suitably sensitive recording instrument (Stafford *et al.,* 2007). Signals from species vocalising and echo-locating at higher frequencies may also be detected but usually at shorter ranges of hundreds to thousands of metres (Zimmer *et al.,* 2008; Kyhn *et al.,* 2009).

The one-year acoustic monitoring programme was split into three, four month recording phases, with mooring and recording equipment deployed at the beginning and retrieved at the end of each phase. During each of the three recording phases, five moorings were laid in 413 to 423 m of water, two moorings deployed a deep-water Autonomous Multichannel Acoustic Recorder (AMAR, JASCO Applied Sciences) and three a deep-water variant C-POD cetacean click detector (Chelonia Ltd.).

Although acoustic monitoring provides a number of advantages for marine mammal detection over visual surveys, there are also some limitations. The results of the survey record the number of vocalisations, which implies relative abundance but do not indicate the location or number of animals present. There is no assessment of inter-species, seasonal, sexual or age related differences in vocalisations, which are likely in species such as baleen whales that rely more on sound for communication than navigation or prey detection. Additionally, there is limited knowledge regarding the range of vocalisations produced by each species. For example, Hipsey *et al.* (2013) did not record any sei whales, although they are known to be regularly sighted during visual surveys. Since the data was analysed in 2013, the known range of vocalisations produced by Antarctic minke whales has been extended to include what are known as ‘bioduck sounds’ (Risch *et al.,* 2014). Therefore, the acoustic data may contain records of this, and other, species that were previously overlooked. Additionally, the survey only covered a period of one year, further data is required to gain a better understanding of inter-annual variation in cetacean presence / abundance.

The acoustic surveys recorded six species of marine mammal; a summary of the results is presented below in Figure 7.75 to Figure 7.80 and Table 7.25. Presented here is the combined hourly distribution of sound files with marine mammal call detections based on the manual analysis of 5% of the acoustic data recorded 31 July 2012 to 24 July 2013 within the Sea Lion Development Area for both Autonomous Multichannel Acoustic Recorders (AMARs). Note that AMAR 1 was not operational after 19 March 2013. Grey areas represent hours of darkness.

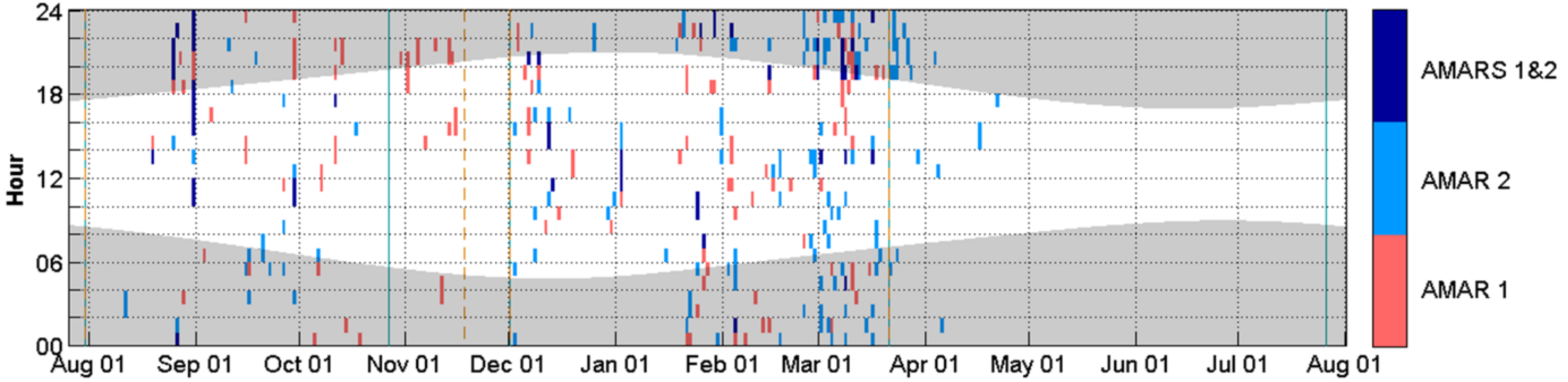


Figure 7.75: Fin whale call detections (source; Hipsey *et al.,* 2013)

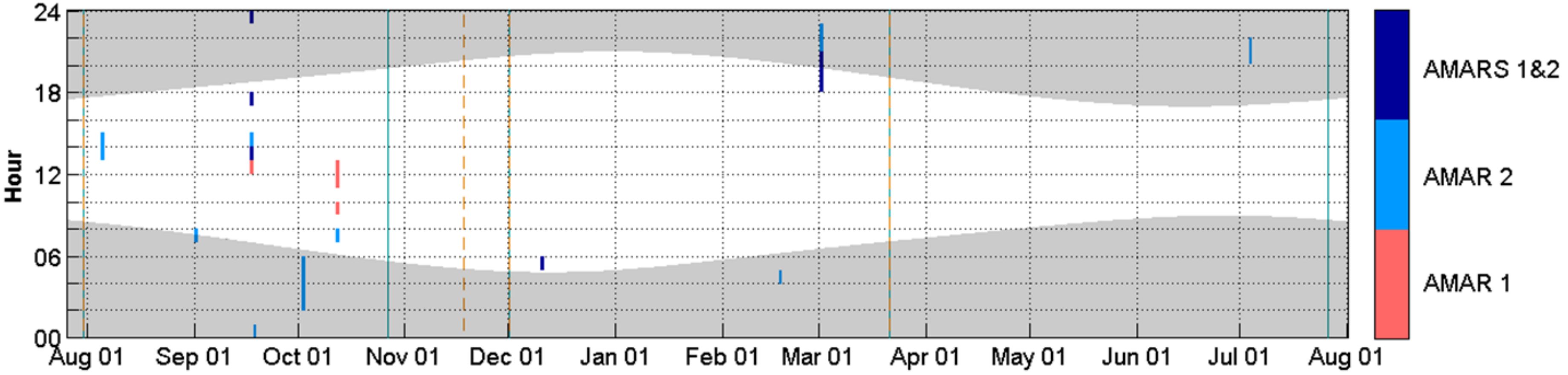


Figure 7.76: Killer whale call detections (source; Hipsey *et al.,* 2013)

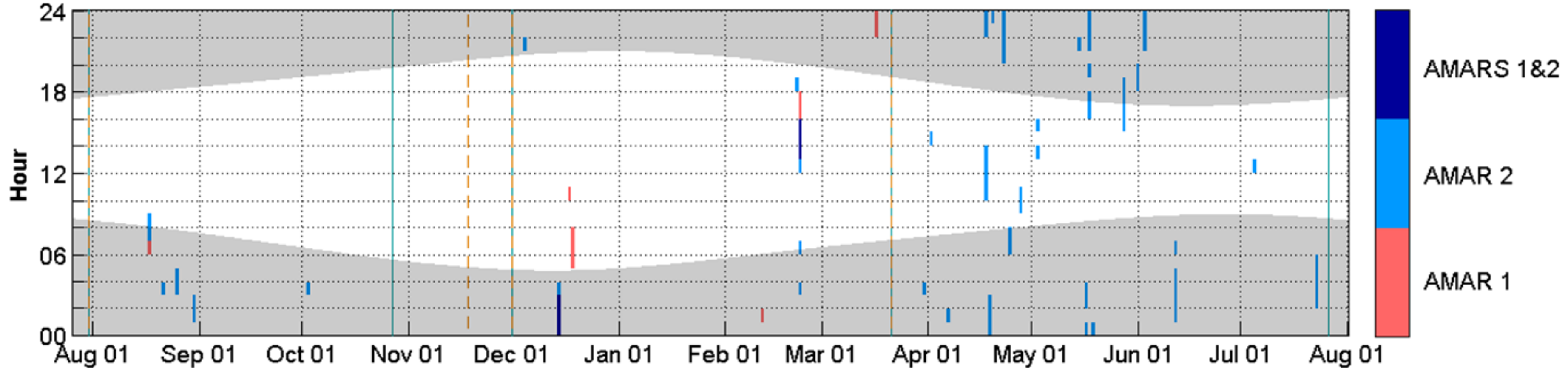


Figure 7.77: Pilot whale call detections (source; Hipsey *et al.,* 2013)

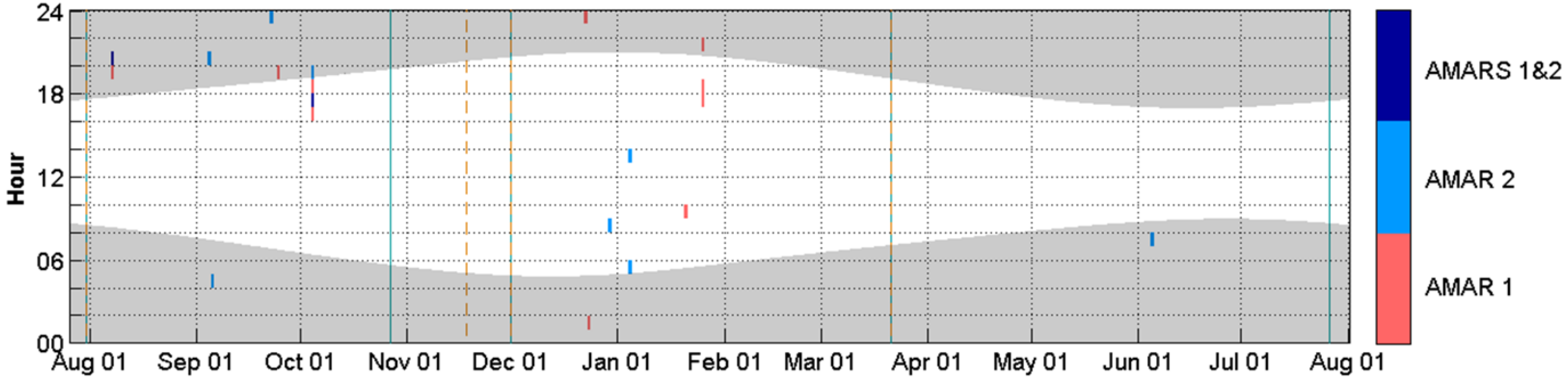


Figure 7.78: Southern right whale call detections (source; Hipsey *et al.,* 2013)

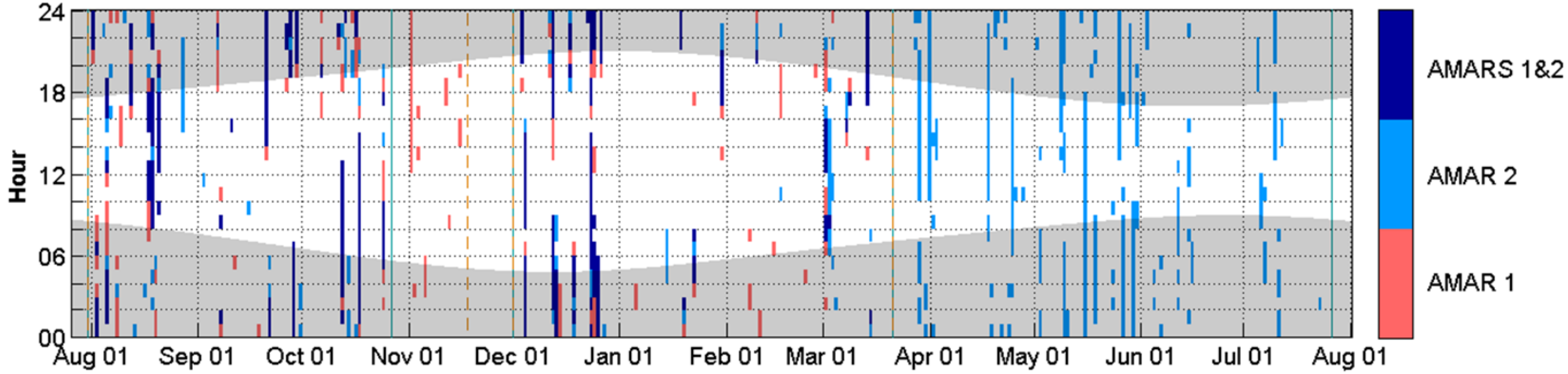


Figure 7.79: Sperm whale call detections (source; Hipsey *et al.,* 2013)

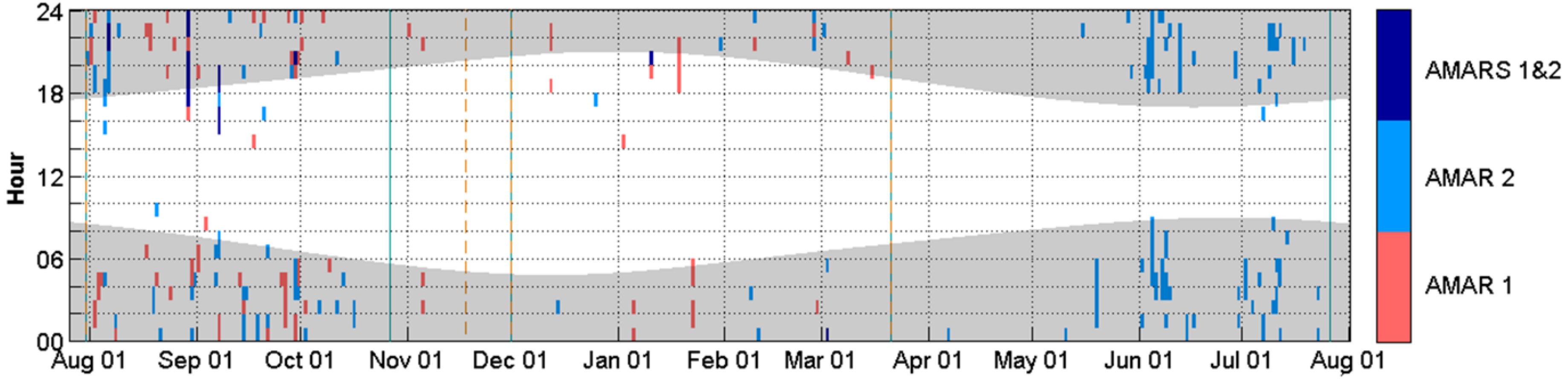


Figure 7.80: Unidentified odontocete (toothed whale) call detections (source; Hipsey *et al.,* 2013)

Table 7.25: Summary of the number of AMAR detections in vicinity of Sea Lion Field from July 2012 to July 2013

Species	Winter - Spring 31 July - 18 Nov 2012		Austral Summer 1 Dec 2012 - 21 Mar 2013		Autumn - Winter 21 Mar - 24 Jul 2013	
	AMAR 1	AMAR 2	AMAR 1	AMAR 2	AMAR 1 [a]	AMAR 2
Leopard seal	0	0	685	744	-	632
Sperm whale	297	208	364	333	-	577
Fin whale	84	48	111	169	-	21
Killer whale	10	15	11	17	-	7
Pilot whale	2	10	30	33	-	100
Southern right whale	9	6	6	4	-	1
Unidentified odontocetes	519	301	165	123	-	245

[a] *The AMAR 1 data was compromised and not analysed.*
(Source: (Hipsey et al., 2013))

Baseline underwater sound levels from acoustic monitoring

Ambient noise levels from each AMAR were examined to document baseline underwater sound conditions in the Sea Lion area. Recorded ambient noise levels were generally consistent with a remote, deep continental shelf location in a temperate climate with occasional fishing activity but little or no regular mercantile shipping traffic (Hipsey *et al.,* 2013). The results from the analysis of both AMARs were generally very similar throughout the recording period, which would be expected given the generally homogenous environmental and bathymetric conditions across the Sea Lion area.

The spectral distribution of sound levels recorded at both AMAR sites suggested a general absence of anthropogenic noise, and that the ambient noise spectrum was heavily influenced by weather conditions. Noise events such as vessels were infrequent and sporadic, except during the second half of February. During this period an increased but small number of detections were made at both AMAR sites (Hipsey *et al.,* 2013).

7.4.6.2.1.3 Marine mammal observations during seismic surveys in the NFB

In addition to the year-long acoustic monitoring programme in the Sea Lion Field, Marine Mammal Observations (MMO) were conducted as mitigation to minimise the potential impacts of seismic surveys being conducted in the NFB. Seismic surveys were conducted between January 2011 and May 2011 in the NFB (Geomotive and MRAG, 2011), and between November 2010 and May 2011 in Licence Block PL001 (Polarcus, 2011), which is adjacent to PL032.

Marine mammal observations by MRAG observers, totalling 1,310 hours and 11 minutes, recorded 142 encounters of 12 different marine mammal species in the NFB (Geomotive and MRAG, 2011).

The concurrent survey within Licence Block PL001 was conducted other a period of 109 days, totalling 794.5 hours of observations. Marine mammals were sighted on 109 occasions, corresponding to 462 individuals, and representing 11 species (Polarcus, 2011).

The MMO data from the seismic surveys provides additional information relating to the presence of marine mammals in the NFB during the austral summer and autumn, which complement the acoustic monitoring data for the Sea Lion Field.

7.4.6.2.1.4 Species-specific summary of cetacean distribution offshore

The following section collates the data from above to provide species-specific accounts of distribution within Falklands waters. A summary of the abundance, distribution, life-cycle and behavioural characteristics of cetacea offshore is provided in Table 7.26 below.

Southern right whale

There is evidence that the population of southern right whales (*Eubalaena australis*) that breed off Peninsula Valdes, Argentina, is increasing, with a doubling time of 10-12 years (Reilly *et al*., 2013). The migratory behaviour of southern right whales suggests that animals may travel through Falklands waters on passage between their Patagonian spring breeding grounds and summer feeding grounds near South Georgia and Antarctica.

The JNCC surveys recorded southern right whales (*Eubalaena australis*) on four occasions over the three-year survey period (White *et al*., 2002). Southern right whale up-calls were recorded in the Sea Lion area on 11 different days during the year-long monitoring period (Hipsey *et al*., 2013). Individual southern right whales were also recorded during the MMO of the seismic surveys, with 10 individuals sighted in PL001 and four individuals during the wider NFB survey (Geomotive and MRAG, 2011; Polarcus, 2011). These results suggest that this species may be more common than suggested by JNCC visual surveys, with animals present within the NFB in low numbers throughout most of the year. The migratory behaviour of southern right whales suggests that there will be peaks in numbers as these animals travel between their Patagonian spring breeding grounds and summer feeding grounds near South Georgia and Antarctica. There is evidence that the population of southern right whales that breed off Peninsula Valdes, Argentina, is increasing, with a doubling time of 10-12 years (Reilly *et al*., 2013).

During the winter of 2017, an unusually high number of southern right whales was recorded in coastal waters around East Falkland (section 7.4.6.3.1.2). This adds to the evidence of significant inter-annual variation in the number of these animals present within Falklands waters.

Blue whale

Historically, blue whales (*Balaenoptera musculus*) would have been present within Falkland Islands waters. At present they are sighted extremely rarely (Augé *et al*. 2016; Costa and Cazzola, 2018) within Falklands waters. Whaling in the Atlantic sector of the Southern Ocean killed many thousands of blue whales (Moore *et al*., 1999). Although there is anecdotal evidence that the number of encounters with blue whales are increasing, the paucity of blue whale sightings in the wider Scotia Sea indicates that the population of these animals has not yet recovered.

Fin whale

Acoustic monitoring recorded fin whales (*B. physalus*) in the Sea Lion area during late August 2012, and consistently in late winter and early spring (August and September) (Hipsey *et al*., 2013). Detections stopped abruptly in April and did not resume before the end of the monitoring in July. Fin whales were not sighted in August and October during the JNCC surveys (White *et al*., 2002). Five individuals were observed in September but most sightings occurred from November to January (White *et al*., 2002). Fin whales were sighted by MMO during both of the seismic surveys in the NFB, with largest numbers (12 individuals) recorded in waters adjacent to but west of the Sea Lion area (Geomotive and MRAG, 2011).

The acoustic monitoring programme recorded fin whales as present in the Sea Lion area from September until March, suggesting that past visual surveys (White *et al*., 2002) underestimated their occurrence north of the Falkland Islands or that there is inter-annual variation in the occurrence of fin whales in this area. In the nearby waters of the Scotia Sea (southeast of the Falkland Islands), large numbers of fin whales have been observed in recent years (A. Black pers. obs). However, most of these sightings are offshore and the exact location of these animals can show considerable inter-annual variation, which is likely to be linked to the distribution of food resources. The presence of these animals in waters to the south of the Falklands is seasonal and therefore it is reasonable to assume that many migrating animals will pass through Falkland Islands waters. Fin whales have recently been downgraded to Vulnerable on the IUCN Red List, due to increasing population size, and are also afforded conservation status and management under Convention on International Trade in Endangered Species (CITES) and the Convention on the Conservation of Migratory Species of Wild Animals (CMS).

Fin whales have been detected acoustically in the Scotia Sea and off the western Antarctic Peninsula starting in February and peaking in late summer and the autumn (Širović *et al*., 2009). Large aggregations of feeding fin whales were also observed in the autumn (March–April 2012) off Elephant Island at the tip of the Antarctic Peninsula (Burkhardt and Lanfredi, 2012). The peak in Falklands recordings in March followed by the cessation of all detections could therefore indicate a pulse of migrating whales from those feeding grounds.

Sei whale

JNCC surveys recorded 45 sei whales (*B. borealis*). Most of these were off the east coast of the Islands (White *et al*., 2002). Sei whale was the most frequently sighted, and third most abundant, species recorded during the MMO of the PL001 seismic survey with 67 individuals recorded (Geomotive and MRAG, 2011), and the third most frequently sighted, fourth most abundant, species recorded during the NFB seismic survey (Polarcus, 2011). Conversely, analysis of the acoustic data from the Sea Lion area did not contain any confirmed sei whale calls. It is believed that this is due to the potential overlap in calls from sei and fin whales (Watkins, 1981; Baumgartner *et al*., 2008), it is possible that the fin whale detection records included some sei whale calls (Hipsey *et al*., 2013). Acoustic detection of sei whales is further hampered by the absence of sei whale call descriptions for the South Atlantic, Therefore, the lack of sei whale detections in the acoustic data is likely to be due to technical issues rather than an absence of the animals in the NFB.

For many years large numbers of sei, and possibly fin, whales have been observed in inshore waters around the Falkland Islands (White *et al*., 2002; Otley, 2012; Augé *et al.,* 2016). These animals are only present on a seasonal basis and are likely to pass through the NFB during their migration. Two recent projects have surveyed the distribution of sei whales, and other cetaceans, in inshore waters (Thomson and Munro, 2014, Weir, 2017; Costa and Cazzola, 2018). The preliminary results and anecdotal observations indicate that sei whales are frequently encountered in inshore waters during the summer and autumn months (see section 7.4.6.3.1 for further details). Sei whales are listed as Endangered on the IUCN Red List and are also afforded conservation status and management under CITES and CMS.

Antarctic minke whale

Antarctic minke whales (*B. bonaerensis*) were encountered widely within Falklands waters and recorded throughout the year, although most animals were recorded between September and April (White *et al*., 2002). Minke whales were recorded during both of the marine mammal surveys conducted during seismic operations in the NFB (Geomotive and MRAG, 2011; Polarcus, 2011) but were not detected by acoustic surveys (Hipsey *et al*., 2013). The lack of minke whales in the acoustic record is unexpected but could be due to poor knowledge of the vocal range of this species in the South Atlantic at the time of the analysis.

Humpback whales

Humpback whales (*Megaptera novaeangliae*) have been rarely recorded within Falklands waters. JNCC surveys encountered seven animals in Patagonian Shelf waters, all between October and March. Acoustic monitoring and marine mammal observations from seismic vessels did not record humpback whales in the NFB.

Satellite tracking (*Zerbini et al*., 2006) and photo-identification indicate that animals from the population breeding off the coast of Brazil migrate to feed off South Georgia and the South Sandwich Islands in the summer months. Satellite tracks and the lack of sightings of these animals suggest that few of these whales pass through Falklands waters during this migration.

Sperm whale

Sperm whales (*Physeter macrocephalus*) were observed on 21 occasions in the JNCC surveys, the highest number of sightings occurring in October. About half of the sightings occurred in an area just north of the Sea Lion area. Although this seems to be a small number of sightings over a three-year survey, the distribution of the records indicates that animals are present in the deeper waters of the FOCZ year-round. A single sperm whale was observed during the MMO in PL001 and four individuals were observed during MMO in the NFB seismic survey (Geomotive and MRAG, 2011; Polarcus, 2011). The low number of sightings is likely to be due to the behaviour of the animals, which spend much of their time below the surface, and the limited survey effort in their preferred habitat type. Nevertheless, because sperm whales echolocate almost continuously while diving, and dive for extended periods of time, acoustic monitoring is a powerful survey method for this species (Whitehead, 2003). Indeed, Hipsey *et al*., (2013) found sperm whales were the most commonly recorded species during their year-long study. Detections occurred throughout the acoustic monitoring period without any obvious seasonal trend.

Sperm whales are notorious for depredating Patagonian toothfish in the local longline fishery (White *et al*., 2002; Yates and Brickle, 2007). All the available evidence suggests that sperm whales, likely to be mature males, are present within the deeper waters of the Falklands Conservation Zones throughout the year.

Southern bottlenose whale

The JNCC surveys recorded southern bottlenose whales (*Hyperoodon planifrons*) between September and February. All encounters occurred in waters over 1,000 m deep. This species was apparently absent from Falklands waters in the winter months. This species was not detected during acoustic monitoring and a single animal was observed during seismic operations (Geomotive and MRAG, 2011).

Unidentified beaked whales

Beaked whales (*Mesoplodon species*) are notoriously difficult to identify at-sea and none of the 15 animals recorded during JNCC surveys were specifically identified. All sightings occurred in waters over 1,000 m deep, with the majority coming from the region of the Falkland Trench to the south east of the Islands. Stranding records indicate that a number of *Mesoplodon* species could be present within Falkland Islands waters (Otley *et al*., 2012).

Killer whale

The JNCC surveys recorded seven killer whale (*Orcinus orca*) sightings over three years, primarily on the Patagonian Shelf, (White *et al*., 2002). Killer whales were detected in the Sea Lion area on ten different days during the year-long acoustic monitoring period, with seven of the records occurring between July and mid-October (Hipsey *et al*., 2013). Killer whales were observed during the PL001 and NFB seismic surveys on two and one occasion respectively (Geomotive and MRAG, 2011; Polarcus, 2011). Killer whales are known to regularly depredate longlines in the Falkland’s Patagonian toothfish fishery when vessels are fishing in the north of the FOCZ, relatively close to the Licence Blocks (White *et al*., 2002; Yates and Brickle, 2007). Observers on fishing vessels recorded killer whales only to the northeast of the Islands despite a considerable amount of fishing in other areas throughout the year (Yates and Brickle, 2007). The evidence suggests that a small resident population of killer whales may occur in the region of the shelf-break to the north of the Falkland Islands.

Satellite tracking indicates that Type B killer whales migrate just east of the Falkland Islands when travelling between the Antarctic Peninsula and sub-tropical waters of the South Atlantic (Durban and Pitman, 2012). These animals appear to travel rapidly through the region but they could account for some of the acoustic detections and sightings.

Long-finned pilot whale

Long-finned pilot whale (*Globicephala melas*) sightings occurred primarily between February and September during the JNCC surveys (White *et al*., 2002). Acoustic detections from the Sea Lion area also indicated the presence of pilot whales during the austral autumn and winter, with the majority of detections occurring from mid-February until late August (Hipsey *et al*., 2013). Pilot whales were recorded on approximately 35 days throughout the year-long monitoring period (Hipsey *et al*., 2013). Several small groups of pilot whales were also observed during the seismic survey MMO, with a total of 88 individuals over three sightings in PL001 and 75 individuals over four sighting occasions in the NFB survey (Geomotive and MRAG, 2011;

Polarcus, 2011). In contradiction to most survey results, while observing on fishing vessels working in the deeper waters of the FOCZ, pilot whales were observed on a daily basis in large numbers during the summer but rarely during the winter months (A. Black pers. obs.).

The large number of pilot whale strandings on the Falkland Islands (Otley, 2012) suggests that there is a sizeable population associated with Falklands waters. This species is regularly sighted in large groups from fishing vessels operating over the deep-water slope (A. Black pers. obs.). White *et al*. (2002) often recorded other species of cetacean in association with pilot whales, especially hourglass dolphins and to a lesser extent southern right whale dolphins.

Peale's dolphin

Peale's dolphin (*Lagenorhynchus australis*) was the most commonly recorded marine mammal species during the JNCC survey period with 1,952 animals recorded during 644 encounters. Peale's dolphins were almost exclusively restricted to Patagonian Shelf waters and were only regularly recorded in waters deeper than 200 m to the south-west of the Falkland Islands (Figure 7.81). Peale's dolphins were regularly recorded at the western boundary of the Falklands EEZ, a strong indication that the distribution of the species is continuous between the Falkland Islands and mainland South America. However, genetic sampling from inshore waters indicates little genetic mixing between the Falklands and South American populations (Costa and Cazzola, 2018). There was no clear evidence of any seasonal changes in the abundance, distribution or behaviour of these animals.

Peale's dolphin was also the most frequently recorded marine mammal on both seismic vessel surveys (Geomotive and MRAG, 2011; Polarcus, 2011)

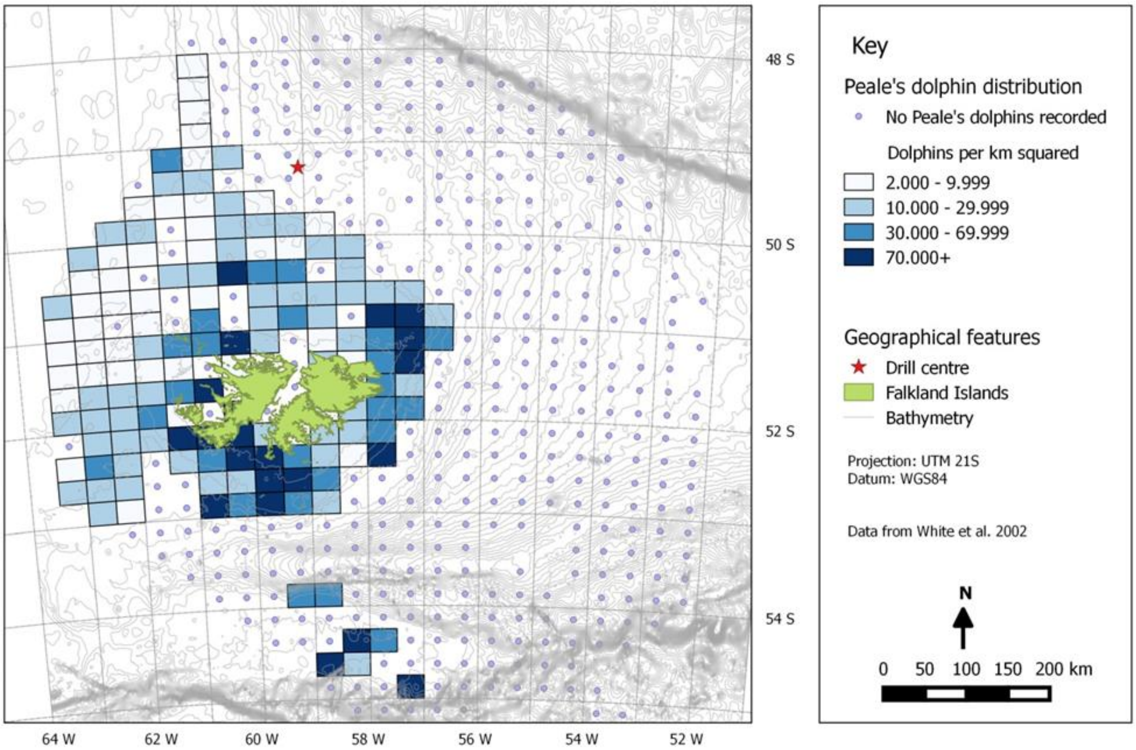


Figure 7.81: Peale's dolphin distribution recorded during JNCC surveys, all months

Hourglass dolphin

A total of 150 sightings of 792 hourglass dolphins (*L. cruciger*) was recorded during the JNCC surveys. Between September and February, hourglass dolphins were recorded frequently during surveys in oceanic waters. Outside this period, hourglass dolphins were only rarely recorded, suggesting that they occur seasonally within Falklands waters. The majority of hourglass dolphin records were in continental shelf slope and oceanic waters (Figure 7.82). The JNCC surveys clearly identified spatial segregation between Peale's and hourglass dolphins, with virtually no overlap in the ranges of these two species (White *et al*., 2002). Hourglass dolphins were also one of the most frequently recorded species from seismic vessels (Geomotive and MRAG, 2011; Polarcus, 2011).

The acoustic monitoring survey recorded an unidentified odontocete species (toothed whale; including killer whale and dolphins), which could not be definitively identified to species level (Hipsey *et al*., 2013). The occurrence of the odontocete calls closely matched the dolphin C-POD detections and the click characteristics and habitat preferences suggest the hourglass dolphin as the potential source (Hipsey *et al*., 2013).

It is likely that hourglass dolphins would occur in the deeper waters surrounding the Sea Lion area.

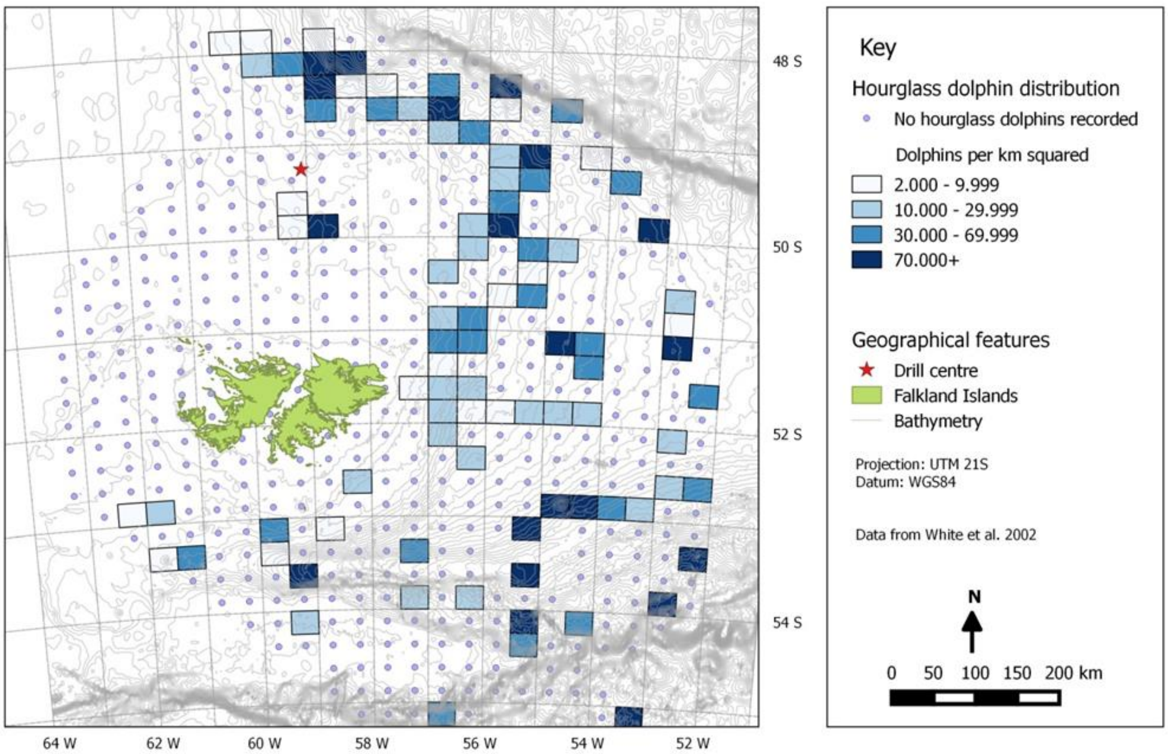


Figure 7.82: Hourglass dolphin distribution recorded during JNCC surveys, all months

Commerson's dolphin

Commerson's dolphins (*Cephalorhynchus commersonii*) were recorded during JNCC surveys in every month of the year except May. A total of 276 animals was recorded in 84 encounters. All records of Commerson's dolphins were from either partially enclosed or coastal waters in the immediate vicinity of the Falkland Islands (section 7.4.6.3.1.2).

Southern right whale dolphin

Southern right whale dolphins (*Lessodelphis peronii*) were only recorded on five occasions during JNCC surveys, all in waters over 200 m deep. However, the tendency for this species to occur in large groups resulted in a total of 231 animals recorded. Over half of these were in a single group of 120 animals, the largest group of any dolphin species recorded during surveys. On all five occasions when southern right whale dolphins were recorded they were in the company of long-finned pilot whales.

7.4.6.2.2 Pinniped abundance and distribution surveys in the NFB (offshore)

The presence of pinnipeds in the NFB was recorded during:

- The JNCC SAST surveys described above; and
- Acoustic monitoring within the Sea Lion Field; and
- Using satellite tracking studies.

7.4.6.2.2.1 Species-specific pinniped distribution and abundance in the NFB

The following describes the distribution and abundance of pinniped species in the NFB.

South American sea lion

Sea lions (*Otaria flavescens*) were recorded in all months but the majority of records came from inshore waters (White *et al.,* 2002). Sea lions were also recorded in low numbers during surveys from seismic vessels (Geomotive and MRAG, 2011; Polarcus, 2011).

Tracking of adult female sea lions indicates a high degree of specialisation regarding foraging strategy, which is consistent over a number of years. Although largely restricted to Patagonian Shelf waters, adult female sea lions displayed either inshore or offshore strategies, with offshore foragers consistently tracked to the edge of the Patagonian Shelf (waters of approximately 200 m depth). Telemetry and diet data indicate a further specialisation in animals foraging offshore, with individuals displaying either benthic foraging or a mixture of benthic and pelagic foraging (Baylis *et al*., 2015).

The predicted distribution, from tracking data, is shown in Figure 7.83, which supports earlier results of tracking and at-sea observations.

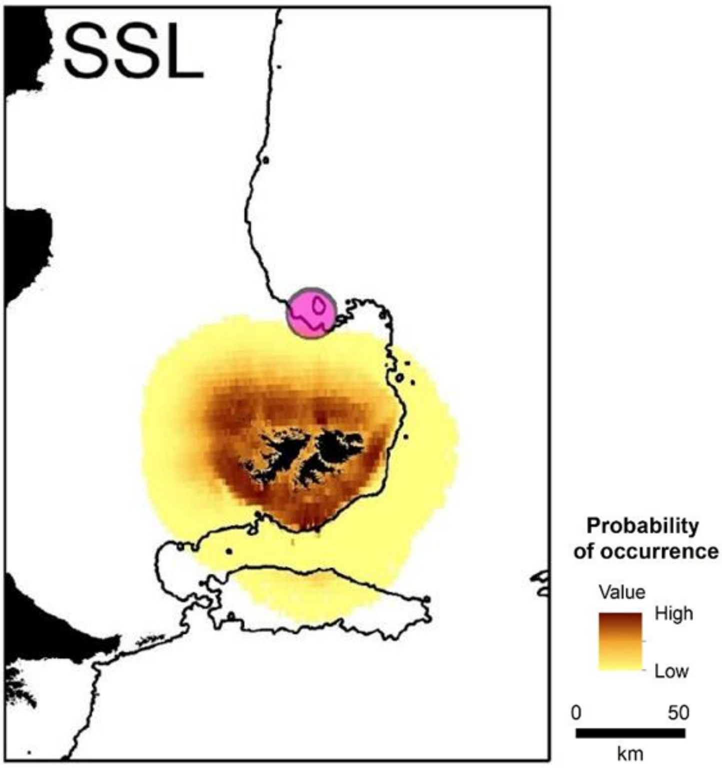


Figure 7.83: South American sea lion, predicted habitat use (predicted presence) for sea lions breeding on the Falklands from the available biotelemetry and biologging data. Adapted from Baylis *et al.* (2019). The pink dot represents the drill centre.

Fur seal species

Fur seals (*Arctocephalus* species) were the most numerous pinniped recorded during JNCC surveys. Although the observers were aware that South American and Antarctic fur seals were both present, it was not possible at sea to reliably identify all fur seals to species level and therefore all fur seals were recorded as ‘fur seal species’. They were recorded in all months but there was a distinct peak in the number recorded during the winter. It is thought that this marked an influx of Antarctic fur seals into Falklands waters from the South Georgia breeding population, a hypothesis that is supported by tracking data (Staniland *et al.,* 2012).

Fur seals from North Fur Island, Volunteer Rocks and Bird Island have been tracked during the winter non-breeding period and spring breeding (lactation) seasons (Figure 7.84A and B respectively. Throughout the tracking studies, fur seals rarely travelled beyond the edge of the Patagonian Shelf. During the mid to late lactation period (winter and spring), fur seals appear to disperse more widely, travelling as far as the South American coast, but remain over the Patagonian Shelf (Baylis *et al*., 2017).

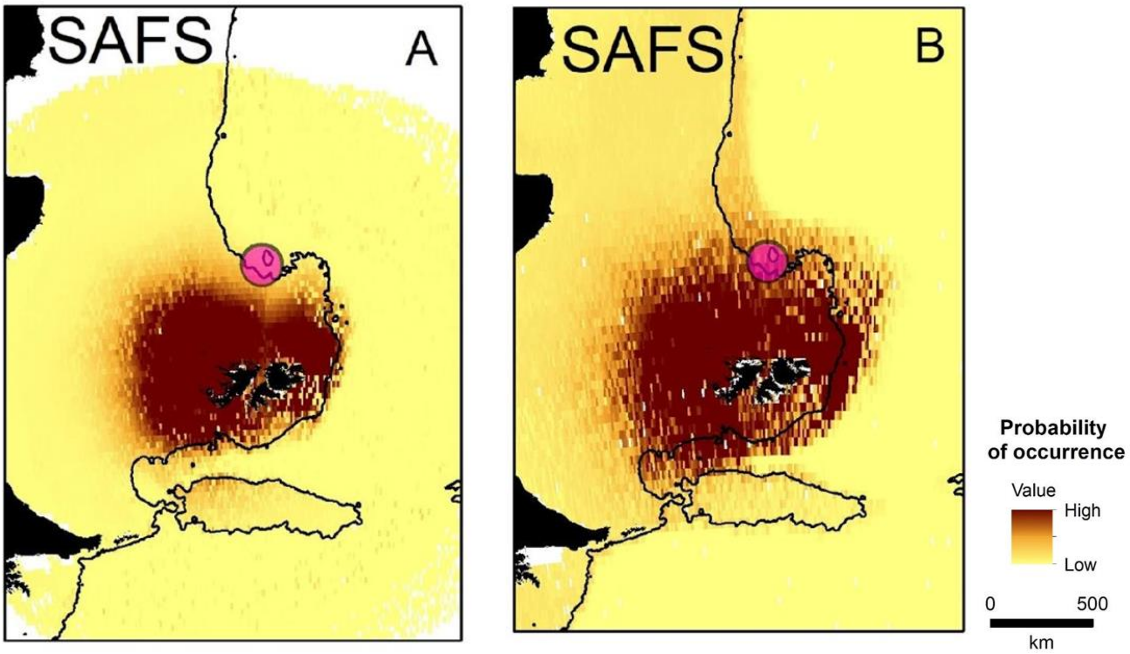


Figure 7.84: South American fur seal, predicted habitat use (predicted presence) for birds breeding on the Falklands from the available biotelemetry and biologging data. Adapted from Baylis *et al.* (2019). The pink dot represents the drill centre.

Southern elephant seal

Southern elephant seals (*Mirounga leonina*) spend the majority of the time below the surface, and therefore visual surveys are unlikely to accurately record the distribution of the species. White *et al.* (2002) recorded 13 southern elephant seals and no other visual or acoustic surveys have recorded this species. Most of the records were clustered along the shelf break to the north of the Islands.

Between 2009 and 2011, 23 female elephant seals were satellite tracked from Sea Lion Island (Galimberti and Sanvito, 2012), the main breeding location for elephant seals in the Falkland Islands. The resulting tracks indicate that the majority of foraging trips of the animals tracked are to the south of the Falklands (some extending into the South Pacific), although three animals were tracked to the shelf break to the north of the Falkland Islands.

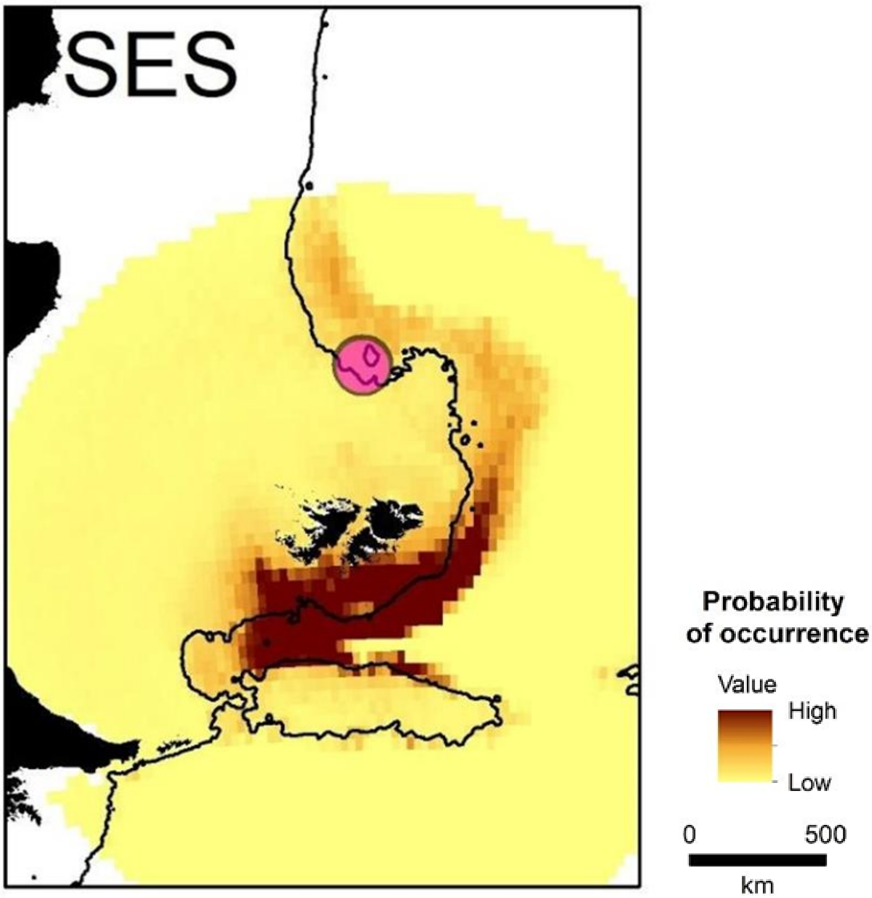


Figure 7.85: Southern elephant seal, predicted habitat use (predicted presence) for birds breeding on the Falklands from the available biotelemetry and biologging data. Adapted from Baylis *et al.* (2019). The pink dot represents the drill centre.

Leopard seal

Leopard seals (Hydrurga leptonyx) accounted for the greatest number of detections throughout the acoustic monitoring study with the majority of leopard seal detections occurring in March and April, and all detections concentrated in late austral summer and autumn (Hipsey *et al*., 2013). In contrast, there were no sightings of this species during the JNCC surveys or during the MMO on the seismic vessels in the NFB (White *et al*., 2002; Geomotive and MRAG, 2011; Polarcus, 2011). The characteristics of the recorded calls indicate the calling animals were sexually immature males (Hipsey *et al*., 2013). During the summer, leopard seals occur in the Antarctic pack ice and disperse northward with the advancing pack during the winter. Leopard seals are known to be more numerous around sub-Antarctic islands, such as South Georgia, in the winter months (Walker *et al*., 1998; Rodríguez *et al*., 2003). In the Falklands, individual leopard seals are seen from time-to-time but they are not regarded as anything more than occasional visitors (Strange, 1992). Records elsewhere in the world indicate that this species, particularly young males, have a tendency to wander far from their Antarctic breeding grounds (Aguayo-Lobo *et al*., 2011; Rodríguez *et al*., 2003; Hamilton, 1939).

7.4.6.2.3 Summary of marine mammals in the NFB

Table 7.26 provides a summary of marine mammal abundance in the NFB, distribution, life-cycle and behavioural characteristics.

Table 7.26: Summary of cetaceans in the NFB and Sea Lion Field

Species	IUCN status	Present in the Sea Lion area	Global distribution	Foraging strategy	Auditory type	Behaviour
Southern right whale	LC	✓ Spring / Summer / Autumn / Winter	Widespread in the southern hemisphere	Surface skim-feeding	Low frequency	Slow lumbering swimmers but can be acrobatic, breaching clear of the water or lifting the tail clear of the water. Growing population breeds off the coast of Argentina in September, migrates to Southern Ocean in the summer.
Blue whale	EN	✓ Although not recorded in the Sea Lion area during surveys, blue whales are known to be present in very low numbers in the region.	Found in all oceans in low numbers	Lunge feeding	Low frequency	Migrate between low latitude wintering grounds and high latitude feeding grounds in summer
Fin whale	EN	✓ Spring / Summer / Autumn / Winter	Found in all oceans of the world	Lunge feeding	Low frequency	Capable of swimming at speeds of 19 knots. Movements poorly understood but most frequently encountered off-shore or where deep water is found near the coast. Seen in small groups many of which may be present within a small area (10s of km^2)
Minke whale	LC	✓ Spring / Summer / Autumn / Winter	Globally, the most common of the rorquals	Lunge feeding	Low frequency	Movements poorly known but some populations appear to be resident year-round
Sei whale	EN	✓ The most abundant large whale seen in inshore waters also frequently sighted offshore.	Found in all oceans, sub-Antarctic waters are favoured feeding	Lunge feeding	Low frequency	Dives more regularly than most large whales, surfacing at approximately minute intervals. One of the fastest of the great whales, sei whales swim a few metres below the surface and progress can be followed by ‘fluke prints’ left on the surface in the animal’s wake.

Species	IUCN status	Present in the Sea Lion area				Global distribution	Foraging strategy	Auditory type	Behaviour
		Spring	Summer	Autumn	Winter	grounds in summer			
Humpback whale	LC	✓ Although not recorded in the Sea Lion area during surveys, humpback whales are known to be present in low numbers in the region.				Found in all oceans of the world	Lunge feeding	Low frequency	A population breeding off the coast of Brazil is thought to migrate to feed off the South Sandwich Islands in the summer months. However, these animals are not thought to pass through Falklands waters
		Spring	Summer	Autumn	Winter				
Sperm whale	VU	✓				Found from the Arctic to the Antarctic	Deep diving	Mid frequency	Sperm whales are encountered in the deeper water of the Falkland Islands throughout the year. All the animals present are males that periodically migrate to warmer waters to breed; however, these movements are not co-ordinated.
		Spring	Summer	Autumn	Winter				
Southern bottlenose whale	LC	✓				Found throughout the Southern Ocean	Deep diving	Mid frequency	Present in the deeper waters of the Falklands during the spring and summer months. A number of other species of beaked whale are present but these animals are rarely seen.
		Spring	Summer	Autumn	Winter				
Long-finned pilot whale	DD	✓				High latitudes in the northern and southern hemisphere	Shallow divers	Mid frequency	Can be encountered in large groups (100 + animals). There appears to be seasonal changes in distribution within Falklands waters but movements not fully understood.
		Spring	Summer	Autumn	Winter				
Killer whale	DD	✓				Found in all oceans of the world.	Shallow diving predators	Mid frequency	Killer whales are known to pass through Falklands waters on rapid transit from Antarctic Peninsula to sub-tropical waters. Additionally, there are likely to be resident populations. Seen year-round from longline vessels fishing to the north-east of the Sea Lion Field.
		Spring	Summer	Autumn	Winter				

Species	IUCN status	Present in the Sea Lion area	Global distribution	Foraging strategy	Auditory type	Behaviour
Commerson's dolphin	DD	×	Only southern South America, the Falklands and Kerguelen	Shallow diving	High frequency	Only observed in coastal waters.
Peale's dolphin	DD	✓ Largely restricted to the Patagonian Shelf (waters <200 m). Spring | Summer | Autumn | Winter	Restricted to southern South America and the Falkland Islands	Shallow dives	High frequency	Thought to be resident with no discernible seasonal movements detected in the survey data. More numerous inshore but found across the Patagonian Shelf (waters <200 m). Very enthusiastic bow-riders.
Hourglass dolphin	LC	✓ Most likely dolphin species to be encountered in the Sea Lion Field. Spring | Summer | Autumn | Winter	Found throughout the Southern Ocean	Shallow dives	High frequency	Thought to undergo seasonal movements, migrating northwards in winter and south in summer. Often seen accompanying other cetaceans, especially long-finned pilot whales.

Key: Relative abundance of marine mammals within Falklands waters

• **Not recorded**	• **Low**	• **Moderate**	• **High**	• **Very High**

7.4.6.3 Marine mammals in and around Berkeley Sound (inshore)

7.4.6.3.1 Cetacean abundance and distribution surveys in and around Berkeley Sound (inshore)

In recent years, several projects have focused on studying inshore cetaceans.

- A series of coastal bird surveys within Berkeley Sound also recorded marine mammals (SAERI, 2016, 2017, 2018 and 2019);
- Anecdotal observations of cetaceans around the Falklands have been collated to give an indication of trends in species abundance.
- Weir (2017) reports on dedicated surveys of sei whales, and other cetaceans, in Berkeley Sound;
- The 'Dolphins of the kelp' project focused on Commerson's and Peale's dolphins but also recorded other cetaceans within Berkeley Sound and elsewhere around the Falklands; and
- Tracking of fur seals from Volunteer Rocks and sea lions from colonies to the north and south of Berkeley Sound, which help to determine the use of inshore waters by these animals.

These sources supersede the marine mammal data collected in or adjacent to Berkeley Sound by JNCC SAST surveys, although this data still helps to provide historical perspective.

The relevant results from the above are summarised below with the data collated into species-specific summaries in section 7.4.6.3.1.7.

7.4.6.3.1.1 Cetaceans recorded during Berkeley Sound coastal bird surveys

The Berkeley Sound coastal surveys are designed to record animals along the coastal fringe, within 100 m of the shoreline, and therefore are not specifically designed to record cetaceans. Although Commerson's dolphin, Peale's dolphin and sei whales were recorded, these sightings add little to the findings of dedicated cetacean projects (see sections 7.4.6.3.1.4 and 7.4.6.3.1.5 below). The exception, however, was the winter of 2017, which saw an unprecedented influx of southern right whales into coastal waters off the east coast of the Falklands. Animals had been present for a number of weeks prior to the survey in late July and were recorded on several different days in the outer Sound (Figure 7.85). Southern right whales have also been recorded by several other independent surveys during the winter of 2017. Whether this is simply an unusual year or the start of a long-term trend is yet to be determined.

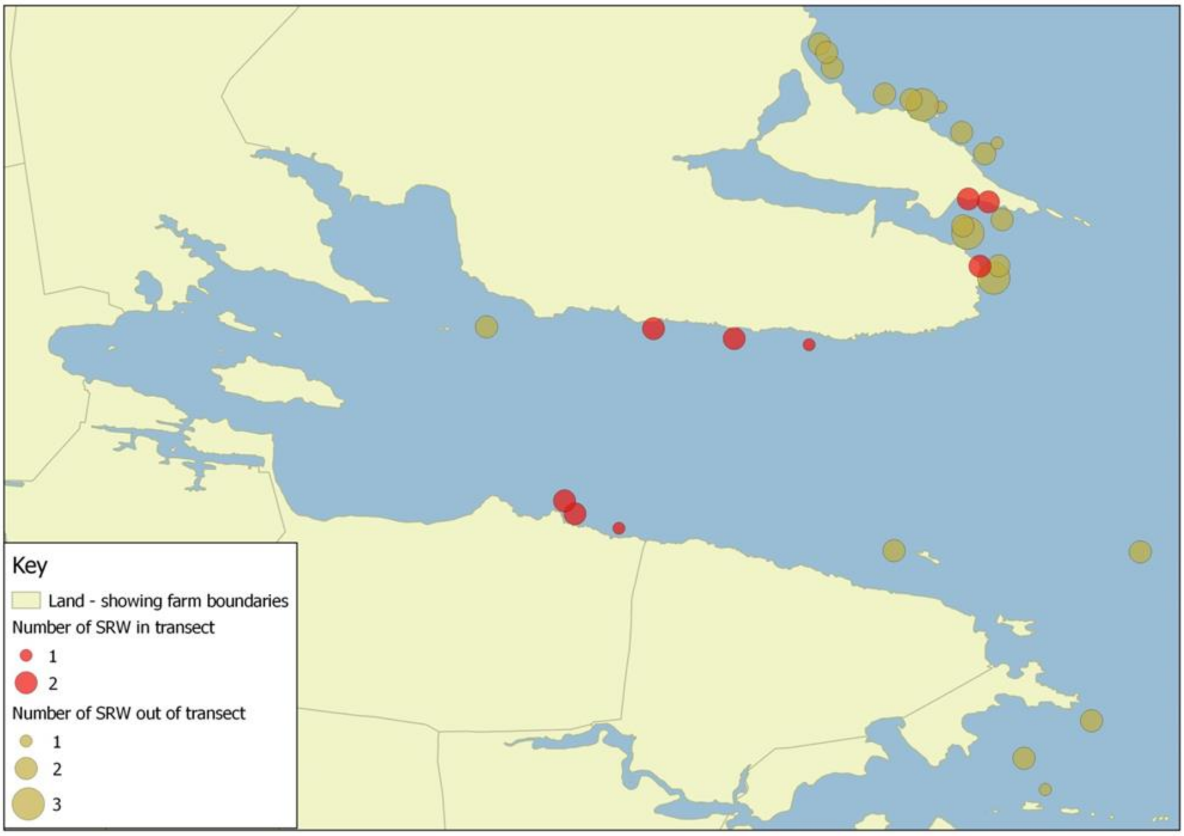


Figure 7.86: The distribution of southern right whale records during the winter 2017 survey

7.4.6.3.1.2 Cetaceans recorded during JNCC seabirds at-sea surveys

Observations of marine mammals were made and recorded during JNCC SAST surveys between 1998 and 2004, described in section 7.4.5.2.1.1. Although the methodology used was not specifically designed to survey the distribution of marine mammals, all animals sighted were recorded and White *et al.* (2002), remains the most comprehensive account of the at-sea distribution of marine mammals within Falkland Islands' waters.

It should be noted, however, that the survey vessels rarely entered Berkeley Sound or coastal waters (i.e. those less than 2 km from shore). An examination of the data collected in waters adjacent to Berkeley Sound gives a hint at the seasonal abundance of marine mammals in this restricted area; however, little dedicated survey effort was achieved within Berkeley Sound during the JNCC surveys, most effort is associated with the route taken in and out of Port William.

Table 7.27 shows the number of individuals of each marine mammal species recorded on a monthly basis. Figure 7.87 shows the distribution of cetacean in the waters adjacent to Berkeley Sound and shows an apparent association between many of the cetacean records and headlands, namely Volunteer Point, Mengeary Point and Cape Pembroke. It is possible that mixing created by currents and bottom topography make these areas particularly productive.

Table 7.27: Cetacean observations in waters adjacent to Berkeley Sound

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Peale's Dolphin	16	34	19	41	70	34	22	10	5	12	9	9	281
Sei Whale			4	2	1		4						11
Minke Whale				8		1				1			10
Commerson's Dolphin									3	4			7
Large Whale species			1				1						2
Southern Right Whale												1	1

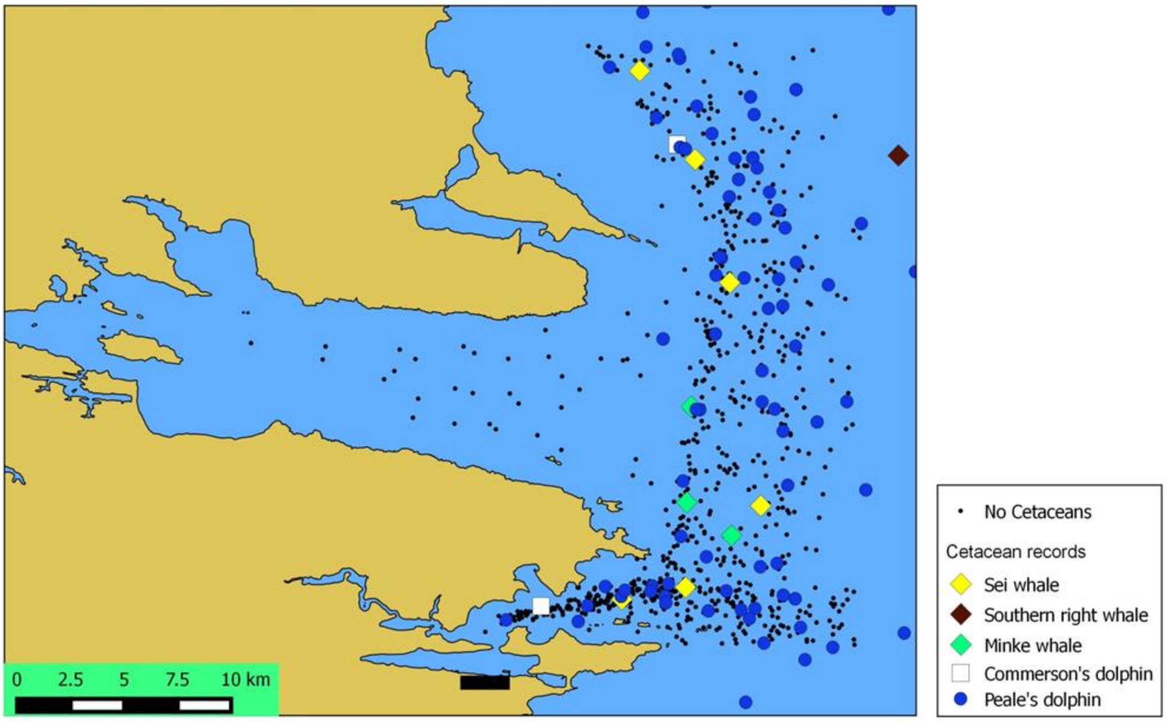


Figure 7.87: The distribution of all cetacean records in the waters adjacent to Berkeley Sound from SAST JNCC data

7.4.6.3.1.3 Anecdotal inshore cetacean sightings

As part of on-going development of the Falkland Islands Marine Spatial Plan, a project to record local ecological knowledge regarding large cetacean sightings culminated in 2016 (Frans and Augé, 2016). The results highlight a clear increase in numbers of whales sighted, from no observations in the 1970s to 350 observations between 2010 and 2015 (mostly of Endangered sei whales and Vulnerable fin whales) for similar observer effort.

Although seen throughout the inshore waters of the Falklands (see Thomson and Munro, 2014, Costa and Cazzola, 2018), several areas of high sighting density in recent years (since the 1990s) were identified, including Berkeley Sound (Figure 7.88a). There is some indication however, that some areas of high sighting density reflect the distribution of observers rather than the absolute density of the cetaceans in these areas. For example, the hotspot in the middle of Falkland Sound is on the route of the ferry between East and West Falklands; the area near Stanley is adjacent to the only major centre of human habitation and the focus of shipping activity.

It is difficult to attribute observer effort to anecdotal observations. Frans and Auge (2016) asked contributors to the frequency of visits to an area on a decadal basis, which were scored from 1 to 5 (Once to Frequent; see Table 7.28). These scores were then averaged for all observers, which has produced some unusual results as areas of high activity have lower average frequency scores than anticipated (Figure 7.88b).

Table 7.28: Descriptions of visits and sightings categories (from Frans and Auge, 2016)

Frequency of ...	Effort Value	Category	Description
Visits (per decade)	1	Once	One instance or specific event per decade
	2	Few	2-5 visits per decade
	3	Occasional	One or a few visits per year
	4	Often	Visiting over long periods (<6 months) per year
	5	Frequent	Residing or passing through the location >6 months per year
Sightings (across visits)		Once	One sighting in a given decade, or for a specific visit
		Seldom	Rare sightings (e.g. 2-3 sightings across visits)
		Occasional	Seen for <1/2 the visit frequency
		Often	Sighting for >1/2 the visit frequency
		Always	Sighting at almost each visit

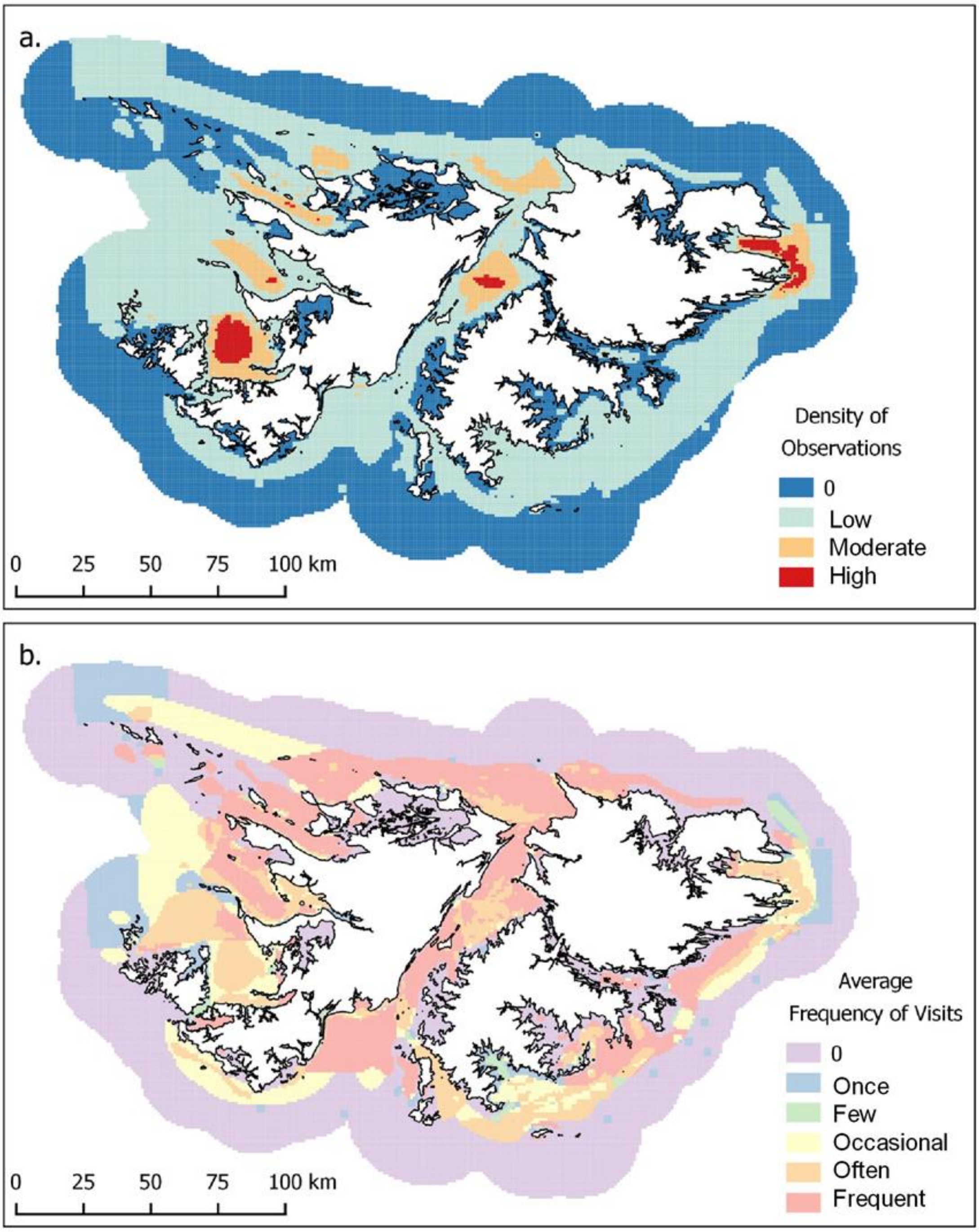


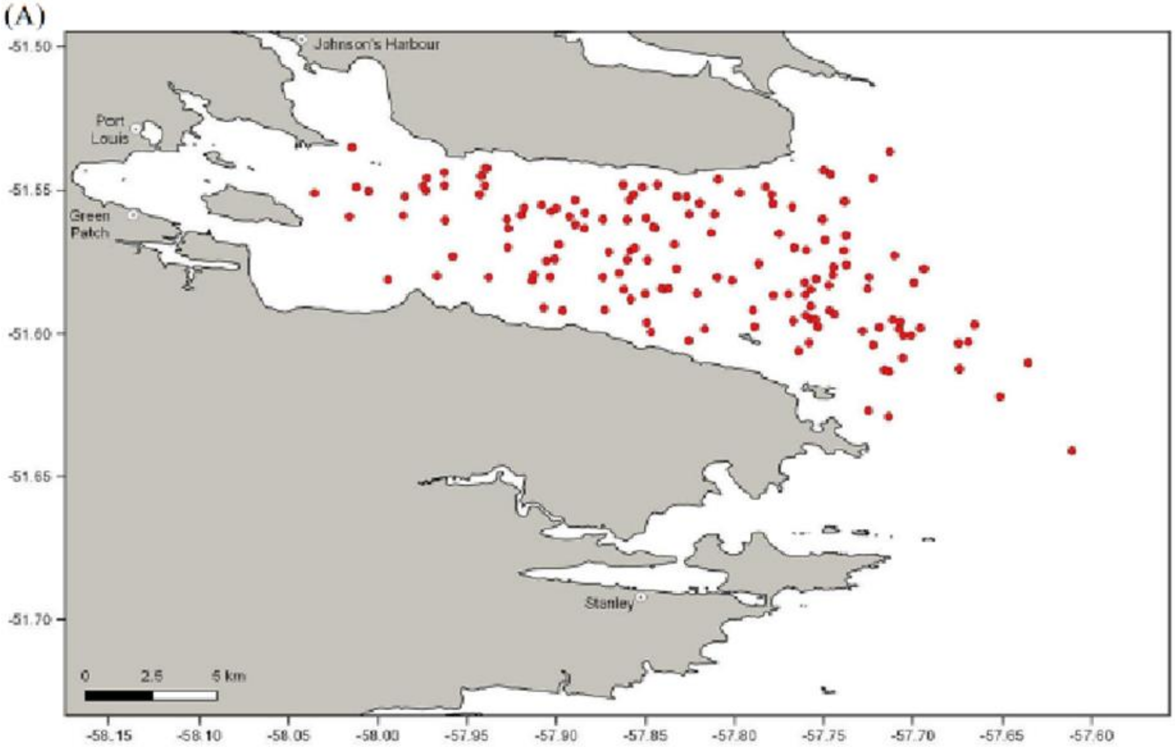
Figure 7.88: Distribution of anecdotal large cetacean records around the Falkland Islands *(Source: Frans and Augé, 2016)*

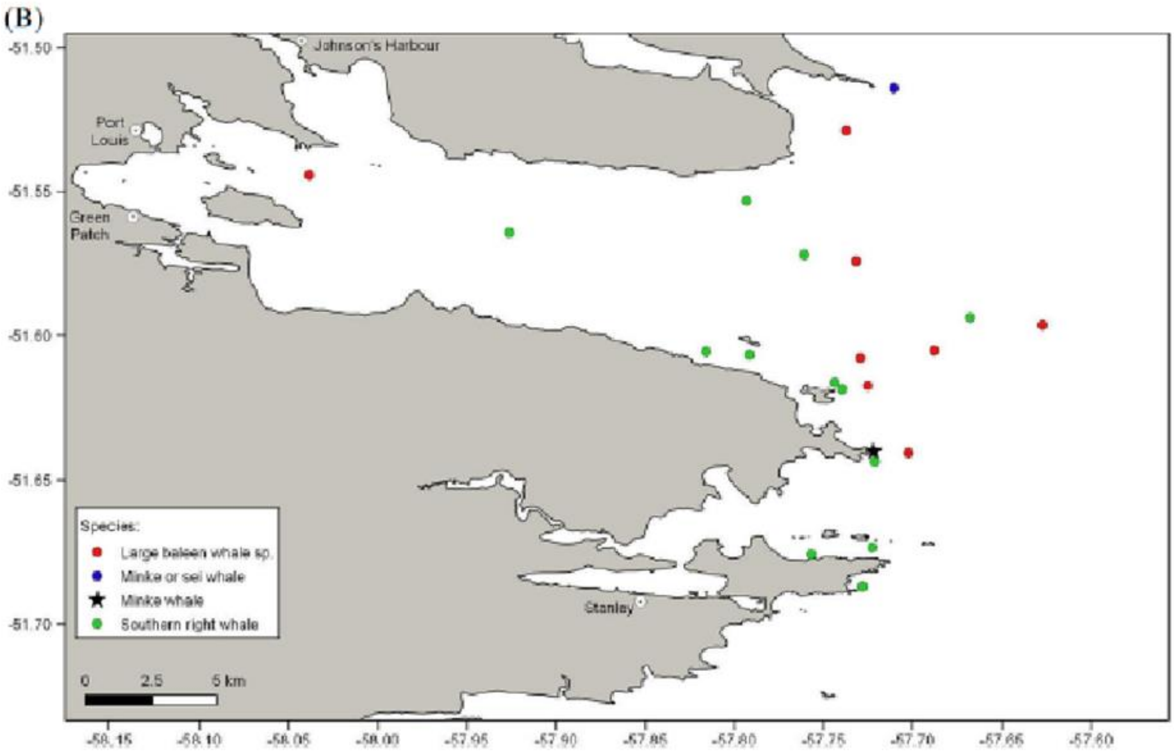
7.4.6.3.1.4 Falklands Conservation's cetacean surveys in Berkeley Sound

During early 2017, Falklands Conservation initiated a project entitled, 'Developing a site-based conservation approach for sei whales (*Balaenoptera borealis*) at Berkeley Sound, Falkland Islands'. The project aims to improve knowledge of sei whales in the Falkland Islands, increase awareness and provide information on the potential for interaction between whales and human activities, and results are presented in Weir (2017).

Surveys were conducted between January and June, utilising land-based, aerial and boat-based techniques. All species of cetacean were recorded but the project focussed on sei whales, the initial locations of all sei whale sightings are shown in Figure 7.89. Data collected indicates that sei whales occur throughout Berkeley Sound (east of Long Island) and adjacent coastal waters, including the approaches to Port William. Although surveys were only undertaken during the first half of the year, the results support previous reports of seasonal presence of sei whales, with all sightings occurring between January and May. The majority of animals observed were seen in water depths of 20 – 50 m, with relatively few in water less than 15 m in depth. Behavioural observations indicate that the area is used as a feeding ground and analysis of feacal material confirmed that lobster krill are the primary prey species.

Between February and May 2017, 26 boat-based surveys resulted in 2,841.6 km of survey effort and 149 sightings of sei whales (300 individuals). In total, 87 individual sei whales were recognised by photo-identification with the number of identifiable animals recorded on any one day ranging between 0 – 20 individuals. This is a minimum indication of the number of animals using Berkeley Sound as many animals could not be photographed or would pass through the area between surveys. Most (64.6 %) of the sei whales that were photo-identified in Berkeley Sound were captured on one survey date only and the most frequently recorded individual was recorded on eight dates. The available evidence suggests that the majority of individuals are present within Berkeley Sound for brief periods but some remain for longer periods or return after a period of absence.


(A)
Johnson's Harbour
Port Louis
Green Patch
Stanley
0 2.5 5 km
-51.50
-51.55
-51.60
-51.65
-51.70
-58.15
-58.10
-58.05
-58.00
-57.95
-57.90
-57.85
-57.80
-57.75
-57.70
-57.65
-57.60


(B)
Johnson's Harbour
Port Louis
Green Patch
Stanley
Species:
Large baleen whale sp.
Minke or sei whale
Minke whale
Southern right whale
0 2.5 5 km
-51.50
-51.55
-51.60
-51.65
-51.70
-58.15
-58.10
-58.05
-58.00
-57.95
-57.90
-57.85
-57.80
-57.75
-57.70
-57.65
-57.60

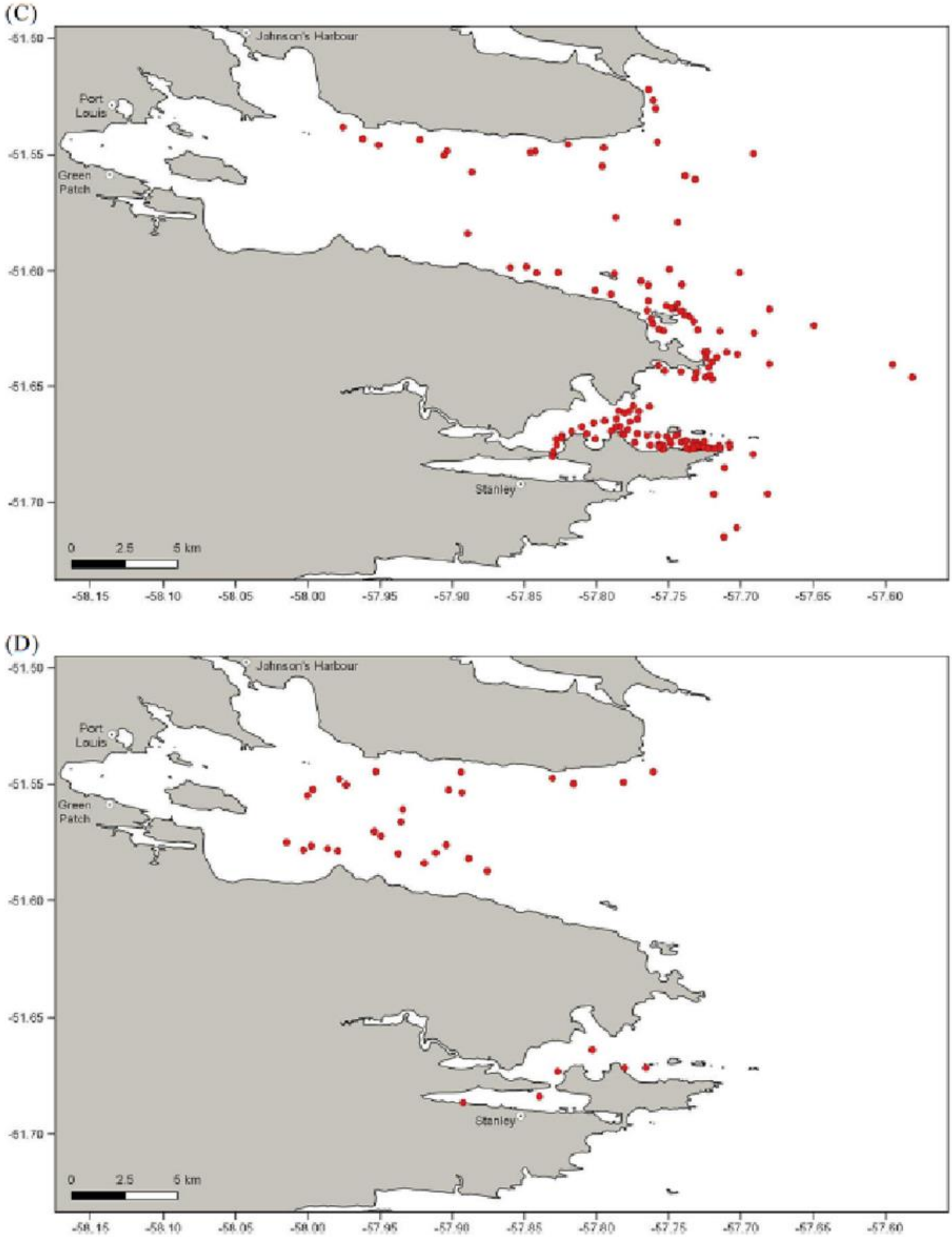


Figure 7.89: The spatial distribution of cetacean sightings recorded during boat-based surveys in Berkeley Sound (A) sei whale; (B) other baleen whales; (C) Peale's dolphin and (D) Commerson's dolphin, source: Weir (2017).

Observers also recorded blow rates and dive times (Weir, 2017), which could eventually be used to correct abundance estimates and develop ship-strike models. Over 20 observation periods, a mean breathing rate of 32.2 blows / hr was recorded, which equates to a mean dive cycle of 112 seconds. The maximum dive time recorded within Berkeley Sound was 13.5 minutes. The recorded swimming speed in Berkeley Sound averaged 6 km / hr with the maximum observed speed of 22 km / hr (12 knots). It is clear that dive profiles and swimming speed will vary depending on an animal's activity; however, observations indicate that movements of sei whales in and out of Berkeley Sound are likely to occur rapidly.

In 2018, visual and photographic surveys were conducted on the sei whale population in Queen Charlotte and King George Bays, to the west of the Falklands (Weir, 2018). The results indicate that sei whales are present in considerable number around the Falklands coastline. Two individuals that were identified in Berkeley Sound during 2017 were resighted to the west of the Falklands, indicating repeat visits to the Falklands in different years and hints that animals may move around the entire Falklands coastline.

7.4.6.3.1.5 Dolphins of the Kelp (DOKE)

The 'Dolphins of the Kelp' (DOKE) project ran between 2016 and 2018 under the auspices of SAERI. The projects aimed to establish baseline data on the abundance, distribution, natural history and genetic diversity of the Falklands inshore cetacean populations to provide a scientific basis for conservation and ecosystem-based marine management initiatives (Costa and Cazzola, 2018).

The project was broadly split into three phases:

- A Falklands-wide aerial transect survey to map the distribution of all cetaceans within 10 km of the coast;
- Focussed studies on Commerson's and Peale's dolphins at three sites to investigate seasonal site fidelity, local abundance and movements which included:
  - Repeat boat-based transect surveys;
  - Photo-ID; and
  - Passive Acoustic Monitoring.
- Tissue sampling to determine genetic diversity and relatedness with other South American populations.

Island wide aerial transect survey

In total, 217 transects running perpendicular to the coast, spaced 5 to 6 km apart, were superimposed over the inshore waters (Figure 7.90). These transects were followed by a Falkland Islands Government Air Service (FIGAS) plane at an altitude of 150 m and speed of 90 knots between March 18th and May 8th 2017. Observers recorded all animals sighted using distance sampling techniques. On completion of the survey, the total length of survey track was 4,317 km and 454 sightings, of seven species, were made (Table 7.29). Figure 7.91 shows the distribution of Commerson's and Peale's dolphins recorded and Figure 7.92 shows the distribution of baleen whales recorded.

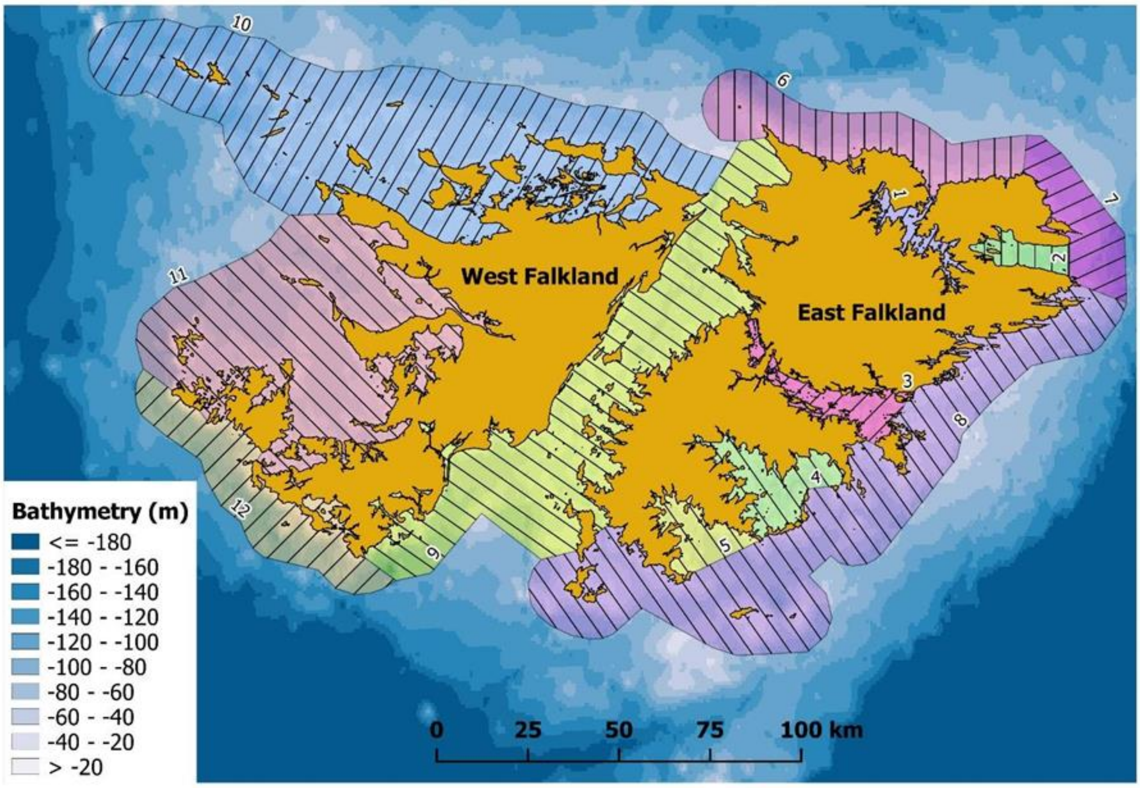


Figure 7.90: Map of the inshore waters of the Falkland Islands showing the positions of aerial survey transects (source, Costa and Cazzola, 2018)

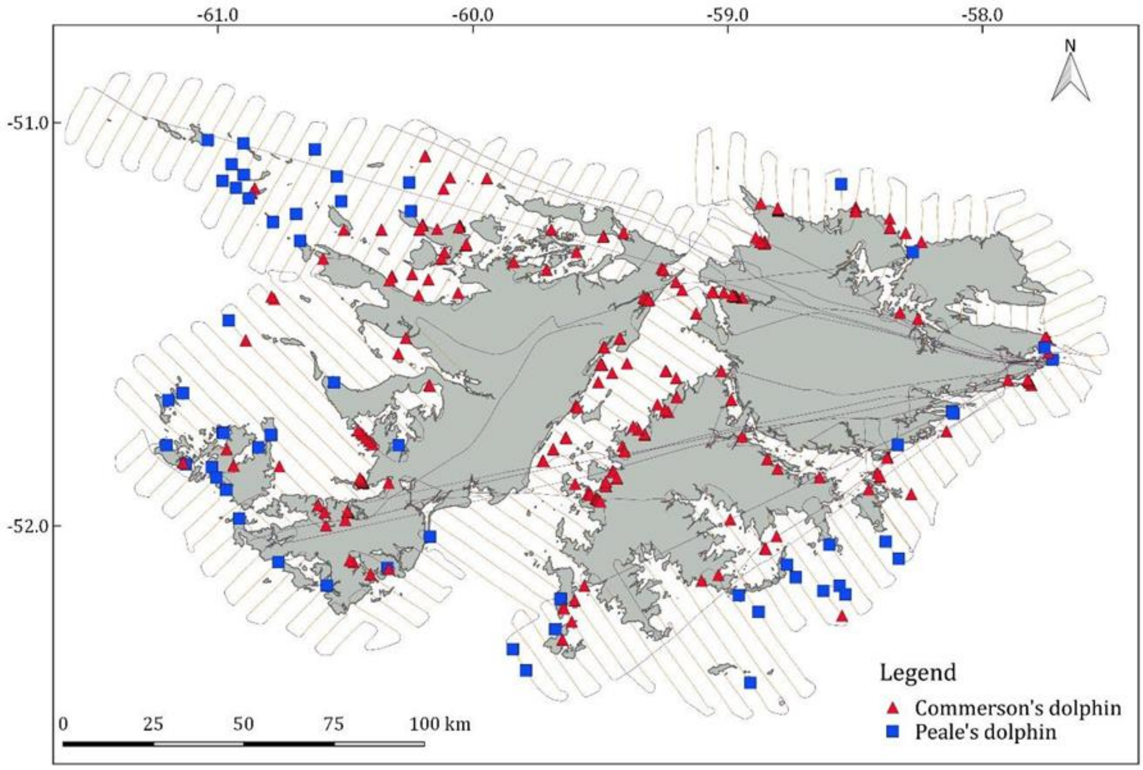


Figure 7.91: Locations of Commerson’s (red triangles) and Peale’s dolphin (blue squares) recorded during aerial surveys from March to May 2017 (source: Costa and Cazzola, 2018)

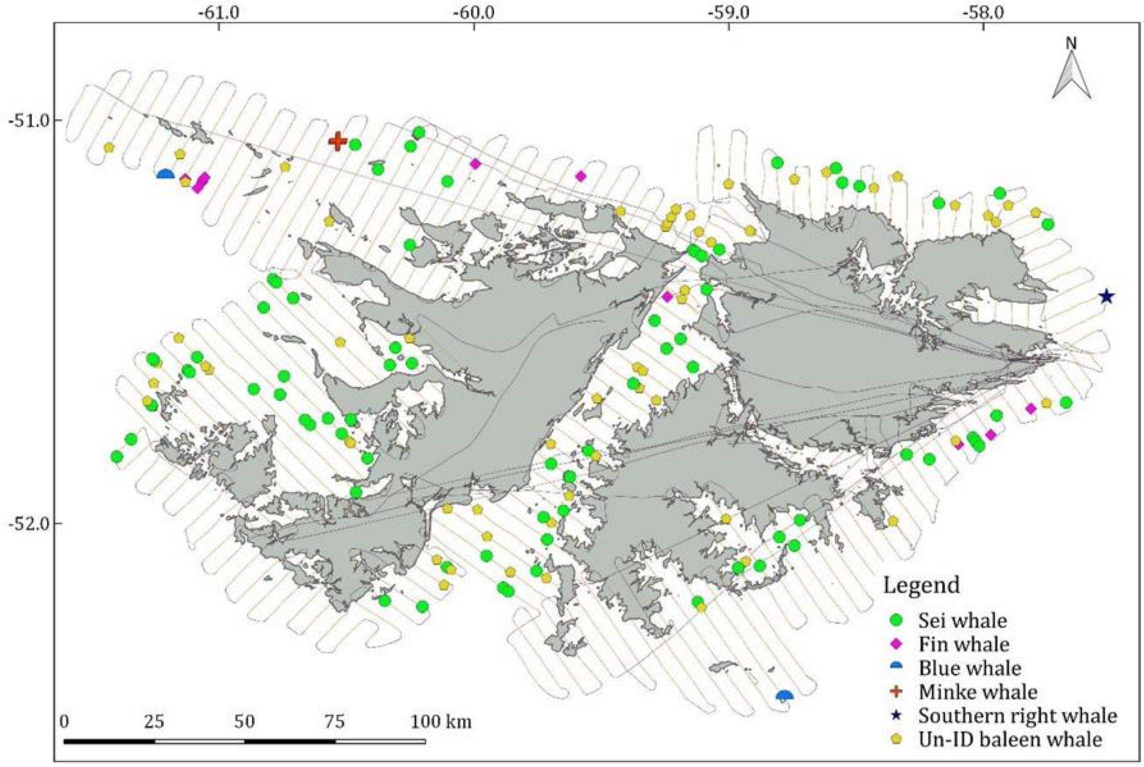


Figure 7.92: Locations of baleen whales sighted from March to May 2017 (source: Costa and Cazzola, 2018)

Table 7.29: Summary of cetacean sightings made during the DOKE aerial survey

Species	Number of sightings	Estimated population
Commerson's dolphin	238	5,789
Peale's dolphin	60	1,896
Sei whale	74	341
Fin whale	12	64
Minke whale	2	13
Blue whale	2	NA
Southern right whale	1	NA
Unidentified baleen whale	65	

Focussed studies on Commerson's and Peale's dolphins

Repeated boat-based transect surveys were designed to determine the habitat types favoured and seasonal movements by Commerson's and Peale's dolphins. Six surveys were completed at each of the three sites between November 2016 and July 2018 (Figure 7.93). In total, 5,417 km of survey effort was achieved, which produced 348 Commerson's dolphins, 162 Peale's dolphin, 23 southern right whale, 20 sei whale, three minke whale and one killer whale sightings.

Preliminary results suggest that;

- Commerson's dolphins are present all along the coastline but where 'hotspots' exist the number of animals present was higher in summer than winter:
- Peale's dolphins showed a restricted distribution (Port William seems to be a 'hotspot' for this species), although recorded in summer and winter more animals were sighted in the winter; and
- Where the two species overlap, Commerson's occupied the inner part of the bay and Peale's the outer.

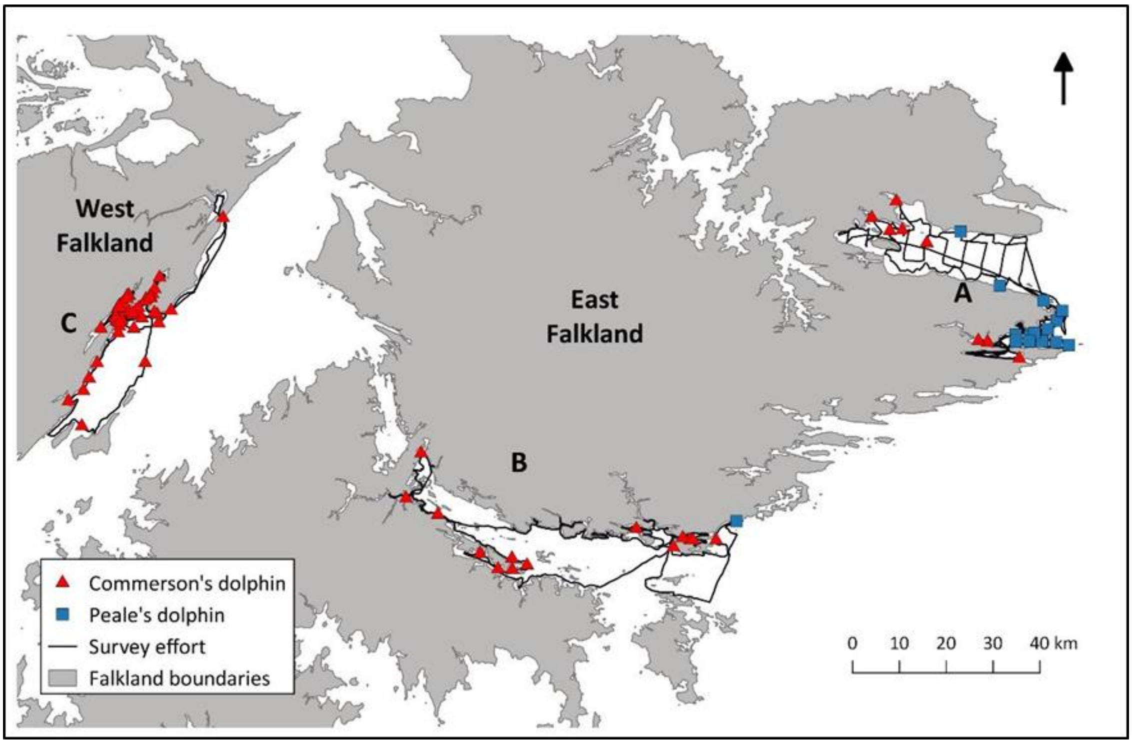


Figure 7.93: Survey effort and dolphin sightings between 21st November and 22nd December 2016, in the three focal areas; A, Port William and Berkeley Sound; B, Choiseul Sound and Bertha's Beach; C. Port Howard and many Branch Harbour (source: Costa and Cazzola, 2018)

Passive acoustic monitoring devices (C-PODs) were deployed in Many Branch Harbour to further investigate the behaviour of Commerson's dolphins, in particular diurnal patterns of behaviour. It was found that activity within the most sheltered areas peaked during daylight hours in February and March, the calving period for this species in the Falklands.

Genetic diversity

Tissue samples were collected from Commerson's and Peale's dolphins at the sites shown in Figure 7.94. Primary results suggest:

- There are highly significant differences between animals sampled in the west and east of the Falklands;
- Commerson's dolphins did not show evidence of population differentiation between sampling locations; and
- Both species have limited sharing of haplotypes with mainland South American populations.

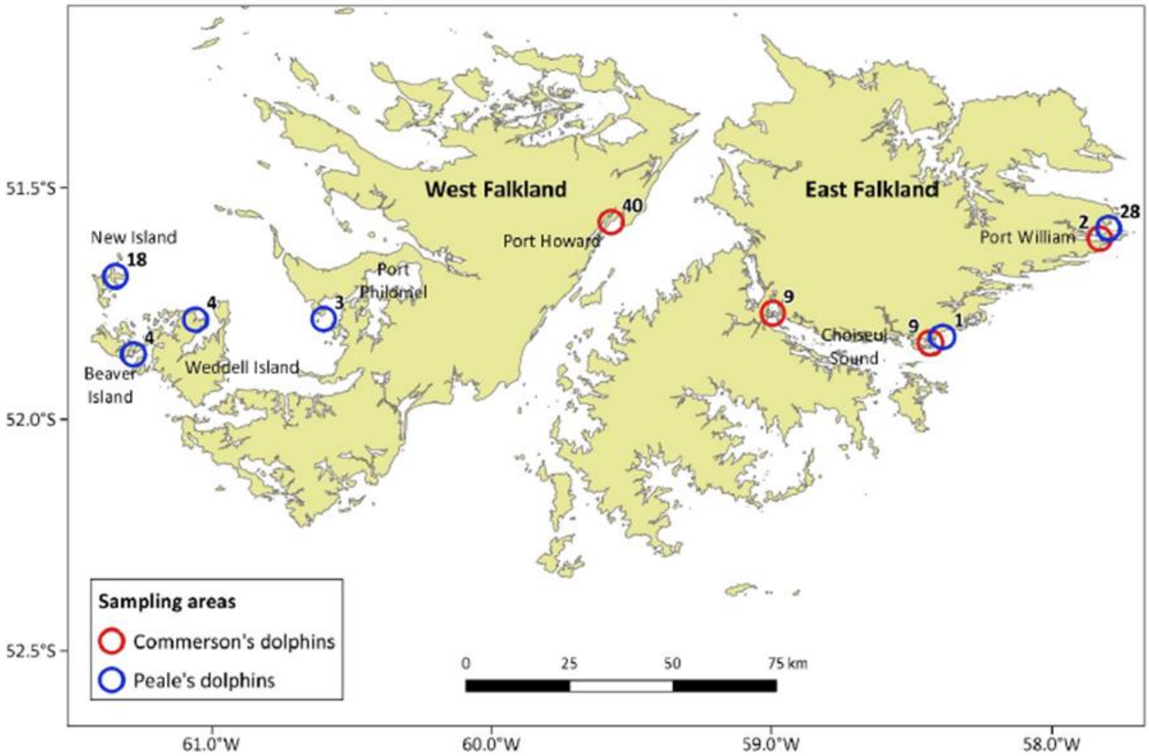


Figure 7.94: The location and number of tissue samples collected from Commerson's and Peale's dolphins for genetic analysis

7.4.6.3.1.6 Species-specific summary of cetacean distribution inshore

In addition to the many cetacean species that have been recorded in the wider NFB and near the Sea Lion Field (section 7.4.6.2), a number of species have been recorded specifically within and around Berkeley Sound, as recorded in the surveys described above.

Notably, of the species that are regularly observed within Berkeley Sound, the sei and fin whales, are listed as 'Endangered' on the IUCN Red List. Further, two species of dolphin, Peale's and Commerson's dolphins, are regularly observed within Berkeley Sound and these species, and all other cetaceans, are listed as species of conservation priority and are the subject of a Falkland Islands Cetacean Management Plan (FIG, 2008c).

The following provides a species-specific account of the collated survey results. Further, a general summary of the abundance, distribution, life-cycle and behavioural characteristics is provided in Table 7.30 below.

Sei whale

For many years large numbers of sei whales (*B. borealis)* have been observed in inshore waters around the Falkland Islands (White *et al.,* 2002; Frans and Augé, 2016). Although they can be seen throughout much of the year, their abundance is far higher during the summer and autumn (November to April), peaking in March such that their presence is considered to be seasonal.

The results of inshore surveys (Thomson and Munro, 2014, Costa and Cazzola, 2018) and anecdotal observations by Frans and Augé (2016) indicate that, during the summer and autumn months, sei whales are encountered throughout most of the inshore waters of the Falklands. Interviews with local residents indicate several hotspots of sightings including Berkeley Sound (Frans and Augé, 2016). Further, the anecdotal observations hint that sei whales are now more numerous within Falklands waters than they were at the time of the JNCC's at-sea surveys (Frans and Augé, 2016).

The results of Falklands Conservation's 2017 project (Weir, 2017) support much of the existing knowledge of sei whales but add considerably to our understanding of sei whale movements and behaviour within Berkeley Sound. There is clearly a large number of sei whales using the inshore waters of the Falkland Islands as a late summer / autumn feeding ground. However, photo-identification within Berkeley Sound indicates that the animals are transitory with most animals spending a short period of time within Berkeley Sound (Weir, 2017). Return visits by individuals in different years was confirmed and more evidence of large scale movements by individuals within Falklands waters was achieved in 2018 (Weir, 2018). Therefore it is assumed that a high proportion of the overall population of sei whales could be exposed to any human induced environmental change if it were to coincide with the seasonal presence of these animals.

Sei whales are listed as Endangered on the IUCN Red List and have priority conservation status in the Falkland Islands.

Fin whale

Fin whales (*Balaenoptera physalus)* are known to seasonally occur in the offshore waters around the Falkland Islands (section 7.4.6.2.1.4) and there are fewer confirmed sightings from inshore waters (Weir, 2017; Costa and Cazzola, 2018). Local knowledge indicates however that fin whales have been seen inshore throughout the year with a definite peak in numbers in March (Frans and Augé, 2016). There are two apparent hotspots of fin whale sightings in inshore waters; one to the west of the Islands and the other in Berkeley Sound (Frans and Augé, 2016). However, Weir (2017) did not record fin whales within Berkeley Sound and suggests that the sightings reported in Frans and Augé (2016) could be misidentified. Like all large whales, there is a perception that the number of fin whales present in the waters around the Falklands has increased over the past twenty years or so.

Fin whales are listed as Vulnerable on the IUCN Red List and also have priority conservation status in the Falkland Islands.

Antarctic minke whale

Antarctic minke whales (*B. bonarensis*) were encountered widely within Falklands waters with most animals recorded between September and April (White *et al.,* 2002). Inshore, sightings have predominantly occurred during the summer and autumn months (Frans and Augé, 2016). Anecdotally, minke whales are frequently sighted off the eastern coast of Kidney Island (A. Black *pers. obs*; Frans and Augé, 2016). Dedicated inshore cetacean surveys conducted during 2017 recorded minke whales in low numbers (Wier, 2017; Costa and Cazzola, 2018).

Southern right whale

Once they arrive on their feeding grounds, southern right whales (*Eubalanus australis*) tend to be found in coastal or inshore waters (*c.f.* Black, 2005b). Several right whales have been sighted within Stanley Harbour (A. Black *pers. obs*; Frans and Augé, 2016) and one was sighted in Berkeley Sound during July 2015 (BSL, 2015). Interviews conducted by Frans and Augé (2016) however, indicate that southern right whales are rarely sighted and their presence in Falklands waters is very seasonal (late summer / early autumn). Although more sightings occur to the west of the Falklands (Frans and Augé, 2016), until 2017 the available evidence suggests that southern right whales are periodically present within Berkeley Sound.

During the winter of 2017 (May to August), a large influx of southern right whales occurred (see section 7.4.6.3.1.2 and Weir, 2017). The number of animals sighted was unprecedented and it remains unclear whether 2017 was an unusual year or the start of a long-term trend.

Humpback whales

Humpback whales accounted for approximately 12 % of the whales processed at the New Island shore station in the early 1900s (Weir, 2017). While humpback whales (*Megaptera novaeangliae*) have been recorded within Falklands waters (White *et al.,* 2002), acoustic monitoring and marine mammal observations from seismic vessels did not record humpback whales in the North Falkland Basin and interviews with local residents did not produce many additional records of humpback whales inshore (Frans and Augé, 2016). An intense period of dedicated inshore cetacean surveys in 2017 did not produce any sightings of humpback whales (Weir, 2017; Costa and Cazzola, 2018). Despite their historical presence and apparent increase in numbers elsewhere, the available evidence suggests that humpback whales are rarely encountered within Falklands waters.

Killer whale

The JNCC surveys recorded seven killer whale (*Orcinus orca*) sightings (18 animals in total) over three years, (White *et al.,* 2002). Killer whales are regularly sighted inshore around Sea Lion Island, to the south of East Falkland (Sanvito and Galimberti, 2018) and occasionally elsewhere inshore. Although there are no known records from Berkeley Sound, killer whales may visit the area.

Satellite tracking indicates that Type B killer whales follow a migration route to the east of the Falkland Islands when travelling between the Antarctic Peninsula and sub-tropical waters of the South Atlantic (Durban and Pitman, 2012). These animals appear to travel rapidly through the region but they could account for some of the acoustic detections and sightings within Falkland waters.

Long-finned pilot whale

Long-finned pilot whale (*Globicephala melas*) strandings have been regularly recorded on the Falkland Islands since 1866 (Otley, 2012). Since 1984, pilot whale strandings have been recorded as a near annual event, with 43 recorded incidents ranging in number from less than ten individuals to up to 500 animals. The mean number of animals involved in each event is 105 (Otley, 2012). There appears to be a seasonal component to the strandings with 50 % occurring during the autumn, 32 % in winter, 12 % in summer and 6 % in spring. It is unclear what causes these strandings but the seasonal component suggests that there may be seasonal movements of these animals both inshore and offshore. This is supported by surveys and observations offshore (White *et al.,* 2002).

The high number of pilot whale strandings on the Falkland Islands (Otley, 2012) hints that there is a sizable population associated with Falklands waters. However, this species is generally regarded as a deep water species and are not regularly sighted inshore. Pilot whales were not sighted during a period of intense inshore cetacean surveys in 2017.

Peale's dolphin

Five groups of Peale's dolphin (*Lagenorhynchus australis)* were recorded during the 2016 coastal survey (section 7.4.5.3.1.1). There was a cluster of three records close to Monkey Point but this species could be encountered anywhere within Berkeley Sound. Peale's dolphin was recorded both inshore and offshore during the JNCC surveys and was by far the most abundant species of cetacean recorded near the entrance to Berkeley Sound (Figure 7.87 above) and offshore on the Patagonian Shelf (Figure 7.81). There was no clear evidence of any seasonal changes in the abundance, distribution or behaviour of these animals. Little is known about the biology of Peale's dolphins, but these animals are thought to be largely resident and to calve between October and April (Shirihai, 2006).

The results of the DOKE project indicate that Peale's dolphins are present within Berkeley Sound but in relatively low numbers, they are far more numerous in Port William (Costa and Cazzola, 2018). The results of genetic analysis indicate significant differences in the genetics between animals sampled in the east and west of the Islands, which hints that these animals do not travel widely.

Dusky dolphin

There have been few confirmed sightings of dusky dolphin (*L. obscurus*) within Falklands waters (Weir and Black, 2018). During inshore cetacean surveys in 2017 and 2018, a single dusky dolphin (identifiable by a large nick in its dorsal fin) was repeatedly observed in Port William and at the entrance to Berkeley Sound (Costa and Cazzola, 2018; Weir and Black, 2018). This animal was always recorded in association with Peale's dolphins, it is believed that this association is unusual. The lack of other confirmed sightings during a period of intensive inshore cetacean surveys in 2017 and 2018 indicates that dusky dolphins are rare visitors to inshore Falklands waters.

Commerson's dolphin

During the JNCC surveys, Commerson's dolphins were recorded in every month except May (Figure 7.94) although very few animals were actually recorded. The number of these animals is very likely to have been underestimated due to their preference for coastal waters and the JNCC surveys were rarely conducted in the core habitats used by this species. Of the observations made, all were in partially enclosed or coastal waters and sightings were most frequently recorded from the waters within, or close to, the north and south entrances to Falkland Sound (Figure 7.94). These results are supported by the pilot inshore cetacean survey, which recorded more Commerson's dolphins between islands than towards open waters (Thomsen and Munro, 2014).

There was no evidence of seasonal variation in the distribution or abundance of Commerson's dolphin and the apparent decreases in some months, for example May, are, again, believed to be due to variation in the distribution of JNCC survey coverage rather than changes in the distribution of the dolphins. Anecdotally, highest densities of Commerson's dolphins are most frequently observed in enclosed coastal waters; such as settlement harbours (A. Black *pers. obs.*) which were rarely visited on any of the previous boat-based surveys.

The results of the DOKE surveys support previous observations (Figure 7.90) and provide evidence of seasonal and diurnal movements within inshore waters. The results of an Islands-wide survey indicate that Commerson's dolphins are by far the most numerous cetacean found in waters within 10 km of the coast (Table 7.29, Costa and Cazzola, 2018)

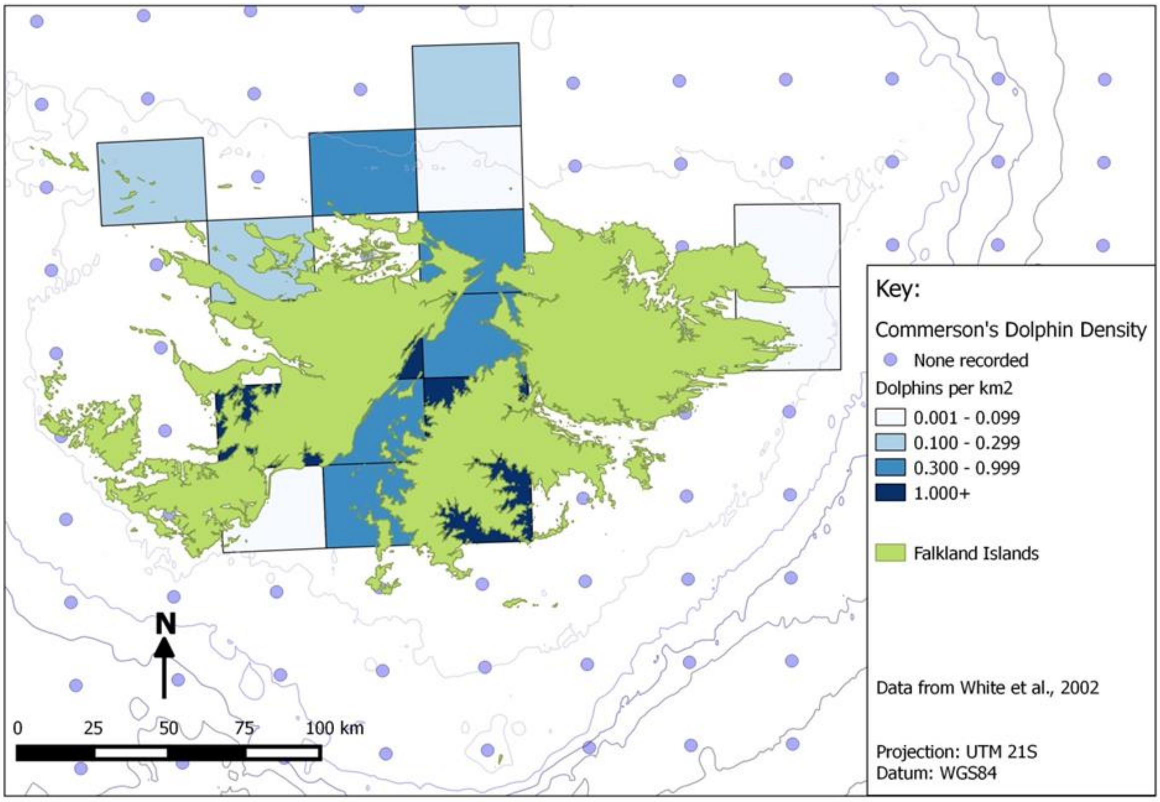


Figure 7.95: Commerson's dolphin distribution recorded during JNCC surveys, all months

7.4.6.3.2 Pinniped abundance and distribution surveys in and around Berkeley Sound (inshore)

In understanding the baseline distribution and abundance of pinnipeds in Berkeley Sound, data from the following surveys and studies have been used.

These surveys include:

- Coastal bird surveys carried out by SAERI under contract to Premier;
- The JNCC SAST survey; and
- Tracking studies.

7.4.6.3.2.1 Pinnipeds recorded during the 2016 and 2017 coastal survey

The coastal bird surveys undertaken between 2016 and 2019 (described in section 7.4.6.3.1.1) also recorded all pinnipeds observed hauled-out or in coastal waters.

7.4.6.3.2.2 Pinnipeds recorded during JNCC seabirds at-sea surveys

While the SAST did not carry out dedicated marine mammal observations, marine mammals were recorded regularly in low numbers in inshore waters near Berkeley Sound.

7.4.6.3.2.3 Tracking studies

There has been some limited tracking of fur seals breeding at Bird Island (off the south coast of West Falkland; Thompson *et al.,* 2003). Female sea lions from three locations on East Falkland have also been tracked (Baylis *et al.,* 2015). The results of tracking associated with the GAP programme are summarised in Baylis *et al*. (2019).

7.4.6.3.2.4 Species-specific pinniped distribution and abundance in and around Berkeley Sound

The following species-specific summaries draw on data taken during the surveys described above. A summary of the abundance, distribution, life-cycle and behavioural characteristics is provided in Table 7.30 below.

South American fur seal

Volunteer Rocks at the northern entrance to Berkeley Sound is known to be a breeding site for South American fur seals (*Arctocephalus australis*); where approximately 150 pups are born each year (Figure 7.96). This represents approximately 1 % of the known Falkland Islands population (based on a population of 18 – 20,000 animals; Strange, 1992). Reflecting this, most of the fur seals recorded during the summer and winter coastal surveys were close to this site. Fur seals were the most numerous pinniped recorded during JNCC at-sea surveys (White *et al.,* 2002).

The results of tracking studies indicate distinct seasonal differences in the distribution of female fur seals breeding at the Bird Island location. South American fur seals commence breeding in early November with the establishment of territories by the dominant bulls. Pups are born around mid-December and are suckled for 6-12 months. In the early part of the breeding season, females make short, nocturnal foraging trips. During mid-lactation, the duration of foraging trips increased but the distribution remained close to the breeding site. By the autumn, the duration and range of foraging trips had increased (Thompson *et al.,* 2003). Along with seasonal differences in food requirements, fur seal foraging strategies are likely to be influenced by local conditions and may therefore vary considerably between colonies.

South American sea lion

Infrequent surveys of the breeding population of South American sea lions (*Otaria flavescens*) have been conducted in the past, which recorded a single breeding site on the north coast of Berkeley Sound (Thompson *et al.,* 2005). Although pup counts for all colonies are not presented in Thompson *et al*. (2005), it is estimated that close to 2 % of the Falklands breeding population (2,747 pups produced in 2003) are found at this site. In support of this, during the 2016 coastal survey, most of the 60 South American sea lions recorded were in two groups; one at a haul-out site on Hog Island and the other at the colony on the northern coast of the outer Sound (often referred to as Diamond Cove; Figure 7.96). Sea lions were also observed on Cochon and Kidney Islands (Figure 7.96). During the winter 2017 survey, sea lions were recorded in low numbers throughout the Sound. At-sea, sea lions were recorded in all months during the JNCC surveys with the majority of records came from inshore waters (White *et al.,* 2002).

Contrary to the accepted view that South American sea lions are generalists, satellite tracking of female South American sea lions has identified that individuals have specialised foraging strategies; in terms of location (inshore vs. offshore) and prey type (benthic or pelagic) (Baylis *et al.,* 2015).

South American sea lions are known to return to land at favoured haul-out sites throughout the year and therefore all animals are susceptible to impacts in inshore waters throughout the year. However, those that specialise as inshore foragers are at greatest risk.

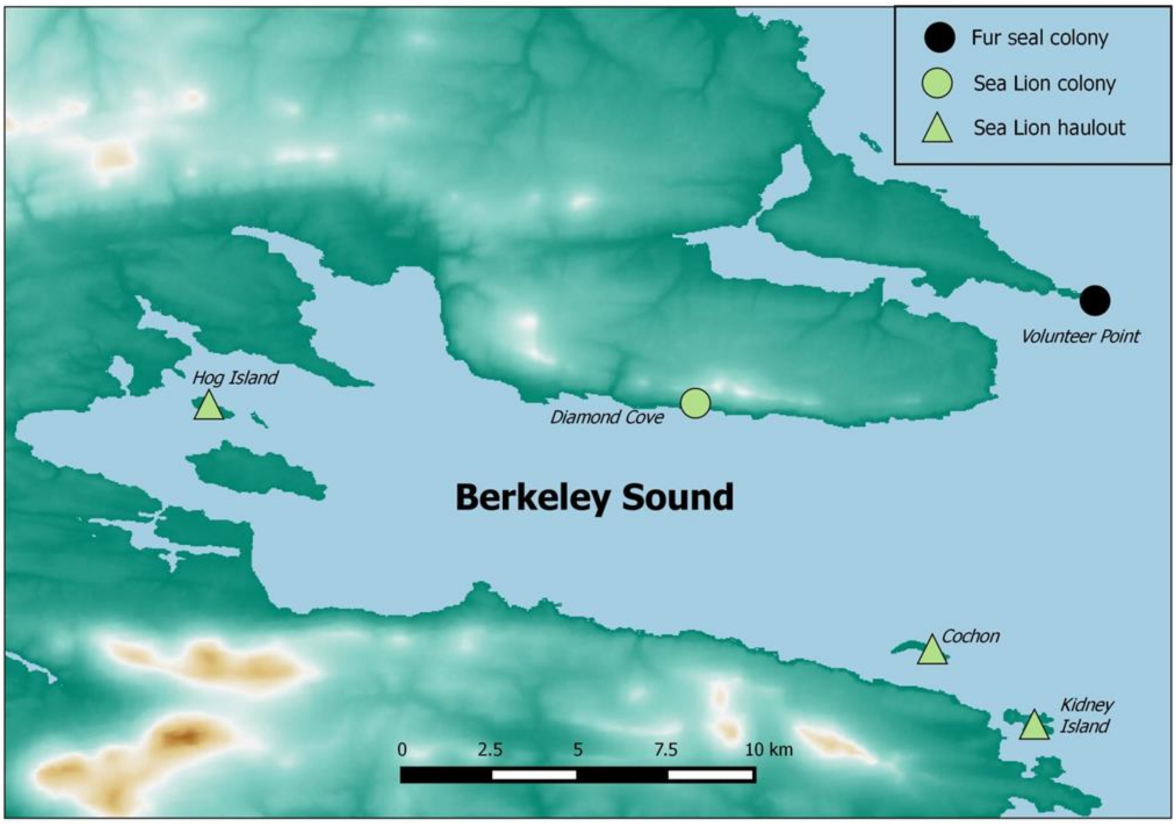


Figure 7.96: Sea Lion and fur seal colonies in Berkeley Sound

7.4.6.3.3 Summary of marine mammals in and around Berkeley Sound

Table 7.30 provides a summary of marine mammal abundance in Berkeley Sound, distribution, life-cycle and behavioural characteristics.

Table 7.30: Summary of marine mammals found inshore around the Falkland Islands

<table>
<tr><th>Species</th><th>IUCN status</th><th colspan="4">Presence in the Berkeley Sound[a]</th><th>Global distribution</th><th>Foraging strategy</th><th>Auditory type</th><th>Behaviour</th></tr>
<tr><td colspan="10">Cetaceans</td></tr>
<tr><td rowspan="3">Southern right whale
Eubalaena australis</td><td rowspan="3">LC</td><td colspan="4">✓
Rarely sighted before 2017 but confirmed to be present in Berkeley Sound and other inshore waters (A. Black *pers. obs.*). Unprecedented influx of a large number of whales during winter 2017.</td><td rowspan="3">Widespread in the southern hemisphere</td><td rowspan="3">Surface skim-feeding</td><td rowspan="3">Low frequency</td><td rowspan="3">Slow lumbering swimmers but can be acrobatic, breaching clear of the water or lifting the tail clear of the water.
Growing population breeds off the coast of Argentina in September, migrates to Southern Ocean in the summer.</td></tr>
<tr><td>Spring</td><td>Summer</td><td>Autumn</td><td>Winter</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">Fin whale
Balaenoptera physalus</td><td rowspan="3">VU</td><td colspan="4">Rarely sighted inshore</td><td rowspan="3">Found in all oceans of the world</td><td rowspan="3">Lunge feeding</td><td rowspan="3">Low frequency</td><td rowspan="3">Capable of swimming at speeds of 19 knots. Movements poorly understood but most frequently encountered off-shore or where deep water is found near the coast. Seen in small groups many of which may be present within a small area (10s of km^2)</td></tr>
<tr><td>Spring</td><td>Summer</td><td>Autumn</td><td>Winter</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">Antarctic minke whale
Balaenoptera bonarensis</td><td rowspan="3">LC</td><td colspan="4">✓
Regularly sighted within Berkeley Sound</td><td rowspan="3">Globally, the most common of the rorquals</td><td rowspan="3">Lunge feeding</td><td rowspan="3">Low frequency</td><td rowspan="3">Movements poorly known but some populations appear to be resident year-round</td></tr>
<tr><td>Spring</td><td>Summer</td><td>Autumn</td><td>Winter</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">Sei whale
Balaenoptera borealis</td><td rowspan="3">EN</td><td colspan="4">✓
The most abundant large whale seen in inshore waters (including Berkeley Sound) also frequently sighted offshore.</td><td rowspan="3">Found in all oceans, sub-Antarctic waters are favoured feeding grounds in summer</td><td rowspan="3">Lunge feeding</td><td rowspan="3">Low frequency</td><td rowspan="3">Dives more regularly than most large whales, surfacing at approximately minute intervals. One of the fastest of the great whales, sei whales swim a few metres below the surface and progress can be followed by ‘fluke prints’ left on the surface in the animal’s wake. Some detailed observations of dive behaviour now available for Berkeley Sound.</td></tr>
<tr><td>Spring</td><td>Summer</td><td>Autumn</td><td>Winter</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

Species	IUCN status	Presence in the Berkeley Sound[a]	Global distribution	Foraging strategy	Auditory type	Behaviour
Humpback whale *Megaptera novaeangliae*	LC	Although not recorded in Berkeley Sound, humpback whales are known to be present in low numbers in the region. Spring / Summer / Autumn / Winter	Found in all oceans of the world	Lunge feeding	Low frequency	A population breeding off the coast of Brazil is thought to migrate to feed off the South Sandwich Islands in the summer months. However, these animals are not thought to pass through Falklands waters
Long-finned pilot whale *Globicephalus melas*	DD	Known to strand regularly (annually) in the Falklands but not within Berkeley Sound Spring / Summer / Autumn / Winter	High latitudes in the northern and southern hemisphere	Shallow divers	Mid frequency	Can be encountered in large groups (100 + animals). There appears to be seasonal changes in distribution within Falklands waters but movements not fully understood.
Killer whale *Orcinus orca*	DD	? Regularly sighted inshore around Sea Lion Island, off the south coast of East Falkland but no known sightings in Berkeley Sound Spring / Summer / Autumn / Winter	Found in all oceans of the world.	Shallow diving predators	Mid frequency	Killer whales are known to pass through Falklands waters on rapid transit from Antarctic Peninsula to sub-tropical waters. Additionally, there are likely to be resident populations. Seen year-round from longline vessels fishing to the north-east of the Sea Lion Field.
Commerson's dolphin *Cephalorhynchus commersonii*	DD	✓ Frequently sighted in coastal waters of the Sound Spring / Summer / Autumn / Winter	Only southern South America, the Falklands and Kerguelen	Shallow diving	High frequency	Observed throughout the Falklands in coastal waters.
Peale's dolphin *Lagenorhynchus australis*	DD	✓ Frequently sighted throughout the Sound Spring / Summer / Autumn / Winter	Restricted to southern South America and the Falkland Islands	Shallow dives	High frequency	Thought to be resident with no discernible seasonal movements detected in the Falklands population. More numerous inshore but found across the Patagonian Shelf (waters <200 m). Very enthusiastic bow-riders.

Species	IUCN status	Presence in the Berkeley Sound[a]	Global distribution	Foraging strategy	Auditory type	Behaviour
Pinnipeds						
South American fur seal (*Arctocephalus australis*)	LC	✓ Breed on Volunteer Rocks at the northern entrance to the Sound. Spring / Summer / Autumn / Winter	Restricted to southern South America and the Falkland Islands	Shallow dives	Otariid	Most breeding sites found off the northwest and southwest of the Falklands. Volunteer Rocks are the only known breeding site off the east coast of the Islands. Adults thought to disperse away from breeding colonies in winter but considered to be non-migratory.
South American sea lion (*Otaria flavescens*)	LC	✓ A small breeding colony is located on the north coast of the Sound. Haul-out sites on Kidney and Hog Islands. Spring / Summer / Autumn / Winter	Restricted to southern South America and the Falkland Islands	Shallow dives	Otariid	There are 68 breeding sites spread throughout the Falklands. The population has suffered a drastic long-term decline. In 2003, the population was reduced to 3.4% of the 1937 estimated population.

Key: Relative abundance of marine mammals within Falklands waters

Not recorded	Low	Moderate	High	Very High

Sources: IUCN, 2016; NOAA, 2015; Shirihai, 2006; Strange, 1992; Thompson et al., 2005; White et al., 2002.

7.4.6.4 Marine mammals in Stanley Harbour and surrounding areas

Commerson's dolphin (*Cephalorhynchus commersonii*) and Peale's dolphin (*Lagenorhynchus australis*) have frequently been recorded within Stanley Harbour (Falklands Conservation Cetacean Watch records; MMO surveys misc.). Due to their limited range Commerson's dolphin has a greater potential to be impacted by operations than Peale's dolphin. The Peale's dolphin has a greater range of mobility and may move between more sheltered waters, kelp forests, exposed coastlines and shelf waters (White *et al.,* 2002). However, no quantitative data on density or site fidelity is available.

Female South American sea lions (*Otaria flavescens*) are regularly sighted within the Harbour and hauled-out on existing jetties.

7.4.7 Terrestrial Habitats surrounding Berkeley Sound

7.4.7.1 Terrestrial habitat mapping and classification

Satellite images (see Figure 7.39 above) were used to map the terrestrial surrounding Berkeley Sound, details of the methodology used can be found in EnvSys (2016).

Using the information from fieldwork the remote sensing data was reanalysed and the terrestrial habitats mapped. A small section of the final map where fieldwork points had been used to guide the classification is provided in Figure 7.97.

The full map of the terrestrial vegetation surrounding the Sound can be seen in Figure 7.98, with the Magellan Cove area highlighted ('boxed'). The proportion of each habitat mapped is shown in Table 7.31.

In the coves and valleys where streams run into the Sound the vegetation comprises a mixture of flushes and marshy grassland close to the stream with species rich or semi-improved grassland in the valley bottoms. Away from the streams, the ground is not marshy but there is more available water than on the slopes and cliff edges and more palatable grass species occur, which flourish under these conditions. These areas attract grazing sheep which tends to lead to a cycle of nutrient enrichment as the sheep gather there; this leads to the semi-improved nature of many of these grasslands. Adjacent to the sandy beach, and in patches on the lower cliffs, are maritime grasslands, which contain a wide range of species.

Only on the low lying peaty and wetter land near Long Island, do the blanket bog and modified bogs reach within the 200 m zone of influence around the Sound, although these habitats are common further inland where the cliff edges flatten out. Cushion forming species generally occur in mosaics with acid grassland; they occur on shallower slopes throughout the Sound but generally in fairly small patches. The vegetation is also modified by penguin colonies which create swaths of bare ground which are often first colonised by sheep's sorrel *Rumex acetosa*. The nutrient enrichment of these areas generally results in the establishment of the more productive unimproved acid grassland after the penguins move on. The most significant habitats around the Sound are the flushes, which contain a range of less common species, and the areas of tussock grass found on some of the islands.

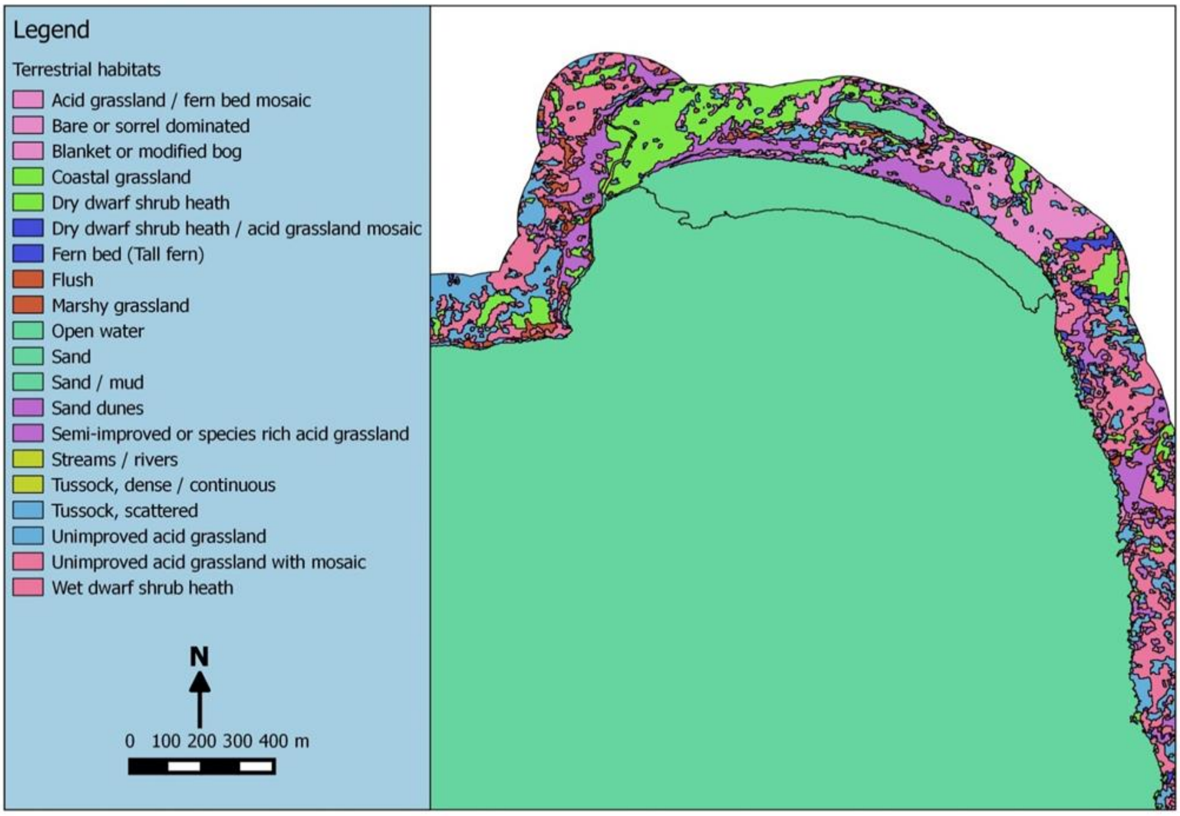


Figure 7.97: Terrestrial habitat mapping: Magellan Cove

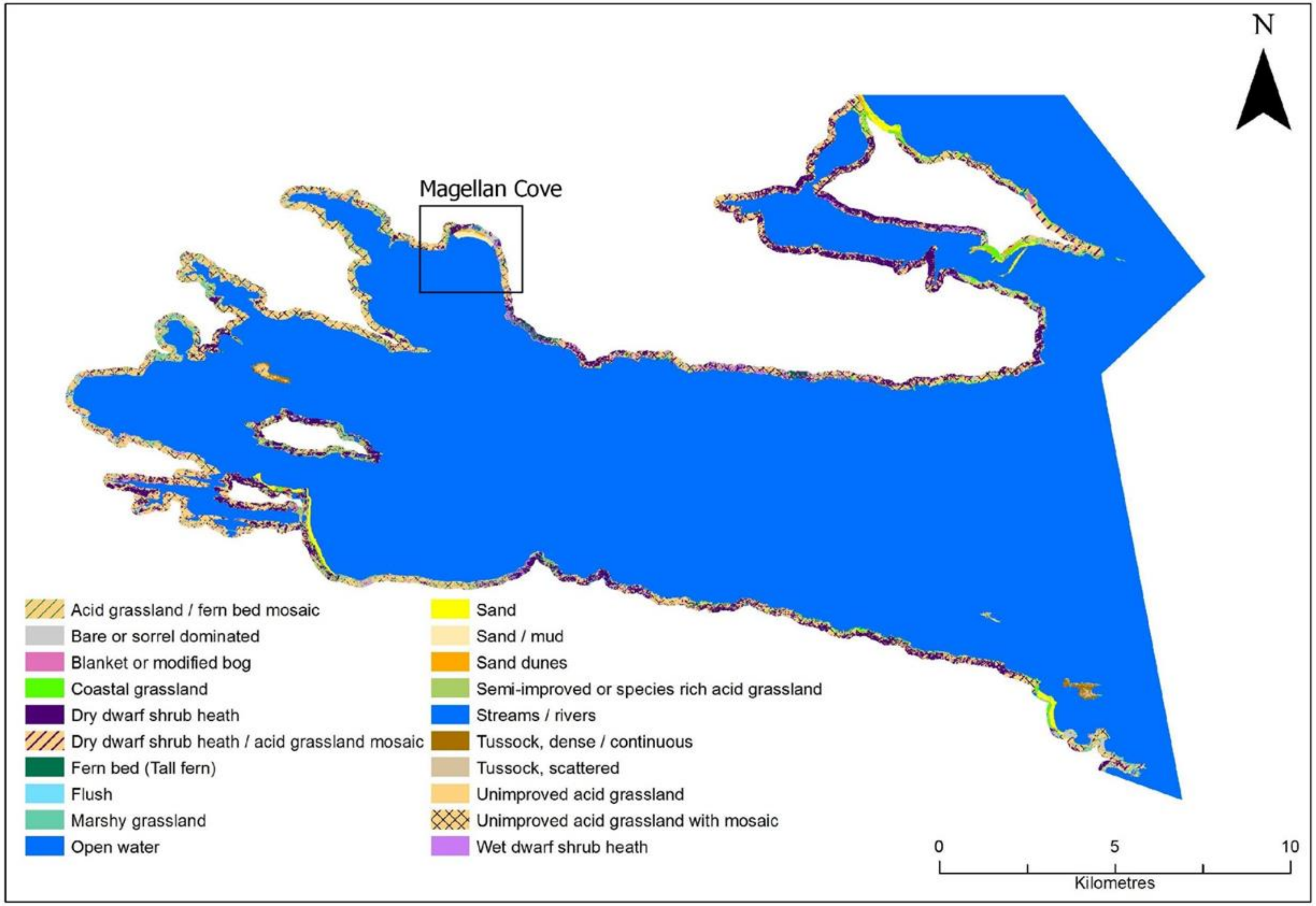


Figure 7.98: Terrestrial habitat map for Berkeley Sound (EnvSys, 2016)

Table 7.31: The area and percentage composition of terrestrial habitat types within 200 m of the Berkeley Sound shore

Habitat	Area (ha)	%
Unimproved acid grassland with mosaic including fern bed	869.07	25.05
Dry dwarf shrub heath	851.49	24.55
Unimproved acid grassland	571.34	16.47
Semi-improved or species rich acid grassland	269.97	7.78
Dry dwarf shrub heath / acid grassland mosaic	197.01	5.68
Wet dwarf shrub heath	138.41	3.99
Marshy grassland	120.15	3.46
Coastal grassland	110.33	3.18
Sand	83.34	2.40
Bare or sorrel dominated	80.00	2.31
Fern bed (tall fern)	40.48	1.17
Flush	33.65	0.97
Tussac grass, dense / continuous	30.72	0.89
Sand / mud	29.66	0.86
Sand dunes	19.72	0.57
Streams / rivers	7.63	0.22
Tussac grass scattered	7.30	0.21
Blanket or modified bog	7.05	0.20
Acid grassland / fern bed mosaic	1.34	0.04
Total	3,468.66	100

7.4.7.2 Environmentally sensitive terrestrial habitats

In terms of the potential impact of oil and gas related activity within Berkeley Sound, any pollutants released or spilt will be marine in origin and therefore have greatest potential of impacting the coastal (littoral) environment. Low lying coastal areas may be at risk of being inundated by the sea and thus height above sea level is an important consideration. Figure 7.99 shows the terrain coloured up according to what might be considered 'risk' zones with the:

- Red areas being within 1 m above the mean high water line;
- Orange areas within 5 m above the mean high water line; and,
- Yellow areas being within 20 m above the mean high water line.

This map clearly shows the low-lying areas where the streams output into the Sound as being most at risk of being impacted by any potential spill and strong winds / high tides. These areas also have some of the most significant vegetation, in terms of the diversity and uncommon species that they support. Although Important Plant Areas (section 7.5.2.3.2) or priority conservation habitats (section 7.5.2.4) are not known to occur around the coast of Berkeley Sound, three priority conservation species do occur (section 7.5.3).

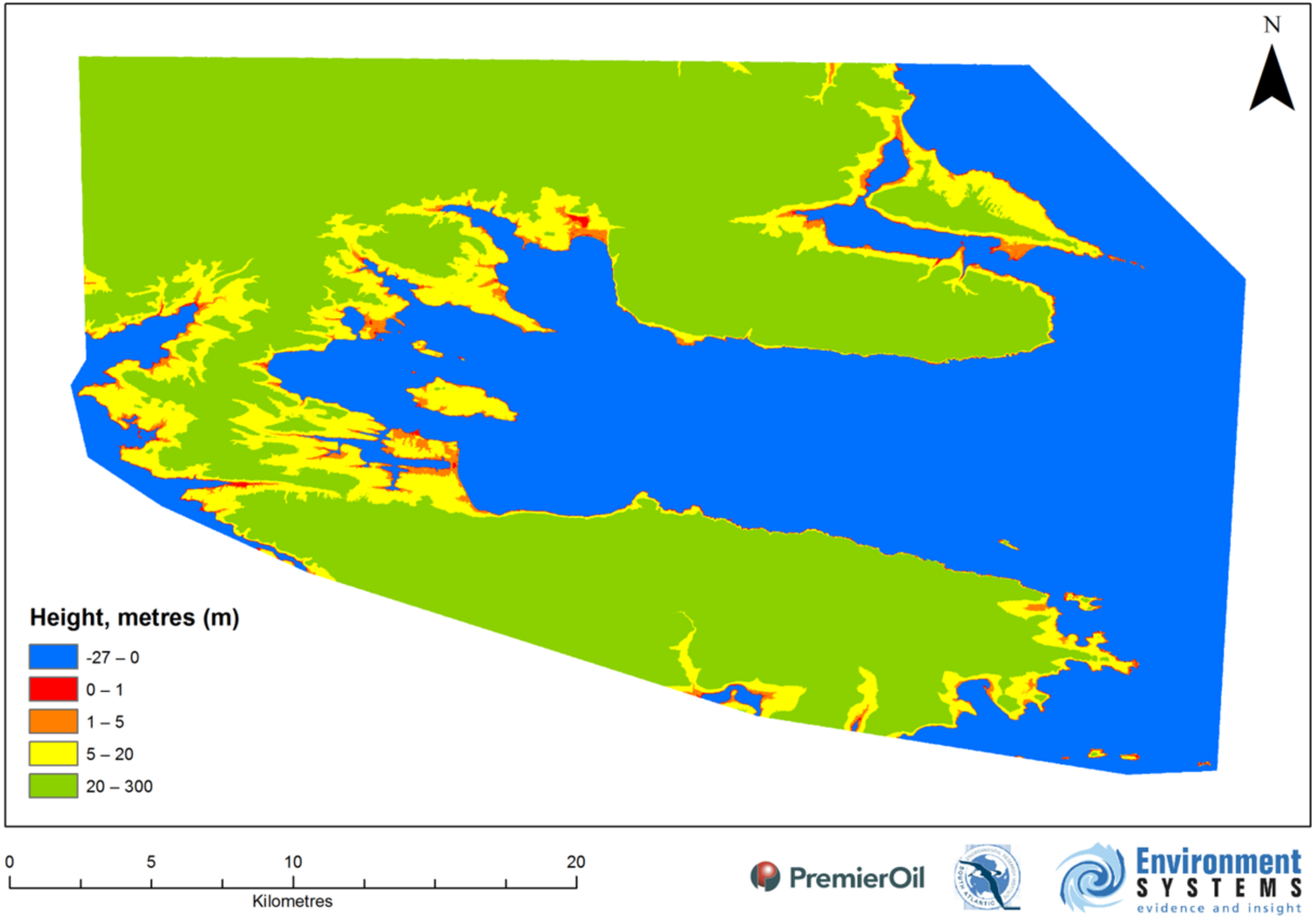


Figure 7.99: Terrain model data coloured to show low-lying land liable to marine inundation

7.5 Conservation designations for sites, species and habitats

7.5.1 Protected species

7.5.1.1 Benthic marine species

There is little specific protection for benthic marine species (or indeed marine habitats) within the waters of the Falkland Islands. This is partly because the marine environment and species assemblages are relatively poorly described.

Work is currently underway to address these data gaps (section 7.2.4.2). Marine Protected Areas (MPAs) (section 7.5.2.2) may be designated in the future but currently there are none in the Falkland Islands.

7.5.1.2 Fish species

Fish species in their own right do not have specific protection. However, the Fisheries Ordinance 2005 (section 3.1.6.3.9) caters for the use of closed areas (for protecting spawning sites). This comprises a combination of closed areas and a three-mile no-take zone around the entire coastline (Figure 7.100 below).

Therefore, coastal waters, including Berkeley Sound, are not subject to commercial fishing. It should be noted that there are a number of small scale aquaculture (e.g. sea trout) and harvesting (e.g. snow crab) operations within coastal waters elsewhere in the Islands. However, while there are potentially exploitable resources within Berkeley Sound (Davidson, 2016) these are currently unexploited.

7.5.1.3 Wild bird species

The majority of native wild birds are protected under the Conservation of Wildlife and Nature Ordinance, which was enacted in 1999 (section 3.1.6.3.8).

The ordinance protects all bird species, except for the:

- Upland goose (*Chloephaga picta*) and feral domestic goose, which may be hunted and killed at any time of the year; and
- Patagonian crested duck (*Lophonetta specularoides*) and yellow-billed (speckled) teal (*Anus flavirostris*), both of which cannot be killed during the closed season (1 July to 31 March).

Further, the Ordinance bans the collection of eggs, birds and animals; however, a permit holder may still collect eggs from some species, including Magellanic and gentoo penguins. More recent amendments to the Ordinance forbid the collection of black-browed albatross and rockhopper penguin eggs. The Ordinance extends to cover the territorial waters of the Falklands (up to 12 nm offshore).

Note that the Fisheries Ordinance 2005 described above also requires the use of mitigation measures to prevent the incidental capture of seabirds in longline and trawl fisheries.

7.5.1.4 Marine mammals

The Marine Mammal Ordinance 1992 (section 3.1.6.3.7) protects all marine mammals within Falkland Islands waters. It is an offence to take, wound or kill any marine mammal. According to the IUCN Red List, which assesses the conservation status of all species, there are four cetacean species that occur within Falkland Islands waters that are formally threatened. Sei, fin and blue whales are 'Endangered' and sperm whales are classified as 'Vulnerable'. Sei whales are regularly sighted within Berkeley Sound (section 7.4.6.3.1.4).

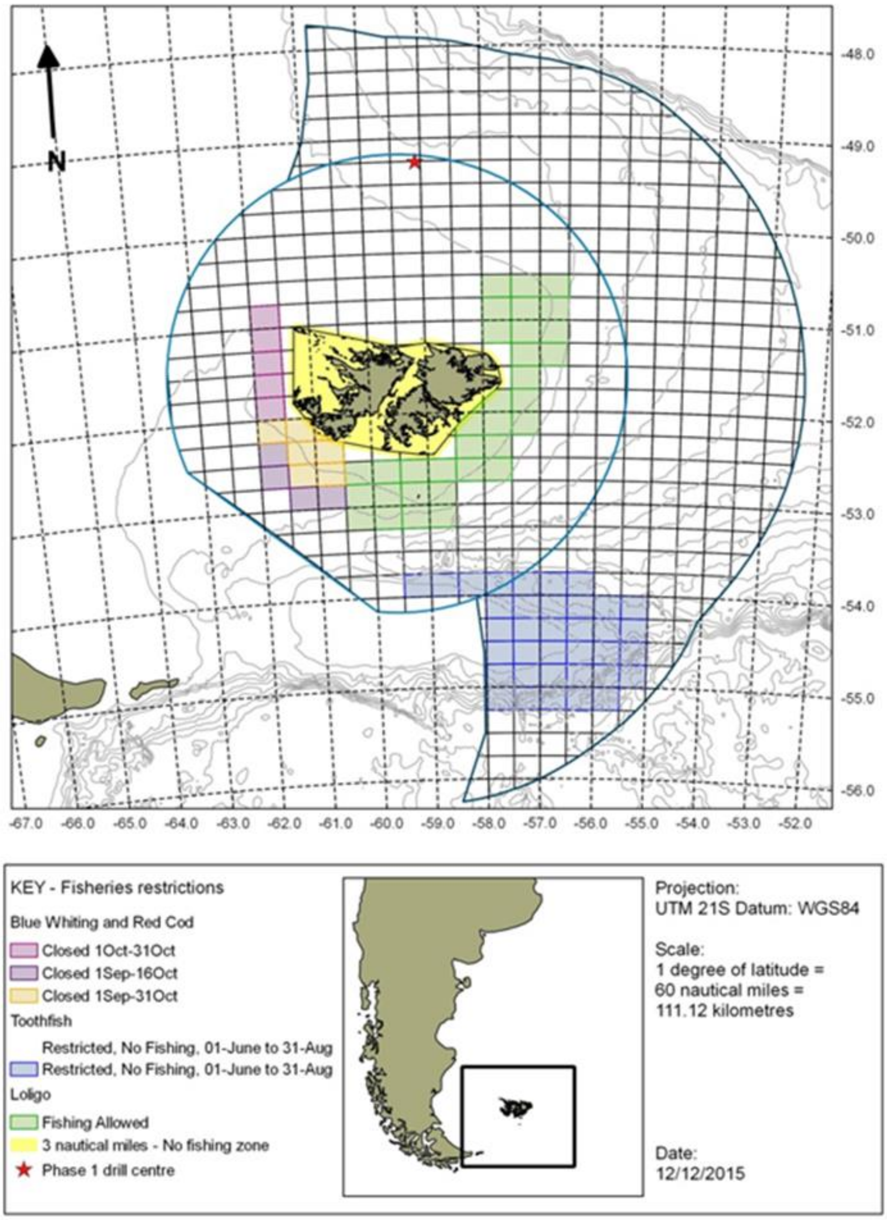


Figure 7.100: The Falkland Islands Conservation Zones showing permanent and seasonal no-take zones

7.5.1.5 Terrestrial plant species

The Important Plant Area directory for the Falkland Islands (Upson, 2012) identifies a number of endemic plant species and habitats that are of international conservation importance within the

Falkland Islands. There are 178 vascular plant species native to the Falkland Islands including 14 endemic species, with 19 species currently protected under the Conservation of Wildlife and Nature Ordinance 1999. Six endemic species, listed below, are categorized as of global conservation concern, mostly due to their small population sizes and restricted ranges (Upson, 2012):

- Antarctic cudweed (*Gamochaeta Antarctica*) Endangered;
- Falkland false-plantain (*Nastanthus falklandicus*) Endangered;
- Hairy daisy (*Erigeron incertus*) Endangered;
- Moore's plantain (*Plantago moorei*) Endangered;
- Falkland rock-cress (*Phlebolobium maclovianum*) Vulnerable; and
- Falkland nassauvia (*Nassauvia falklandica*) Unlisted.

Upson and Lewis (2014) summarise all the available information regarding plant distribution in the Falkland Islands into a distribution atlas. The distribution of the six species listed above are described as follows:

- Atlantic cudweed was only found in approximately six locations over the entire Falkland Islands;
- Falkland rock-cress is distributed across the Islands, although none have yet been found in the south of East Falkland;
- False plantain has only been found in the south of West Falkland;
- Hairy daisy is found in several locations along the west of West Falkland and in four locations on East Falkland;
- Falkland nassauvia and its distribution is still being studied; and
- Moore's plantain is also only found at a few locations in the south of West Falkland (Upson, 2012).

Antarctic Cudweed, Falkland Rock Cress and Hairy Daisy are all found in coastal environments and have been confirmed to occur in Port Louis Harbour within Berkeley Sound (Upson and Lewis, 2014). They may occur more widely in the Berkeley Sound area but detailed surveys have not been conducted in all areas. These species could be impacted by beach stranded oil or by vehicular and personnel access for response operations. The remaining three species (False Plantain, Moore's Plantain and Falkland *Nassauvia*) occur only on West Falkland (Upson and Lewis, 2014) and are not significant to the current assessment.

7.5.2 Protected habitats

There are currently three categories of environmental and wildlife protection which are applicable within the Falkland Islands:

- National Nature Reserves (through the Conservation of Wildlife and Nature Ordinance (1999);
- Marine Protected Areas (MPAs - none in place to date);
- Scientific designations for globally important habitats:

- Important Bird Areas (IBAs);
- Important Plant Areas (IPAs); and
- Ramsar sites.

7.5.2.1 National Nature Reserves

National Nature Reserves (NNRs) are established under the Conservation of Wildlife and Nature Ordinance (1999). There are currently 19 NNRs within the Falkland Islands (Table 7.32, Figure 7.101), which are either owned by FIG, private landowners, or organisations, such as Falklands Conservation. There are two NNRs within Berkeley Sound; Cochon and Kidney Islands and Volunteer Point and Cow Bay (Table 7.32, Figure 7.101).

Although the protection of these NNRs is underpinned by legislation, the main mechanism used to facilitate protection and management of these sites is the development and implementation of management plans by both FIG and landowners/stakeholders. FIG can designate marine NNRs. Although marine NNRs have yet to be proclaimed, there are some sites currently under review. Terrestrial NNRs may also be extended by 15 miles offshore from the coast.

Table 7.32: National Nature Reserves in the Falkland Islands and Berkeley Sound in particular

Date	Order	Designated Area	Landowner	IBA/IPA Ramsar Status	Distance from Sea Lion Licence block (km)
Falkland Islands overall					
1973	Jason Islands	Flat Jason 51º 06'S 60º 53'W (Designated separately, 1966) Elephant Jason 51º 09'S 60º 51'W South Jason 51º 12'S 60º 53'W North Fur Is. 51º 08'S 60º 44'W South Fur Is. 51º 15'S 60º 51'W Jason East Cay 51º 00'S 61º 18'W Jason West Cay 50º 58'S 61º 25'W The Fridays 51º 03'S 60º 58'W White Rock 51º 17'S 60º 53'W Seal Rocks 51º 07'S 60º 48'W	FIG	IBA	224
1964	The Twins Islands	51º 15'S 60º 38'W Northwest of Carcass Island	Falklands Conservation	IBA	230
1964	Low Island	51º 19'S 60º 27'W Southeast of Carcass Island	Private	IBA	235
1966	Middle Island	51º 38'S 60º 20'W King George Bay, West Falkland	FIG	IBA	263
2009	Chartres Horse Paddock	51º42'S 60º 03' W East of Chartres Farm Settlement, West Falkland	Private	IPA	265
1998	Narrows	51º 41'S 60º 19'W Narrows Farm, West Falkland	Private	-	267

Date	Order	Designated Area	Landowner	IBA/IPA Ramsar Status	Distance from Sea Lion Licence block (km)
1998	East Bay	51º 48'S 60º 13'W East Bay Farm, West Falkland	Private	-	277
1993	New Island South	51º 43'S 61º 18'W	Private	IBA	302
1978	Sea Dog Island	Sea Dog Island 52 00'S 61 06'W	FIG	-	321
1969	Bird Island	Bird Island 52º 10'S 60º 54'W	FIG	IBA	333
1978	Arch Islands	Big Arch Island 52 13'S 60 27'W Natural Arch Clump Island Tussac Island Pyramid Rock Last Rock and Albemarle Rock	FIG	-	325
1964	Beauchêne Island	52º 54'S 59º 11'W	FIG	IBA	390
1970	Bleaker Island	52º 18'S 58º 51'W Bleaker Island north of Long Gulch	Private	IBA	310
2012	Sea Lion Island	Sea Lion Island 52º25'S 59º 05'W	Private	IBA Ramsar	338
1973	Stanley Common	51º 43'S 57º 49'W	FIG	IPA (Cape Pembroke)	269
1968	Cape Dolphin	51º 15'S 58º 51'W	Private	-	208
1996	Moss Side	51º 23'S 58º 49'W, Pond and sand-grass flats behind Elephant Beach	Private	-	222
Berkeley Sound					
1964	Cochon and Kidney Islands (Berkeley Sound)	Kidney Island 51º 38'S 57º 45'W Cochon Island 51º 36'S 57º 47'W	FIG	IBA	262
1968	Volunteer and Cow Bay (Berkeley Sound)	51º 29'S 57º 50'W East Falkland	Private	IBA	260

(Source: FIG, 2014)

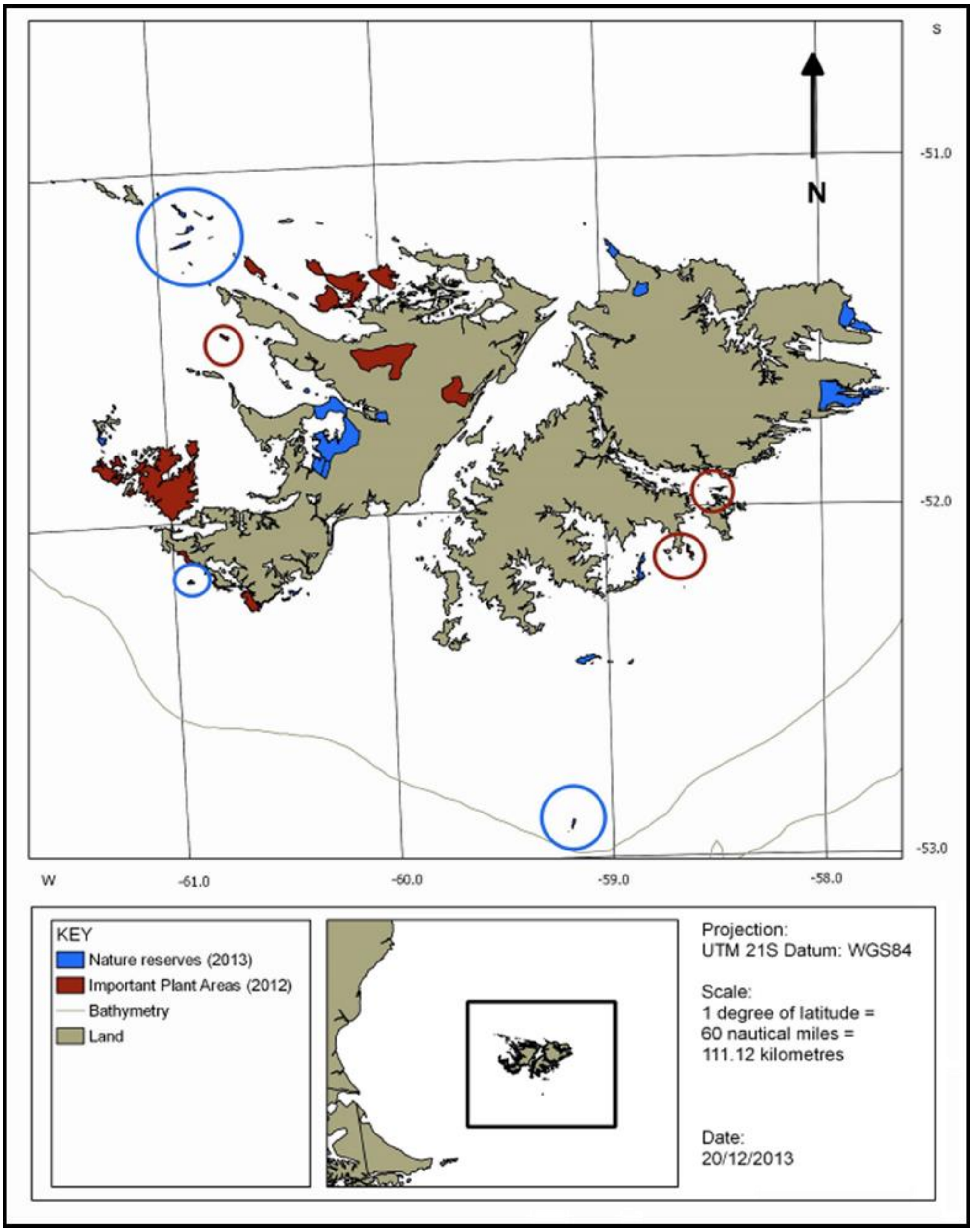


Figure 7.101: Falkland Islands National Nature Reserves and Important Plant Areas

7.5.2.2 Marine Protected Areas (MPA)

The Falkland Islands EEZ is rich in marine biodiversity, including globally threatened seabirds and marine mammals. The Fisheries Ordinance 2005 does afford protection to the marine environment and designates a number of no-take zones. However, to date no MPA's have been officially designated in the seas surrounding the Falkland Islands. There is already risk to the Falkland Islands marine environment from resource extraction; such pressures are likely to intensify and include new developments and related changes to coastal land-use. Existing practice and legislation need to be improved to manage current and potential future threats, to protect threatened species, sites and habitats.

The Falkland Islands Biodiversity Framework 2016-30 (FIG, 2015a) sets out the Falkland Islands Government vision with regards to biodiversity namely to *'conserve and enhance the natural diversity, ecological processes and heritage of the Falkland Islands, in harmony with sustainable economic development*'. The lack of integrated land / sea zoning and management has been identified as one of the highest priorities that need addressing in the Falkland Islands in the 2012 workshop report from the FCO/JNCC funded project 'Environmental Mainstreaming' (JNCC, 2012).

SAERI and partners have completed a project that conducted a series of reviews, stakeholder meetings and workshops together with creating a GIS for data analyses and visualisation relating to habitats, coastlines, fauna/flora, fisheries and hydrocarbon resource extraction. The outcome provided advice on appropriate policies, practices and frameworks for marine spatial planning in the coastal, inshore and offshore waters of the Falkland Islands. This will include specific advice on the establishment of potential provisions for areas of environmental, ecological and biological sensitivity (Augé, 2016a). In 2018 SAERI and partners embarked on the Darwin Plus project called 'Fine scaling the design of Falkland Islands Marine Management Areas' to develop a network of MPAs. The two and half year long multidisciplinary project, represents a multi-institution collaboration between FIG, SAERI, the Shallow Marine Surveys (SMSG) and the British Antarctic Survey (BAS). One of the main objectives is to deliver key baseline data for 3 proposed MMAs. Five steps have been identified for successful design/implementation of the MMAs, including 1) economic consequences of the MMA designs, 2) modern and inclusive site Management Plans, 3) policy formulation 4) Suggested legislative framework and 5) Legacy Planning (resourcing, financial, human).

The MSP/MMA process in the Falklands encapsulates the requirements for both multiple sustainable economic use of the marine environment, and marine conservation and protection. The requirement for a robust evidence-base to make designation of MMAs meaningful from an ecological perspective is also core to the Falklands MSP process.

More information about the programme can be found at https://www.south-atlantic-research.org/research/marine-science/fine-scaling-the-design-of-falkland-islands-marine-management-areas/

7.5.2.3 Scientific designations for globally important habitats and sites

In addition to the NNR system, there are a number of scientific designations that serve to recognise the globally important nature of sites within the Falkland Islands. Important Bird Areas (IBAs) and Important Plant Areas (IPAs) use a set of internationally agreed criteria and regionally defined thresholds to determine whether a particular site meets the requirements. In the Falkland Islands, IBA and IPA status does not provide legal protection *per se*, but should be considered as important informants to forward planning (e.g. Protected Area establishment) and risk assessment initiatives. Ramsar sites are also designated on the basis of meeting a set of criteria, but are slightly different to IBAs and IPAs in that the Falklands are included in the UK ratification of the Ramsar Convention, and have certain responsibilities under the ratification.

7.5.2.3.1 Important Bird Areas (IBAs)

The IBA system was developed by BirdLife International as a means of recognising globally important sites for birds, to inform the protection and conservation of bird species. Within the Falkland Islands, Falklands Conservation is responsible for administering the IBA programme. There are currently 22 IBAs in the Falkland Islands, 17 of which are islands or island groups, and the other five are found on the mainland of East or West Falkland (Table 7.33; Figure 7.102). Any terrestrial based IBA may be extended by 15 miles into the offshore environment. Although there are currently no marine IBAs established, work is ongoing to determine candidate areas. The level of legal protection associated with IBAs varies from country to country. In the Falklands, IBA status does not infer any legal protection but they are useful for informing management decisions.

Table 7.33: Confirmed Important Bird Areas for breeding sites in the Falkland Islands and Berkeley Sound in particular [a]

IBA Code	Site Name	Area (km^2)	IBA trigger seabird Species, life-cycle	Distance from Sea Lion Field (km)
Confirmed IBA – Terrestrial breeding areas (Falkland Islands overall)				
FK001	Beauchêne Island	1.7	MC, GP, RP, BBA, FP, SS: breeding	291
FK002	Beaver Island Group	59.6	GP, MP, SGP: breeding	303
FK022	Bertha's Beach, East Falkland	33.0	GP, MP: breeding	274
FK003	Bird Island	1.2	RP, BBA, TBP, SS - breeding	331
FK004	Bleaker Island Group	21.5	GP, RP, MP, SGP, IS – breeding	305
FK018	Bull Point, East Falkland	15.0	GP, MP - breeding	324
FK005	Elephant Cays Group	2.5	MP, SGP – breeding	293
FK019	Hope Harbour, West Falkland	17.6	GP, RP, MP, BBA – breeding	241
FK006	Hummock Island Group	6.7	RP, IS – breeding	257
FK007	Jason Islands Group	33.7	MC, RP, MP, BBA, SGP – breeding	223
FK008	Keppel Island	36.3	GP, RP, MP, BBA – breeding	218
FK010	Lively Island Group	67.9	GP, MP, SGP - breeding	288
FK011	New Island Group	25.5	GP, RP, MP, BBA, TBP, WCP, IS - breeding	290
FK012	Passage Islands Group	8.8	GP, RP, SGP – breeding	268
FK013	Pebble Island Group	109.6	MC, GP, RP, MP, SGP, SS – breeding	208
FK014	Saunders Island	124.0	GP, RP, MP, BBA – breeding	222
FK015	Sea Lion Islands Group	10.3	GP, RP, MP, SGP, SS – breeding	337
FK020	Seal Bay, East Falkland	31.0	GP, RP, MP, SS – breeding	230
FK016	Speedwell Island Group	0.9	GP, MP, SGP, SS – breeding	308
FK017	West Point Island Group	35.0	GP, RP, MP, BBA - breeding	229
• **Confirmed IBA – Terrestrial breeding areas (Berkeley Sound)**				
FK009	Kidney Island Group	0.4	MP, WCP, SS - breeding	262
FK021	Volunteer Point, East Falkland	40.6	GP, MP – breeding	240

[a] IBA trigger species: BBA – black-browed albatross, FP – fairy prion, , GP – gentoo penguin, IS – imperial shag, MC – Macaroni penguin, MP – Magellanic penguin, RP – rockhopper penguin, SGP – southern giant petrel, SS – sooty shearwater, TBP – thin-billed prion, WCP – white-chinned petrel. *Source: BirdLife International, 2014.*

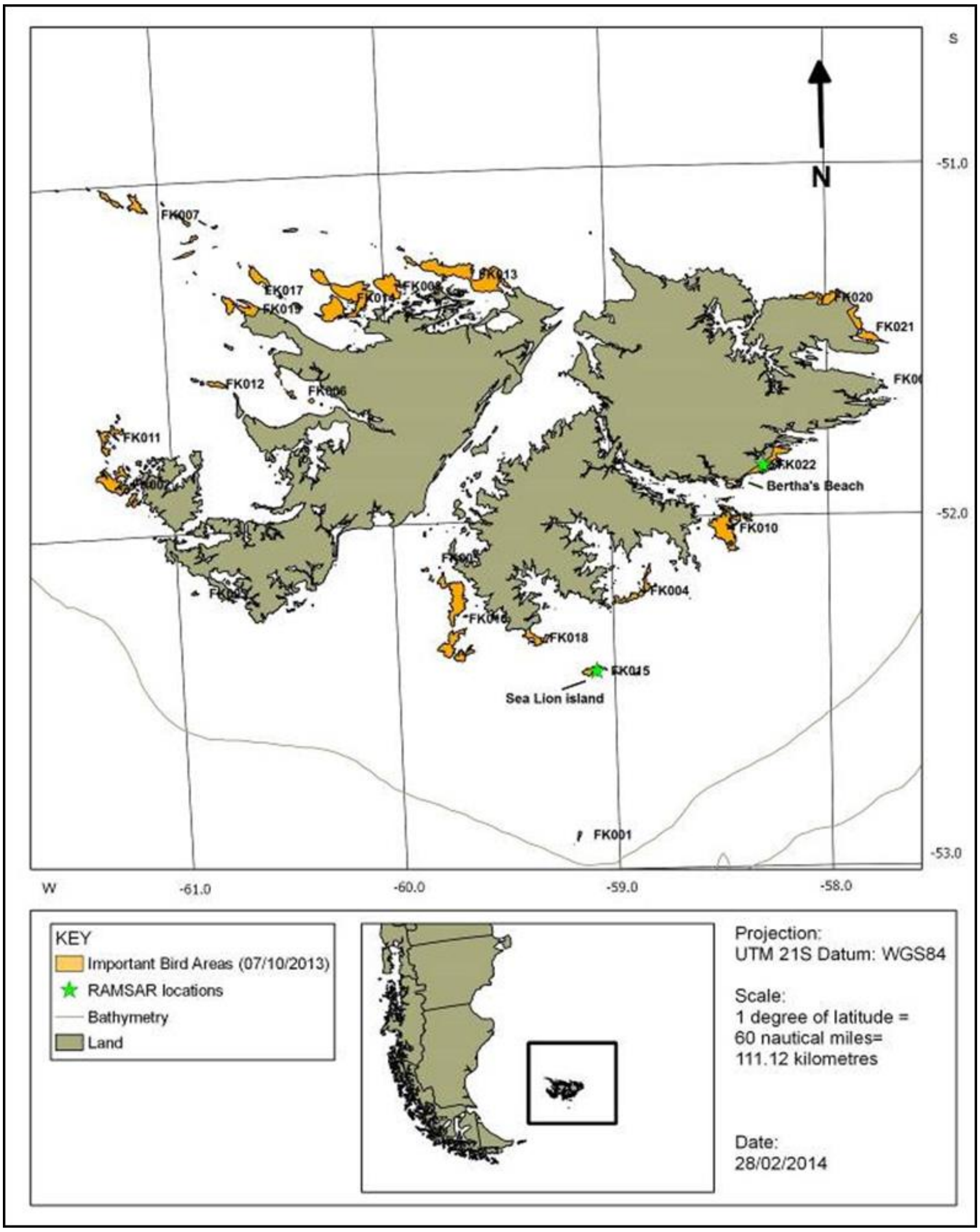


Figure 7.102: Current Important Bird Areas (IBAs) and Ramsar Sites (Bertha's Beach and Sea Lion Island) around the Falkland Islands *(Source: BirdLife International, 2014a)*

7.5.2.3.1.1 IBAs in Berkeley Sound

Kidney Island Group

The Kidney Island Group is composed of two small islands off the southern coast of Berkeley Sound; Kidney and Cochon Islands. Kidney Island lies approximately 400 m off the coast of East Falkland at the mouth Berkeley Sound, near Mengeary Point, and is 32 hectares (ha) in area. Cochon Island is situated approximately 1,330 m to the northwest of Kidney Island, about one km off the coast of East Falkland, and is eight ha in area. The Group is owned by the FIG and is designated as a NNR and an IBA.

Kidney Island is low lying and dominated by mature tussac (*Poa flagellata*), which grows to over 2.5 m in height. Tussac grass forms habitat for a number of burrowing seabird species, with sooty shearwaters being the most numerous breeding species on the Island. The population has increased in size since the 1960s and is now believed to number in excess of 100,000 pairs (Falklands Conservation, 2006; Clark *et al*., 2019). Other burrowing seabirds that are known to breed on the Island include; Magellanic penguin, white-chinned petrel, great shearwater, grey-backed storm-petrel and common diving-petrel. The northern coast is fringed by cliffs (18 m in height) and is home to breeding rockhopper penguins, rock and imperial shags.

Kidney Island remains rat-free and is home to breeding populations of the Falklands' two endemic bird species: Cobb's wren and Falklands steamer duck.

The sub-littoral waters around Kidney Island support a diverse range of habitats and species (SMSG, 2012).

Cochon Island largely consists of steep-sided slabs of rock, which rise to 30 m above sea level. There is little soil on the Island and vegetation is largely restricted to patchy tussac grass. The diversity of breeding birds on Cochon Island is not as great as that on Kidney but it does support a small population (250 pairs) of rockhopper penguins and a large colony of imperial shags.

Both Islands are used as haul-out sites for South American sea lions, although they are not known to breed on the Kidney Island Group.

The proximity of these Islands to shipping routes and anchorages in Berkeley Sound mean that there is a risk of impact from accidental oil spills or the introduction of non-native species; such as rats. A management plan has been written to address the management issues that affect both of these Islands (FIG, 2013a).

The Kidney Island Group are designated as an Important Bird Area (Falklands Conservation, 2006). The most significant species contributing to the IBA status are shown in Table 7.34.

Along with the species listed in Table 7.34, Kidney Island is the only confirmed breeding site for great shearwater outside of the Tristan da Cunha Group (Woods, 1970). A very small population, estimated at no more than 15 pairs (Woods and Woods, 1997), breed at the western end of the Island. The sooty shearwater colony on Kidney Island is believed to be the largest in the Falkland Islands.

Table 7.34: Kidney Island Group IBA criteria (from Falklands Conservation, 2006)

Species	IBA Criteria	Population estimate	Comment
White-chinned petrel	A1: Vulnerable species	Approx. 1,000	Kidney population mainly along southern coastal slopes
Rockhopper penguin	A1: Vulnerable	512	Kidney (257) increasing slowly, but historic decline since 1930s (c.3,500 pairs), Cochon (264) declining
Magellanic penguin	A1: Near Threatened	unknown	Numerous Kidney, not counted
Sooty shearwater	A1, A4ii: Near Threatened, > 1% of the global population	>100,000	Kidney population has increased since 1960s, possibly 2 burrows per square metre

Species	IBA Criteria	Population estimate	Comment
Cobb's wren	A1, A2: Vulnerable, Restricted range	unknown	Widespread and numerous on Kidney not counted
Tussock bird	A2: Restricted range	unknown	Numerous on Kidney beaches not counted
Falklands steamer duck	A2: Restricted range	15	Fluctuates from 6-15 pairs
Combined seabirds	A4iii: Supports >10,000 pairs of seabirds	>102,000	-

Volunteer Point and Cow Bay

Volunteer Point is a lowland peninsula on the northern coast of Berkeley Sound and marks the northern entrance to the Sound. North of Volunteer Point, lies Cow Bay, which combined represent a NNR and IBA covering 4,060 ha. The land is privately owned by Jan Cheek and is a popular tourist visitor site.

The northern coast of Volunteer Point includes; a range of low cliffs, sandy and boulder beaches with extensive kelp beds offshore. The southern side of the peninsula borders Volunteer Lagoon and includes the extensive sand flats and dunes of Lagoon Bar.

Volunteer Green supports the largest colony of king penguins in the Falklands but also supports breeding gentoo and Magellanic penguins. Beyond the penguin colonies on the green, Volunteer Lagoon supports a variety of waterfowl. The species that contribute to the IBA status are shown in Table 7.35.

Table 7.35: Volunteer Point IBA criteria (from Falklands Conservation, 2006)

Species	Criteria	Breeding pairs	Comment
Gentoo penguin	A1: Near threatened	1,368	2001 Volunteer Green 766, Lagoon Bar 325, Cow Bay 277
Magellanic penguin	A1: Near threatened	>2,000	2003, extensive coastal colony
Ruddy-headed goose	A2: Restricted range species	>100	Scattered throughout site
Black-throated finch	A2: Restricted range species	Unknown	Breeding in heathland and coastal vegetation, no counts
Falkland steamer duck	A2: Restricted range species	About 75	Volunteer Point 60 along coast, Cow Bay 10

7.5.2.3.2 Important Plant Areas (IPAs)

IPAs were established by Plantlife International and the IUCN with a view to identifying locations that will allow the best protection of threatened plant species. The IPAs are chosen based on whether the location has one or more species that are of global conservation concern, or has a rich population of regional flora (Upson, 2012). There are currently 17 IPAs within the Falkland Islands, none are close to Berkeley Sound (Upson, 2012).

7.5.2.3.3 Ramsar sites

The Ramsar convention was established in 1971. It provides for the protection of all habitats that fall under the umbrella description 'wetlands', which includes marshes, peat bogs, oases, ponds, lakes and the marine inshore environment. There are currently two Ramsar sites within the Falkland Islands: Sea Lion Island and Bertha's Beach (Figure 7.102 above), both of which are also designated as IBAs; Sea Lion is also an NNR. There are currently two further sites which are being considered for Ramsar designation: Pebble Island East and East Bay.

7.5.2.4 Threatened terrestrial habitats

Under the Falkland Islands Biodiversity Framework, four terrestrial habitats have been identified as vulnerable, these are;

- Mainland tussac;
- Whitegrass-fachine acid grassland;
- Fachine scrub; and
- Boxwood scrub (framework still in draft)

However, this list of threatened habitats is only preliminary as it is based on the current, limited knowledge of these habitats and the extent and degree of threat that they face. A variety of wetland sites may also be under threat, but this requires further investigation. The main threat to terrestrial habitats has been through degradation associated with the introduction of grazing herbivorous animals for farming (RPS Energy, 2009; Upson, 2012).

7.5.3 Threatened species and habitats

A number of species and habitat types have been identified through criteria associated with listings under international conventions, global and national conservation status and changes in population, distribution and risk from specific threats as a priority for conservation efforts in the Falklands (FIG, 2008b). The species and habitats concerned are listed in Table 7.36. Specific action plans have been prepared for some, but not all, of these.

Many of these priority species are marine or coastal in distribution and are therefore vulnerable to oil and gas industry related impacts. Additionally, these species are likely to be the focus of inshore monitoring efforts. However, to date no sub-littoral species or habitats have been identified as a priority for conservation.

Table 7.36: Species and habitats of conservation concern in the Falklands and their action plan status

Comprehensive Action Plan required		Basic Action Plan required	
Mainland tussac grass		Endemic plants (13 species)	
Whitegrass-fachine acid grassland		Californian club-rush stands	
Fachine scrub		Mountain bluegrass	
Boxwood scrub		Falklands steamer duck	

Comprehensive Action Plan required		Basic Action Plan required	
Threatened plant species (22 species)		Pelagic cetaceans	
Black-browed albatross	✓	Peale's and Commerson's dolphins	✓
Striated caracara		Seals and sea lions	✓
Southern rockhopper penguin	✓	Southern giant petrel	✓
Cobb's wren	✓	Gentoo penguin	
Zebra trout		Magellanic penguin	
-		Falkland fritillary	
-		Ruddy-headed goose	
-		White-chinned petrel	✓

7.6 Coastal sensitivity to oil spills

7.6.1 Environmental Sensitivity Index

IPIECA (2011) provides a framework for coastal sensitivity mapping for oil spill response based upon coastal habitat type and the associated Environmental Sensitivity Index (ESI) developed from Gunlach and Haynes (1978) Oil Sensitivity Index. The ESI is a ranking system whereby different coastal zones with varying characteristics are ranked according to their environmental sensitivity. The ESI ranks habitats, assessed qualitatively, on the ease of cleaning, the rate of natural oil degradation (high / low energy) and the likely probability that an impact will be observed, rather than attempt to quantify the actual absolute impact.

The ESI (Table 7.37), ranging from 1 (low sensitivity) to 10 (very high sensitivity), can be adapted for a range of habitat types and integrates the:

- Shoreline type (grain size, slope) which determines the capacity of oil penetration and / or burial on the shore, and movement;
- Exposure to wave (and tidal energy) which determines the natural persistence time of oil on the shoreline;
- Shoreline slope;
- Ease of clean-up; and
- Ease of restoration.

The assessment was predominantly based upon shoreline type derived from *Google Earth* imagery and local knowledge along with a subjective assessment of exposure given predominant wind directions. A full breakdown of the methodology and results is given in Marengo (2014b).

Table 7.37: Environmental Sensitivity Index (ESI) definitions

ESI	Estuarine	Riverine
1A	Exposed rocky shores	Exposed rocky banks
1C	Exposed rocky cliffs with boulder talus base	Exposed rocky cliffs with boulder talus base
2A	Exposed wave-cut platform in bedrock / mud / clay	Rocky shoals, bedrock ledges
2B	Exposed scarps and steep slopes in clay (unconsolidated sediment)	-
3A	Fine to medium-grained sand beaches	-
3B	Scarps and steep slopes in sand (unconsolidated sediment)	Exposed, eroding banks in unconsolidated sediments
3D	Scarps / steep slopes in bedrock or flat rocks	-
4	Course-grained sand beaches	Sandy bars and gently sloping banks
5	Mixed sand and gravel beaches	Mixed sand / gravel bars and gently sloping banks
6A	Gravel beaches (granules and pebbles)	Gravel bars and gently sloping banks
7	Exposed tidal flats	-
8A	Sheltered scarps in bedrock, mud or clay. Sheltered rocky shores (impermeable)	-
8B	Sheltered solid man-made structures. Sheltered rocky shores (impermeable)	Sheltered, solid man-made structures
8D	Sheltered rocky rubble shores	-
8E	Peat shorelines	-
8F	-	Vegetated, steeply-sloping bluffs
9A	Sheltered tidal flats	-
9B	Vegetated low banks	Vegetated low banks
9	Hyper-saline tidal flats	-
10A	Salt- and brackish-water marshes	-
10B	Freshwater marshes	Freshwater marshes

7.6.2 Sensitivity of north Falklands coastline to offshore oil spills

In 2014, Premier conducted an assessment of the environmental sensitivity of the north Falklands coastline to a spill of hydrocarbons from the proposed Sea Lion Development (Premier, 2014b). This sensitivity assessment was carried out using industry developed techniques and was informed by conceptual oil spill modelling studies which predicted the potential distribution of oil, and the risk of oil beaching in along the north Falklands coastline, in the unlikely event of a worst case oil spill from the proposed Development location.

The Falklands Coastline Environmental Sensitivity study (Premier, 2014b) remains relevant to this EIA as it highlights the most sensitive sites along the north Falklands coastline, which will inform management decisions in the event that a shoreline oil spill response operation does needs to be initiated.

During the 2018 coastal bird surveys in Berkeley Sound, observations of typical Falkland Islands shoreline types were recorded and given a classification index for the purposes of oil spill planning that parallels the IPIECA (2011) system of Environmental Sensitivity Index. While this does not affect the assessment, it improves the mitigation in terms of the detailed oil spill contingency plans that will follow approval of the project.

7.6.2.1 Coastal Sensitivity Assessment Outputs

Modelling an offshore oil spill (section 12.1) shows that East Falkland has a higher probability of oil 'waxlets' beaching than islands to the west. The likelihood of waxlets reaching shore declines to the west across West Falkland, reaching a minimum on the western Jason Island chain. Likewise, to the east and south of McBride Head, towards Volunteer Point and Cape Pembroke, the likelihood of waxlets beaching declines. The most northerly headlands of Cape Dolphin, Cape Bougainville and Seal Bay / McBride Head showing the highest overall probabilities of oil beaching in the event of an offshore spill.

The results of the study highlighted that the north Falklands coastline is exposed and rocky with wave cut platforms and deep scarps which are considered to be of low sensitivity (ESI 1-3) to oil impacts. High sensitivity areas (ESI 8 – 10) include inland tidal creeks, and sheltered tidal flats and were identified as: Volunteer Lagoon, Swan Pond (Port Louis), Salvador Waters, Brazo del Mar, Limpet Creek, Little Creek, Smylie's Inlet, Inner White Rock Bay, Inner Tamar Pass (North and South), Inner Port Purvis, Victor Creek (Pebble Island), Justice Inlet (Keppel), NE Bay Saunders, Brett Harbour (Saunders), Penguin Island (Saunders) (Figure 7.103 and Figure 7.104). In addition to the general sensitivity of the coastline, there is a range of IBAs, IPAs, NNRs and Ramsar Sites that were considered along with sites of known environmental importance with significant concentrations of wildlife (section 7.5). While a range of taxa may be impacted by an oil spill, the assessment was predominantly based upon colonial seabirds for which census data are available.

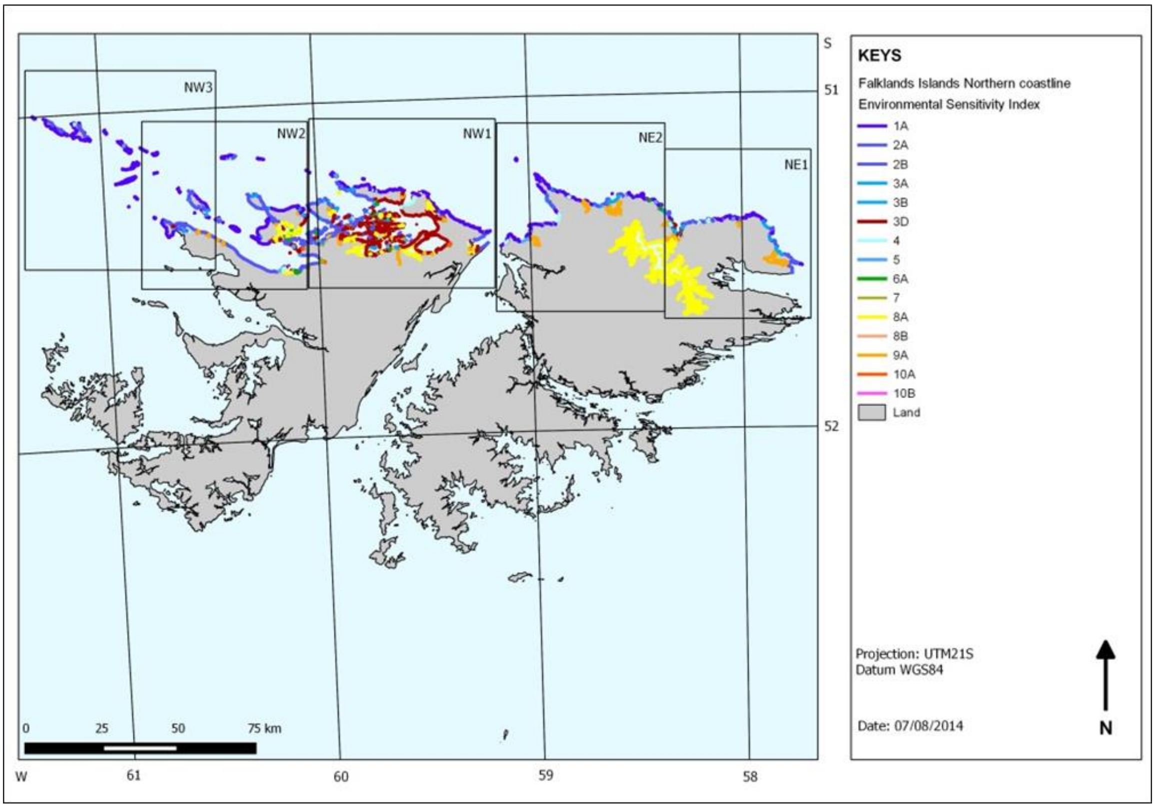


Figure 7.103: ESI North Falklands Coastline. Coastal sensitivity categorised by Environmental Sensitivity Index habitat types 1-10 *(source: Gunlach and Haynes (1978) and IPIECA (2011))*

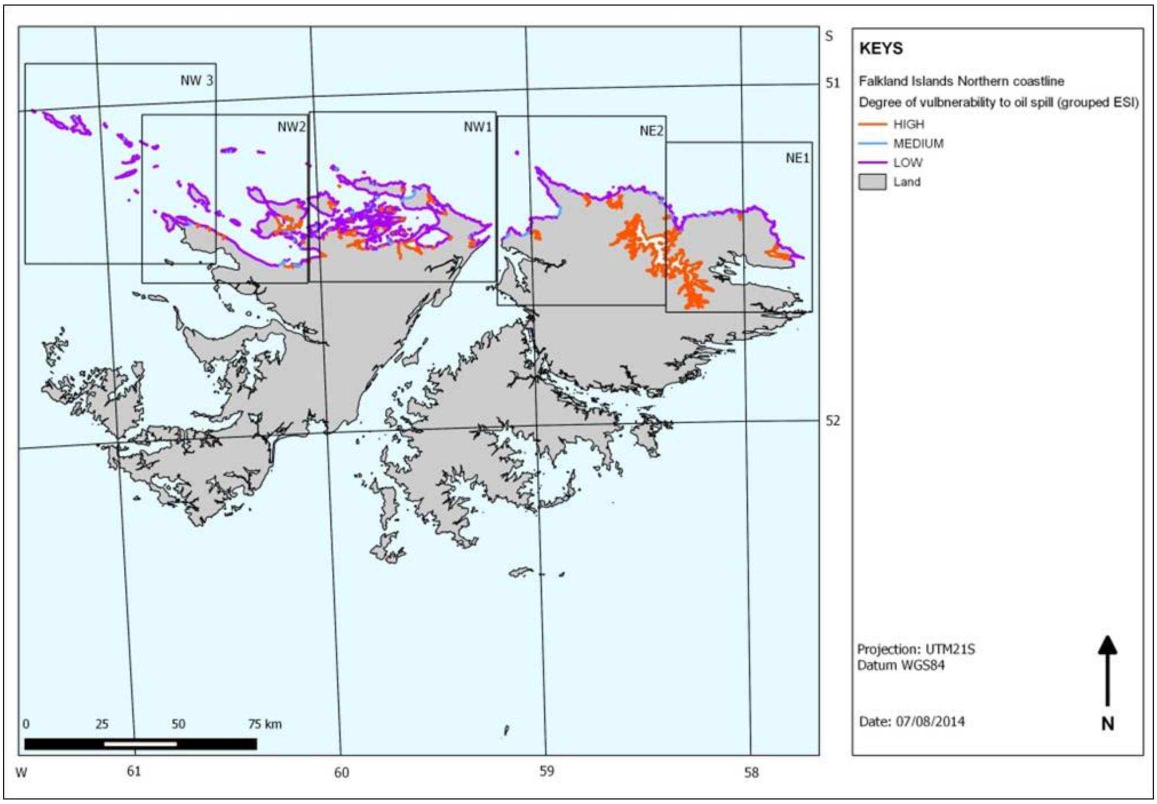


Figure 7.104: North Falklands Coastline. Environmental Sensitivity Mapping (ESI) categorised as Low (ESI 1-3), Moderate (ESI 4-7) and High (ESI 8-10) vulnerability to offshore oil spill.

7.6.2.1.1 Environmental sensitivity to offshore oil spill

A review of the seabird colony locations with respect to coastline type, the seasonality of occurrence and the Oil Vulnerability Index (OVI) of the species (section 7.4.5.6) suggest that gentoo penguins may be the most vulnerable to impacts and would be suitable to use as a ranking proxy. Gentoo penguins showed the greatest overlap with sensitive coastline types (ESI), associate with breeding colonies through-out the year, and have a high OVI sensitivity.

The conservation importance of black-browed albatross and rockhopper penguins was recognised. Due to the tendency of these species to utilise more exposed rocky coastlines of low sensitivity, sites were not prioritised in the first instance. Real-time monitoring during an incident should determine the need for any subsequent re-prioritisation or response intervention on site.

Additional species and taxa were not considered either due to a lack of quantitative data that could be extrapolated to un-surveyed coastlines or to a widespread distribution across the coastal habitat types, which gave little differentiation between coastlines for ranking purposes.

7.6.2.1.2 Socio-economic sensitivity to offshore oil spill

Socio-economic factors were considered and the relative level of tourism utilised to further differentiate the environmental and socio-economic sensitivity of sites. The occurrence of fine-grained sand beaches in proximity to penguin colonies was identified as an important tourism resource, albeit that these sites are of relatively low sensitivity (Figure 7.103 above, ESI 3).

The study also mapped the location of infrastructure that might assist a response and mobilisation to the northern coastline. For example, the location of road, tracks, jetties (and slipways), ports, airstrips, settlements and shanties was detailed and mapped, along with their condition where appropriate. This will enable Premier to define the level of resources required to mount an appropriate response.

7.6.2.1.3 Prioritisation and management of offshore oil spill response

Due to the spatial extent of the north Falklands coastline and the associated issues with regards to access and response time, it is evident that some prioritisation will be required. Prioritisation should focus response on those areas where capacity can be best deployed to tackle the maximum extent of sites, which are most at risk of biologically significant or socio-economic impacts.

A pragmatic compromise will need to be reached that balances the importance of a site with the level of resources that are required. This may mean that some important sites may not be tackled in favour of other more accessible sites where remedial actions will be able to be conducted over a greater spatial area.

The final long-listing of sites utilised the coastal ESI, location of notable scenic beaches, the occurrence of gentoo penguins, overlap with an environmental land designation and relative level of tourism activity.

The highest ranked sites for response are located at;

- Volunteer Point;

- Pebble Island;
- Saunders Island; and
- Carcass Island.

Important and secondary ranked sites for response are located at;

- Swan Pond and Seal Bay coastline;
- Brazo del Mar and entrance to Salvador Waters;
- Bougainville, Concordia and Limpet Creek coastline;
- Cape Dolphin Swan Pond Beach;
- Smylie's Inlet and Paloma Beach;
- Grave Cove, Dunbar; and
- Steeple Jason.

The grouping of sites into geographical areas will assist in the mobilisation of resources, and may permit some secondary ranked sites to be tackled with adjacent higher priority sites. Geographic groupings with multiple sites would include;

- Volunteer Point and Cow Bay;
- Swan Pond and Seal Bay;
- Entrance to Salvador Waters;
- Limpet Creek and Concordia;
- Cape Dolphin and Elephant Beach;
- Paloma Beach, Smylie's and Race Point;
- Pebble Island; and
- Saunders Island.

The ESI classification and location of significant wildlife sites provides the background and basis for prioritising sites for oil spill response. It is however recognised by IPIECA (2011) that the relative importance of ranking criteria will be influenced by local perceptions and that ranking should not rely solely upon a quantitative analysis. A consultative approach incorporating local stakeholders into the planning process and final prioritisation should be conducted.

7.6.3 Sensitivity of Berkeley Sound coast to inshore oil spills

The inshore coastal sensitivity assessment was predominantly based upon shoreline types identified using *Google Earth* imagery and local knowledge along with a subjective assessment of exposure given predominant wind directions. A full breakdown of the methodology and results is given in Marengo (2014b).

Figure 7.105 maps the coastline of Berkeley Sound to show the distribution of ESI category habitats. Within Berkeley Sound sensitive coastlines are limited to the upper reaches of the Sound to the west of the LTV anchorages and would be less at risk of oil contamination given the prevailing westerly winds. The coastlines of the outer Sound are largely composed of steep-slopes or cliffs, which have low ESI scores (Figure 7.105). To the north of Berkeley Sound, the adjacent Volunteer Lagoon represents an area of higher sensitivity.

Berkeley Sound, and associated coastline (see Figure 7.105), has a total length of 295 km. Of this, 34 % (101 km) was classed as high sensitivity, 10 km (3 %) is moderate sensitivity and 184 km (62 %) is classed as low sensitivity.

In addition, it is important to understand and map the location of internationally recognised sites and nationally designated sites of environmental importance to identify sensitive ecosystems, critical habitats and endangered species. Therefore to highlight environmentally sensitive areas within the coastal zones adjacent to Berkeley Sound, the occurrence of nationally protected areas and the known locations of key faunal and floral species have been mapped throughout this baseline chapter.

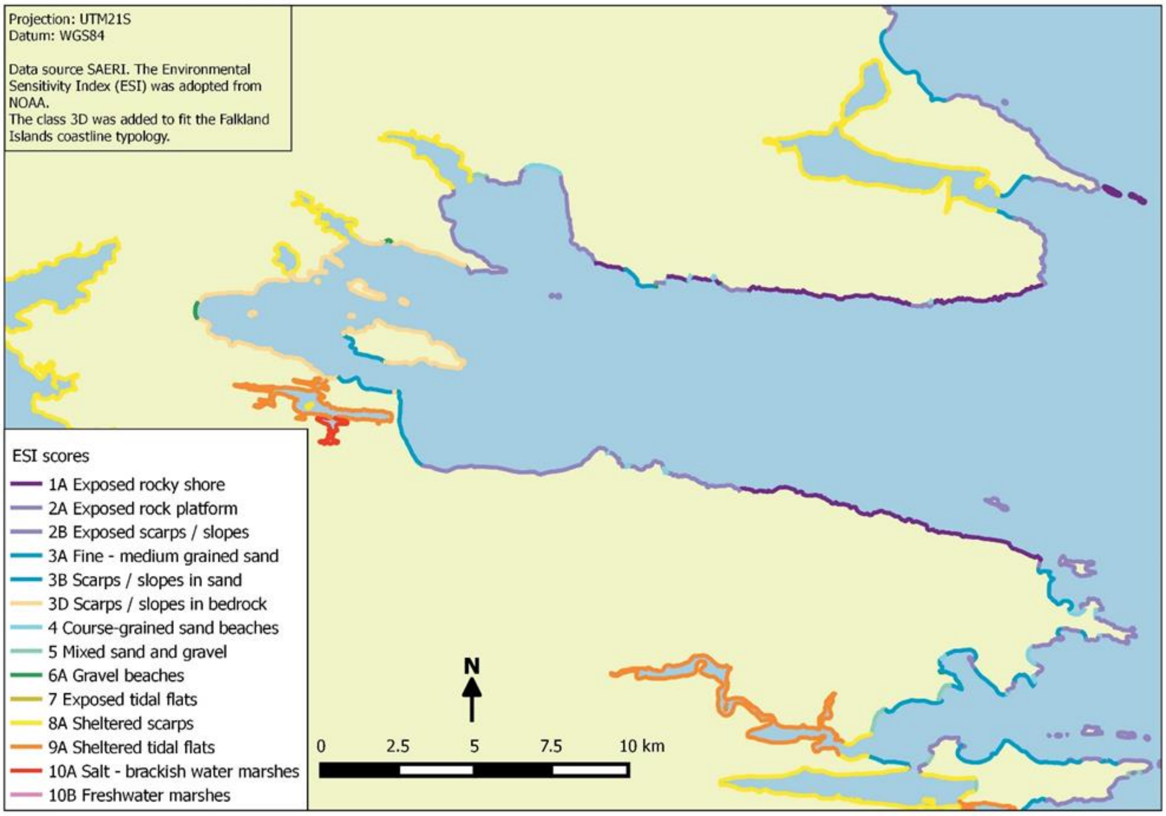


Figure 7.105: ESI Berkeley Sound. Coastal sensitivity categorised by Environmental Sensitivity Index habitat types 1-10

7.7 Social environment

7.7.1 Falkland Islands socio-economic description

In 2012, Rockhopper Exploration commissioned an independent socioeconomic impact assessment to identify potential impacts and mitigation measures to minimise any negative impacts from O&G that could be associated with the project (Plexus Energy, 2012). The FIG also commissioned an independent socio-economic study of oil and gas development in the Falkland Islands (Regeneris, 2013). With support from the O&G industry, FIG have initiated a

Social and Economic Monitoring Programme (SEMP), which relies on extensive public consultation. Initial results were published in the Social Economic Monitoring Programme (SEMP report), Regeneris (2015). Premier Oil have updated their Socio-economic Impact Assessmnent in 2019. This section outlines the current socio-economic baseline for the Falkland Islands and draws on all of the above reports as well as FIG data, including the recent 2016 Falklands Census. Much of the information presented here is to provide background reference. The EIS focuses on environmental impacts and risks not socio-economic impacts; however, where environmental impacts have a knock-on socio-economic impact these are discussed further in the relevant sections.

7.7.2 Human population

7.7.2.1 National identity

The culture of the Falkland Islands is a blend of British culture and elements that have emerged given the Islands' history, location and geopolitical relationships. There is a strong sense of allegiance to Great Britain.

The 2016 Census asked people to state their national identity: 49 % of residents considered themselves Falkland Islanders, 24 % British, 8 % St. Helenian and 5 % Chilean, (FIG, 2017).

There is a strong sense of local community and cohesion due to the small population. High levels of familiarity encourage a safe and welcoming community. While the majority of the population is based in Stanley, the rural life is an important part of Falklands culture. Areas outside Stanley are referred to as 'Camp'.

7.7.2.2 Population size and main settlements

The total resident population of the Falkland Islands was 3,200 in 2016 according to the 2016 Population Census (FIG, 2017). In recent years the economic pull of Stanley, the capital and only town, has attracted people away from Camp (Table 7.38). In 2016, 2,460 people, about 77 % of the total population, resided in Stanley, 11 % in Camp and 11 % (non-military personnel) at the Mount Pleasant Complex (MPC), the joint army, air force and navy complex operated by the UK Ministry of Defence (MoD) at Mount Pleasant.

After Stanley the next most populous settlement in the Falkland Islands is Mount Pleasant some 36 miles southwest of Stanley. In 2016, the population in Camp grew for the first time since the 1950s; by 9 % overall. Goose Green, Fitzroy and North Arm are the most populated settlements on the East; Fox Bay, Port Howard and Hill Cove are the largest on the West (FIG, 2017). Figure 7.106 shows the main islands in the Falklands archipelago and the locations of the main settlements and connecting roads.

The population of the Falkland Islands is aging with 23 % of the population in Camp being over 60 years of age and 16 % in Stanley in 2016 (FIG, 2017). Population in Camp has increased slightly since 2012 from 351 to 381 people in 2016.

Alongside the population of Camp and Stanley there are an estimated 359 civilian contractors who work and reside at MPC. Serving members of the armed forces are not counted in census statistics. The MPC is a largely self-contained community and provides the main airport for international flights to and from the Falkland Islands.

At the last census, 389 work permit holders were recorded in Stanley (FIG, 2017). Work permit holders are employed in all sectors in the Falklands, except real estate. Over one third (148 people) are employed by FIG. 87 % of all employees in the professional, scientific and technical sector have temporary immigration status; other sectors that are reliant on this category of employees are hospitality (48 % of employees), retail (33 %) and business and administration services (29 %). The number of work permit holders is significant to the EIA as accommodation has to be found for all these people. It is difficult for work permit holders to find affordable accommodation in the private rental sector (A. Black *pers. obs.*).

Throughout the Islands, the largest proportion of all workers were employed by FIG (29 %). The next largest primary employment sector was agriculture (12 %), followed by retail (11 %), and construction (10 %). The number recorded as working in the other two major economic sectors; fishing and tourism, were lower at 3 and 5 % respectively.

Table 7.38: Location of population, excluding MPC, (FIG, 2017)

Location of population present on census night	1991	1996	2001	2006	2012	2016
Stanley	1,582	1,636	1,989	2,115	2,120	2,460
East Falkland (outside Stanley)	246	233	208	194	202	190
West Falkland	198	174	144	127	127	151
Outer Islands	65	38	38	42	22	40
Total usual resident population	**2,091**	**2,081**	**2,379**	**2,478**	**2,471**	**2,841**
Stanley population	**76 %**	**79 %**	**84 %**	**85 %**	**86 %**	**87 %**

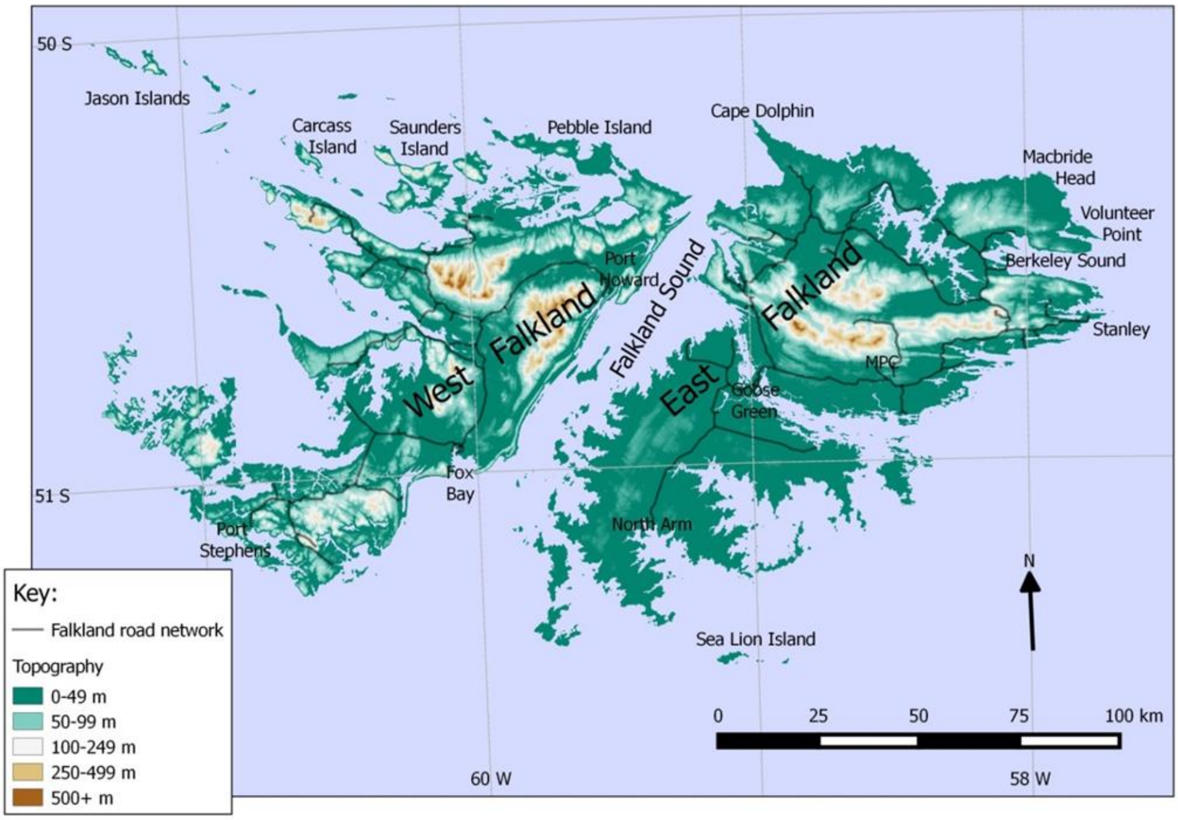


Figure 7.106: Prominent geographic features, major settlements and roads within the Falkland Islands

7.7.2.3 Berkeley Sound residents

The land surrounding Berkeley Sound is divided between six landowners / farms (Figure 7.107 below) and is primarily used for grazing sheep. However, several farms also run tourism-based businesses, which are described in section 7.7.4.6.1.

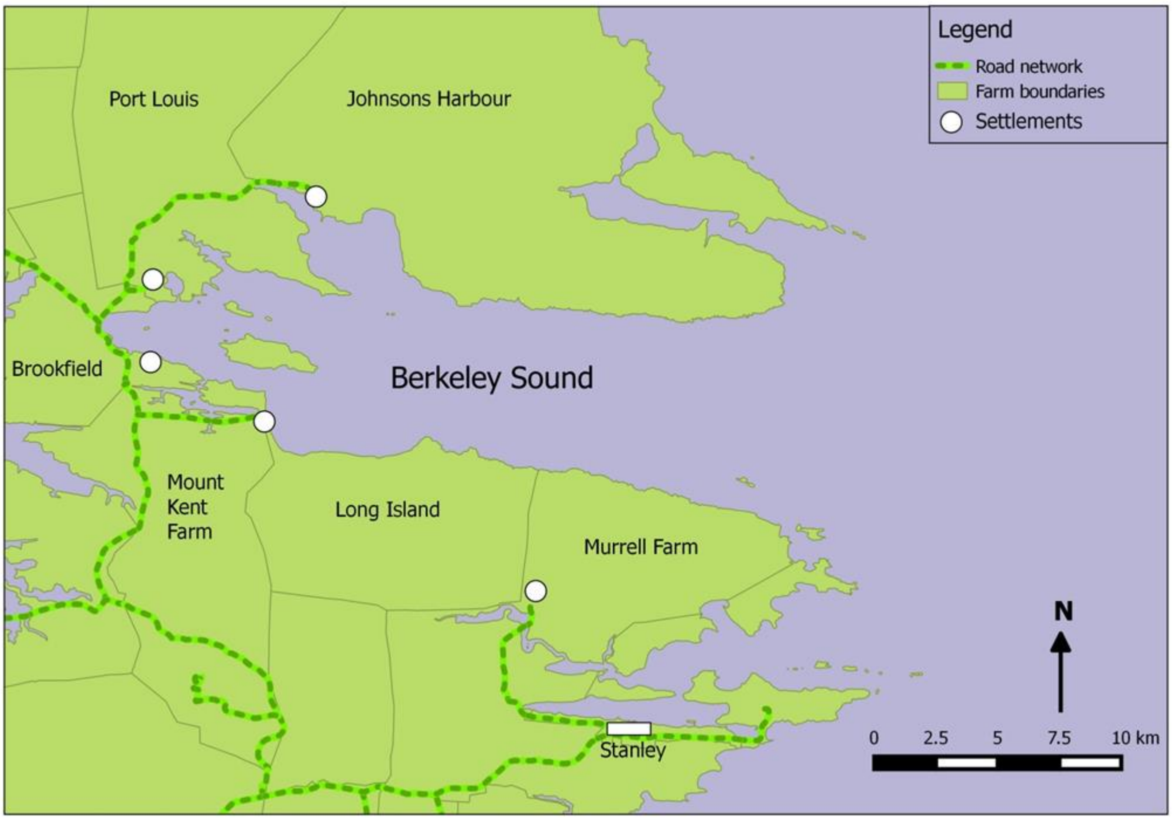


Figure 7.107: Farms with land bordering Berkeley Sound

7.7.2.4 The Falkland Islands economy

Prior to the mid-1980s, the Falkland Islands economy was almost completely based on agriculture, mainly sheep farming and the export of wool for income. Following the establishment of the FICZ in 1986 for fishery purposes, and the creation of a 200 nautical mile Exclusive Economic Zone (EEZ) in 1990, the bulk economic activity shifted to the sale of fishing licences to foreign vessels operating within the Falkland Islands EEZ (Plexus Energy, 2012). The income from these licence fees fluctuates, but currently makes up 50-60 % of the Government's revenue (FIG, 2014a). The other main contributors to the Falkland Islands economy are tourism and agriculture.

Since the late 1970s, the seas around the Falkland Islands have been an important area for commercial fisheries, with multinational fleets operating in the waters around the Islands. The creation of the EEZ was critical in transforming the post-1982 Falklands' economy, previously dependent on the production of wool, into one of the wealthiest communities *per capita* in the South American region. The fishing licensing regime has generated millions of pounds in revenue and currently contributes between 50 and 60 % of total GDP annually (FIG, 2014a).

It is therefore important to understand current fishing activity within the area of the Sea Lion Field and Berkeley Sound in order to determine to what extent the potential future Development of the area might interfere with fishing activities and 'other users of the sea' (section 11.1 and 11.2). For example, whether or not exclusion of fishing vessels from 500 m radius around the FPSO could translate into loss of revenue for the fishing fleet or the FIG as a result of licence sales.

7.7.3 Other users of the sea

7.7.3.1 Other users of the NFB

7.7.3.1.1 Fishing industry

This section provides a description of the fishing activity and catches in the region of the proposed Phase 1 Development. This area is known to support very low fishing activity, which is likely to be due to water depth.

This review is based on the Summary Report of fishing activity over the Sea Lion development area, conducted by Pale Maiden Consulting (April 2013), and FIG Fisheries Department Catch Report Database from 2008 to 2018 (FIG, 2019). Some information is also taken from the Fishing and Trawling Risk Study conducted by Jee (2013) on behalf of Premier.

The Falkland Islands EEZ contains rich fishing grounds, particularly for the two important squid species, Argentine shortfin squid and loligo (Patagonian squid). Table 7.39 presents total catch (tonnes) data for the main target species in the Falkland Islands fishery between 2012 and 2018 (FIG, 2019). The most notable feature of the data is the considerable inter-annual variation in the catch of a number of species. In particular, if catches between 2012 and 2018 are averaged, Argentine shortfin squid represents the largest catch by weight. However, from one year to the next, the catch of this species varies greatly, from over 350,000 tonnes in 2012 to virtually nothing in 2013. Loligo squid catches are more consistent from year-to-year and account for 20.1 % of the catch by weight between 2012 and 2018.

Patagonian rock cod has increased in importance over recent years, experiencing 20-30 fold increase in catches, the rise in this fishery followed the decline in the blue whiting fishery in 2007 (Laptikhovsky *et al.,* 2013). However, from 2016 the catches of this species have decreased significantly and represented only 1.3 % of the catch by eight in 2018.

A number of other finfish species are caught but these account for a far smaller percentage of the total catch, commercially caught finfish species include:

- Whiptail hake (hoki) (6.5 %);
- Hake (3.5 %);
- Skates and rays (1.9 %)
- Red cod (1.2 %);
- Blue whiting (1.0 %);
- Kingclip (1.0 %); and
- Patagonian toothfish (0.5 %) (Table 7.39).

The relative importance of finfish is skewed by inter-annual variation in *Illex* catch.

The Argentine shortfin squid is primarily fished by jiggers from the Far East, whereas the smaller inshore squid species loligo, and other finfish species, particularly hake, have been the target of the European bottom trawling fleet (FIG, 2019).

For fisheries licensing and management purposes, the Falkland Islands Conservation Zones, are divided into grid squares. Each grid square is 15’ of Latitude by 30’ of Longitude, or approximately 15 nautical miles by 17 nautical miles in size. These grid squares are the same as those used for Seabird data (section 7.4.5.6.1) and are referred to as the ¼ ICES squares. Each square can be referred to by a four letter code (the first two letters denote Latitude and the second two Longitude). Falkland Islands Government Fisheries Department (FIGFD) fisheries statistics from 2008 to 2014 indicate that the most important fishing areas corresponding to the highest catch (tonnes) per grid square are concentrated around the 200 m depth contour surrounding the Falkland Islands. The Patagonian toothfish is fished in depths greater than 600 m with the best catch per unit effort achieved off Burdwood Bank to the south and on the Deep Slope area to the northeast (FIG, 2010-2019).

Table 7.39: Annual fishing catch by target species in the FICZ / FOCZ (source: FIG, 2019)

Target Species	Catch (Tonnes)							% Catch
	2012	2013	2014	2015	2016	2017	2018	12 - 18
Argentine shortfin squid	87,002	142,619	306,111	357,722	2,360	67,445	54,405	53.7
Loligo squid	70,894	40,168	48,702	30,317	46,447	64,676	79,996	20.1
Patagonian rock cod	63,510	32,435	56,693	29,086	7,039	2,520	2,213	10.2
Hake	10,489	12,308	14,875	21,054	23,363	15,589	27,021	6.6
Hoki	15,867	16,849	7,392	6,845	11,562	4,053	4,438	3.5
Skates and Rays	6,655	5,932	5,555	6,393	5,906	3,189	1,994	1.9
Red cod	4,629	5,164	3,467	3,340	3,143	1,379	1,654	1.2
Southern blue whiting	1,596	2,698	3,612	2,790	5,415	2,309	992	1.0
Kingclip	3,510	3,977	2,881	2,983	1,612	1,632	1,445	1.0
Patagonian toothfish	1,311	1,422	1,297	1,227	1,499	1,579	1,259	0.5
Others	572	1,023	372	729	813	588	728	0.3

7.7.3.1.1.1 Fisheries operating within the vicinity of the Sea Lion Field

The drill centre for the Phase 1 Sea Lion Field Development is located on the border between FIGFD grid squares XEAK and XFAK, approximately 20 to 37 nautical miles northeast of the 200 m depth contour line, in water approximately 450 m deep. These grid squares have been rarely fished by any licenced vessels in recent years and is currently only open to vessels with a B license. The B license allows vessels (jiggers and trawlers) to fish for Argentine shortfin squid and, rarely, for the sevenstar flying squid (*Martialia hyadesii*). Jiggers fish at sea anchor and deploy light weight lines and therefore do not pose a great risk to subsea infrastructure. *Illex* are generally caught by pelagic (mid-water) trawls although they can be 'flown' close to the seabed. This type of gear is generally light-weight. However, the vessel currently licensed to fish for *Illex* operates a demersal trawl, which drag heavy nets, chains and trawl doors across the seabed and therefore pose a greater risk of interacting with subsea infrastructure. Trawlers generally target *Illex* with light-weight pelagic (mid-water) trawls, although the nets can be 'flown' close to the seabed. However, the vessel currently licensed to fish for *Illex* operates a demersal trawl, which drags heavy nets, chains and trawl doors across the seabed and therefore this type of gear poses a greater risk of interacting with subsea infrastructure.

Data extracted from the Fisheries Department database (Table 7.40) indicate that both jiggers and trawlers have fished in the area, but there is considerable inter-annual variation in fishing effort and catch in the area.

However, further analysis of Vessel Monitoring System (VMS) data indicates that most of the vessels reporting catch in these squares were in fact fishing elsewhere. Catches and fishing effort in the grid squares occupied by the Sea Lion Field (XEAK and XFAK) are relatively low (FIG, 2019). Exceptionally high catches of Illex squid were made in 2014, 2015 and 2017 reflecting high catches throughout the zone during these seasons. Data indicate that generally the area of the Sea Lion Field is rarely fished.

It is clear that the vast majority of fishing effort and catch comes from waters shallower than the Sea Lion Field. However, this is largely due to the distribution of target species, rather than technical difficulty, and trawlers have explored the area, with limited success, in the past.

Table 7.40: Total annual catch and effort in grid squares XEAK and XFAK

Species	2008	2009	2010	2011	2012	2012
	Jigger	Trawler	Jigger	Jigger	Jigger	Trawler
Catch (tonnes)						
Argentine shortfin squid	84,215	0	6,950	53,925	9,405	0
Rock cod	0	0	0	0	0	240
Hoki	0	15,664	0	0	0	49,680
Common hake	0	40	0	0	0	0
Rays	0	1,498	0	0	0	1,680
Kingclip	0	88	0	0	0	0
Patagonian toothfish	0	90	0	0	0	174
Total	84,215	17,380	6,950	53,925	9,405	51,774
• **Effort (jigger night, trawler day)**						
XEAK and XFAK	2 nights	1 day	4 nights	1 night	4 nights	2 days

(Source: FIFD daily catch reports)

Species	2014	2014	2015	2015	2017	2017	**2018**
	Jigger	Trawler	Jigger	Trawler	Jigger	Trawler	**Jigger**
Catch (kg)							
Argentine shortfin squid	595,965	1,214	347,658	0	252,466	26,228	54,530
Rock cod	0	530	0	600	0	0	0
Hoki	0	0	0	0	0	0	0

Species	2014	2014	2015	2015	2017	2017	**2018**
	Jigger	Trawler	Jigger	Trawler	Jigger	Trawler	**Jigger**
Catch (kg)							
Common hake	0	940	0	0	0	12,818	0
Rays	0	13,636	0	184	0	0	0
Kingclip	0	0	0	0	0	5,356	0
Red cod	0	0	0	0	0	267	0
Patagonian toothfish	0	0	0	36	0	63	0
Total	595,965	16,320	347,658	820	252,466	44,732	54,530
Effort (jigger night, trawler day)							
XEAK and XFAK	19 nights	12 days	9 nights	3 days	9 nights	13 days	4 nights

(Source: FIFD daily catch reports)

7.7.3.2 Other users of Berkeley Sound

It is important to be aware of the other users of the east coast and Berkeley Sound, and whether the inshore activities (LTV and installation vessel activity for a period of up to 12 months) will have the potential to interact with fisheries, tourism and / or areas used for military exercises.

7.7.3.2.1 Fisheries

7.7.3.2.1.1 Fisheries operating in the region of the approaches to Berkeley Sound

The Falkland Islands EEZ contains rich fishing grounds, particularly for the two important squid species, Argentine shortfin squid and loligo (Patagonian squid). The majority of fishing effort takes place to the north and west of the Falklands with the exception of the loligo fleet, which operates over the continental shelf to the east of the Islands (FIG, 2019). As an example, Figure 7.108 shows the distribution of loligo catch over the two fishing seasons in 2017. Two areas; one to the north-east and the other to the south of East Falkland, consistently produce the highest catches. Although there is no fishing within Berkeley Sound, activity within the Sound could impact this fishery.

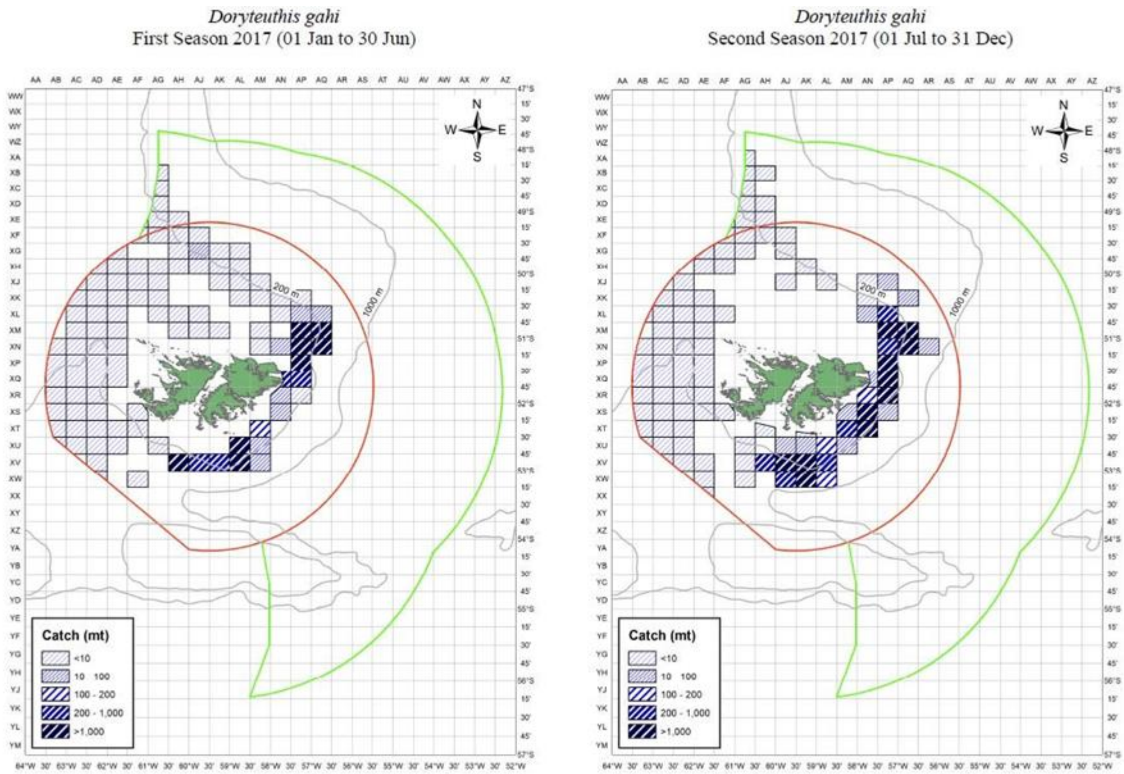


Figure 7.108: Loligo catch statistics from 2017 (FIG, 2018)

7.7.3.2.1.2 Fisheries related activity within Berkeley Sound

Berkeley Sound is used as an anchorage for vessels engaged in the transhipment of fish. Reefer vessels (refrigerated cargo vessels) anchor in the Sound and are visited by fishing vessels to offload their catch. Once full, reefers transport the catch to market. There can also be a number of tanker vessels present within the Sound to bunker vessels with fuel oil.

In a 'normal' fishing year (when *Illex* catches are good) vessel use of Berkeley Sound is highly seasonal, with peak activity between March and June. The different types of vessel vary in size, which is summarised (expressed as vessel length) in Table 7.41. The areas used by vessels cover the relatively deep waters in the centre of the Sound, Figure 7.110 shows vessel positions (both stationary and moving) derived from AIS data recorded between May 2014 and May 2015.

The degree of activity can vary from year-to-year depending on the amount of fish (squid) caught in any one year. *Illex* squid is primarily fished for by jiggers from the Far East, whereas loligo, the smaller inshore squid species, and finfish species, particularly hake, are targeted by the European bottom trawling fleet (FIG, 2016c). A summary of all vessel use in Berkeley Sound is provided in section 7.7.3.2.5.

Note: The latest catch data presented in Table 7.39 confirms that 2014-2015 represent the most significant fishing years in recent times and so have been used as a worst case benchmark for the assessments herein.

Table 7.41: Summary of size (length) of vessels using Berkeley Sound (May 2014 to May 2015)

Vessel type	Mean length (m)	SD	Minimum length (m)	Maximum length (m)
Fishing	62.5	12.1	45	114
Reefer	142.5	15.5	95	195
Tanker	111.5	22.1	98	151

7.7.3.2.2 Tourism service providers and Berkeley Sound

While a few cruise vessels visit Berkeley Sound, many pass the entrance to the Sound *en route* to and from Stanley.

During the cruise ship season many people take time off from their regular work to drive tourists to see wildlife around the Islands. In Camp, tourism accounts for a greater share of income than in Stanley. According to FIG figures, tourism accounts for an estimated 17 % of whole farm income, with the outer islands experiencing a greater share of tourism income at 41 % of the total. A summary of all vessel use in Berkeley Sound is provided in section 7.7.3.2.5.

7.7.3.2.3 Military uses of Berkeley Sound

There has been a substantial military presence in the Falkland Islands since 1982, which provides air, land, and sea coverage.

A summary of all vessel use in Berkeley Sound is provided in section 7.7.3.2.5 which shows that there is very limited use of Berkeley Sound by military vessels.

7.7.3.2.4 Other vessels

Research vessels, such as the British Antarctic Survey (BAS) vessel the RRS *James Clark Ross* often transit through Falklands waters *en route* to South Georgia, Antarctica or other areas within the South Atlantic. It is possible that these vessels, and other commercial shipping, may use Berkeley Sound as an anchorage from time-to-time (see).

7.7.3.2.5 Summary of vessel number and position in Berkeley Sound

A summary of all the above vessel uses in Berkeley Sound for the period 2014 to 2018 is provided in Figure 7.109, and the positions of vessels for the peak period (2014-2015) are provided in Figure 7.110. 2014 - 2015 period represent the most significant fishing years in recent times. These years have been have been used as a worst case benchmark for the baseline and assessments herein.

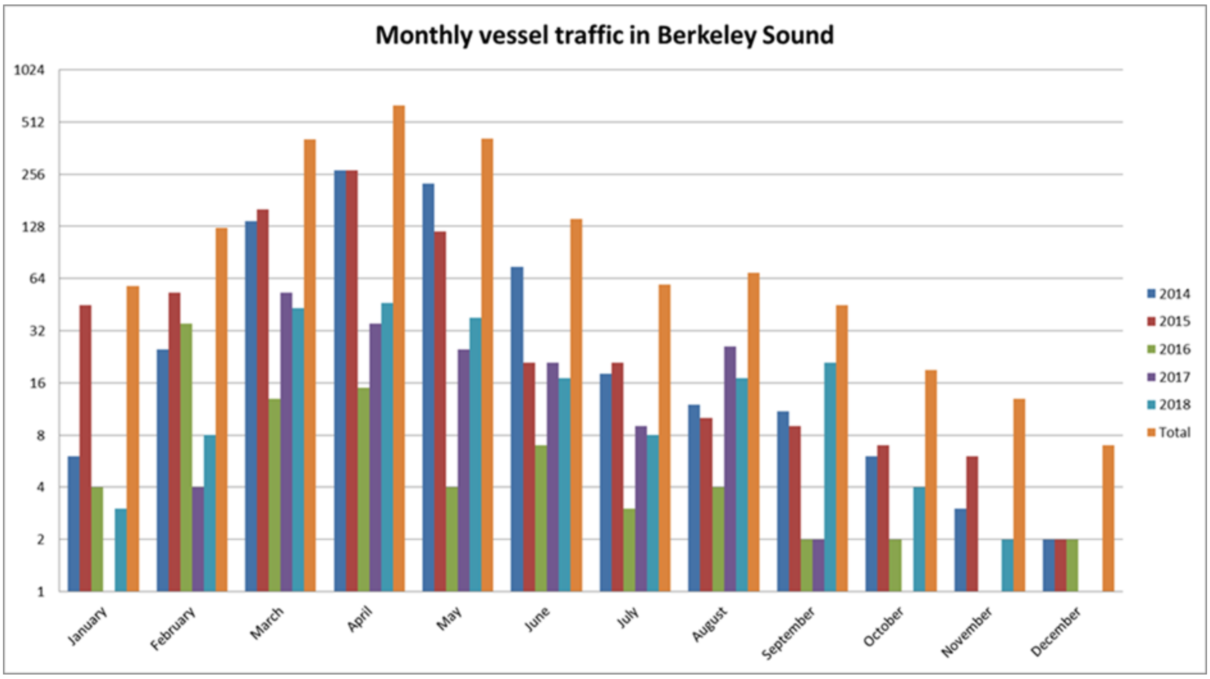


Figure 7.109: Vessels days in Berkeley Sound, 2014 to 2018

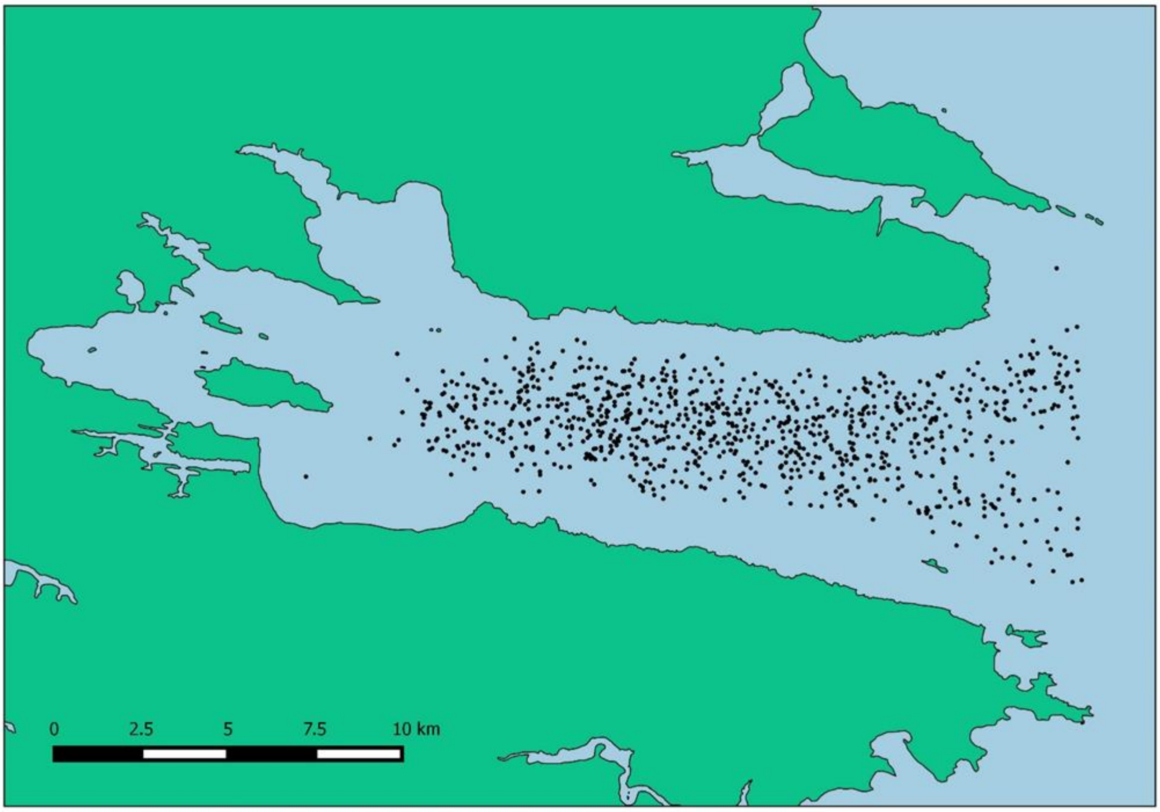


Figure 7.110: Positions of vessels within Berkeley Sound, May 2014 to May 2015

7.7.4 Tangible property

7.7.4.1 Port facilities

The Falkland Islands have port facilities at Mare Harbour and Stanley, through the Falklands Interim Port and Storage System (FIPASS) and the Temporary Dock Facility (TDF).

7.7.4.1.1 Mare Harbour (East Cove Military Port)

Mare Harbour is a deep-water port in Choiseul Sound, East Falklands, operated by the MoD. Mare Harbour is primarily used by the UK Royal Navy vessels patrolling the South Atlantic but also cargo vessels. It is the port facility and depot for MPC and approximately 36 miles southwest of Stanley by road.

7.7.4.1.2 Stanley Harbour - Jetties and FIPASS

Harbour operations in Stanley are currently managed by the Falkland Islands Government Department of Natural Resources with support from other Government Agencies. In March 2015, ExCo agreed on the establishment of a Maritime Authority and the development of maritime harbour legislation. The Maritime Ordinance 2017 came into force on 1st September 2018, and an action plan for its implementation is in progress (FIG, 2018b).

There are several jetties within Stanley Harbour:

- **East Jetty** - 45 m berthing face with approximately 3.7 m of water at its head is used by a variety of vessels from privately owned visiting yachts to commercial trawlers 75 m in length;
- **Public Jetty** - used only for landing passengers from launches and other small craft. It has approximately 3 m of water at its head;
- **The Camber** – is located on the opposite side of the Harbour to Stanley but is occasionally used as a winter lay-up for charter yachts or trawlers, FIG (2015d);
- **The Temporary Dock facility (TDF) -** is situated in the east end of the Harbour and was constructed to support oil and gas exploration in the NFB**;** and
- **FIPASS (Falklands Interim Port and Storage System)** - was constructed in 1984 and consists of flexi-port pontoon structures (Figure 7.111), which to date have provided suitable port facilities. It consists of seven permanently moored barges giving 300 m of berthing face, (FIG, 2015e). Depth of water varies from 5.7 - 7 m depending on the berth (FIG, 2015e). FIPASS is managed under contract from FIG by Atlink LTD. who are responsible for the maintenance and manning of the facility and collect berthing fees, hard-standing, warehouse and utilities charges on FIG's behalf. At times, there is not enough berthing space at FIPASS to meet demand, which represents the most significant potential conflict between users of the Harbour. Vessels can take bunkers of freshwater and fuel from FIPASS, at a rate of 25 and 35-40 tonnes per hour respectively.

A number of different types of vessel use the facilities in Stanley Harbour and each vessel type has quite specific requirements. The number of vessels visiting Stanley on a monthly basis is shown in , and are described below.

7.7.4.1.3 Fishing vessels

Fishing vessels are regular visitors to Stanley Harbour throughout the year, where they undergo license inspections, crew changes and transfer catch. The degree to which Stanley Harbour is utilised by fishing vessels varies considerably between vessel types and target species.

Jiggers visit Stanley Harbour for license inspections and customs clearance prior to commencing fishing, number of vessel visits peak in February. However, most Jiggers anchor, with very few visits to FIPASS recorded (Table 7.43, FIG, 2019).

Trawlers are licensed to target finfish and loligo squid, during two fishing seasons (approximately February to May and August to November) and are regular visits to Stanley Harbour throughout the year. Although fewer trawlers are licensed to fish within Falklands waters than jiggers, trawlers make greater use of the facilities at FIPASS (Table 7.43).

While there is generally only one longliner licensed to fish within Falklands waters at any time, vessels that fish at South Georgia are regular visitors to Stanley Harbour as they all have to undergo catch verification at the end of the fishing season (Table 7.43).

Note: 2015 fishing vessel data is presented as it represents a good *Illex* year and correspondingly high vessel numbers.

7.7.4.1.4 Fishery Patrol Vessels (FPVs)

The Falkland Islands and South Georgia and the South Sandwich Islands Governments' Fishery Patrol Vessels (FPVs) are regular visitors to Stanley Harbour throughout the year and go alongside FIPASS when space is available. During 2014, FPVs visited FIPASS on 37 occasions. During 2018 FPVs visited FIPASS on 48 occasions (Table 7.43).

7.7.4.1.5 Cargo vessels

Cargo vessels visit Stanley on a regular basis and require a berth at FIPASS to transfer cargo onshore. In 2014, 38 cargo vessels visited FIPASS. In 2018 cargo vessel visits to FIPASS were slightly less at only 32 (Table 7.43).

7.7.4.1.6 Cruise ships

The majority of cruise ships visiting Stanley anchor in the Harbour or Port William, from where they ferry passengers onshore to the Public Jetty in tenders. The vast majority of cruise ship visits occur between October and April. Some of the smaller cruise vessels will go alongside FIPASS (Table 7.43).

7.7.4.1.7 Reefers

Reefers are refrigerated vessels that tranship catch from fishing vessels for delivery to market. They usually anchor in Port William or Berkeley Sound and rarely enter Stanley Harbour.

7.7.4.1.8 Tankers

Up to 20 tankers visit FIPASS annually to transfer fuel (Table 7.43). The supply of fuel has to meet demand, if demand increases due to O&G activity the supply will have to increase proportionately.

7.7.4.1.9 Yachts and pleasure craft

In 2014, 61 yachts came into Stanley Harbour. 71 yachts came into Stanley Harbour in 2018. These usually moor at the Public Jetty or the East Jetty or anchor in the Harbour.

7.7.4.1.10 Royal Navy vessels

A Royal Naval (River Class) patrol vessel is permanently based in the Falkland Islands, to conduct the South Atlantic Patrol around the Falklands and South Georgia. The HMS Protector, an Ice Patrol Ship, is on station close to in the waters of Antarctica and the southern hemisphere for 330 days a year (Royal Navy, 2019).

7.7.4.1.11 Research vessels

The British Antarctic Survey (BAS) operates three research stations in the Antarctic and two on South Georgia, (BAS, 2015a). BAS operates two vessels to support these stations and conduct research at-sea. Throughout the summer season (September/October to May/June) these vessels may dock at FIPASS to resupply, change crew and scientists (Table 7.43).

Figure 7.111: FIPASS, (FIG, 2015e)

Table 7.42: Vessels entering Stanley Harbour (during 2014 and 2018)

Vessel Type		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Cargo	2014	4	2	5	5	3	2	5	4	1	2	2	3	38
	2018	2	2	3	3	2	3	2	5	4	3	5	3	37
Cruise ship	2014	9	12	8	1	0	0	0	0	0	6	14	14	64
	2018	21	5	9	1	0	0	0	0	0	5	18	12	71
Jigger	2014	0	92	15	3	1	0	0	0	0	0	0	0	111
	2018	0	103	4	6	1	0	0	0	0	0	0	0	114
Longliner	2014	1	4	5	3	1	5	7	9	3	4	4	1	47
	2018	3	3	4	6	3	3	3	6	4	2	3	1	41
Naval vessel	2014	0	3	0	2	0	3	0	0	0	1	1	2	12
	2018	0	2	0	0	1	1	0	0	0	0	0	1	5
Patrol vessel	2014	1	4	2	3	3	4	4	5	3	3	3	8	43
	2018	3	5	5	5	4	3	2	3	3	3	8	4	48
Research	2014	1	2	1	1	0	0	0	0	0	0	1	1	7
	2018	1	1	4	3	3	2	0	0	0	0	1	1	16
Tanker	2014	2	1	1	3	3	1	2	1	1	1	1	0	17
	2018	1	0	1	1	1	2	0	1	2	1	0	1	11
Trawler	2014	3	17	13	14	12	3	16	11	6	16	6	0	117
	2018	4	14	14	8	16	3	10	12	15	10	3	2	111
Tug	2014	0	0	3	2	0	1	0	0	0	3	5	2	16
	2018	0	1	0	0	0	1	0	0	0	0	0	2	4
Yacht	2014	8	6	11	7	1	0	1	1	3	6	4	13	61
	2018	9	7	13	6	2	2	0	1	3	6	14	8	71
Total	2014	38	149	68	46	26	19	35	31	17	44	46	47	566
	2018	51	146	59	42	33	20	17	28	31	31	55	38	551

(Source: FIG fisheries department data (FIG, 2015o) updated FIG Marine, DNR 2019)

Table 7.43: Visits to FIPASS (during 2014)

Month		Cargo	Cruise ship	Jigger	Longliner	Naval vessel	Oil related	Patrol vessel	Research	Tanker	Trawler	Tug	Yacht	Total
Jan	2014	4	3	0	1	0	6	1	1	2	3	0	0	**21**
	2018	2	8	0	2	0	0	3	1	1	4	0	6	**27**
Feb	2014	2	5	3	4	1	5	3	1	1	15	0	0	**40**
	2018	2	1	0	3	0	0	4	1	0	10	1	1	**23**
Mar	2014	5	3	0	3	0	4	2	1	1	12	2	2	**35**
	2018	3	4	0	4	0	0	4	3	1	12	0	2	**33**
Apr	2014	4	0	0	2	1	2	3	1	3	10	0	1	**27**
	2018	3	1	2	4	0	0	3	2	1	7	0	1	**24**
May	2014	3	0	1	1	0	2	3	0	3	10	0	0	**23**
	2018	2	0	0	3	0	0	2	3	1	11	0	0	**22**
Jun	2014	2	0	0	3	2	0	3	0	1	2	1	0	**14**
	2018	3	0	0	3	1	0	3	1	2	3	1	0	**17**
Jul	2014	5	0	0	5	0	0	3	0	2	13	0	0	**28**
	2018	2	0	0	1	0	0	2	0	0	9	0	0	**14**
Aug	2014	4	0	0	6	0	0	3	0	1	10	0	0	**24**
	2018	3	0	0	4	0	0	3	0	1	11	0	0	**22**
Sep	2014	1	0	0	2	0	0	3	0	1	5	0	1	**13**
	2018	4	0	0	1	0	0	3	0	2	15	0	0	**25**
Oct	2014	2	3	0	2	1	2	3	0	1	14	3	2	**33**
	2018	2	3	0	2	0	0	2	0	1	8	0	0	**18**
Nov	2014	2	5	0	4	0	4	3	1	1	5	3	0	**28**
	2018	3	9	0	3	0	0	4	1	0	2	0	3	**25**
Dec	2014	3	6	0	1	2	2	7	1	0	0	2	5	**29**
	2018	3	5	0	1	1	0	1	1	1	2	1	3	**19**
Total	2014	37	25	4	34	7	27	37	6	17	99	11	11	315
	2018	32	31	2	31	3	0	34	13	11	94	3	8	262

7.7.4.1.12 Temporary Dock Facility (TDF)

The Temporary Dock Facility (TDF), a floating barge of similar construction to FIPASS, was installed in 2014 to support the 2015 oil exploration campaign. It is proposed that the TDF will continue to support the activities of Premier during the Phase 1 Development. The initial planning consent for the TDF was granted for three years for exploration and appraisal only. In March 2018, the conditions of the initial planning consent were varied to permit the use of the TDF for Sea Lion development and production operations. Any upgrades to the TDF will be subject to separate planning applications/consents (section 5.11.1.1.1,).

7.7.4.1.13 Port facilities in Berkeley Sound

Berkeley Sound is a deep-water Harbour used for the transhipment of frozen fish and squid and is a designated port. The Sound is also used for licensed bunkering operations from tankers or reefers. However, only those vessels that have been licensed by Stanley Services Ltd. can provide bunkers to other vessels within Falkland Islands territorial waters.

While there are no shore facilities in Berkeley Sound, several companies in Stanley service the Sound (moving people and goods) by harbour launch.

Berkeley Sound is used for licensed bunkering operations from tankers or reefers. Currently, fishing vessels using Berkeley Sound solely for the purpose of transhipment of catches may freely enter and depart, provided 'Entry' and 'Exit' reports are made to the Fisheries Department via VHF radio. The Reporting Line stretches between Volunteer Point (51° 31'S; 57° 44'W) and Cape Pembroke (51° 41'S; 57° 43'W). This line forms the outer limit of Berkeley Sound and Port William.

7.7.4.2 Road network

Until the 1980s, there were only tracks in the Falkland Islands outside Stanley. By 2008, the road network in the Falkland Islands covered 862 km, with 489 km on East Falkland and 373 km on West Falkland. The road network has increased slightly since 2008. This is mainly on the west with extensions to the road to Byron Heights, the road to West Lagoons and the current construction of the road to Philomel Farm. The only increases on the East are on the road to Wineglass Station and the Onion Range road. (C Summers, *pers. comm.*).

However, the majority of the road network remains unpaved, consisting of a consolidated gravel surface with drainage ditches on both sides. The only asphalted roads are those within Stanley, those within the Mount Pleasant Complex (MPC) and sections of the main road between Stanley and the MPC.

Though regularly regraded ('ploughed' and rolled), the surface becomes badly potholed and rutted from vehicle wear. A constant programme of maintenance is required to keep the road network in a useable condition

Over the years the number of vehicles, the weight of vehicles and the number of heavy vehicles has increased significantly having a bearing on the condition of road, particularly during winter months.

In April 2010, over a 19 day period, 5,484 vehicles (of which 2 % were Heavy Goods Vehicles) used the road between Stanley and Mount Pleasant. This represents a 170 % increase over the previous 10 years for all vehicles (FIG, 2012b). Although it is the heavier traffic which causes the greatest damage to any road, sealed or unsealed, road usage for all types of vehicles has increased disproportionately for a number of reasons; including:

- Cargoes from the UK now arrive at Mare Harbour and are delivered to Stanley by road;
- Movements to and from New Haven ferry terminal, including a significant increase in stock movements to the Abattoir;
- General increase in Islands wide movements by land rather than sea; and

- Increased localisation of posts for workers at MPC.

More recently, between 2011 and 2015, the FIG PWD Roads section have deployed pressure activated vehicle loggers at a number of sites to determine the number of vehicle passes, class of vehicle, weight of vehicle and the speed of vehicles.

Average daily usage on the MPC road over the three sampled periods (two locations) averaged 483 vehicle passes / day. The majority of these vehicles were cars, 4x4, minibuses or Light Goods Vehicles (LGV) with these groups accounting for 87.2 % of transit in 2015.

Daily usage on the Airport Road (measured between the Chandlery and Stanley Growers Market Garden), over a single sampled period, averaged at 1,755 vehicle passes / day. Again the majority of vehicles were cars, 4x4s, minibuses or LGVs with these groups accounting for 92.2 % of transit in 2015.

There has not been a detailed road usage survey since 2015. In general FIG believes that the usage remains the same. However FIG notes that:

- There has been an increase in the use of the South American Atlantic Service (SAAS) shipping service and therefore there has been an increase in heavy vehicle movements to and from the SAAS yard;
- With increased construction activity in the Stanley area there has been an increase in activity to the Mary Hill spoil dumping area;
- Road transportation of wool is steadily increasing, although numbers are not believed to be particularly significant; and
- The proposed site for the municipal waste transfer facility is at the east end of Megabid and will significantly increase the traffic movements in the area.

(C Summers, *pers comm*.)

MPC Road usage has generally increased significantly year on year, however exact recent trends are not certain and road usage may have stabilised.

In 2012, FIG introduced a Highways Asset Management Plan, which categorises the Islands' road network on the basis of its strategic importance and prioritises maintenance in respect of this (Table 7.44 and Figure 7.112).

Table 7.44: Road classification (FIG, 2015)

Road Classification	Definition
Class A Road	Primary link road between major national assets
	Greatest traffic use by volume and weight
Class B Road	Link road between all Class A and C roads
	Major tourist destinations
	Major supply route to abattoir
Class C Road	All other roads
MoD Road	Roads linking MoD facilities with the national road network

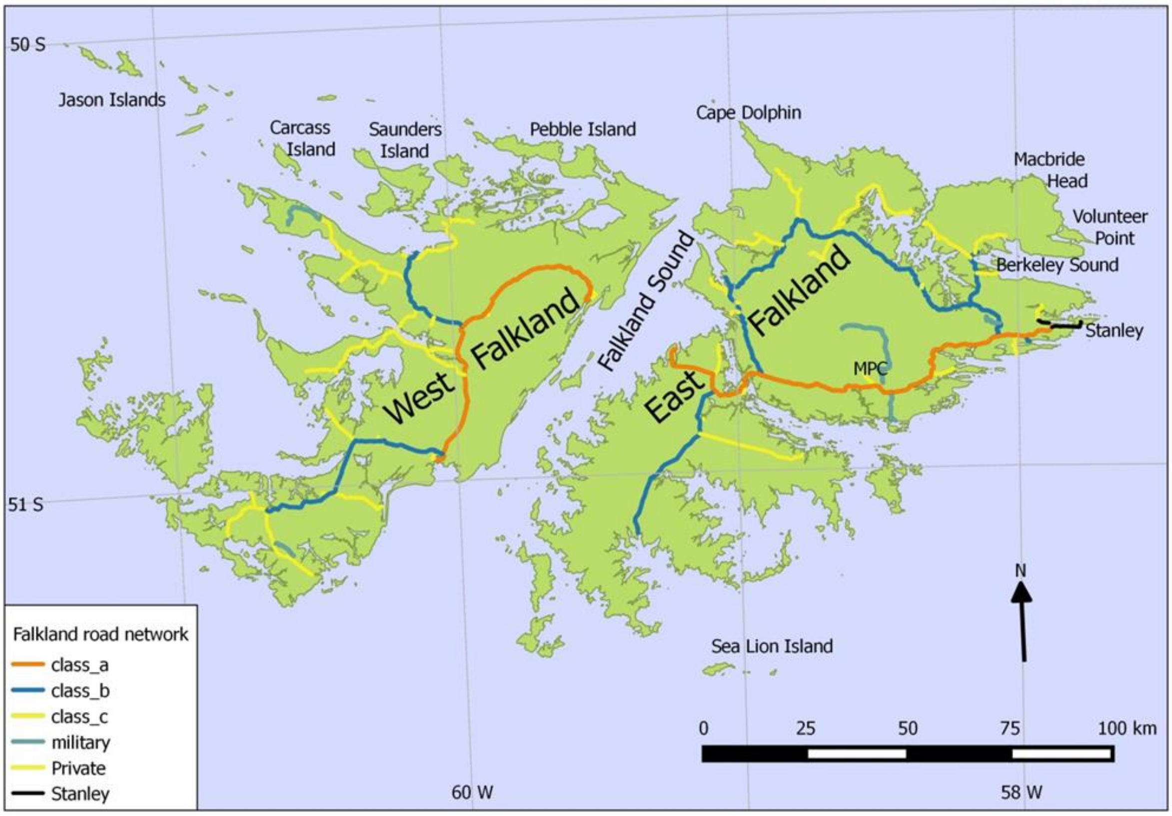


Figure 7.112: Road map of the Falkland Islands, indicating road class

7.7.4.2.1 Roads supporting Berkeley Sound

The settlements and farms at the head of Berkeley Sound are linked to the rest of the Islands by unpaved, gravel roads, as shown in Figure 7.107 above. The land surrounding the remainder of the Sound is only accessible by 4x4 vehicle during the summer months. During the winter, the land is wet and boggy, which increases the risk of becoming stuck in the mud (‘bogged’). Access to tracks, such as the one leading to Volunteer Point, is closed to the public during the winter months.

7.7.4.3 Airport and air-links

There are two main paved runways in the Falkland Islands, one at Mount Pleasant International Airport and one at Stanley Airport.

7.7.4.3.1 Mount Pleasant International Airport

The Falkland Islands are currently serviced by two international air-links:

- The MoD air-bridge link to the UK; and
- The LATAM commercial service to Santiago, Chile.

The MoD operates a chartered aircraft between RAF Mount Pleasant and RAF Brize Norton (UK) twice weekly. The current charter service is fulfilled by AirTanker under contract. An agreement with FIG provides for a fixed civilian seat allocation on each flight. At present 31 seats are allocated for civilian use on each flight. The average seat utilisation is 20 seats per flight. The number of airbridge flights per annum that are at full capacity is approximately 8-10 flights on both the south and the northbound legs. Average figures should be treated with some caution as there is high seasonality in flight occupancy rates with August and Christmas periods showing the highest demands linked to school holidays. Medical flights are also routinely scheduled with accompanied medical teams for referrals from King Edward Memorial Hospital to the UK NHS for treatment. This may at times reduce capacity on individual flights.

LATAM operates a commercial flight once weekly to Punta Arenas and onwards to Santiago, Chile from where international connections can be made. Once per month the flight makes a brief stop-over in Rio Gallegos, Argentina.

A second commercial air-link with mainland South America to be operated by LATAM Airlines Brazil has recently been confirmed by the Falkland Islands Government. The new scheduled route is due to commence on 20th November 2019 and will provide a weekly service to São Paulo, with a stopover in Cordoba, Argentina once a month in each direction. This new route will allow passengers to make onward connections to multiple destinations in South and North America, Europe and Asia.

The LATAM service currently utilises an Airbus 320 with 174 seats. Occupancy is variable through the year and ranges from 12 - 100 % seat occupancy with an annual average of 54 % occupancy (2016-2018 data); this would provide an average weekly spare capacity of approximately 80 seats. The peak season is through the summer tourist season between the months of November to March when 6 – 12 flights may be fully booked for cruise-vessel passenger exchanges. A secondary peak occurs during August corresponding with the winter school holidays. This route is increasingly popular with travellers and passenger numbers continue to rise; figures for the last five years show an annual increase of 7%. Flights can be fully booked, often due to cruise-vessel passenger exchanges and advance provisional block booking of flights.

However, it is anticipated that the second commercial flight to São Paulo, which will provide 220 seats on a Boeing 767-300, will alleviate the heightened demand for flights during peak times.

Some of the key statistical information regarding air links to the Falkland Islands are summarised in below.

Table 7.45: Summary of flights to and from the Falkland Islands [a]

Statistic	MoD Airbridge	LATAM Airlines (Santiago Route)	LATAM Airlines (São Paulo Route)
Route	Mount Pleasant, Falkland Islands – Brize Norton, UK	Mount Pleasant, Falkland Islands – Punta Arenas, Chile	Mount Pleasant, Falkland Islands – São Paulo, Brazil
Aircraft	Airbus A330 variant KC2 Voyager	Airbus 320	Boeing 767-300
Frequency of flights	Twice per week	Once per week	Once per week
No. flights per year	104	52	52
Commercially available seats	31	174	220
Average Occupancy seats	20 (65%)	81 (46%)	Unknown as yet, new route
No. flights per annum which are at full capacity	8 - 10	6 – 12	Unknown as yet, new route
Seasonality	August and Christmas (school holidays)	November – March (cruise vessels and tourism) August (school holidays)	Anticipated to mirror Santiago route seasonality
Average spare capacity	11	93	Unknown as yet, new route

[a] Summary of restricted commercial data provided by FIG

7.7.4.3.2 Stanley Airport

Stanley Airport has for many years primarily been operated for the domestic inter-island Falkland Islands Government Air Service (FIGAS). It was also used as a heli-base for the 2010-12 and 2015 exploration drilling campaigns. FIGAS' fleet of four Britten-Norman BN2-B Islander aircraft will be supplemented by a new airframe early in 2020.

Falkland Islands Helicopter Services are a new local company which currently operate from Stanley Airport with a Robinson 44 four-seat light helicopter. They provide a charter services for most locations within the Islands and have the capacity to cater for groups of up to three people per trip.

7.7.4.4 Importers of supplies / goods to and from the Falkland Islands

The majority of goods are shipped into the Falklands. There are two main routes; direct from the UK or via South America.

7.7.4.4.1 Falkland Islands Resupply Service (FIRS)

The Falkland Islands Resupply Service (FIRS) is a service contracted by, and provided to, the Ministry of Defence (MoD), primarily to carry military freight to re-supply MPC. It provides a regular (35 day service) Ro-Ro container vessel from the UK and operates between Marchwood, Southampton, in UK, and Mare Harbour on the Falkland Islands. This carries commercial freight as well as bringing in most of the food imports and other civilian supplies.

7.7.4.4.2 South American Atlantic Service (SAAS)

The South American Atlantic Service (SAAS) also provides a shipping link between the Falkland Islands and the UK via Montevideo, Uruguay, and makes periodic visits to Punta Arenas in Chile.

7.7.4.4.3 Air Freight

No specific civilian / private-sector allowance is made for commercial air-freight. Availability of commercial freight is limited by size and weight which is, in turn, limited by the air-frame of the aircraft available. Furthermore freight capacity is dependent upon passenger numbers and thus spare air-frame load. On high occupancy flights, air freight is not available. However, the new LATAM route to Sao Paolo will increase the capacity and availability of air freight.

7.7.4.5 Existing resource infrastructure and use

7.7.4.5.1 Accommodation

7.7.4.5.1.1 Existing housing

The 2016 Census (FIG, 2017) indicates that the overall civilian population of the Falkland Islands has increased from 2,840 to 3,200 since 2012 (FIG, 2017).

Similarly, Stanley with 2,460 inhabitants, which accounts for 77 % of the total number of residents island-wide, has shown a population growth of around 16 % since 2012.

The number of households in Stanley continues to grow and it is considered that overall there is an ongoing shortage of affordable housing for purchase and rental in Stanley (Regeneris, 2013).

The 2016 Census recorded a total of 1,189 resident households, of which, 1,026 (86 %) are located in Stanley (Table 7.46).

In 2016, the majority of houses were mortgaged or owned outright (57%) (Table 7.46). Approximately 32 % of Stanley households were held under rental, while a further 9 % were provided rent free as part of an employment package (Table 7.46). Currently, only residents with permanent residential permits or full Falkland Islands status are able to own property in the Falklands. ExCo can grant permission to Non-Permanent Residents (NPR) and work-permit holders, however, most commonly NPR are excluded from owning property. Therefore, NPR form a large part of the rental market, both within FIG housing and the private sector.

In 2012, 7 % or 87 properties were built in the 6 years leading up to the census. This number doubled in 2016 to 177 or 15 per cent of all properties and reflects the increased rate of construction of both public and private housing in recent years (FIG, 2017).

Table 7.46: The number and proportion of Stanley households owned outright, owned under mortgage, rented or provided rent free. [a]

Household Ownership Class	2006		2012		2016	
	No.	%	No.	%	No.	%
Rent Free	57	6	62	6	109	9
Rental	288	31	322	32	378	32
Mortgage	270	29	263	26	291	24
Owned	315	34	355	35	389	33
Unknown	-	-	-	-	22	2
Total	930	100	1,002	100	1,189	100

[a] Source: FIG 2016 Census (FIG, 2017)

7.7.4.5.1.2 Future developments and town planning

The Stanley Town Plan (FIG, 2015u) recognises the need to plan for increased housing if future economic development is not to be impeded. The plan, which is based upon Regeneris (2013) projections of need, provides for a target of an additional 450 units over the 17 year duration of the plan from 2013 – 2030. This amounts to a housing target of approximately 26 units per annum.

In order to meet these future demands the Stanley Town Plan has nominally identified and zoned areas for residential housing. These zones incorporate both FIG land that would be available for phased land release and private land that could be developed through market forces. A total plot capacity of 768 building plots has been identified, with 362 plots considered to be potentially viable for development within the duration of the plan. In addition to residential zoning within the plan, proposals for permanent structures to provide transitory accommodation (e.g. short term accommodation for offshore workers) would be supported within land identified for light industrial uses.

The development of some sites may be impeded by the location and current capacity of FIG to provide utility services such as water, power and sewage to the site. Nonetheless, the Planning Ordinance 1991 includes provision for the production of Developer Contribution Regulations. This would provide a mechanism to allow developers to fund 3rd party activity on land which is outside the developers control to address the infrastructure needs or impacts of the development. This could allow the fast tracking of development if infrastructure servicing is met by 3rd parties or remunerated for.

7.7.4.5.1.3 Hotels and guesthouses

The main hotel in Stanley is the Malvina House Hotel which has 72 rooms, followed by the Waterfront Hotel (six rooms) and Shorty's Motel (six rooms).

Additionally, there are several small Bed & Breakfast establishments in Stanley, and additional hostel style rooms at Lookout Lodge (56 rooms).

7.7.4.5.2 Fresh (potable) water supply

Freshwater in Stanley is a finite resource and, under present operating procedures, water availability and Stanley usage are largely balanced. In order to assess the impact of the additional freshwater requirements from the Phase 1 Development, it is necessary to quantify the baseline water availability. Therefore, it is necessary to understand:

- Freshwater required by Stanley; and
- Freshwater available to Stanley and the factors which may limit this supply:
  - The number of water catchment sources (i.e. the means of capturing rainwater);
  - Untreated water supply (i.e. how fast is the rainwater carried from the catchment source to the Dairy Paddock Reservoir and how long for each day);
  - Water treatment (i.e. how fast can it be treated, and the duration of pumping each day, so it can be supplied to the consumer as needed); and
  - Treated water storage capacities (i.e. where is the treated water held prior to use by the consumer).

7.7.4.5.2.1 Freshwater required by Stanley

Forecasts conducted in 2004 showed that there had been an upward trend in annual water consumption of approximately 3 % per annum over the previous 24 year period from 1980. The year on year increase in Stanley consumption has continued into the present with increases of c. 2- 3 % p.a. reaching a baseline maximum annual water use of 322,181 m^3 (880 m^3/day) in 2016, for a year without the additional demand of oil exploration. Overall use during phases of oil exploration have caused spikes in water usage over and above this baseline increase, with an overall maximum consumption of 346,087 m^3 in 2015 during exploration, which related to an increase of 23 % upon the previous year of 2014 without oil exploration.

7.7.4.5.2.2 Freshwater available to Stanley and the factors which may limit this supply

Water sources

Potable water is supplied to Stanley by the FIG Public Works Department water filtration plant.

As shown in Figure 7.113, untreated water (rainwater) is supplied via two catchment sources:

- The Moody Brook catchment; and
- The Upper Murrell River catchment.

The Upper Murrell River catchment was brought on-line in 2016 and was developed owing to:

- The increase in residential households in Stanley;
- Increasing demand (including from new industries e.g. the abattoir, fishing, cruise vessels, and oil exploration activities); and
- The observed drying of the Falkland Islands climate that limits catchment recharge (FIG, 2008a).

The Murrell catchment area has increased the rain water catchment for Stanley by over 60 % and will safeguard the continuity of supply. With the commissioning of the Murrell River catchment, supply continuity is no longer considered a limiting factor for current water needs.

However, whilst the dual catchments have increased the security of supply they have not increased the volume of supply to Stanley, which is still limited to a single water pipeline with a fixed capacity from the Moody Brook pump station.

Outside of Stanley, the quarry and abattoir are supplied from the Stanley system through a pump system to augmented pressure. The Mount Pleasant military base operates independently and has a small reservoir and filtration system whilst small camp settlements and farms are served by private groundwater springs without processing.

Untreated water supply (filtration rates and duration)

Rainfall catchment is pumped from the Moody Brook and the Murrell River catchments to the Dairy Paddock Storage Reservoir (DPR) at a rate of 60 m3/hr (Figure 7.113) through a single pipeline. Over the current 14.5 hour operating day, this relates to a capacity of 870 m3/day of water pumping into the DPR which has a capacity of 1,500 m3.

From the DPR water is processed through the PWD water filtration plant. The water is filtered through clarifiers and treated to ensure it is fit for human consumption. The theoretical maximum filtration rate is 77 m^3/hr. However, this rate cannot be sustained in the long-term as it exceeds the rate at which the DPR fills (60 m^3/hr). Filtration rates that exceed 60 m^3/hr can only be achieved in the short-term if the DPR is used as an additional buffer supply and run down through the filtration plant working day, to be recharged overnight by leaving the catchment water feed running and the DPR to refill unattended. The DPR is an integral component of the Stanley two-day contingency water supply storage and hence draw down of the reservoir is not taken as standard current procedure except in extenuating circumstances of critical demand.

With a total of 870 m^3/day supplied to the DPR over a 14.5 hr day, the water demand during the most recent exploratory campaign in 2015 for the first time passed the previous supply capacity and requiring extended pumping times.

In summary, the water availability is affected by the:

- Supply of water from Moody Brook and Murrell River to the DPR (60 m^3/hr);
- Filtration rates at the filtration plant (theoretical maximum of 77 m^3/hr);
- Operational hours of the Moody Brook and Murrell River pumps (usually 14.5 hrs/day, but can be left on overnight to recharge the DPR in extenuating circumstances); and
- Operational hours of the filtration plant which are restricted by staffing and maintenance requirements.

Potable water storage and supply

Following filtration, potable water is pumped to interim storage header tanks to provide pressure head to the mains system. Two separate systems are utilised:

- Murray Heights Low Level System: Storage of 1,232 m^3 which supplies central ‘old’ Stanley, and harbour frontage to FIPASS and TDF.
- Sappers Hill High Level System: Storage of 1,440 m^3 which supplies new development areas and the by-pass / airport road. A pressure booster system supplies the abattoir and quarry.

Whilst the tanks can provide some degree of buffer storage, in practise it is not possible to fully draw down the tanks because:

- Excessive draw down of tanks can cause in-line system debris sedimentation, (which does not affect potability, but can lead to discolouration and may cause issues to some consumers); and
- The remit is to maintain two days' worth of potable water supply to Stanley at all times.

The two days' buffer of potable water would be prioritised to Stanley and emergency service usage in the event of shortfalls. In case of restriction there is a hierarchy of users that would be restricted and ultimately disconnected if required and subject to emergency provision. At present the TDF is classified as of lowest priority and restriction would likely be conducted as follows, TDF, FIPASS, PWD Megabid, and FIGAS, before restrictions were applied to Stanley.

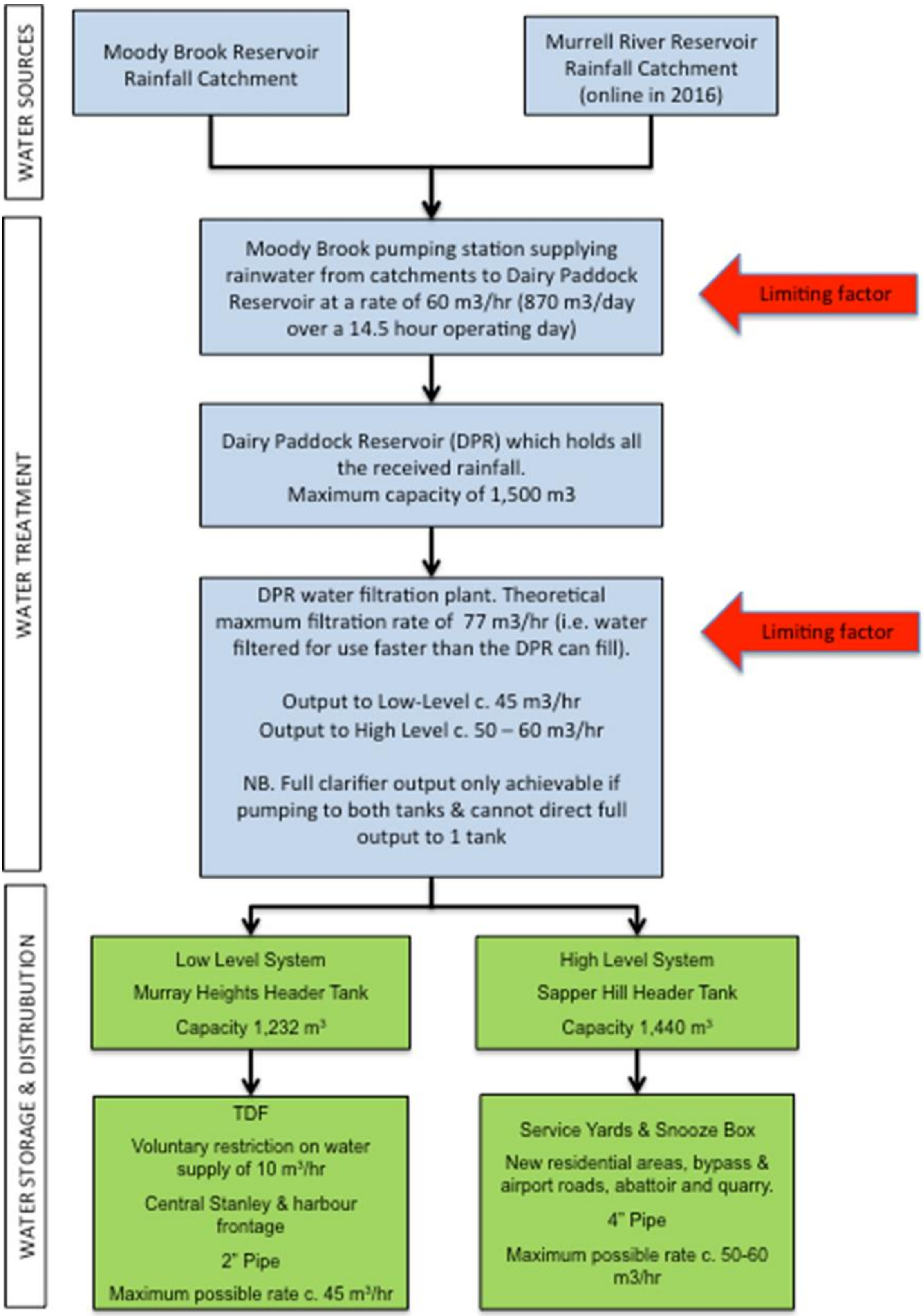


Figure 7.113: The Stanley filtration and water supply system with the limiting capacity of each stage.

7.7.4.5.3 Non-Potable process water

At present, it is not possible to supply lower quality non-potable water as this would lead to contamination of sections of the potable water supply. In addition the full capacity of the existing catchment supply pipeline is utilised by the filtration plant excluding the possibility of a take-off from this pipeline.

7.7.4.5.4 Fuel and bunkering

Stanley Services Limited (SSL) was founded in 1987 and operates under an exclusive license from FIG (current licence due to expire in 2023), to provide all domestic fuels and a bunkering service to all vessels within territorial waters (12 Nautical miles).

SSL stocks fuel according to demand. The SSL contract with FIG for supply to the local population requires SSL have three months' worth of supply of each grade of product.

SSL operates a terminal with a capacity of 7,500 cubic metres of Marine Gas Oil (MGO) in Stanley and can supply fuel to vessels moored at FIPASS, Stanley (ex-pipe alongside the wharf). When there are no O&G vessels operating, SSL only issue minimal amounts to local vessels, several fishing vessels and on occasion to small cruise ships. If there are more vessels operating, the tanks are replenished more regularly. SSL has room in their terminal to build further tank storage if required (R. Rowlands *pers. comm.*).

Additionally, bunkering operations can take place in the open sea or in the relative safety of the natural harbour of Berkeley Sound. Together with joint shareholder Lavinia Corporation, SSL provides bunkering coverage to the fishing fleet on the high seas as well as in Berkeley Sound, supplying both MGO and 180 centistokes (cST) Bunker Fuel. There are two tankers in operation and during the height of the fishing season there are also numerous reefer vessels with large fuel capacities operating on the high seas fishing grounds in the South Atlantic.

With regard to aviation grades of fuel, SSL stocks one grade for the local Islander aircraft and also stocks jet fuel which is generally only supplied to helicopters supporting O&G operations. The SSL terminal in Stanley can stock about five weeks' worth of jet fuel. Jet fuel is replenished from the military base tank farm, 60 kms away by road (R. Rowlands *pers. comm.*).

7.7.4.5.5 Electricity

In order to assess the impact of power use by the Phase 1 Development, it is necessary to understand the baseline electrical capacity to enable comparison. When quantifying the baseline it is necessary to consider the overall amount of power available, as well as the amount available at any given time. Therefore, electrical capacity needs to be considered in terms of the:

- Power available in Stanley;
- Power required by Stanley:
  - Power consumption (in kiloWatt hours (kWh)) (i.e. the total power used over a unit of time); and
  - Peak power demand (in kiloWatts (kW)) (i.e. the instantaneous power available for use at any given moment in time).
- Future power output.

7.7.4.5.5.1 Power available in Stanley

Stanley Power Station (FIG Power section *pers. comm.*) uses eight in-house diesel generators and supplies over 99 % of the electrical usage within Stanley. Outside of Stanley there is no central power grid with settlements and farms serviced by their own independent systems. Mount Pleasant Complex was until recently entirely serviced by diesel generators but a wind farm has now been constructed at Mare Harbour to supplement the generators.

Within Stanley, the FIG Power Station is the electrical distribution hub and balances supply from the generators and the Sand Bay wind farm.

The Sand Bay wind farm comprises six turbines and meets, on average, 32 % of demand. This use of a renewable resource has reduced diesel consumption at the Stanley Power Station by approximately 35 – 40 %. However since this source is reliant on meteorological conditions and output cannot be modified to balance demand, the power needs of Stanley must be considered in the context of the diesel generators alone in order to take a conservative and precautionary approach.

7.7.4.5.5.2 Power required by Stanley

Current Stanley energy use in 2018/19 amounts to 17,608,162 kWh per annum with an average daily use of 48,242 kWh (Table 7.47). This figure is considered typical of current baseline usage and trends. Within the two year period 2013-14 to 2015-16, electrical energy use increased by 16 %. To be conservative within the assessment this is taken as largely relating to the oil exploration activity conducted in that year. However, as can be seen from Figure 7.48 usage figures did not drop back down to pre-exploration figures in subsequent years, remaining 10% (2016-17) and 6% (2017-18) above the 2013-14 figures. It is thus not entirely possible to accurately assign what was the direct and indirect effect of oil exploration against a general increase in electrical usage.

The instantaneous power output is limited by the capacity of the generators. Stanley peak power output is limited to *c*. 5,100 kW depending upon which of the generators are under-going deep services or are on stand-by. However, under normal operating conditions, with a second generator on stand-by, the standard operating power output is considered to be 3,600 kW. Power generation output must be matched to demand load and sudden peak loading can cause failure or drop out in the system.

Table 7.47: Electrical power use (kWh = one unit in domestic usage) over a four year period (each period covering July - June)

Year	Usage (kWh)						
	2012-13[a]	2013-14	2014-15[b]	2015-16[c]	2016-17	2017-18	2018-19
Total Annual Units	16,387,386	16,172,330	16,826,545	18,725,371	17,873,420	17,168,730	17,608,162
% Production from windfarm	32	32	32	32	30	32	30
Average Daily Units	44,897	44,308	46,100	51,162	48,968	47,038	48,241
Average Weekly Units	315,142	311,006	323,587	360,103	337,234	337,188	345,941
Maximum Weekly Units	353,124	349,404	379,505	412,300	377,510	386,250	393,700
Minimum Weekly Units	259,895	249,380	253,319	297,410	274,910	253,322	272,487
% Production Increase from 2012-13 base-year	+1	Base Year No Exploration	+4	+16	+11	+6	+9

[a] Drilling operations with support from the supply base for 5 months.
[b] Drilling operations with support from the supply base for 4 months.
[c] Drilling operations with support from the supply base for 8 months.

7.7.4.5.5.3 *Future power output*

It is recognised within capital project planning and the Stanley Town Plan (FIG, 2015u) that the current five diesel generators are reaching the end of their design life with resultant issues for capacity, reliability and maintenance costs. Contingency planning is progressing two initiatives concurrently:

- An interim Stanley Power Station upgrade in the short to medium-term; and
- A new Power Station in a new location in the long-term.

Approval was given to an interim measure to upgrade the existing Stanley power station through the provision of three new 2,000 kW high-speed modular containerised generator sets that can be installed in parallel to the existing generators, such that both new and old generator set may be used together. This will increase total generator capacity by 6,000 kW, therefore potentially doubling maximum power output and even considering rotational offline servicing will lift considerations of peak power out of any critical limitations.

The three new generator sets have been installed at the existing power station in 2019 and should be commissioned and working in the first quarter of 2020. Whilst the current EIS/S continues to assess the status-quo, given the developments there is a high expectation that the limits identified within the assessment will be resolved within the immediate future with the commissioning of the new generator capacity.

7.7.4.5.6 Waste management infrastructure - Landfill sites

Current waste disposal and recycling facilities in the Falklands are very basic, consisting of landfill and reuse of glass (as aggregate) and scrap metal.

Eliza Cove is a landfill site accepting general waste from Stanley. The site was regarded as being at capacity as long ago as 1997 and was recommended for closure in a study on waste management by Halcrow and Partners, but is still operating.

There are various small landfill sites in Camp. Much general waste on farms and outer islands is burned.

Currently there is no hazardous waste treatment infrastructure in the Islands and hazardous waste streams are stored onshore and shipped in batches to the UK for treatment and disposal.

There is some low level recycling such as reuse of plastic bags and food containers. FIG has implemented a voluntary code of conduct to charge for single use plastic bags. There is a glass imploder that is operated by the Public Works Department and there are numerous glass recycling bins located around Stanley in which residents can deposit their glass waste. FIG collects used glass from hospitality establishments. The crushed glass is used as an infill material for road surfacing.

FIG recently approved funding for a phased comprehensive waste management strategy in collaboration with the MoD. In addition to the continued separation and collection of glass, this strategy comprises:

- Separation and collection of tin cans, to be fed into a proposed MoD recycling facility;
- The incineration of all combustible household waste;
- The construction of a waste collection facility to allow the public to dispose of waste which is not placed in kerbside bins; and
- The construction of a joint FIG/MoD landfill site.

Alongside this, FIG is continuing to explore options for batteries, waste electrical and electronic items (WEE), large metal waste and hazardous waste. (FIG 2019b)

There is currently no legislation regarding recycling in the Falkland Islands. However, in line with planned waste management strategy and associated investment, FIG is committed to development of appropriate legislation. (FIG 2018a)

7.7.4.6 Scenery, wildlife and tourism resources

The role of tourism in the Islands' economy is increasing. Tourist numbers continue to grow, with many attracted by the Islands' pristine environment and its diverse wildlife. Approximately 60,000 tourists visit the Islands by cruise ship each year, and a further 1,600 'land-based' tourists arrive by air annually (FITB, 2018a). The total number of cruise ship passengers arriving in the Islands per season (October to April) from 1995/96 to 2017/18 is shown in Figure 7.114. Visitor numbers rose steadily year on year until the 2007/08 and 2008/09 seasons. There was then a decline as a consequence of the global economic turn-down. Visitor numbers have since recovered to slightly more than those achieved prior to the global economic downturn with the peak number of cruise ship visitors to date being achieved in the 2017/18 season.

Many cruise ships will visit locations in the west of the Islands to see wildlife but virtually all vessels will visit Stanley. Within Stanley, there are a number of businesses and individuals that support tourist excursions to locations within driving distance of the town. Many of these sites are important for the wildlife that they support; however, they are also important recreational sites for residents and tourism. Important sites include:

- Surf Bay;
- Gypsy Cove;
- Cape Pembroke;
- Volunteer Point;
- Murrell Farm;
- Kidney Island;
- Long Island; and
- Bluff Cove.

The tourism sector is the second largest contributor to the Islands economy and contributes approximately £4 m to annual GDP (FIG, 2014a). FIG aims to increase the economic benefits from tourism to the Falkland Islands. A key aspect of the Tourism Development Strategy (TDS) is sustainable development, preserving and protecting the Falkland Islands' character, building on the Islands' abundant wildlife, flora, clean air, open skies, space and remote location, as well as their friendly people and virtually crime-free environment (FITB, 2016a).

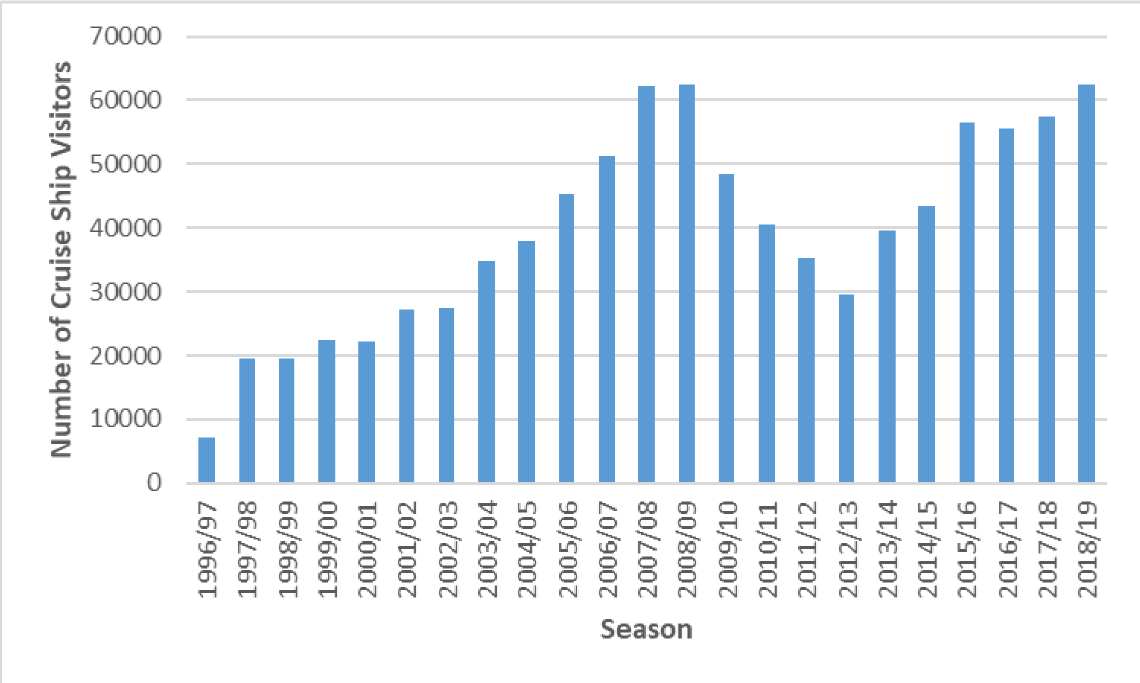


Figure 7.114: Total number of cruise ship visitors per season, from 1996/1997 to 2018/2019

7.7.4.6.1 Tourism in Berkeley Sound

Berkeley Sound qualifies as a tourism resource owing to the wildlife and scenery of the area. Berkeley Sound already has a seasonally high level of shipping activity, which may impact on the view and perception of wilderness experienced by tourists (Tyler Grange, 2016), although peak vessel and tourist activity have limited overlap. The LTVs will be significantly larger than reefers and fishing vessels and potentially present at any time of the year and therefore may pose a potentially greater visual impact.

There are a number of sites around Berkeley Sound that are visited by tourists during the summer (

Table 7.48). Many of these arrive on cruise ships and take over-land day trips from Stanley.

In terms of visitor numbers, the king penguin colony at Volunteer Point is one of the most visited wildlife sites in the Falklands. Additionally, rockhopper penguin colonies on the south side of Berkeley Sound and gentoo penguins at Kidney Cove, both on Murrell Farm land, are popular wildlife attractions. Other tours include trips to Long Island Farm, where visitors can experience life on a Falklands farm.

Tourism away from these sites is at a low level due to access difficulties for independent visitors, although it is possible to hire a 4x4 with driver the number of tourists visiting other sites is generally low. However, many sites in Camp are popular with local visitors.

As an alternative to over-land travel, there are also organised visits by harbour launch to Kidney Island to see the wildlife and whale-watching trips to Berkeley Sound.

Table 7.48: Summary of tourist visitor sites around Berkeley Sound (from Premier, 2015c)

Site	Cruise ship landings	Cruise ship day trips	Independent tourists	Tourists with local guide	Local
Volunteer Point	Occasional	High	No	High	High
Long Island Farm	Occasional	Mod	No	Low	Low
Murrell Farm rockhoppers	Occasional	Mod	No	Mod	Low
Murrell Farm gentoos	No	Mod	No	Mod	Low
Kidney Island	No	Low	Low	Low	Low
Berkeley Sound launch trips	No	Low	Low	Low	Low

7.7.4.6.2 Tourism service providers

While a few cruise vessels visit Berkeley Sound, many pass the entrance to the Sound *en route* to and from Stanley.

During the cruise ship season many people take time off from their regular work to drive tourists to see wildlife around the Islands. In Camp, tourism accounts for a greater share of income than in Stanley. According to FIG figures, tourism accounts for an estimated 17 % of whole farm income, with the outer islands experiencing a greater share of tourism income at 41 % of the total.

7.7.4.7 Livestock and agricultural resources

Agriculture was the main economic activity in the Falkland Islands for most of the 20th century and remains an important part of the Islands economy and culture. Although its relative importance in terms of GDP has been lower than the fisheries sector in recent years, it remains one of the largest employers outside of the public sector (Plexus Energy, 2012).

Until recently the mainstay of the agricultural sector was wool production. A key constraint is the distance to markets, which makes Falklands' wool relatively expensive. The focus has therefore been on organic wool and the production of finer wool, which can hold a premium of up to 10 %. In an effort to diversify the Camp economy and to help to encourage people to stay in Camp, measures were taken in 2002 to generate additional income from meat export (lamb, mutton and beef), complemented by improved farming practices and pasture improvements (Plexus Energy, 2012).

Most farming activity takes place during the summer months (September to March) and as a result there is much seasonality associated with employment in Camp. This period is also the core tourist season and as such there is competition for labour during the summer months. Contract labour is often used for shearing, fencing or tractor work and is often difficult to source, particularly at peak times of the year (Plexus Energy, 2012).

7.7.4.8 Fisheries resources

Fisheries are described under section 7.7.3.2.1.

7.7.5 Baseline noise, odour and light levels

7.7.5.1 Stanley

7.7.5.1.1 Noise

Three noise monitoring exercises have been conducted to date in Stanley that provide information on baseline noise levels in the vicinity of the onshore supply base and TDF. Noise measurements have previously been conducted on behalf of:

- Noble Energy Falklands Ltd in March 2014;
- Workboat Services Ltd in March 2013; and
- Premier Oil in August 2016.

Locations of the monitoring points are shown in Figure 7.115 and the data collected are summarised in Table 7.49.

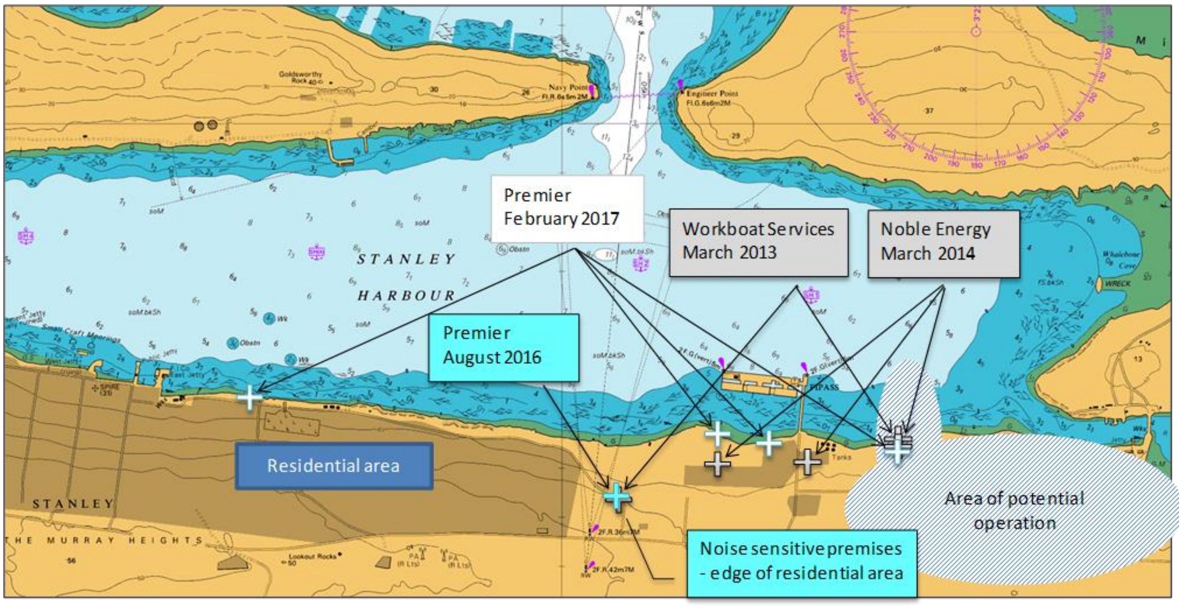


Figure 7.115: Location of noise monitoring points in Stanley

Table 7.49: Summary of the measured noise data

Reference	Description	Time period	LAeq dB[a]	LA90 dB[b]
Workboat Services March 2013	Liberty Lodge	Daytime	45.3	38.9
		Night-time	38.8	35.7
	Coastal Finger Pier	Daytime	43.4	37.7
		Night-time	37.5	34.4
Noble Energy Falklands Ltd March 2014	Stanley Growers	Daily	48.0 - 49.1	Not reported
	TDF	Daily	53.3 - 58.7	Not reported
Premier Oil August 2016	Liberty Lodge	Daily	45.3	41.7

[a] LAeq dB is the average noise level over the measurement period in decibels (dB)

[b] LA90 dB is the noise level exceeded 90 % of the time

7.7.5.1.2 Conclusions from previous surveys

Noble Energy concluded that the levels of noise at the noise sensitive premises (Stanley Growers and from construction and operation activities at the TDF during exploration well campaign) were ‘negligible’ but there was a subsequent complaint from a local resident.

Workboat Services concluded that noise levels from construction and operation of a jetty including the TDF area would be ‘negligible’ at Liberty Lodge.

7.7.5.1.2.1 Premier Oil survey August 2016

Noise monitoring equipment was installed outside in open ground in front of Liberty Lodge Rowlands Rise in Stanley for 48 hours. The equipment used to undertake the noise survey was:

- Norsonic Nor118 Sound Level Meter (serial number 28248) with all-weather kit;
- GRas 40AS Microphone (serial number 004142); and

- Gras 26AK Preamplifier (serial number 044482).

Noise measurements were undertaken in accordance with current best practice guidance contained within BS7445 and BS4142. The sound level meter was mounted at a height of approximately 1.5 m above ground and was located more than 3.5 m from the nearest building facade or wall to avoid falsely elevated levels from reflections. The sound level meter was supplied calibrated (by UKAS accredited laboratories) and was fitted with a windshield at all times, to minimise the effect of wind on the measurements.

The measurement conditions at the monitoring point are shown in Table 7.50 and measured sound levels are shown in Table 7.51.

A frequency spectrum was recorded during this measurement period (covering all 48 hours) and is shown in Figure 7.116. The unmodified sound levels, representing the essential sound energy present, are shown by the red line, but these do not account for human hearing sensitivities, which are instead shown by the blue bars which include the human 'A' weighting. The main frequencies measured contributing to noise perceived by humans (blue bars) are 250 Hz - 1000 Hz. Typically these frequencies are associated with traffic noise (e.g. SINTEF, 2008), although there are many other noise sources that give rise to these frequencies.

Although 48 hours is a short window of measurement, the time history (Figure 7.117) shows some potential features of the noise climate that are worthy of note and can be reviewed as further measurements are taken going forwards:

- Sound levels are rarely below 40 dB(A) even at night;
- Quietest periods are between 2300 - 0600;
- There are apparent noise increases relating to diurnal human activity i.e. increases through the morning 0600-0900 and 1500-1730;
- Traffic noise appears to be an important source of noise;
- Wind noise is probably a significant feature of the noise climate; and
- Military jet overflights occur several times per week and add noticeably to overall noise levels despite being of short duration.

Table 7.50: Measurement conditions for baseline sound measurement

Time and date	Location	Weather conditions	Notes
20^{th} August 2016 18:19 to 22^{nd} August 2016 17:39	Liberty Lodge	0-5 Celsius 1-4 m/s wind Intermittent light snow	Melting snow

Table 7.51: Summary of baseline sound levels at Liberty Lodge

Parameter	Value over 48 hours dB(A)	Value over 1st 24 hours[a] dB(A)	Note
A Leq	49.8	45.3	The 'average' noise level over the measurement period.
A Peak	106.3	-	The maximum noise level recorded at any time (during military jet overflight)
AF Max	95.2	72.3	The maximum noise level (F='fast', averaged over 125 milliseconds)
AF Min	31.9	31.9	The minimum noise level ('F')
AFL 1.0	56.6	-	The noise level exceeded 1% of the time (F)
AFL 5.0	52.4	-	The noise level exceeded 5% of the time (F)
AFL10.0	51	-	The noise level exceeded 10% of the time (F)
AFL50.0	44.9	-	The noise level exceeded 50% of the time (F)
AFL90.0	41.3	40.5	The noise level exceeded 90% of the time (F)
AFL95.0	40.5	-	The noise level exceeded 95% of the time (F)
AFL99.0	38.8	-	The noise level exceeded 99% of the time (F)
AFL99.8	37	-	The noise level exceeded 99.8% of the time (F)

[a]The second 24-hours included a period of suspected wind noise so has been discounted. The first 24 hours is considered more representative of overall noise character.

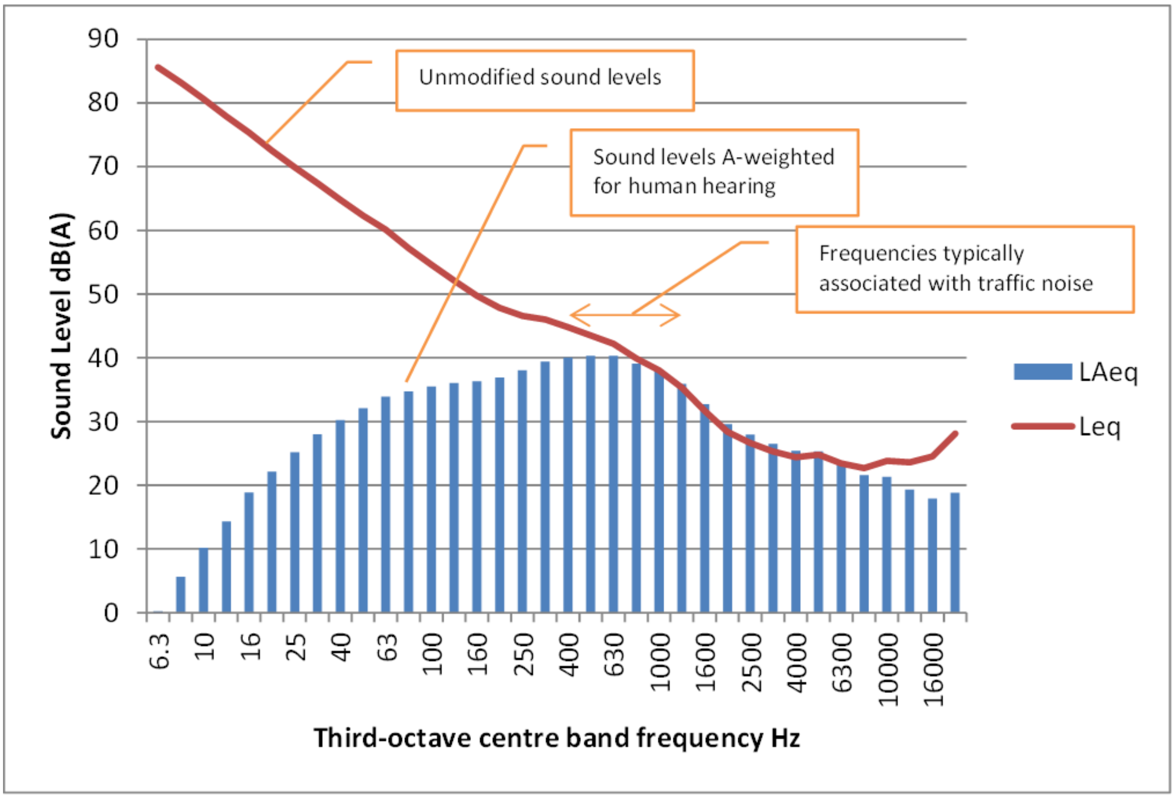


Figure 7.116: Frequency profile for Liberty Lodge sound level measurement

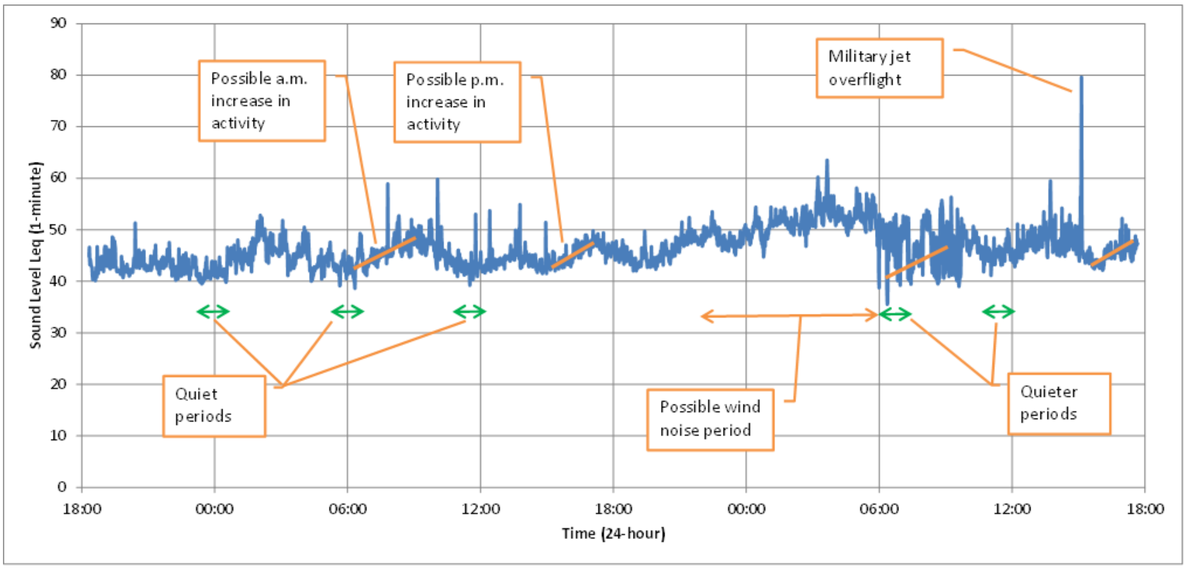


Figure 7.117: Time sequence of noise measurements at Liberty Lodge (1-minute intervals)

7.7.5.1.2.2 Premier Oil survey February 2017

On 16 February 2017, further baseline noise measurements were taken from several points in and around Stanley. For comparison with earlier studies, the locations where measurements were taken in the eastern Stanley are shown in Figure 7.115. Other sites were associated with the power station, one of the loudest sources of ambient noise, and Moody Brook, at the extreme western end of Stanley Harbour. Snap-shot measurements over a period of 5 – 6 minutes were taken at each point using Mirus Sound Level Meter GA117 s/n 35777, Class 1 microphone, UKAS certified, proprietary windshield. The results are summarised in Table 7.52 (all measurements are 'A' weighted).

On the day, the air temperature was 17°C, air pressure was 1,004 mbar and wind speed was c. 5 m/s (equivalent to c. 10 knots). Sources of ambient noise included:

- Several jiggers in the Harbour approximately 200 m from the shore; and
- Ongoing refurbishment of FIPASS, which involved grit blasting, compressors and moving plant.

Table 7.52: Summary of baseline sound levels collected in February 2017

Ref.	Measurement location	Type	Time	Duration	Leq	Lmax	Lmin	Notes
L11	Ross Road - slipway	Sound level only	13:43	00:06:37	51.3 dB	69.6 dB	47.8 dB	Jigger 1. Passing car.
L12	Ross Road - slipway	SL & 3rd Octave	13:50	00:06:28	60.1 dB	73.2 dB	48.8 dB	Jigger 2 starts (louder).
L13	Ross Road - slipway	SL & 3rd Octave	14:03	00:06:46	56.1 dB	78.4 dB	48.6 dB	Jigger 2. Passing cars.
L14	Ross Road - slipway	Sound level only	14:10	00:05:53	54.9 dB	67.2 dB	47.9 dB	Jigger 2. Ship horn sounding. Passing cars.
L15	FIPASS - Shoreline at west extent of FIPASS pontoons (near Stanley Growers)	Sound level only	14:34	00:06:45	60.0 dB	72.4 dB	47.9 dB	Jigger noise. Grit blasting. Metal deck reverberation. Compressor noise.
L16	FIPASS - Shoreline at west extent of FIPASS pontoons (near Stanley Growers)	SL & 3rd Octave	14:41	00:05:03	61.1 dB	72.8 dB	46.6 dB	
L17	FIPASS - Shoreline opposite gap between two east most pontoons	SL & 3rd Octave	14:55	00:05:14	49.2 dB	54.7 dB	43.0 dB	Jigger noise significantly reduced. Grit blasting. Metal deck reverberation. Compressor noise.
L18	FIPASS - Shoreline opposite gap between two east most pontoons	Sound level only	15:01	00:05:42	46.0 dB	58.5 dB	38.7 dB	
L20	TDF - Shoreline	Sound level only	15:30	00:05:59	45.2 dB	51.4 dB	41.0 dB	Subdued noise from FIPASS maintenance and jiggers
L21	TDF - Shoreline	SL & 3rd Octave	15:36	00:05:03	45.3 dB	50.5 dB	41.7 dB	
L23	Outside power station	SL & 3rd Octave	16:34	00:05:49	72.5 dB	75.6 dB	71.1 dB	Highly dominant engine, exhaust and mechanical noise
L24	Outside power station	Sound level only	16:40	00:05:03	72.5 dB	75.2 dB	71.1 dB	
L25	Field above power station	Sound level only	16:48	00:05:02	62.9 dB	84.8 dB	45.4 dB	Power station noise. Passing cars
L26	Field above power station	SL & 3rd Octave	16:53	00:05:04	53.6 dB	68.3 dB	44.2 dB	Power station noise. Loud lorry using engine to brake downhill.
L27	Moody Brook	SL & 3rd Octave	17:09	00:05:03	41.8 dB	63.3 dB	29.4 dB	Background noise. Wind picking up 5-10 m/s, potential crackle.
L28	Moody Brook	Sound level only	17:14	00:05:03	44.0 dB	58.1 dB	29.4 dB	

7.7.5.1.3 Odour

No information is currently available on the odour baseline in Stanley. Scoping consultations did not raise it as an ongoing issue, nor was it raised during previous oil and gas operations.

7.7.5.1.4 Light

Stanley is currently lit at night by street lights and there are ‘operational’ lights at night from the industrial end of town (the Gordon Lines area), as well as from FIPASS. Lights can also be seen from vessels in the harbour; the number of vessels depending on the season but is generally highest in January and February, prior to the start of the *Illex* season. During previous oil and gas operations there were lights at the TDF and supply bases and it was noted during previous scoping consultations that light from the TDF, vessels and yard is noticeable to Stanley residents. A community complaint was also made to Premier during the 2015 exploration drilling campaign regarding the lighting from vessels moored up at the TDF at night.

The New World Atlas of Artificial Brightness shows that the Falklands are a relatively dark sky area, with the majority of the population living with little very light pollution (CIRES, 2016).

7.7.5.2 Berkeley Sound

7.7.5.2.1 Noise

Long Island August 2016

In August 2016, Premier took noise measurements outside Long Island Farm, facing Berkeley Sound, over a period of 30 hours. Unfortunately, they appear to have been affected by wind. Normally, measurements taken in conditions with winds above 5 m/s are not deemed reliable for noise assessments due to the effect of wind on ambient noise and more specifically the effect of buffeting on the microphone, both effects elevating the noise measurement. For assessment or baselining purposes it is recommended to use noise levels derived from measurements taken with appropriate equipment at windspeeds less than 5 m/s. The results are nevertheless shown below. In the absence of wind they would indicate relatively high levels for a rural location, and so are not thought to be reliable. It was not possible to secure another period of quiet weather to re-do the modelling in August 2016; however a further monitoring exercise was undertaken in February 2017 (see below). Table 7.53 shows the measurement conditions for the monitoring. Table 7.54 summaries the measured baseline sound levels.

Table 7.53: Measurement conditions for baseline sound measurement

Time and date	Location	Weather conditions	Notes
23rd August 2016 12:54 to 24th August 2016 19:39	Long Island Farm, Berkeley Sound	1-5 Celsius 2-10 m/s wind No precipitation	Gusting wind

Table 7.54: Summary of baseline sound levels at Berkeley Sound

Parameter	Value over 48 hours dB(A)	Note
A Leq	54.3	The 'average' noise level over the measurement period.
AF Max	89.9	The maximum noise level (F='fast', averaged over 125 milliseconds)
AF Min	35	The minimum noise level ('F')
AFL90.0	46.6	The noise level exceeded 90% of the time (F)

Long Island February 2017

On 21st February 2017, sound recording equipment was deployed at Long Island to establish the ambient, background noise level. A measurement period was deliberately chosen to measure noise in the absence of strong winds. Although winds were not monitored continuously, they were subjectively very low at the start and end of the measurement (c. 0-5 $m.s^{-1}$) and no significant changes in weather were noted locally in this time. This reflects conditions when added noise from proposed Project activities may cause the most annoyance. In this area, wind noise is a common and very apparent feature most of the time, and it was difficult to identify a period of more than a few hours when winds were low, and a previous measurement was discounted as being wind-influenced (section 7.7.5.2.1.1). The results should be read in this context, that they represent unusually 'quiet' conditions and do not reflect long-term averages. Air temperature ranged between 8-14 °C and air pressure 1,002 mbar.

Guidance on how to calculate background noise for assessment purposes was taken from BS4142:2014. Background noise is the 90th percentile of LAeq measurements (i.e. 90% of measurements are above this) and is considered separately for night-time (11pm - 7am) and daytime (7am - 11pm).

Once established, a comparison against commercial or industrial operating noise can be made to assess the potential impacts on human receptors.

The recorded sound levels are shown in Figure 7.118, from which the following background noise levels (in the absence of significant wind noise) are calculated.

- Daytime LA90, 1 hour 30.8 dBA;
- Nighttime LA90, 15 mins 29.5 dBA.

Generally, daytime noise levels average around 40 dB(A), and night-time background levels average around 30 dB(A) for significant periods. Background (LA90 levels) at Long Island Farm are around 10 dBA lower during the daytime and only slightly lower than average at night. Periodic loud noise events are observed lasting 1-2 minutes (Figure 7.118); these are unidentified, but are unlikely to be passing local vehicles given the location of the meter and would be consistent with passing aircraft.

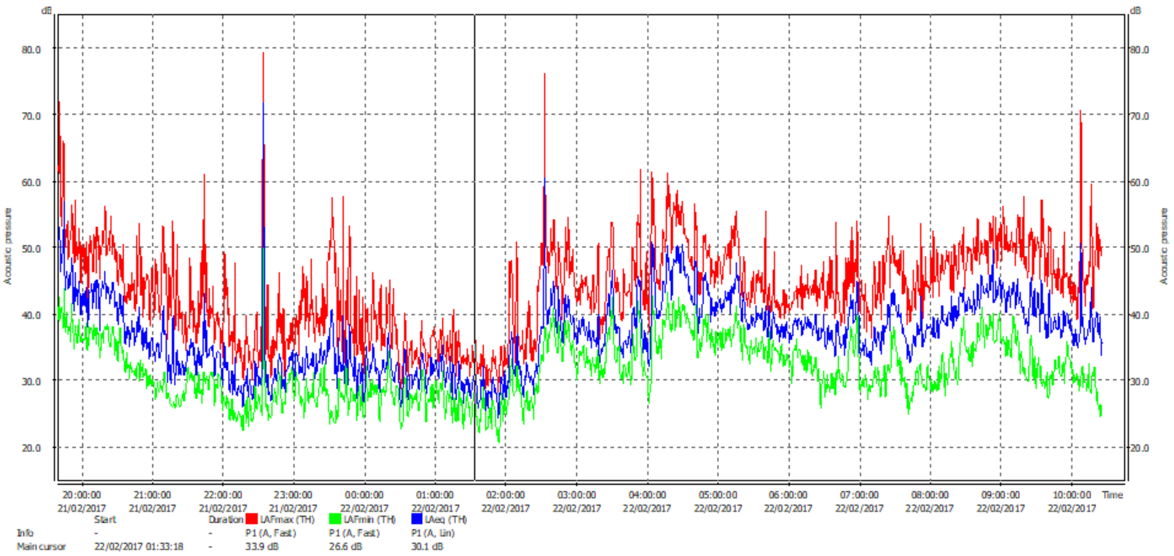


Figure 7.118: Sound pressure levels recorded at Long Island Farm on 21st - 22nd February 2017

7.7.5.2.2 Odour

No information is currently available on the odour baseline in Berkeley Sound. Scoping consultations did not raise it as an ongoing issue.

7.7.5.2.3 Light

Sources of existing anthropogenic light include the jiggers that utilise Berkeley Sound to tranship their catches to reefer vessels and to refuel. Although the full rig of jigging lights is not deployed in Berkeley Sound, there is a considerable amount of light emitted from these vessels, the glow from which can be seen from Stanley (A. Black *pers. obs.).* In addition to the jiggers, other vessels use Berkeley Sound as an anchorage, primarily for the transhipment fish catches.

Although vessels can be present in all months of the year, activity peaks between March and June, when more than a dozen vessels can be present, but this varies considerably from year-to-year. Combined, these vessels represent a large source of anthropogenic light. Despite this, The New World Atlas of Artificial Brightness describes the Falklands are a relatively dark sky area, with the majority of the population living with little very light pollution (CIRES, 2016).

7.7.6 Marine archaeology

7.7.6.1 Wrecks in the NFB and Sea Lion Field

The UK Hydrographic Office Wrecksite database indicates that there are 177 shipwrecks recorded within Falkland Islands waters, with records dating from the 1800's to present day. There are nine recorded wrecks within 100 nautical miles radius of the Phase 1 Development site (Table 7.55); the two closest of these wrecks are both located approximately 40 nautical miles from the field (Figure 7.119). There are no recorded wrecks within the vicinity of the Development site.

Table 7.55: Recorded wrecks within 100 miles of the Phase 1 Development.

Wreck	Vessel Type	Latitude	Longitude	Depth (m)	Date
ARA Comodoro Somellera	Argentine patrol boat	49°30'00.2"S	58°30'17.8"W	400	1982
MFV Chiann Der III	Small fishing boat	48°30'00.0"S	59°43'00.0"W	~480	1986
MFV Dong Yung 510	Trawler	49°05'00.0"S	60°45'00.0"W		1998
MFV Chin Yuan Hsing	Jigger	49°27'00.0"S	60°57'00.0"W		1993
Wreck No 129700356	Unknown	49°55'06.1"S	58°02'47.8"W	300	unknown
MFV Dong Bang 31	Jigger	48°04'00.0"S	60°22'00.0"W		2008
Wreck No 140502865	Unknown	50°17'12.2"S	60°11'17.8"W	160	unknown
MFV Dae Woong 5	Jigger	49°37'00.0"S	61°13'00.0"W		2000
MFV Ferralemes	Falkland Islands trawler	50°15'30.4"S	58°13'23.4"W	135	2008

(Source: UK Hydrographic Office (2014)).

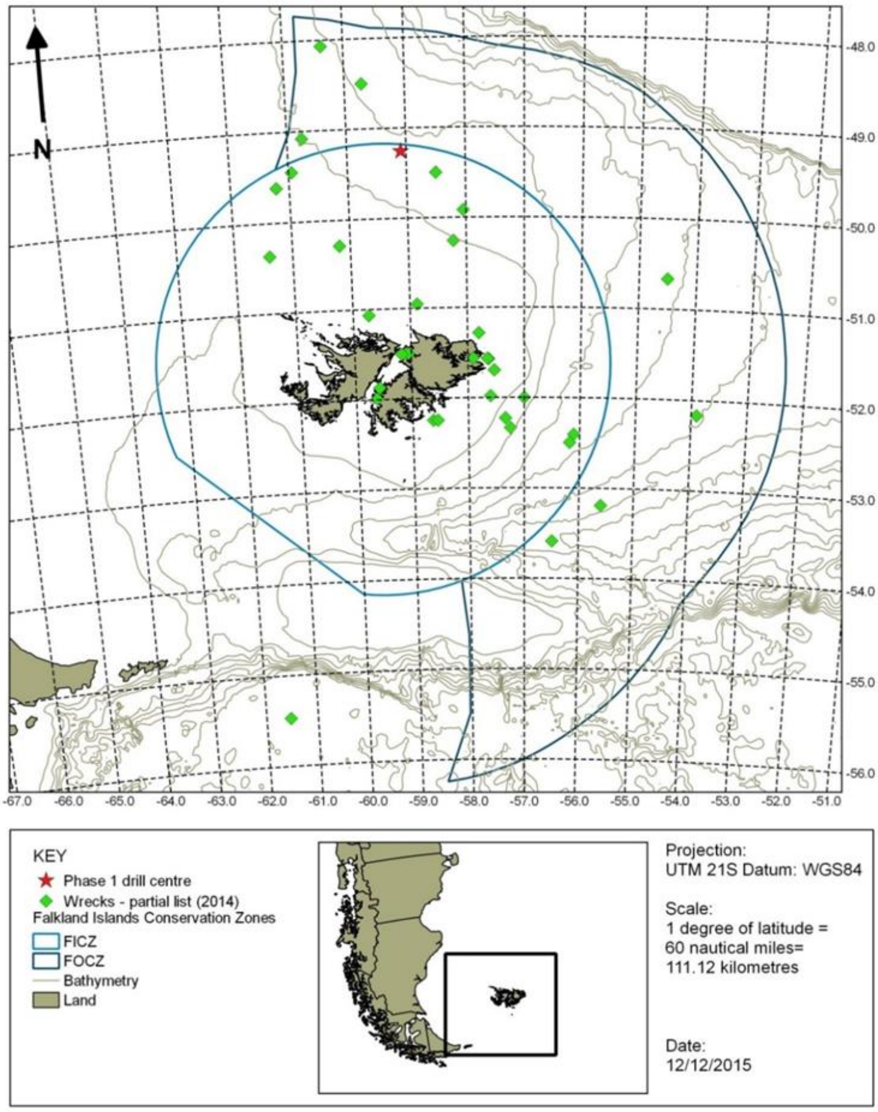


Figure 7.119: Known shipwrecks within the Falklands Continental Shelf

7.7.6.2 Berkeley Sound

7.7.6.2.1 Anchor scars

Reflecting the heavy use of Berkeley Sound as an anchorage, evidence of shipping activity was found throughout the Sound (BSL, 2015a).

The seabed in the sound, especially in the more sheltered western end, is heavily scarred with linear features generated by dragging anchors. A number of anchor scars observed were over 100 m long indicating significant vessel drift, 'anchor drag'. Fan shaped patterns were also observed on the seabed, which are thought to be caused by anchor chains dragging across the surface as a vessel 'swings' on its anchor (BSL, 2015a).

The physical dragging of the anchors disturbs benthic communities, stripping hard surfaces and overturning soft sediments. Seabed imagery indicated the possible presence of the filamentous bacteria *Beggiatoa* sp. within the anchor scars, visible as a white mat on the seabed. This bacteria is generally only found in areas that interface aerobic and anaerobic conditions and is often found in areas of organic enrichment.

7.7.6.2.2 Man-made objects

During a sonar survey in 2015, a total of 1,459 potentially man-made objects were identified within Berkeley Sound (BSL, 2015b). A contact was interpreted as man-made if it had a distinctly linear shape or shadow and appeared to be of man-made origin; otherwise it was classified as a boulder. Where possible further details were added, however, many targets have been listed at 'debris' if the object could not be further identified.

Many contacts were identified as tyres, piping and lengths of rope, cable or chain which have distinctive forms allowing easy identification. These sorts of debris are typical of an area used by commercial shipping and fishing vessels. Some targets warranted further investigation due to their size and / or proximity to the proposed Berkeley Sound anchorage location. A box shaped object was identified on sonar located at 434699E 4285499N with dimensions of 2.4 m x 2.4 m x 0.7 m (Length x Width x Height). A drop down camera pass was undertaken over the target which showed a metal frame with meshing which looks to be some lost or discarded fishing equipment, possibly a jigger arm (Figure 7.120).

7.7.6.2.3 Wrecks

Two wrecks were identified within the survey area Figure 7.121, the trawler Ocean 8 to the northwest and the Blakeney to the southeast. Both wrecks are charted on Admiralty Charts; however, the charted position of the Blakeney wreck is approximately 1 km due east of the position interpreted from the sonar data. The wreck of the *Ocean 8* lies approximately 100 m southwest of the charted position but within the Admiralty buffer.

The wreck *Ocean No. 8* was observed within the priority 2 survey area at 437260E, 4287300N with a shallowest point of 21.5 m surrounded by a seabed of 31 m below CD (Stanley).

Figure 7.120: Photograph of large man-made object found on the floor of Berkeley Sound (BSL, 2015b)

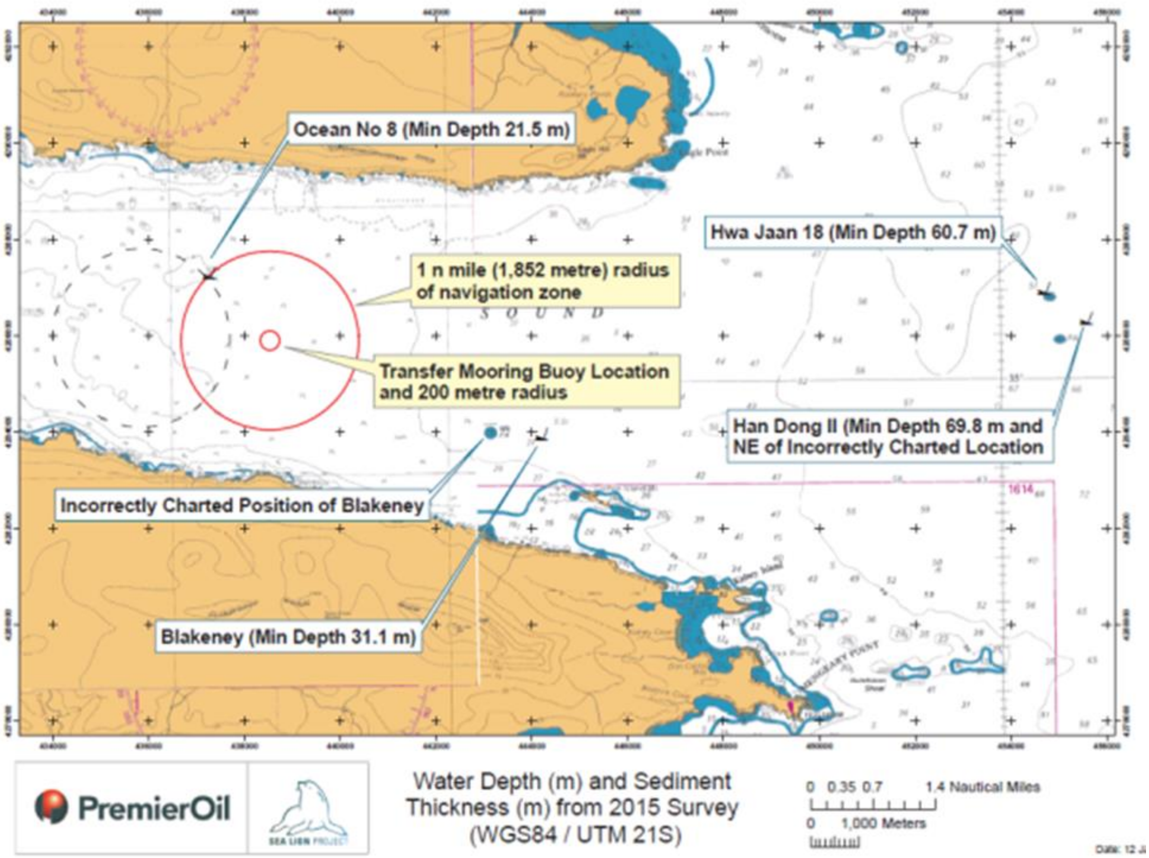


Figure 7.121: The location of wreck sites within Berkeley Sound

7.8 Summary of key environmental and social sensitivities

7.8.1 Key environmental sensitivities

The key biological sensitivities of the Falkland Islands offshore environment and Berkeley Sound are summarised in Table 7.56 and Table 7.57 respectively. Note that in order to give an overview of the environmental sensitivities, the tables indicate the relative importance of each month, regardless of which particular species, fishery or site is the cause.

Table 7.56: Summary of key environmental sensitivities in the Sea Lion Phase 1 Development area

Environmental baseline and sensitivity at Sea Lion											
Low[a]				Medium[a]				High [a]			
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Plankton: Plankton comprises of small to microscopic plants (phytoplankton) and animals (zooplankton) that drift in the surface layers of the sea. Phytoplankton require sunlight, like all other plants, to survive, and zooplankton graze upon the phytoplankton or prey on other zooplankton. The oceanic fronts around the Falkland Islands result in nutrient rich waters which create an area of very high phytoplankton productivity immediately to the north of the Islands (and approx. 60 km to the south of the Sea Lion Field). This phytoplankton productivity is seasonal and in turn supports complex communities of zooplankton, which then support complex pelagic (in the water column) and demersal (near the seabed) ecosystems.											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Marine flora: Not applicable to offshore location.											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Benthic fauna: Benthic fauna are those animals which live on, or below, the seabed. Overall, benthic fauna around the Sea Lion area is very uniform, with polychaetes (i.e. marine worms) and crustaceans (e.g. crabs) being the two most abundant groups present, followed by molluscs (e.g. clams).											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fish and shellfish: The convergence of the temperate and sub-Antarctic regions in the Falkland Islands archipelago results in the presence of species belonging to both. The six sub-Antarctic, and seven temperate, fish and squid species found in abundance in Falkland Islands' waters primarily utilise the NFB as feeding grounds, migrating in and out of the area as food availability changes and to follow seasonal spawning migrations. Other species feed in the area as juveniles and move to deeper waters as they mature and become adults. This results in seasonal changes in the fish assemblages across the ecosystem.											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Seabirds: Over 70 % of the global population of black-browed albatross breed on the Falkland Islands with a significant proportion of the global populations of gentoo and rockhopper penguins doing the same. The waters surrounding the Falklands also support numerous species that breed elsewhere. Of the species recorded in the Sea Lion area, the Atlantic petrel, grey-headed albatross, and northern royal albatross are all listed as 'Endangered' on the IUCN Red List, and the southern rockhopper penguin, white-chinned petrel, southern royal albatross and the wandering albatross are listed as 'Vulnerable'.											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Marine mammals: Confirmed records indicate that 25 species of cetacean (whales, dolphins and porpoises) occur within Falkland Islands waters and three species of pinniped (seals) breed on the Islands. Many of the cetacean species are rare and inconspicuous and some are only known from stranded animals. Of these 25 cetacean species, two species are listed as 'Endangered' on the IUCN Red List, namely the sei whale, and one species, the sperm whale, are listed as 'Vulnerable'.											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Conservation sites: There are no designated marine protected areas in Falkland Islands waters. However, work is ongoing to identify marine areas that support important aggregations of seabirds and other fauna. On land, a number of Important Bird Areas (IBAs) have been designated and the influence of these extends 15 miles into the surrounding marine environment. Additionally, a network of National Nature Reserves (NNR) and Important Plant Areas (IPAs) protect many of the most important seabird breeding sites and areas supporting native flora respectively.											

[a] Note that the terms Low, Medium and High in this context provide a guide only as to the general sensitivity / abundance as it is relevant to each receptor. Specific sensitivities of each receptor to each environmental impact are explored in full within the EIS.

Table 7.57: Summary of key environmental sensitivities in Berkeley Sound

Environmental baseline and sensitivity in Berkeley Sound											
Low[a]				**Medium[a]**				**High [a]**			
Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Plankton: Plankton comprises small to microscopic plants (phytoplankton) and animals (zooplankton) that drift in the surface layers of the sea. The most conspicuous component of the inshore zooplankton community is lobster krill, which is an important prey species for higher predators (such as penguins and whales).											
Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Marine flora: Marine plants are the major primary producers in the marine environment. The most common species of seaweed within the Falklands are the giant kelp and the tree kelp, which are found around the entire Falklands coastline. Kelp is a habitat forming species and is a very important part of the inshore ecology.											
Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Benthic Fauna: Benthic fauna are those animals which live on, or below, the seabed. Berkeley Sound supports a wide range of benthic habitats (including biogenic and geogenic reefs), each supporting a characteristic range of species. Although none of the species found is rare or protected under any Falkland Islands legislation. Work is ongoing to identify important marine areas, and as such work develops, new designations can be incorporated in the ongoing management of the project via the EMMP and the 5-yearly review of the EIS.											
Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Fish and shellfish: The most conspicuous species found inshore off the east coast is loligo squid, which play a key role in the inshore ecology as predator and prey. n addition, loligo support the second largest fishery in the Falklands. Loligo are known to migrate inshore to spawn, although the key spawning sites remain unknown. Periods of 'high sensitivity' reflect the spawning periods of the two loligo cohorts. There are several species of shellfish found within Berkeley Sound that are commercially exploited elsewhere but not currently in the Falklands.											
Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Seabirds: Berkeley Sound encompasses significant breeding populations (>1% of the national population) of gentoo and rockhopper penguins and a far higher proportion of the national populations of king penguins, sooty shearwaters and white-chinned petrels. In addition to king and gentoo penguins, there are large resident populations of imperial and rock shags and Falklands steamer ducks, which are present year-round. Of the species breeding in Berkeley Sound the white-chinned petrel, southern rockhopper penguin and Cobb's wren are listed as 'Vulnerable' on the IUCN Red List.											
Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Marine mammals: Berkeley Sound supports small breeding populations of South American sea lions (Diamond Cove), South American fur seals (Volunteer Rocks) and is likely to have breeding populations of Commerson's and Peale's dolphins. Conspicuous seasonal visitors include sei whales, which are most numerous in the late summer and autumn. Several other species of large whale have been recorded within Berkeley Sound including southern right and Antarctic minke whales. An unprecedented influx of southern right whales was recorded during the winter of 2017.											
Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Conservation sites: The entrance to Berkeley Sound is flanked by two National Nature Reserves (Volunteer Point and Cow Bay, and the Kidney Island Group), which are also classed as Important Bird Areas.											

[a] Note that the terms Low, Medium and High in this context provide a guide only as to the general sensitivity / abundance as it is relevant to each receptor. Specific sensitivities of each receptor to each environmental impact are explored in full within the EIS.

7.8.2 Key social sensitivities

The key social sensitivities of the Falkland Islands are summarised in Table 7.58.

Table 7.58: Summary of key social sensitivities in the Sea Lion Phase 1 Development area

Social baseline and sensitivity											
Low[a]				Medium[a]				High[a]			
Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Commercial fisheries: The two most important fisheries within the Falklands Economic Exclusion Zone (EEZ) are the jig fishery for Argentine shortfin squid and the trawl fishery for Patagonian long-finned squid, which accounted for 68% and 11% of the 2014 catch by weight respectively. There is also a fleet of trawlers that operate over the Falklands continental shelf that target a range of finfish species. Currently, the only other fishery in the Falklands EEZ is the longline fishery for Patagonian toothfish, which operates in deeper waters (≥ 600 m).											
Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Tangible property and resources: There is a range of onshore infrastructure on the Falkland Islands that will be utilised during the Phase 1 Development, which could lead to competition for resources with other users of these facilities. The main areas of potential impact include the use of: port facilities, supply routes, airports and airlinks, the road network, accommodation, freshwater and electricity supply. During the austral summer period, accommodation, flight availability and freshwater may all be less available.											
Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Tourism: The majority of tourists visiting the Falkland Islands arrive on cruise ships. Many cruise ships visit locations in the west of the Islands to see wildlife and most vessels visit Stanley. Within Stanley, there are a number of businesses and individuals that support tourist excursions to locations within driving distance of the town. Many of these sites are important for the wildlife that they support; however, they are also important recreational sites for residents.											
Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Marine archaeology: The UK Hydrographic Office Wreck site database indicates that there are 177 wrecks recorded within Falkland Islands waters, with records dating from the 1800's to present day. There are six recorded wrecks within 100 nautical miles of the proposed drilling sites; the closest of these wrecks is located approximately 50 nautical miles from the nearest well site. Two wrecks were identified within the Berkeley Sound survey area: the trawler *Ocean 8* to the northwest, and the *Blakeney* to the southeast.											

[a] Note that the terms Low, Medium and High in this context provide a guide only as to the general sensitivity as it is relevant to each receptor. Specific sensitivities of each receptor to each social impact are explored in full within the EIS.

8 ENVIRONMENTAL IMPACT & RISK ASSESSMENT METHODOLOGY

Table of Contents

8.1 Introduction

The impact and risk assessment process provides a framework for assessing the potential environmental and social consequences that may arise from the proposed development based on the information made available during project planning. The purpose of this chapter is to describe the methodology used to identify and assess the environmental aspects and potential impacts and risks resulting from the Phase 1 Development.

The methodology has been prepared based on the:

FIG Environmental Planning Department (EPD) Hydrocarbons Environmental Impact Assessment Guidance Note (FIG, 2015m);

Premier Falklands Islands Business Unit (FIBU) HSES Risk Management Standard (FK-BU-PMO-HS-STD-0006); and

International best practice (IEEM, 2010; Horvath (IAIA), 2013; Morris and Therivel, 2009; Glasson *et al*., 2013).

Note: while these methods are broadly based upon the FIBU HSES Risk Management Standard there are some adaptations with regard to the distinction between impact and risk and the detail in definitions of sensitivity, severity and likelihood.

8.2 Overview of the environmental impact and risk assessment process

The International Standard for Environmental Management (ISO14001:2015) defines an environmental impact as ‘any change to the environment, whether adverse or beneficial, wholly or partially resulting from a project’s environmental aspects’. Environmental aspects refer to the way in which the project activities may interfere with the environment.

Environmental aspects, impacts and risks can be identified by assessing the planned activities that must occur for the project to be successfully completed and by exploring what could happen as a result of these activities. Further, during the course of any project execution, there is a risk that unplanned and accidental events may occur and it is therefore also necessary to consider what could go wrong.

Planned activities give rise to environmental impacts, while unplanned and accidental events pose a risk of environmental impact, if they occur. The risk of environmental impacts resulting from unplanned or accidental events is evaluated by taking the likelihood of the event occurring into consideration.

Therefore with regard to assessing the Phase 1 Development:

- Planned activities are subject to an impact assessment only; and
- Unplanned and accidental activities / events are subject to the same impact assessment followed by an assessment of the likelihood that the unplanned or accidental event will actually occur.

Initial assessment of the impacts and risks takes account of key legal compliance requirements, additional industry standards, controls that are built-in to the basis of design / design philosophies to reduce impacts, and also any input from key stakeholders received during the scoping exercises (Chapter 6). 'Impacts and risks that are initially assessed as 'Low' or 'Very Low' using the base case mitigations, industry-standard and HSES-MS measures were not prioritised with regard to further project-specific mitigation as extensive additional measures were not considered 'reasonably practicable'. Where an impact or risk is deemed 'significant' (i.e. 'Moderate' or above), alternatives must be considered and project-specific mitigation measures proposed, to eliminate impacts and risks, or reduce them to a level that is 'As Low As is Reasonably Practicable' (ALARP). Following identification of project-specific mitigation measures, the 'residual' impact or risk is assessed.

Residual impacts and risks that are assessed as 'Very Low' or 'Low' using the base case mitigations, industry-standard and HSES-MS measures were not prioritised with regard to further project-specific mitigation as extensive additional measures were not considered 'reasonably practicable'. Where a residual impact remains 'Moderate' or above, offsetting measures were considered (see section 8.9.2). Additionally, throughout the process, the potential for any positive or beneficial impacts is noted.

Further to the assessment of the individual impacts and risks associated with the Phase 1 Development, the potential for cumulative impacts, which may be caused by the presence of other operations ongoing in the vicinity, are also assessed.

Throughout the whole process, the assessment follows a precautionary approach, taking account of any data gaps and uncertainties. However, upon completion of each assessment, a confidence rating is assigned to the impact and risk rating to inform the reader on the overall level of confidence in each assessment, and to inform the level of monitoring that may be required throughout the life of the operation.

All monitoring requirements will be captured within the Environmental Monitoring and Management Plan (EMMP). Future remedial action may be required where monitoring indicates that an impact is higher than predicted in this EIS and / or where the prescribed regulatory requirements and best practice are considered insufficient. An overview of the EIA process is provided in Figure 8.1 below.

8.3 Aspect, impact and risk identification

Using the project basis of design (Chapter 5), the environmental aspects are determined by walking through the different stages of the Phase 1 Development and identifying the ways they may impact upon the environment or society (i.e. the human population).

When identifying the environmental and social aspects, impacts and risks, it is important to note that the project activities (e.g. drilling, production, use of vessels etc.) can interact with the environment in many ways.

It is understood that:

- Planned activities with known outputs will lead to impacts e.g. it is inevitable that there will be some atmospheric emissions and waste;
- Unplanned events may occur which carry the risk of an impact due to:

- The potential for downtime in equipment e.g. the vapour recovery package, the produced water reinjection unit; and / or
- The potential for events that are outwith Premier's control e.g. birds may strike vessels due to the physical presence or artificial light.
- Accidental events may occur which carry the risk of an impact in the event of a loss of control over project activities e.g. oil spills would only result from an accidental or uncontrolled event such as a vessel collision or well blow-out.

Therefore, impacts, and / or the risk of an impact, are associated with planned activities and with unplanned / accidental events.

Environmental and social aspects, impacts and risks are identified during ENVironmental Impact IDentification (ENVIID) workshops. The outcomes of the Phase 1 ENVIID are described in Chapter 9.

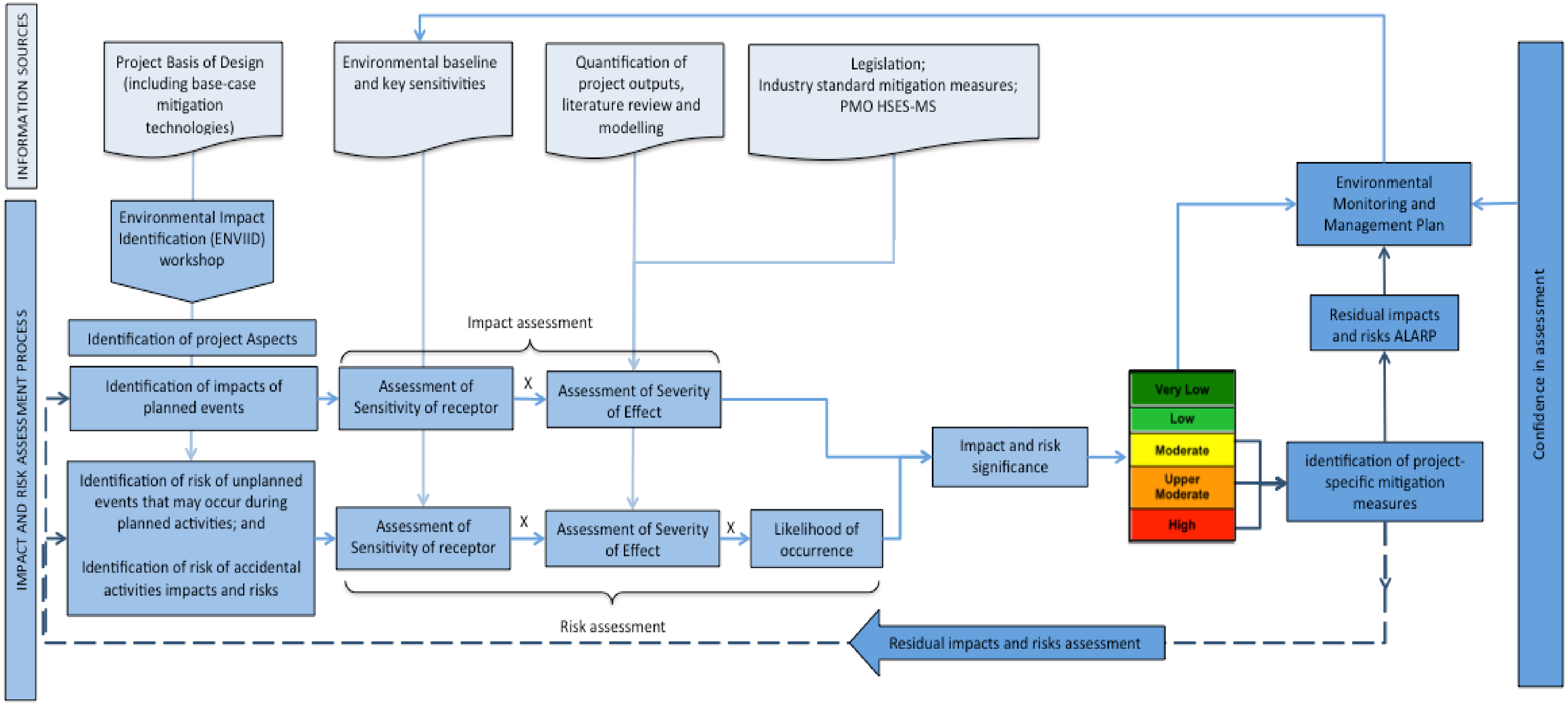


Figure 8.1: Overview of EIA process

8.4 Environmental baseline and receptor identification

In order to assess the impact or the risk it is necessary to have an understanding of the existing environment and the components within it (i.e. the environmental receptors). Full detail on the environmental and social baseline is provided in Chapter 7.

The term 'environmental receptor' effectively describes the receiving environment which may be impacted by an activity or outcome of the development (i.e. environmental aspect). Environmental receptors therefore include individuals, species, populations, habitats, the physical environment (locally and globally) and ecological processes. The environmental components or receptors which must be considered in an EIA are defined within Annex C – Schedule 4 of the FIG Offshore Minerals Ordinance (section 3.1.6.3.1) and are listed below. Some receptors have been broken down into sub-components to demonstrate how they have been addressed in this EIA.

The sensitivity of the following receptors to environmental impact is described in section 8.5.2.1 below.

- Human population;
  - Stakeholder and or regulatory concern;
  - Disturbance;
  - Health;
  - Commercial fisheries;
  - Tourism; and
  - Transboundary impacts.
- Flora;
- Fauna:
  - Benthic (animals living on or in the seabed) and terrestrial ecology;
  - Plankton (plant or animals which live in the water column and drift with the ocean currents);
  - Fish ecology;
  - Seabirds;
  - Marine mammals; and
  - Designated sites (on account of their populations of flora or fauna).
- Soil (including the seabed) [referred to in this EIA as Seabed (including soil)];
- Water quality (including the sea and aquifers under the seabed);
- Air quality (local);
- Climatic factors (global);
- Landscape and seascape;
- Tangible property (e.g. fishing vessels and finite resources such as landfill space, diesel, potable water);

- Architecture and archaeological heritage; and
- The interaction between these factors (in any combination).

8.5 Impact assessment methodology for planned events

This section describes the methodology used for the assessment of environmental impacts arising from planned events.

8.5.1 Environmental Impact Assessment process

The evaluation of impacts follows a structured methodology that systematically:

- Identifies planned project activities and environmental aspects that could lead to an environmental impact (section 8.3);
- Assesses the sensitivity of the receptor (section 8.5.2.1);
- Assesses the severity of the effect (section 8.5.2.2) on the respective receptor/s taking account of statutory and industry standard safeguards, BAT (Best Available Technology / Techniques) and BEP1 (Best Environmental Practise) mitigation technologies built-in to the project basis of design (section 8.7);
- Assesses the initial significance of the impact (section 8.5.3) of planned activities based on the above;
- Identifies project-specific mitigation measures (section 8.7) as required to reduce any 'significant' environmental impacts to ALARP;
- Evaluates the residual impact (section 8.8) taking account of project-specific mitigation measures;
- Evaluates the potential for cumulative impacts and impact interaction (section 8.10); and
- Assesses the degree of confidence (section 8.11) in the impact assessment.

8.5.2 Assessment of environmental impacts

During the assessment of the sensitivity of receptors and the severity of effect, a precautionary approach is taken.

8.5.2.1 Assessment of sensitivity of receptors

Assessment of the 'sensitivity of the receptor' draws upon the data in the environmental baseline description (Chapter 7) and considers a number of factors (IEEM, 2010; Morris & Therivel, 2009) including, but not limited to:

- The relative importance of the local population size e.g. as a percentage of global / regional population size;
- The conservation status of the habitat or species e.g. does it sit within an IUCN (International Union for Conservation of Nature) threat category;
- Whether the habitat is a designated conservation site;
- The seasonal migrations and abundance of species and populations e.g. whether or not the species or population is likely to be in the relevant area at the time of the proposed activity;

- Species sensitivities e.g. during vulnerable periods of a species' lifecycle; and
- Sensitivity to ecosystem services resulting in changes to species health and ability to survive, including livelihoods and aesthetics or forced behavioural change (migration pattern, livelihoods).

Project-specific guidelines were developed to inform the assessment of receptor sensitivity (Table 8.1). These are based on the criteria for assigning value to ecological features as described in IEEM (2010).

The guide descriptions provided in Table 8.1 are purposefully kept at a high level to afford a degree of flexibility and judgement during the assessment. Details on the rationale behind the allocation of a category e.g. 'Low' is provided in the narrative in the impact assessment chapters. Each descriptor may not be applicable to each receptor and some receptors may be classified within two different categories. For example, a receptor may have an IUCN status of 'Least Concern' ('Very Low') but may also comprise 1 % of the global population ('Very High') such as the Southern Giant Petrel. In such a case, the worst case category ('Very High') is applied.

8.5.2.1.1 Sensitivity of global (transboundary) receptors

While most receptors have a sensitivity value based on local conditions, it is acknowledged that emissions have a global impact on climate change which is measured over time (i.e. current day compared to pre-industrial times) rather than by global location. Consequently, the assessment of sensitivity of the atmosphere, or global climate, as a receptor is not included within the sensitivity guidelines in Table 8.1, but is assessed based on the latest IPCC Climate Change 2014 Synthesis Report, Summary for Policy Makers Report.

Within this impact assessment the current sensitivity status of the global receptor, climate, is considered to be 'Very High', based on the following statements from IPCC, 2014:

- Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems;
- Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed; the amounts of snow and ice have diminished, and sea level has risen;
- Effects of anthropogenic greenhouse gas emissions have been detected throughout the climate system and are extremely likely to have been the dominant cause of the observed warming since the mid-20th century;
- In recent decades, changes in climate have caused impacts on natural and human systems on all continents and across the oceans. Impacts are due to observed climate change, irrespective of its cause, indicating the sensitivity of natural and human systems to changing climate;
- Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems. Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions, which together with adaptation, can limit climate change risks; and

- Many aspects of climate change and associated impacts will continue for centuries, even if anthropogenic emissions of greenhouse gases are stopped. The risks of abrupt or irreversible changes increase as the magnitude of the warming increases.

Table 8.1: Project-specific guidelines for the sensitivity of environmental receptors (as adapted from the Premier HSES Risk Management Standard (FK-BU-PMO-HS-STD-0006)

Level	Category	Environmental receptor sensitivity guide description
5	**Very High**	**Flora and Fauna:** • Population size, of any species present, is of international importance (1 % of global population) and is within the zone of influence of project activity; • Habitat / site is of international value and is protected under international designation (e.g. RAMSAR sites, IBAs during breeding season); • Habitat / site is undesignated but considered to be of international importance (e.g. an IBA that is not formally protected); • A species with IUCN 'Critically Endangered' status has notable presence[5] within the zone of influence of project activity; • Large populations of animals considered under wider threat (e.g. ACAP species) are present within the zone of influence of project activity; and / or • Presence of individuals or species in vulnerable phases of life cycle (e.g. high concentration of synchronous spawning fish) within the zone of influence of project activity. **Seabed (including soil):** Seabed sediment unmodified (e.g. no known demersal fishery). High-grade soil quality, high likelihood of transmitting contaminants to nearby sensitive receptors. **Water quality**: Enclosed water body with no flushing. **Air quality:** Very densely populated area within 20 m, very sensitive receptors (e.g. school, hospital), sheltered from winds. **Landscape and seascape:** Location is currently undeveloped, is considered locally an area of beauty, and is 'used or appreciated' by businesses, residents and / or visitors for business promotion and / or recreation e.g. Kidney Island. Includes distinctive, individual or rare features. Placement of objects would conflict with the current use of the area. **Human population:** The receptor has little or no capacity to absorb change without fundamentally altering its present character, or is unacceptable to all stakeholders. **Tangible property**: Resource use has direct or indirect environmental or social impact (e.g. use of diesel, freshwater, landfill space) and resource being used is unsustainable in the short-term (e.g. within 5 years of commencement of the project). **Architecture and archaeological heritage:** International heritage importance whether designated or not, extremely well preserved.

Level	Category	Environmental receptor sensitivity guide description
4	**High**	**Flora and Fauna:** • Population size, of any species present, is of regional importance (1 % of biogeographic population) and is within the zone of influence of project activity; • Habitat / site is of national value and is protected under national designation (e.g. fishery closed areas or spawning sites, Falkland red-list habitats); • Habitat / site is undesignated but considered to be of regional importance (as informed by the consultation process); • A species with IUCN 'Endangered' or 'Vulnerable' status has notable presence within the zone of influence of project activity; • Local conservation priority species are present within the zone of influence of project activity (Falklands red-list species); and / or • Presence of individuals or species in vulnerable phases of life cycle (e.g. high concentration of asynchronous spawning fish) within the zone of influence of project activity. **Seabed (including soil):** Seabed sediment experienced previous modification event (e.g. longline fishing effort). Moderate grade soil quality, moderate potential to transmit contaminants to nearby sensitive receptors. **Water quality**: Semi-enclosed water body with limited flushing. **Air quality:** Densely populated area within 20 m exposed to strong winds, moderately populated area within 20 m sheltered from winds. **Landscape and seascape:** Location is partially developed with non-industrial infrastructure e.g. residential settlements or agricultural buildings in camp and may therefore be used for recreational purposes. Distinct landscape character. Placement of objects could conflict with the current use of the area. **Human population:** The receptor has low capacity to absorb change without fundamentally altering its present character, or, unacceptable to the majority of stakeholders. **Tangible property**: Resource use has direct or indirect environmental or social impact (e.g. use of diesel, freshwater, landfill space) and resource being used is unsustainable in the medium term (e.g. between 5 and 30 years of commencement of the project). **Architecture and archaeological heritage:** Regional heritage importance; well preserved.

3	**Moderate**	**Flora and Fauna:** • Population size, of any species present, is of national importance (1 % of Falkland Islands population) and is within the zone of influence of project activity; • Habitat / site is undesignated but considered to be of national or local importance (as informed by the consultation process); • A species with IUCN 'Near Threatened' status has notable presence within the zone of influence of project activity; and/or • Presence of individuals or species in vulnerable phases of life cycle (e.g. moderate concentration of dispersed spawning fish) within the zone of influence of project activity. **Seabed (including soil):** Seabed sediment subject to infrequent modification (e.g. infrequent demersal trawling). Poor grade soil quality, low potential to transmit contaminants to nearby sensitive receptors. **Water quality**: Semi-enclosed water body with good flushing. **Air quality:** Moderately populated area within 20 m, suburban or edge of town, commercially sensitive land within 20 m, exposed to strong winds. **Landscape and seascape:** Location is used commercially and is developed by local businesses and residential buildings. Some distinct landscape features. Placement of objects would be unlikely to conflict with the current use of the area. **Human population:** The receptor has moderate capacity to absorb change without significantly altering its present character, or, unacceptable to minority of stakeholders. **Tangible property**: Resource use has direct or indirect environmental or social impact (use of diesel, freshwater, landfill space) and resource being used is limited and unsustainable in the medium term (e.g. more than 30 years of commencement of the project). **Architecture and archaeological heritage:** Local heritage importance, averagely well preserved.
2	**Low**	**Flora and Fauna:** • Low numbers of any species of geographical importance present within the zone of influence; • Habitat / site is undesignated and of poor quality; • A species with IUCN 'Least Concern' status has notable presence within the zone of influence of project activity; and/or • Presence of individuals or species out with vulnerable phases of life cycle (e.g. dispersed spawning fish) within the zone of influence of project activity. **Seabed (including soil):** Seabed sediment subject to frequent modification (e.g. annual demersal trawling). Very poor grade soil quality, no potential to transmit contaminants to nearby sensitive receptors. **Water quality**: Coastal water body in shallow water. **Air quality:** Sparsely populated area within 20 m exposed to strong winds **Landscape and seascape:** Location is considered an 'industrial hub' and is developed e.g. an industrial estate, a quarry. No distinct landscape features. Area designated for industrial use. **Human population:** The receptor is tolerant of change without detriment to its character, or, unacceptable to a handful of stakeholders. **Tangible property**: Resource use has direct or indirect environmental or social impact (e.g. use of diesel, freshwater, landfill space) but resource being used is not unsustainable. **Architecture and archaeological heritage:** Local heritage interest, site integrity already compromised and value limited by poor preservation.

1	**Very Low**	**Flora and Fauna:** • Negligible numbers of any species of geographical importance present within the zone of influence; • Habitat / site is undesignated, of poor quality and / or already degraded; • Species of IUCN 'Least Concern' status notable presence within the zone of influence of project activity; and/or • Presence of individuals or species out with vulnerable phases of life cycle (e.g. highly dispersed asynchronous spawning fish) within the zone of influence of project activity. **Seabed (including soil):** Very poor grade soil quality, no potential to transmit contaminants to nearby sensitive receptors. Seabed sediment highly modified (e.g. multiple demersal trawls per year). **Water quality**: Open ocean conditions. **Air quality:** Unpopulated area exposed to strong winds. **Landscape and seascape:** Location is severely degraded e.g. a waste dump. **Human population:** The receptor is not resistant to change, or, issue is acceptable to all stakeholders. **Tangible property**: Resource use has no direct or indirect environmental or social impact and / or resource being used is unlimited or is created by the development. **Architecture and archaeological heritage:** No heritage value.

8.5.2.2 Assessment of severity of effect

Assessment of the 'severity of the effect' on the receptor draws on the data in the project description and the base case mitigations (Chapter 5), information gathered in subject-specific literature reviews on the nature of the impact, quantification of the project outputs (where possible) and modelling (where it has been carried out). Taking account of these, the assessment of the severity of effect considers:

- Whether the effect is positive or negative;
- The spatial extent of the effect e.g. the footprint area, or zone of influence, over which the impact occurs;
- The magnitude of the effect e.g. the size or amount of an effect such as the number of seabirds that may be affected;
- The duration of the effect e.g. duration over which the impact is expected to last prior to recovery;
- The timing and frequency of the activity e.g. when the activity will occur and how many times it may be repeated;
- The reversibility of the effect e.g. whether or not recovery from the impact is possible or whether the effect is irreversible and thus permanent; and
- Exposure of the receptor to the effect.

Project-specific guidelines intended to inform the assessment of the severity of the effect on the receptor were adapted from IEEM (2010) and Morris and Therivel (2009) and are presented in Table 8.2.

Table 8.2: Project-specific guidelines for the severity of effect (as adapted from the Premier HSES Risk Management Standard (FK-BU-PMO-HS-STD-0006))

Level	Severity	Environmental severity of effect guide description
5	**Major**	**Flora, Fauna, soil, water quality**: Major effect over large (regional) area. Potential for long-term damage to species / regional population / habitat / ecosystem (recovery period is receptor specific[8]). **Air quality:** Emissions exceed Air Quality Objectives (AQO)[9] by >5 % in locations where receptors are exposed. **Atmospheric emissions (Climatic factors):** Extensive contribution to global emissions, (e.g. when compared to UK annual emissions and current annual Falkland Islands emissions) which will impact upon UK ability to meet current emissions targets and / or future targets. **Landscape and seascape:** Object will be permanently located *in situ* for full Field Life (23 years), is prominent and will be visible from many perspectives, at all times to residents and visitors, potentially imposing upon 'iconic' views. **Human population:** Irreversible effect on livelihood and / or health e.g. permanent damage to fishing grounds, inconvenience of resource use, or very high levels of disturbance to local population, is considered to be a concern to all stakeholders **Tangible property:** Extensive and frequent use of a finite resource throughout lifecycle of project. **Architecture and archaeological heritage:** Major impact on integrity of internationally significant heritage, intrusive, impair appreciation and seriously damage the setting.
4	**Serious**	**Flora, Fauna, soil, water quality**: Serious effect over large but sub-regional area. Serious and long lasting (multi-year) but eventually reversible (recovery period is receptor specific) impact on species / habitat / ecosystem. **Air quality**: Emissions exceed AQO by up to 5 % in locations where receptors are exposed. **Atmospheric emissions (Climatic factors)**: Large contribution to global emissions (e.g. when compared to UK annual emissions and current annual Falkland Islands emissions) which could impact upon UK ability to meet current emissions targets and / or future targets. **Landscape and seascape**: Object will be *in situ* for full Field Life (23 years), is quite prominent and will be visible from limited perspectives to residents and visitors e.g. the supply base which blends into the existing context. **Human population:** Long-term effect on livelihood and / or health e.g. seasonal closure of fishing grounds adjacent to the proposed project, inconvenience of resource use, high levels of disturbance to local population, is considered to be a concern to the majority of stakeholders. **Tangible property**: Extensive but infrequent use of a finite resource throughout lifecycle of project. **Architecture and archaeological heritage**: Damaging to regionally or nationally significant heritage assets, adversely affect the setting and appreciation of the assets.

Level	Severity	Environmental severity of effect guide description
3	**Moderate**	**Flora, Fauna, soil, water quality**: Moderate effect in local area. Temporary and reversible impact on species / habitat / ecosystem (recovery period is receptor specific). **Air quality**: Emissions exceed the UK Environment Agency (EA) 'significance' threshold[10] over long- or short-term duration AQO where receptors may be exposed, but *do not* exceed the actual AQO. **Atmospheric emissions (Climatic factors)**: Moderate contribution to global emissions (e.g. when compared to UK annual emissions and current annual Falkland Islands emissions) which will not impact upon UK ability to meet current emissions targets but may in the future as targets are reduced. **Landscape and seascape**: Object will be *in situ* periodically for full Field Life (23 years), will be prominent only when in place and will be visible from limited perspectives to residents and visitors e.g. vessels using port facilities. **Human population:** Medium-term impact on livelihood and / or health e.g. localised temporary closure of fishing grounds, inconvenience of resource use, moderate levels of disturbance to local population, is considered to be a concern to a minority of stakeholders. **Tangible property**: Moderate use of a finite resource throughout lifecycle of project. **Architecture and archaeological heritage**: Compromise the integrity of locally important heritage, be intrusive to the setting and appreciation of the assets.
2	**Minor**	**Flora, Fauna, soil, water quality**: Minor, localised short-term, fully reversible environmental effect once activity ceases. Barely detectable impact on species / habitat / ecosystem. Highly localised. **Air quality**: Emissions exceed the UK Environment Agency (EA) 'screen out' threshold[11] over long- or short-term duration AQO where receptors may be exposed, but *do not* exceed the 'significance threshold'[9]. **Atmospheric emissions (Climatic factors)**: Low contribution to global emissions (e.g. when compared to UK annual emissions and current annual Falkland Islands emissions) but which will not impact upon UK ability to meet current emissions targets and are unlikely to impact upon future targets. **Landscape and seascape:** Object will be in place temporarily and may impact upon the view from close range e.g. unplanned losses of non-biodegradable waste such as plastics. **Human population:** Short term / minor impact on livelihood and / or health, inconvenience of resource use, minor levels of disturbance to local population, is considered to be a concern to a handful of stakeholders **Tangible property:** Minimal use of a finite resource throughout lifecycle of project or moderate use for finite stages of the project. **Architecture and archaeological heritage:** Minor detrimental impact on the context of locally important historic environment.

Level	Severity	Environmental severity of effect guide description
1	**Slight**	**Flora, Fauna, soil, water quality**: Negligible environmental effect, change not detectable above background variability, rapidly and fully reversible once activity ceases (short-term impact); highly localised effects. No habitat / population effects. **Air quality**: Emissions do not exceed the UK EA 'screen out' threshold[10] over long- or short-term duration AQO at locations where receptors may be exposed. **Atmospheric emissions (Climatic factors)**: Negligible contribution to global emissions (e.g. when compared to UK annual emissions and current annual Falkland Islands emissions) with no impact upon UK ability to meet emissions targets in future. **Landscape and seascape**: Object will be in place temporarily and may impact upon the view from close range e.g. unplanned losses of biodegradable waste. **Human population:** No impact on livelihood or health, negligible levels of disturbance to local population, or there is considered to be no concern to stakeholders **Tangible property**: No or negligible use of a finite resource for a finite period or throughout the lifecycle of project. **Architecture and archaeological heritage**: Negligible impact on the integrity or setting of the historic environment.

8.5.3 Assessment of impact significance

The significance of an environmental impact is assessed as:

The significance of the impact	=	The sensitivity of the receptor to the environmental aspect	x	The severity of the effect on the receptor

The significance of the impact in both the initial and residual assessments, was determined using the impact assessment matrix in Table 8.3, which indicates whether an impact is 'Very Low', 'Low', 'Moderate', 'High' or 'Very High'.

Once the significance has been determined, it is then possible to define whether or not an impact is considered acceptable or otherwise (Table 8.4).

While the significance of an impact is ultimately defined by its category (i.e. 'Very Low', 'Low', 'Moderate', 'Upper Moderate' or 'High'), each category within Table 8.3 is accompanied by an associated score. Note that this score is not on a linear scale and it is not the case that a 'Very High (25)' impact is five times 'worse' than a 'Low (5)' impact. The score simply provides a means of differentiation within the categories in order to inform assessment of what type of mitigation might be most appropriate. For example, where an impact is 'Moderate (5)', a mitigation measure which reduces the severity of effect may be most appropriate. Further, while the mitigation measure may only reduce the severity of effect to such a degree that the overall significance of the impact remains Moderate e.g. from 'Moderate (5)' to 'Moderate (4), the score indicates that improvement has still been achieved (Table 8.3).

Table 8.3: Environmental impact significance of effect matrix [a]

Impact			Severity of Effect				
			1 Slight	2 Minor	3 Moderate	4 Serious	5 Major
Sensitivity of Receptor	Very high	5	5	10	15	20	25
	High	4	4	8	12	16	20
	Moderate	3	3	6	9	12	15
	Low	2	2	4	6	8	10
	Very low	1	1	2	3	4	5

a Dark Green = Very Low, Yellow = Low, Orange = Moderate, Dark Orange = Upper Moderate, Red = High

Table 8.4: Definition and implication of impact significance categories

Impact Significance Level		Impact Significance Definition (planned events) [a]
Unacceptable	High	Action required to eliminate impact via project design or to reduce it to an acceptable level via additional mitigation measures and controls which aim to minimise consequence where feasible, effective and reasonably practicable. If impact cannot be reduced, the project cannot proceed.
ALARP Region (Impact Tolerable if demonstrably ALARP)	Upper Moderate	Impacts assessed as "Upper moderate" may not be tolerable. Action is required to eliminate or reduce impact via project design and / or additional mitigation measures and controls which aim to minimise consequence where feasible, effective and reasonably practicable. Impacts remaining within this category are considered to be within the upper reaches of tolerability and are placed here owing to the combination of a precautionary approach based upon data gaps and / or a lack of further reasonable mitigation options. Where the impact is ALARP and remains within this category, regular reviews (at a minimum of annually) will be held to determine whether the impact can be further reduced based upon the availability of new data and / or new technology. If the impact cannot be further reduced, consideration may also be given to offsetting of the impact (see section 8.9).
	Moderate	Impacts assessed as "Moderate" require action to identify opportunities for improvement via project design, additional mitigation measures and controls which aim to minimise consequence where feasible, effective and reasonably practicable. Where the impact is ALARP and remains within this category, it will be subject to regular ALARP reviews as described above.
	Low	Impacts assessed as low are within the levels of existing natural environmental variability. No project-specific mitigations will be implemented over and above industry-standard measures and controls unless it is stated as a requirement in conditions to approval or Falkland Islands Legislation and / or approved policy. Nonetheless, impacts shall be regularly reviewed to ensure that suitable controls remain in place and shall be subject to continuous improvement where opportunities exist.
Broadly Acceptable	Very Low	Impact barely detectable. No additional actions required beyond industry standard measures and controls. Nonetheless, impacts shall be periodically reviewed to ensure that suitable controls remain in place and shall be subject to continuous improvement where opportunities exist.
	Beneficial	Has a positive effect.

1 Note: Assessment of the Impact Significance is based on the EIA undertaken to date and detailed in this EIS. Initial views of key stakeholders were sought during the scoping consultation process (Chapter 6).

Thereafter, the EIS was updated wherever applicable in response to comments / information received from the previous public consultation.

Further views of wider stakeholders on this EIS will be sought through the formal communication and consultation process. Comments received through this process will be detailed in Chapter 17 in due course (once the statutory EIS process is complete).

8.6 Risk assessment methodology for unplanned and accidental events

This section describes the methodology used for the assessment of environmental risk of unplanned and accidental events.

8.6.1 Environmental risk assessment process

The evaluation of risks follows a similarly structured methodology through systematic:

- Identification of potential unplanned or accidental events that carry the risk of environmental impact;
- Assessment of the significance of the impact (section 8.5.3) based on the sensitivity of the receptor and the severity of the effect should the unplanned event occur;
- Assessment of the likelihood of the unplanned or accidental event occurring (section 8.6.2.2) taking account of statutory industry standard safeguards and BAT / BEP mitigations built-in to the project basis of design (section 8.7);
- Assessment of the initial significance of the risk (section 8.6.3) of accidental or unplanned events based on the significance of the impact and the likelihood of the unplanned or accidental event occurring;
- Identification of any project-specific mitigation measures (section 8.7) as required to reduce 'significant' risks to ALARP by preventing or reducing the likelihood of the event occurring and / or by minimising the consequence should it occur;
- Evaluation of the residual risk significance (section 8.8) taking account of project-specific mitigation; and
- Assessment of the degree of confidence (section 8.11) in the risk assessment.

8.6.2 Assessment of environmental risks

Risks are evaluated in two steps:

1) By assessing the level of environmental impact that could result from the unplanned / accidental event occurring (section 8.5.2); and
2) By assessing the likelihood that the unplanned or accidental event will occur (Table 8.5).

8.6.2.1 Assessment of the potential environmental impact

The significance of an environmental impact that could result from an unplanned / accidental event follows the same methodology as for all impact assessments, see section 8.5.2 above. The sensitivity of receptor definitions are as outlined in Table 8.1 above, and the severity of effect for unplanned or accidental events are as defined in Table 8.2 above.

8.6.2.2 Assessment of the likelihood of an unplanned or accidental event occurring

The likelihood of the unplanned or accidental event considered two factors as appropriate on a case-by-case basis. These are:

- Whether the unplanned or accidental event has occurred within the industry before and the frequency of occurrence if it has; and / or
- The number of control barriers that might need to be breached for the unplanned or accidental event to occur.

Project-specific guidelines were developed to inform the assessment of the likelihood of occurrence of an unplanned event during the Phase 1 Development (Table 8.5). The guidelines have purposefully been kept at a high level to afford a degree of flexibility and details on the rationale behind each assessment are provided in the narrative within the relevant chapters. Where possible, historical frequency of occurrence data will be used to inform the assessment of likelihood and will be described within the respective risk assessment chapters. As with the impact assessment process, a precautionary approach is taken when selecting the likelihood category.

Table 8.5: Project-specific guidelines for assessing the likelihood of an unplanned / accidental event occurring (as adapted from the Premier HSES Risk Management Standard (FK-BU-PMO-HS-STD-0006))

Level	Likelihood	Definition
5	Very Likely	Likely to occur more than once per operation e.g. every well or every shutdown, can occur following breach of a minimal number of controls.
4	Likely	Likely to occur more than once per applicable time unit, can occur following breach of a minimal number of controls.
3	Possible	Likely to occur less than once per applicable time unit and more than once in 10 applicable time units, breach of operational controls would be required e.g. procedural controls.
2	Unlikely	Has occurred previously in the industry, however, failure of numerous operational controls would be required e.g. procedural and engineering controls.
1	Very Unlikely	Impact almost never observed, few if any events in the industry, failure of nearly all operational controls would be required.

8.6.3 Assessment of risk significance

The significance of the risk is assessed as:

		(-------------------Impact-------------------		)		
The significance of the risk	=	The sensitivity of the receptor to the environmental aspect	x	Severity of the effect on the receptor	x	The likelihood that an unplanned or accidental event will occur

The significance of the risk in both the initial and residual assessments, was determined using the risk assessment matrix in Table 8.6, which indicates whether the significance of the risk is ‘Very Low’, ‘Low’, ‘Moderate’, ‘Upper Moderate’ or ‘High’.

The overall significance of a particular risk is determined according to the highest level of risk associated with the project activity against any one of the receptors. For example, in the event that an oil spill was to occur, the risk might be higher to seabirds than to benthic organisms and is therefore ranked according to the highest assessment (i.e. seabirds).

While the significance of a risk is ultimately defined by this category, each category within Table 8.6 is accompanied by an associated score. As with the assessment of impact significance, (section 8.5.3) this score provides a means of differentiation within the categories in order to inform assessment of what type of mitigation might be most appropriate.

Table 8.6: Environmental Risk Assessment matrix a

Risk			Likelihood				
			1 Very Unlikely	2 Unlikely	3 Possible	4 Likely	5 Very Likely
Impact	High	5	5	10	15	20	25
	Upper Moderate	4	4	8	12	16	20
	Moderate	3	3	6	9	12	15
	Low	2	2	4	6	8	10
	Very Low	1	1	2	3	4	5

a Dark Green = Very Low, Yellow = Low, Orange = Moderate, Dark Orange = Upper Moderate, Red = High

Table 8.7: Definition and implication of risk significance categories

Risk Significance Level		Risk Significance Definition (planned events)
Unacceptable	High	Action required to eliminate risk via project design or to reduce it to an acceptable level via additional mitigation measures and controls which aim to minimise consequence where feasible, effective and reasonably practicable. If risk cannot be reduced, the project cannot proceed.
ALARP Region (Risk Tolerable if demonstrably ALARP)	Upper Moderate	Risks assessed as “Upper moderate” may not be tolerable. Action is required to eliminate or reduce risk via project design and / or additional mitigation measures and controls which aim to minimise consequence and likelihood where feasible, effective and reasonably practicable. Risks remaining within this category are considered to be within the upper reaches of tolerability and are placed here owing to the combination of a precautionary approach based upon data gaps and / or a lack of further reasonable mitigation options. Where the risk is ALARP and remains within this category, regular reviews (at a minimum of annually) will be held to determine whether the risk can be further reduced based upon the availability of new data and / or new technology. If the risk cannot be further reduced, consideration may also be given to offsetting of the risk (see section 8.9).
	Moderate	Risks assessed as “Moderate” require action to identify opportunities for improvement via project design, additional mitigation measures and controls which aim to minimise consequence and likelihood where feasible, effective and reasonably practicable. Where the risk is ALARP and remains within this category, it will be subject to regular ALARP reviews as described above.
	Low	Risks assessed as low are with the levels of existing natural environmental variability. No project-specific mitigations will be implemented over and above industry-standard measures and controls unless it is stated as a requirement in conditions to approval or Falkland Islands Legislation and / or approved policy. Nonetheless, risks shall be regularly reviewed to ensure that suitable controls remain in place and shall be subject to continuous improvement where opportunities exist.

Risk Significance Level		Risk Significance Definition (planned events)
Broadly Acceptable	Very Low	Risk barely detectable. No additional actions required beyond industry standard measures and controls. Nonetheless, risks shall be periodically reviewed to ensure that suitable controls remain in place and shall be subject to continuous improvement where opportunities exist.

Note: Assessment of the Impact Significance is based on the EIA undertaken to date and detailed in this EIS. Initial views of key stakeholders were sought during the scoping consultation process (Chapter 6). Thereafter, the EIS was updated wherever applicable in response to comments / information received from the previous public consultation.

Further views of wider stakeholders on this EIS will be sought through the formal communication and consultation process. Comments received through this process will be detailed in Chapter 17 in due course (once the statutory EIS process is complete).

8.7 Impact and risk mitigation

Mitigation measures aim to avoid, reduce or remedy the predicted significant adverse impacts of an activity (Morris & Therivel, 2009; Glasson *et al*., 2013). These different mitigation outcomes are known as the mitigation hierarchy (Glasson *et al*., 2013), which focuses on the principal of 'prevention rather than cure'.

Consequently, for planned events, options to avoid and reduce impacts should be considered and implemented before those to remedy the impact. Similarly, for unplanned events, measures to minimise the 'likelihood of occurrence' should be considered first, followed by those to minimise the consequences should the event occur. Further, it is important that mitigation measures are designed with monitoring in mind to ensure that the efficacy of the measures can ultimately be evaluated (section 8.11.1).

Mitigation measures used in the Phase 1 Development fall into three categories:

- **'Base-case' mitigations** - which refer to the use of BAT / BEP within the project basis of design. These are described in the Development Description (Chapter 5) and are intended to reduce outputs (e.g. emissions) and / or to minimise the likelihood of unplanned events occurring (e.g. the use of inshore exclusion zones, vessel speed restrictions etc.) and thus aim to eliminate (avoid) or reduce impacts. These are factored into the initial impact / risk assessment;
- **Industry standard mitigations** - which include measures which are not defined by law but are accepted as best practise observed within the O&G industry (and are, therefore, often built-in to the basis of design). These are factored into the initial impact / risk assessment along with legislative requirements; and
- **Project-specific mitigations** - which are additional measures intended to further reduce or remediate significant impacts and / or risks. The need for these is specifically informed by the EIA process when the initial impact assessment indicates that an impact or risk remains significant despite the base case and industry standard mitigations.

Ultimately, the aim of all mitigation is to reduce the overall impact or risk associated with an activity to a level that is 'As Low As is Reasonably Practicable' (ALARP), irrespective of whether this is achieved by prevention, reduction and / or remediation. Very importantly however, 'ALARP' is not synonymous with **'Low'** and the concept takes into account the balance between the costs and benefits of a mitigation measure. Here it is recognised that while it may be possible to reduce an impact or risk further, the process of doing so may require excessive time and resource such that it is not considered ‘reasonably practicable’ in light of the benefits that can be gained.

For the Phase 1 Development, and given the concept of ALARP, impacts and risks that were considered to be **‘Low’** (or below) in the initial assessment were not prioritised with regard to project-specific mitigation as extensive additional measures were not considered ‘reasonably practicable’. This said, where project-specific mitigations were immediately available and reasonably practicable, these may be applied even for ‘Low’ impacts and risks.

However, where impacts were of **‘Moderate’** significance or above in the initial assessment, it was considered necessary by Premier to identify and consider project-specific mitigation measures to further drive the impact / risk to a level that is ALARP.

8.8 Residual assessments

The term ‘residual impact / risk’ refers to the impact / risk that remains once project-specific mitigation measures have been taken into account. As described above, residual assessments were only required for those impacts and risks that were considered to be significant i.e. ‘Moderate’ or higher significance during the initial assessment.

The residual assessments of impact and risk follow the same process as described above, using the same definitions of sensitivity, severity of effect, likelihood and impact significance but with awareness of the additional mitigation measures which may reduce the severity of effect and / or the likelihood of an unplanned or accidental event occurring.

8.9 Offsetting of impacts

8.9.1 Legislation and Policy

Section 64C of the Offshore Minerals Ordinance states that EISs must contain a description of measures proposed to “eliminate, or reduce significant adverse effects…remedy those effects and offset them.” Exco paper 124/16 (FIG, 2016d) details FIG’s recommendations for developing offsetting guidance. This in turn has led to the development of Appendix 2 to the Hydrocarbons Environmental Impact Assessment Guidance Note (EPD, 2015).

Exco paper 124/16 (FIG, 2016d) states that hydrocarbon development should seek meaningful offsetting of any impacts that cannot be avoided or mitigated, specifically in relation to greenhouse gas emissions and biodiversity (FIG, 2016d). The options for offsetting of these impacts include:

- Direct offsetting, i.e. the operator develops local projects to offset, like-for-like, the impacts arising from the development that cannot be avoided or mitigated; or
- An environmental fund whereby the operator contributes to a fund with a non-governmental panel direct, manage and overseeing various offsetting projects.

In consultation with stakeholders, FIG has recently developed its thinking in respect of the environment fund approach, structure and governance options and a way forward has been recommended. This will now be the subjected detailed policy development.

It is required to demonstrate how offsetting measures have been considered which may further reduce significant adverse residual impacts identified in the EIS. sections 8.9.2.1 – 8.9.2.3 below detail the options considered by Premier and the reasons for an environmental fund approach being proposed.

8.9.2 Review of offsetting options

Following elimination and / or reduction of all the impacts and risks identified for the Sea Lion Field, Premier conclude that only tangible significant impacts /risks (impacts / risks assessed as 'Moderate' or above), may be offset.

Premier has reviewed its significant residual impacts / risks, and explored practicable, effective and locally beneficial direct offsetting measures in relation to these, see section 8.9.2.1. Premier has also reviewed indirect offsetting, and this is described in section 8.9.2.2. A third option available is a contribution to an environmental fund, which is described in section 8.9.2.3.

8.9.2.1 Direct offsetting

Direct or 'like for like' offsetting means compensating for impacts / risks to the environment at one site through activities that specifically address the nature of the impact in the local area. For example, this might include re-forestation of a nearby area where trees have been cleared for a construction site. For each residual impact / risk assessed as 'Moderate' or above, Premier has looked for practicable, locally beneficial and effective opportunities to directly offset them, see Table 8.8 below. However, for each of the significant residual impacts / risks, Premier do not believe direct 'like for like' offsetting is feasible, effective or reasonably practicable, see Table 8.8. The reasons for this are:

- Premier has not been able to develop or conceive of a suitable project; and / or
- It has not been possible to sufficiently quantify the impact / risk.

Table 8.8: Significant impacts / risks and direct offsetting options considered

Impact / risk	Residual impact / risk	Reason for impact / risk ranking and uncertainties	Offsetting
Risk of bird strikes due to artificial light	Moderate	There are a number of uncertainties around the impact of bird strike. Bird strike monitoring carried out by Premier during the exploration campaign indicates this has not occurred during offshore operations in the area but occurred on two occasions inshore. There are many other, stronger, sources of light in the Southern Ocean and inshore that complicate predictions of impact and measures of effectiveness of mitigation, and the assessment is therefore precautionary.	Offsetting is not practicable in this instance as the uncertainty of the impact makes it difficult to quantify and Premier has not been able to develop a realistic and effective direct offset for this impact.
Impact on and behavioural disturbance to marine mammals	Moderate	Disturbance to marine mammals from continuous noise is assessed as significant largely due to the sensitivity of the receptor.	Identifying a realistic and effective direct offsetting project for this impact has not been possible.

Impact / risk	Residual impact / risk	Reason for impact / risk ranking and uncertainties	Offsetting
from underwater noise offshore			
Impacts of drill cuttings discharge on benthos including burial of benthic fauna, modification of habitat, toxicity and oxygen depletion	Moderate	Burial of benthic fauna is rated as serious in relation to the area of seabed damaged.	In this instance, Premier could not identify a realistic and effective direct offset for this impact.
Impacts from atmospheric emissions	Moderate	The impact of emissions from the project has been rated as Moderate mainly due to the contribution to global warming and ocean acidification.	There are no emissions trading schemes presently running in the Falklands. As such, it is not considered feasible to offset this impact through a cap and trade scheme (or similar) as there is currently no option to do so locally. There would be no benefit to the Falklands' environment if a similar scheme were to be pursued abroad.
Risk of injury to marine mammals via collision in Berkeley Sound	Moderate	Inshore operations involving the LTVs and subsea installation vessels are assessed as moderate severity on a precautionary basis given the uncertainty around potential marine mammal collisions.	Identifying a realistic and effective direct offsetting project for this impact has not been possible and it has not been possible to accurately quantify the risk.
Risk of introducing marine non-native species from Premier chartered coaster vessels	Moderate	Offsetting is not practicable in this instance as the uncertainty of the impact makes it difficult to quantify.	Premier has not been able to develop a realistic direct offset for this impact.
Risk of introducing marine non-native species from third party vessels (i.e. vessels not directly managed by Premier)	Upper Moderate		
Accidental releases of oil to sea offshore	Moderate	Offshore spills, including well blow-out and FPSO inventory loss, are assessed as presenting a significant risk to receptors.	It has not been possible develop a practicable direct offset due to the uncertain impact, particularly as it may not occur during the life of field.
Accidental release of oil to sea inshore	Moderate		

In all instances, it has not been possible for Premier to identify appropriate direct offsetting projects that will benefit the local environment, and that are practicable for Premier to implement. As such, Premier will not pursue direct, like-for-like, offsetting for the residual significant impacts / risks from the Sea Lion Development.

Premier further conclude it is not possible to offset accidental events; that is where the impact may or may not happen, such as an oil spill. There is the risk of a spill occurring but it is not possible to state if, when and what the impact of that spill might be, thus the impact is risk assessed in terms of the likelihood of it occurring. The impact itself is very difficult to quantify, and any efforts to remediate an impact that has arisen as the result of a risk, e.g. an oil spill, is considered 'remediation' as opposed to offsetting.

8.9.2.2 Indirect offsetting

As no direct offsets were identified, Premier also looked at indirect offsetting opportunities. Indirect offsetting refers to implementing measures that do not directly compensate for the impacts / risks identified above but may provide opportunities to achieve environmental benefits and improve the environment of the Falklands in the longer-term. Such measures do not attempt to attain carbon neutrality nor seek to provide net gains in biodiversity.

Premier is not best placed to identify and endorse suitable indirect offsetting projects. ExCo paper 124/16 (FIG, 2016d) acknowledges that operators "do not always have the knowledge, resources, or inclination to take such projects on" (FIG, 2016x). A wider, locally-based group, would be in a better position to oversee these types of offsetting projects. As such, Premier will not pursue indirect offsetting for the residual significant impacts / risks from the Sea Lion Development.

8.9.2.3 Environmental fund

FIG Policy allows for operators to contribute to an Environment Fund to achieve carbon and biodiversity offsetting and environmental legacy. The fund would promote enhanced stewardship of the environment and aim at building wider eco-system resilience and knowledge to create a lasting Falkland Islands environmental legacy. The fund would be managed and governed by a trustee board including environmental stakeholders and industry to award grants and oversee general administration (FIG, 2016x)(ExCo papers 73/19 and 135/19). Thus, the expertise necessary to prioritise and oversee management of offsetting projects and environmental legacy will be available through appointment to the board of suitable trustees, rather than residing with the operator.

A stakeholder workshop was held in August 2019 to develop the environment fund/environment trust concept further. This recommended the forming of a statutory environmental trust to administer offsetting payments made. [Ref ExCo 73/19 2019]. This approach was endorsed by FIG ExCo in September 2019. Detailed policy work will now be undertaken. (FIG, 2019x) [Ref ExCo 135/19].

Premier considered the significant residual impacts predicted to arise from the Sea Lion project in order to explore the opportunity for a formula or methodology for calculating a financial payment commensurate to impacts that might serve as a guide for annual contributions to the proposed Environment Fund. While it is possible to quantify carbon impacts, and it is possible to consider the payments that might be made into a carbon cap and trade scheme in respect of Sea Lion emissions, utilising this approach as a basis for annual contribution to an environment fund presents difficulty because the 'carbon price' fluctuates depending on market conditions.

Additionally, biodiversity impacts are difficult to predict and quantify in order to determine a corresponding financial commitment.

Given these difficulties Premier proposed a level of contribution to the Fund following review / consideration of:

- Premier's support for environmental legacy projects in other areas in which it operates;
- The scale of costs of environmental projects past and present in the Falklands, which are similar to those it is envisaged the fund will support;
- Other operators' environmental legacy projects around the world; and
- Economic context, both in terms of the project itself and the wider Falklands economy.

This analysis enabled an annual contribution to be proposed to FIG. Contributions to the fund will commence from Stage 1 (production drilling) onwards and for all following stages of the project. However, Premier will review this approach and level of contribution every five years, in line with the EIS review, to ensure it remains the most effective way to achieve offsetting.

8.9.3 Conclusion

Due to the difficulties in undertaking operator-led direct and indirect offsetting laid out above, Premier's offsetting approach is to contribute to an Environmental Fund from Stage 1 of the Sea Lion Phase 1 development, at a level agreed with the Falkland Islands Government.

8.10 Cumulative impact assessment and impact interactions

8.10.1 Cumulative impact

The EIA process initially assesses the impacts / risks to environmental receptors from the proposed operation alone. However, the activities associated with the proposed operations are unlikely to occur in isolation and it is thus important to consider the cumulative impacts also. Cumulative impacts may arise from similar activities being carried out by Premier, another O&G operator or by another sector at the same time, or in the same space as the proposed development.

Specifically, spatio-temporal cumulative impacts include:

1) Impacts (such as noise, CO_2 emissions, drilling mud) occurring from more than one source and overlapping in space and time. This may result in an increase in the **concentrations / level** to which the same environmental receptors are exposed (Figure 8.2 below);
2) Impacts (such as noise, CO_2 emissions, drilling mud) occurring from more than one source and occupying adjacent 'spaces' at the same time, or approximately the same time. This may increase the number of organisms directly exposed and thus the **extent and proportion** of the local or regional population that is exposed (Figure 8.2 below); and / or
3) Impacts (such as noise, CO_2 emissions, drilling mud) from more than one source occupying the same 'space' consecutively or soon after each other. This may increase the **duration** of exposure for the same receptors and/or the proportion of the local or regional population (Figure 8.2 below).

Importantly, it is not possible to know what activities may be carried out in the future, or to quantify what their impacts / emissions / discharges may be, and therefore it is not possible to assess the cumulative impacts of the proposed Premier development in combination with future and currently unplanned developments. Therefore, cumulative assessments within this EIA include only those operations that immediately precede the proposed operation and / or will occur simultaneously. Any cumulative impacts of this operation in conjunction with future operations will be assessed in the EIA associated with the future development.

Note that cumulative outputs e.g. emissions, discharges etc. will be quantified where possible. However, most commonly it will not be possible to estimate outputs from other activities and here the cumulative assessment will be in the form of a qualitative narrative.

8.10.2 Impact interaction

Impact interactions include:

1) Different sources of impacts which have known additive or synergistic effects to any of the above, leading to potentially greater negative effects on individuals or ecosystems than would occur if only one type of contaminant were present (Figure 8.2); and/or
2) Different sources of impacts which have known cancelling or ameliorating effects to any of the above, leading to potentially smaller negative effects on individuals or ecosystems than would occur if only one type of contaminant were present (Figure 8.2).

Chapter 13 will consider the impact interactions of the project as a whole. For example, the interaction of impacts of underwater noise on marine mammals in conjunction with the impacts of increased presence of vessels; or the fact that birds attracted to a vessel due to artificial light may be more likely to experience contamination in the event of a spill.

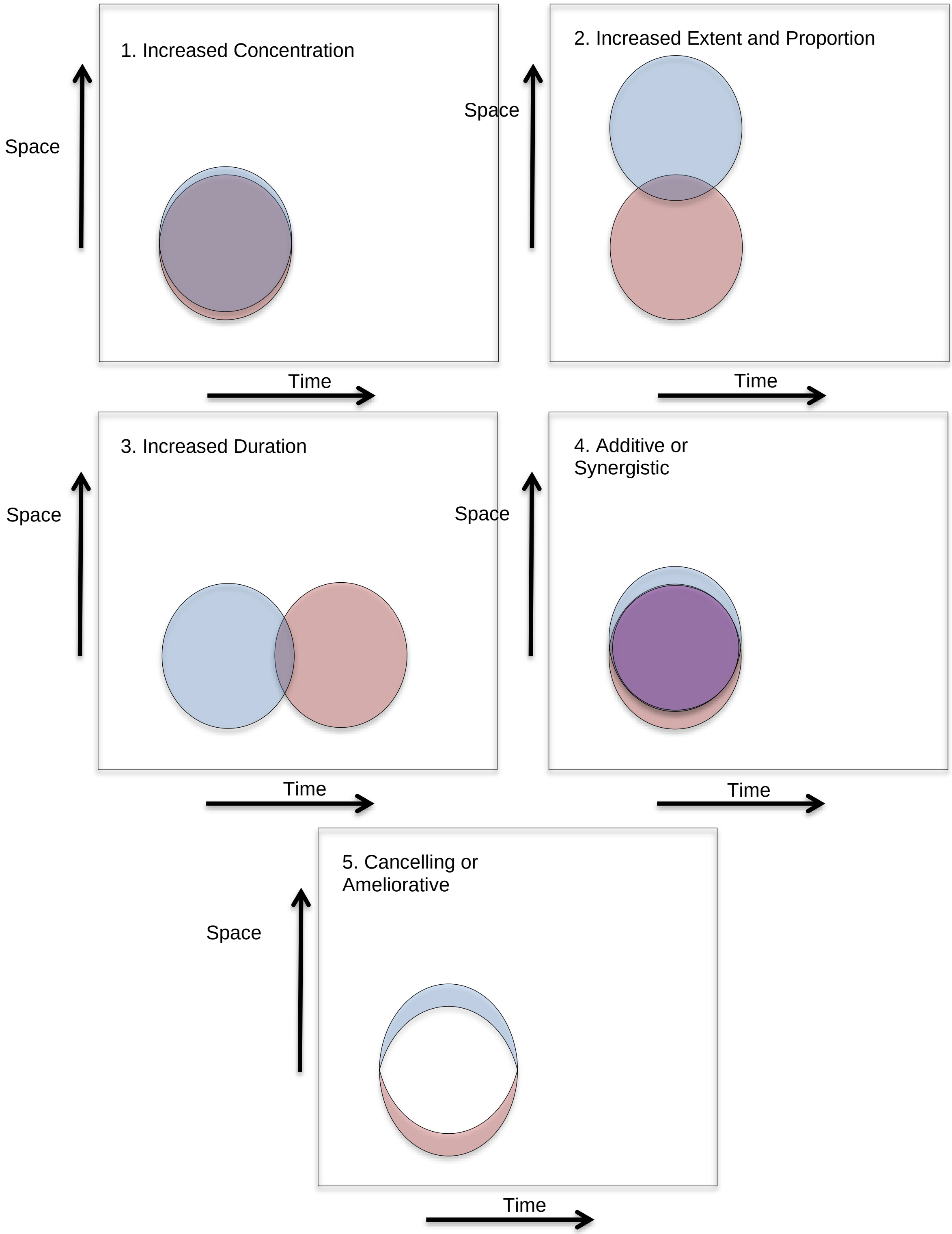


Figure 8.2: Illustrating cumulative impacts and impact interaction on an environmental receptor.

Note: Red circle denotes impact from principal Premier operation, blue circle denotes impact from any other source of impact.

8.11 Confidence in the assessment

While a precautionary approach is taken during the impact and risk assessments such that the level of confidence in the data is reflected in the impact / risk significance, it is important to qualify, and indicate, the overall level of confidence in the assessment. The level of confidence in the outcomes of the impact / risk assessment depends upon the degree of uncertainty associated with the basis for the assessment, including:

- The clarity of definition and degree of certainty of project activities;
- The adequacy of available data, knowledge, and understanding about the environmental component / receptor being assessed;
- The number of data gaps;
- The known reliability of the proposed technology;
- The nature of the project-environment interaction; and
- The efficacy of proposed mitigation measures (IAIA, 2013).

Where moderate or greater levels of uncertainty exist, appropriate levels of monitoring may be determined to more fully characterise the impacts / potential risk as part of the on-going Environmental Monitoring and Management Plan (EMMP) (Chapter 15). Where monitoring indicates that the predictions made in the EIA were incorrect such the impact is greater than anticipated, remedial measures may be taken.

The level of confidence in the impact and risk predictions takes into account key characteristics of the impact (e.g. magnitude, extent, reversibility, duration, timing and frequency of effect), and the sensitivity of the receptor (IAIA, 2013). For the purposes of this EIA, the degree of confidence associated with the assessed impact, is evaluated using the qualitative scale: Certain, Probable, Uncertain (IEEM, 2010). Project-specific definitions for these categories have been developed and described in Table 8.9.

Table 8.9: Project-specific definition of the degree of confidence in the impact assessment

Degree of Confidence	Project-specific Definition
Certain	The project activities are clearly defined and are not subject to change. The nature of the impact is well understood from previous projects in terms of the magnitude, extent, reversibility, duration and frequency of the impact. The sensitivity of the receptor is well understood and documented.
Probable	The project activities have been defined although they may be subject to change as the project progresses, a precautionary approach has been taken. The nature of the impact on the environmental receptor is understood, although data gaps exist. The status and sensitivity of the receptor is largely understood, although some data gaps exist. The data gaps are not considered to have the potential to significantly change the outcome of the assessment.
Uncertain	The project activities are poorly defined and are subject to change as the project progresses. The nature of the impact on the environmental receptor is poorly understood and little monitoring data exists from previous projects. The status and sensitivity of the receptor is poorly understood and large data gaps exist.

8.11.1 Monitoring

Where confidence in the assessment is low due to uncertainties concerning the significance of impacts or the efficacy of proposed mitigation measures, monitoring activities should be identified to address these, including, where appropriate, further studies to fill data gaps.

Opportunities for monitoring are identified throughout the impact assessment process. Monitoring activities will be focused on the aspects that are considered to pose an impact of Moderate significance, or those activities that have been highlighted as a particular concern by stakeholders. Monitoring requirements will be recorded in the project-specific EMMP as per the outline provided in Chapter 15.

Monitoring should be carried out when the measuring and recording of tangible variables (e.g. emissions, sediment deposition, property) can:

- Provide feedback on the efficacy of mitigation measures;
- Facilitated improved assessment of the actual impacts resulting from the project activities;
- Enable comparison between the actual impacts and the predicted impacts;
- Provide additional information relating to the nature of the impact where data gaps existed during the EIA;
- Inform future EIAs;
- Provide an early warning system to identify harmful trends in the vicinity of the project activities before it is too late to take remedial action (Glasson *et al*., 2013); and
- To enable effective impact auditing.

9 ENVIRONMENTAL ASPECT & IMPACT IDENTIFICATION & SCREENING

Table of Contents

9.1 ENVIID workshop

Having identified the activities associated with the Phase 1 Development (Chapter 5) and the environmental and social sensitivities specific to the North Falkland Basin as well as the relevant inshore, onshore and at-shore locations (Chapter 7) it is possible to:

- Identify the environmental and social aspects specific to the project; and
- What the impacts and risks of these may be.

This chapter presents the results of the preliminary aspect, impact and risk identification and screening exercises, which were carried out during ENVironmental Impact IDentification (ENVIID) workshops.

The key objectives of the ENVIIDs were to identify:

- What project activities might interact with the environment and / or the human population, and how (i.e. the aspects, impacts and risks);
- The impacts and risks that could be 'screened out' because of their low significance; and
- The impacts and risks that warranted further investigation in the EIA.

Owing to the broad range of activities involved in the Phase 1 Development, three ENVIIDs were carried out to simplify the process and ensure that all potential impacts / risks were captured. The ENVIIDs were structured to identify impacts and risks in accordance with whether the activities were:

- Offshore;
- Inshore; or
- Onshore / at-shore / logistical.

The ENVIID results are presented in this chapter in accordance with the above criteria. However, in the remainder of the EIS, the assessment chapters have been grouped by aspect e.g. environmental emissions, to avoid repetition. For example, many activities, regardless of their location, will result in atmospheric emissions and these are assessed in a single chapter to ensure a cumulative assessment of emissions is provided and to avoid repeated explanations of how emissions may impact upon the environment and human population.

Note: as described in section 2.2.3.7, decommissioning of the Phase 1 Development will be considered a separate project. Therefore, a separate ENVIID will be carried out in support of the EIA that will accompany the decommissioning programme nearer the end of field life.

Note: as described in section 5.10, Inshore transfer is no longer the base-case and therefore the inshore component of Phase 1 Development has largely been removed from the current proposal.

9.1.1 ENVIID workshop attendees

Each workshop was attended by a multidisciplinary team to ensure that all aspects, impacts and risks were considered. The personnel that attended each ENVIID workshop is summarised in Table 9.1.

Table 9.1: ENVIID workshop attendees

Offshore activities ENVIID	Inshore activities ENVIID	Onshore, at-shore and logistical activities ENVIID
South Atlantic Environmental Research Institute (SAERI) attendees:		
2 x Environmental Consultants; and 1 x Social Consultant	3 x Environmental Consultants	2 x Environmental Consultants
Premier attendees:		
Falkland Islands Business Unit (FIBU) Senior Environmental Manager; Drilling Engineer; Naval Architect; Subsea Engineers; Production Engineers; Production Chemist; and Technical Safety Manager.	External facilitator; General Manager Sea Lion Project; Group Head of HSE & Technical Safety; FIBU HSE manager; Senior Environmental Manager; Graduate HSE Engineer (scribe) Drilling Superintendent; Naval Architect; Offtake Operations; Offtake Operations & FSU Manager; Technical Safety Manager; and Oil spill consultants (x 2)	External facilitator; FIBU HSE manager; Senior Environmental Manager; Graduate HSE Engineer (scribe); Drilling Superintendent; Drilling Logistics; Infrastructure Manager; Falkland Islands Environmental Advisor; and Logistics Manager.

9.1.2 ENVIID workshop process

During the ENVIID workshops, the team did a 'walk-through' of all the activities that will occur during the Phase 1 Development. At the time of the ENVIID workshops, certain aspects of the project had not been developed, e.g. the option to offload crude direct from the FPSO to a CTT. Although not addressed at the workshops, these have since been included in Table 9.2 and Table 9.3 below, as appropriate.

The ENVIID workshop included identification of the specific activities associated with:

- Offshore operations:
  - Development drilling;
  - Installation of subsea drilling and production facilities and hook-up of production facilities and the Floating Production, Storage and Offloading (FPSO) vessel;
  - Concurrent drilling and production operations; and
  - Steady state production.
- Inshore operations:
  - Installation of Mooring Buoy in Berkeley Sound (now no longer being considered);
  - Escorted transit of OLST and Conventional Trading Tanker (CTT) to the Mooring Buoy in Berkeley Sound (now no longer being considered);
  - Transfer of crude from OLST to CTT (now no longer being considered); and
  - Attendance of oil spill support vessel(s) (now no longer being considered).

- Onshore, at-shore and logistical activities required in support of all of the above:
  - Use of onshore supply base;
  - Use of port facilities (i.e. 'at-shore');
  - Use of resources; and
  - Logistical support:
    - Use of vessels; and
    - Use of transportation e.g. fixed-wing flights, helicopters, road transport.

9.1.2.1 Identification of environmental and social aspects

Following a 'walk-through' of the Phase 1 Development activities (Chapter 5), the routes via which the planned Phase 1 activities and unplanned and accidental events may interact with the environment and the human population were identified as:

- Environmental aspects:
  - Placement of objects on the seabed;
  - Drill cuttings and mud discharges to sea;
  - Operational discharges to sea;
  - Thermal discharges;
  - Artificial light offshore;
  - Artificial light inshore;
  - Underwater noise offshore;
  - Underwater noise inshore;
  - Atmospheric emissions;
  - Waste:
    - Discharges to sea of grey water, black water, food, drainage and bilge water; and
    - Management of solid wastes.
  - Noise from use of helicopters;
- Social aspects:
  - Increased vessel use and disturbance to other users of the sea;
  - Competition for resources:
    - Accommodation;
    - Freshwater;
    - Electricity;
    - Road networks; and
    - Airlinks.
  - Disturbance to the human population through:
    - Onshore light,
    - Onshore noise:

    - Odour; and
    - Visual impacts.
  - Inshore emissions and impacts to regional air quality.
- Unplanned / Accidental events:
  - Collisions with marine mammals;
  - Introduction of non-native species;
  - Vessel collisions offshore;
  - Vessel collisions inshore;
  - Loss of control leading to oil / chemical spill;
  - Small spills contributing to chronic oil pollution; and / or
  - Fuel spill either from bunkering operations or from an accidental event.

The environmental and social aspects relevant to each planned, unplanned and accidental activity / event are summarised in the tables below.

9.1.2.2 Identification of impacts from planned activities

When considering the impact of planned activities associated with the above, the following questions were considered and discussed:

- Will this activity:
  - Require the use of artificial light offshore, inshore, onshore or at-shore?
  - Require the use of helicopters over land?
  - Disturb the seabed or require placement of objects or material on the seabed?
  - Generate underwater noise?
  - Require the discharge of drill cuttings?
  - Require the discharge of liquid to sea e.g. produced water or cooling water?'
  - Require the use and / or discharge of chemicals?
  - Result in the discharge of heat to the environment?
  - Result in the emission of greenhouse gases e.g. via fuel combustion, flaring or fugitive emission?
  - Result in, or require, the venting of gases?
  - Require the use of Ozone Depleting Substances or F-Gases?
  - Generate hazardous or non-hazardous solid or liquid waste?
  - Require the use of vessels offshore, inshore or in the Falkland Islands' port facilities?
  - Require the delivery of cargo to the Islands from overseas?
  - Interfere with the activities carried out by other users of the sea?
  - Require the use of resources e.g. accommodation, freshwater, electricity, road networks, airports or airlinks to and from the Islands?
  - Generate airborne noise inshore, onshore or at-shore?
  - Result in odour emissions inshore or onshore?

  - Generate exhaust emissions inshore? and / or
  - Require the transfer of oil between vessels?

9.1.2.3 Identification of risks associated with unplanned events or accidental activities

To identify the risks, each planned activity was considered and the expertise in the workshop was used to determine:

- What unplanned events could happen as a result of the presence of the operation, malfunction of equipment or loss of control; and
- What accidental events could occur?

With regard to the risk of unplanned events therefore, the following questions were asked:

- Could the presence of the operation, malfunction of equipment or loss of control result in:
  - Bird-strikes with vessels?
  - Large dropped objects?
  - Unplanned discharges e.g. of produced water?
  - A release of natural gas?
  - A release of F-gas?
  - The loss of containment of solid or liquid waste to land or sea?
  - The generation of unplanned or unexpected waste quantities?
  - Collision with marine mammals?
  - The introduction of non-native marine or terrestrial species?
  - Collision between vessels?
  - Snagging of subsea infrastructure by trawl fishing gear?
  - Unexpected use of onshore resources?
  - A release of oil offshore via:
    - A well blow-out?
    - A loss of inventory from a vessel, flowline or bunkering hose? and /or
    - The release of small quantities of oil?
  - A release of fuel oil inshore via:
    - A loss of inventory from a vessel due to loss of power, collision or grounding?
    - A loss of inventory from a bunkering / transfer hose?
- A release of fuel oil or chemicals at-shore via:
  - Day-to-day activities at the Temporary Dock Facility?
  - Loss of containment during bulk transfers?

9.2 ENVIID outcomes - preliminary impact assessment and screening

The ENVIID workshop resulted in a detailed list of all planned activities and unplanned and accidental events that could lead to impacts and / or the risk of impacts. Once the potential impacts and risks had been identified, a preliminary assessment of their significance was latterly undertaken by the environmental team using the methodology described in Chapter 8. The preliminary assessment was used to determine which of the potential impacts and risks required further investigation in this EIA and which could be 'screened out'.

Specific activities and associated impacts were **'screened out'** of further assessment when:

- It was established, with a high degree of confidence during the preliminary assessment, that the significance of the impact of the activity would be **'Very Low'**;
- It was determined that the impact could not occur owing to prevention measures built-in to the development;
- It was estimated that the impact from a particular source would be sufficiently covered by the assessment of a similar impact or risk of greater magnitude. For example, not every single source of small oil spill was assessed in place of a general assessment of the chronic impact of repeated small releases of oil (section 12.1).

Aspects and impacts were **'screened in'** for a more detailed assessment when:

- Identified impacts and risks had the potential to be of **'Low'** or **'Moderate'** significance, or above;
- Where there was any uncertainty as to the significance of the impact or risk; and / or
- Concern had been expressed by stakeholders during the scoping consultations (Chapter 6).

Table 9.2 provides a summary of the outcomes of the offshore ENVIID and indicates those aspects, impacts and risks that were 'screened out' and those for which further investigation was considered necessary.

Table 9.3 provides a summary of the outcomes of the inshore ENVIID and indicates those aspects, impacts and risks that were 'screened out' and those for which further investigation was considered necessary.

Table 9.4 provides a summary of the outcomes of the onshore, at-shore and logistics ENVIID, which describes the onshore, at-shore and logistical activities required to support the offshore and inshore activities.

Note that, the activities / aspects that were identified as a concern during the informal stakeholder scoping consultation are described and identified in Chapter 6.

Table 9.2: Summary of the outcomes of the offshore ENVIID and the preliminary assessment, which was used to determine the environmental and social aspects, impacts and risks that required further investigation in the EIA

Action required:	
F	Further assessment required
S	Screened out of EIA

Project activities	Environmental Aspects	Planned / Unplanned / Accidental	Receptors which may be impacted by the activities																Cumulative Impact	Comments
			Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users, residents, livestock)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological		
Offshore operations: Subsea installation, drilling, production, offloading of crude from FPSO to CTT																				
Walk-through of planned activities and unplanned events offshore																				
Placement and presence of objects on the seabed e.g. anchors / manifolds	Placement of objects	P	F						F					F				S	F	Section 10.3: Placement of objects on the seabed. Impacts to archaeological sites were 'screened out' as there are no wrecks in the vicinity of the Sea Lion Field and wrecks near Stanley Harbour have been in place for many years with no impact from other vessels.
Presence of hard substrate on seabed following placement of objects	Placement of objects	P	F						F										F	
Large dropped objects	Placement of objects	U	F											F						

Action required:	
F	Further assessment required
S	Screened out of EIA

Project activities	Environmental Aspects	Planned / Unplanned / Accidental	Receptors which may be impacted by the activities: Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users, residents, livestock)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological	Cumulative Impact	Comments
Offshore operations: Subsea installation, drilling, production, offloading of crude from FPSO to CTT																				
Walk-through of planned activities and unplanned events offshore																				
Small dropped objects e.g. a tool	Placement of objects	U	S											S						Screened out during preliminary assessment: Sensitivity of receptor: 'Very Low'; Severity of effect: 'Slight' Overall Impact: 'Very Low' Likelihood: 'Likely' Overall Risk: 'Low'
Use and discharge of chemicals during drilling	Drill cuttings and mud	P	F	F	F				F										F	Section 10.6: Discharge of drill cuttings and mud.
Discharge of drill cuttings to seabed		P	F	F	F				F										F	

Action required:	
F	Further assessment required
S	Screened out of EIA

Project activities	Environmental Aspects	Planned / Unplanned / Accidental	Receptors which may be impacted by the activities: Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users, residents, livestock)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological	Cumulative Impact	Comments
Offshore operations: Subsea installation, drilling, production, offloading of crude from FPSO to CTT																				
Walk-through of planned activities and unplanned events offshore																				
Discharge of iron to the marine environment (e.g. in water-based mud)	Drill cuttings and mud; and Operational discharges	P		S						S										Screened out during preliminary assessment: Sensitivity of receptor: 'Very Low'; Severity of effect: 'Slight' Overall Impact: 'Very Low'
Perforation of the wells underground using explosives	Underwater noise	P			S	S	S													Screened out: Not conceivable that sound from sub-sea explosions would be detectable at seabed
Use and discharge of chemicals in produced water during initial	Operational discharges	P		F	F	F				F									F	

Action required:	
F	Further assessment required
S	Screened out of EIA

Project activities	Environmental Aspects	Planned / Unplanned / Accidental	Receptors which may be impacted by the activities: Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users, residents, livestock)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological	Cumulative Impact	Comments
Offshore operations: Subsea installation, drilling, production, offloading of crude from FPSO to CTT																				
Walk-through of planned activities and unplanned events offshore																				
production and PWRI unit commissioning																				Section 10.7: Operational discharges to sea
Discharge of oil in produced water during initial production and PWRI unit commissioning	Operational discharges	P		F	F	F				F									F	Discharges associated with the chlorination of seawater were not considered separately as the resulting biocide (sodium hypochlorite) will be discharged with the produced water and are covered by the produced water assessment.
PWRI unavailability and discharge of produced water (oil and chemicals) to sea	Operational discharges	U		F	F	F				F									F	
Chlorination of seawater through hypochlorite unit	Operational discharges	P								S										
Process upsets and blockages leading discharge of produced water and / or use of more chemicals	Operational discharges	U		F	F	F				F									F	
Subsea discharges of chemicals e.g. pre-commissioning pipeline fluids or hydraulic fluid during valve actuation	Operational discharges	P	F							F									F	

Action required:	
F	Further assessment required
S	Screened out of EIA

Project activities	Environmental Aspects	Planned / Unplanned / Accidental	Receptors which may be impacted by the activities: Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users, residents, livestock)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological	Cumulative Impact	Comments
Offshore operations: Subsea installation, drilling, production, offloading of crude from FPSO to CTT																				
Walk-through of planned activities and unplanned events offshore																				
Topside discharge of de-aerated water	Operational discharges	P		S	S					S										Screened out during preliminary assessment: Sensitivity of receptor: 'Very Low'; Severity of effect: 'Slight' Overall Impact: 'Very Low'
Discharge of de-aerated injection water at seabed while flowing until hot	Operational discharges	P	S		S				S											
Sand requiring removal from separator during normal maintenance - oily solids and sands (not predicted to occur from Sea Lion)	Operational discharges	U		S	S					S										Screened out during preliminary assessment: Sensitivity of receptor: 'Very Low';

Action required:	
F	Further assessment required
S	Screened out of EIA

Project activities	Environmental Aspects	Planned / Unplanned / Accidental	Receptors which may be impacted by the activities: Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users, residents, livestock)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological	Cumulative Impact	Comments
Offshore operations: Subsea installation, drilling, production, offloading of crude from FPSO to CTT																				
Walk-through of planned activities and unplanned events offshore																				
																				Severity of effect: 'Slight' Likelihood of occurrence: 'Very Unlikely' Overall Risk: 'Very Low'
Marine life sucked into seawater inlet valve when lifting seawater for injection	Operational discharges	P		S																Screened out during preliminary assessment: Sensitivity of receptor: 'Very Low'; Severity of effect: 'Slight' Overall Impact: 'Very Low'

Action required:	
F	Further assessment required
S	Screened out of EIA

Project activities	Environmental Aspects	Planned / Unplanned / Accidental	Receptors which may be impacted by the activities: Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users, residents, livestock)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological	Cumulative Impact	Comments
Offshore operations: Subsea installation, drilling, production, offloading of crude from FPSO to CTT																				
Walk-through of planned activities and unplanned events offshore																				
Cold start of dual fuel turbines with diesel and fall out of acidic liquid when the temperature is below the acid dew point.	Operational discharges	U								S										Screened out: considered within general operational discharges
Discharge of hot water from cooling systems	Thermal discharges	P		F						F									F	Section 10.8: Thermal discharges to sea
Heat generated subsea (hot fluids inside piping and flowlines, electrically trace heated lines)	Thermal discharges	P	F		F				F										F	
Lighting on installations and vessels offshore and from flaring	Artificial light	P		F	F	F	F												F	Section 10.1: Artificial light offshore
Generation of underwater noise by vessels offshore	Underwater noise	P		F	F	F	F												F	Section 10.4: Underwater noise offshore
Underwater noise from pile-driving or drilling into place of well conductor pipes	Underwater noise	P		F	F	F	F												F	

PremierOil

Action required:	
F	Further assessment required
S	Screened out of EIA

Project activities	Environmental Aspects	Planned / Unplanned / Accidental	Receptors which may be impacted by the activities: Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users, residents, livestock)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological	Cumulative Impact	Comments
Offshore operations: Subsea installation, drilling, production, offloading of crude from FPSO to CTT																				
Walk-through of planned activities and unplanned events offshore																				
Power generation by vessels and installations offshore	Atmospheric emissions	P							F	F	F	F							F	Section 10.9: Atmospheric emissions
Venting during drilling operations e.g. bentonite / barite / cement tanks and mud shakers	Atmospheric emissions	P										F							F	Section 10.1: Artificial light offshore Section 10.9: Atmospheric emissions
Potential need to flare during initial well flowback / testing	Atmospheric emissions	P				F			F	F	F	F							F	
Venting of cargo tank gas blanket if VRP breaks	Atmospheric emissions	U										F							F	
Combustion emissions from HP Flare Pilot light	Atmospheric emissions	P							F	F	F	F								
Need to flare during process upset or incident	Atmospheric emissions	U				F			F	F	F	F							F	
Use of F-gases on MODU / FPSO	Atmospheric emissions	P										F							F	

Action required:	
F	Further assessment required
S	Screened out of EIA

Project activities	Environmental Aspects	Planned / Unplanned / Accidental	Receptors which may be impacted by the activities																	Cumulative Impact	Comments
			Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users, residents, livestock)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological			
Offshore operations: Subsea installation, drilling, production, offloading of crude from FPSO to CTT																					
Walk-through of planned activities and unplanned events offshore																					
Leakage of F-gas	Atmospheric emissions	U										F								F	
Generation of solid hazardous and non-hazardous solid or liquid waste	Waste	P													F		F			F	Section 10.10: Waste Management Section 10.13: Introduction of terrestrial invasive species
Discharge of liquid waste streams to sea e.g. drainage, bilge, hypersaline, black and grey water	Waste	P		F	F	F				F										F	
Loss of containment of solid waste offshore	Waste	U				F	F						F							F	
Loss of containment of liquid waste to sea	Waste	U		F	F				F	F										F	
Generation of excess waste owing to system malfunction (e.g. TCC goes down)	Waste	U													S						Screened out: In the event that the TCC malfunctioned, no extra waste would be generated and cuttings would be stored until the TCC

Action required:	
F	Further assessment required
S	Screened out of EIA

			Receptors which may be impacted by the activities																	
Project activities	Environmental Aspects	Planned / Unplanned / Accidental	Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users, residents, livestock)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological	Cumulative Impact	Comments
Offshore operations: Subsea installation, drilling, production, offloading of crude from FPSO to CTT																				
Walk-through of planned activities and unplanned events offshore																				
																				was operational again
Deluge water system activated	Waste	U								S										Screened out: If the deluge system is triggered, it could backfill the open drains. However, these specific activities were not assessed further in the EIA as such discharges would be required under force majeure
Emptying of rainwater out of uncontaminated bunds into drainage system	Waste	P								S										Screened out during preliminary assessment: Sensitivity of receptor: ‘Very Low’;

Action required:	
F	Further assessment required
S	Screened out of EIA

Project activities	Environmental Aspects	Planned / Unplanned / Accidental	Receptors which may be impacted by the activities: Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users, residents, livestock)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological	Cumulative Impact	Comments
Offshore operations: Subsea installation, drilling, production, offloading of crude from FPSO to CTT																				
Walk-through of planned activities and unplanned events offshore																				
																				Severity of effect: 'Slight' Overall Impact: 'Very Low'
Washing of turbines to remove salt build-up etc. in turbine	Waste	P								S										Screened out: Covered by hypersaline discharges in section 10.7
Presence of vessels and collision with a marine mammal offshore	Marine mammal collision	U					F												F	Section 10.11: Collision with marine mammals.
Marine growth on MODU / FPSO / vessels when they arrive at Sea Lion Field	Non-native species	U															S			Screened out: The introduction of marine invasive species to the offshore environment is not considered to be a concern over and
Introduction of marine invasive species to offshore environment through ballast water / biofouling	Non-native species	U															S			

Action required:	
F	Further assessment required
S	Screened out of EIA

Project activities	Environmental Aspects	Planned / Unplanned / Accidental	Receptors which may be impacted by the activities: Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users, residents, livestock)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological	Cumulative Impact	Comments
Offshore operations: Subsea installation, drilling, production, offloading of crude from FPSO to CTT																				
Walk-through of planned activities and unplanned events offshore																				
																				above the introduction to inshore waters.
Introduction of marine invasive species from Falklands water to elsewhere in the world	Non-native species	U															S			Screened out: out of scope; the ecosystems of remote Islands, such as the Falklands, are deemed of greater significance than the impacts of non-native species on regions that adjoin continental land masses
Presence of MODU, FPSO and vessels offshore	Physical presence	P												F					F	Section 11.1: Disruption to other users of the sea offshore
Presence of vessels offshore	Physical presence	P												F					F	

Action required:	
F	Further assessment required
S	Screened out of EIA

Project activities	Environmental Aspects	Planned / Unplanned / Accidental	Receptors which may be impacted by the activities																Cumulative Impact	Comments
			Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users, residents, livestock)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological		
Offshore operations: Subsea installation, drilling, production, offloading of crude from FPSO to CTT																				
Walk-through of planned activities and unplanned events offshore																				
Presence of 500 m exclusion zone around MODU / FPSO / Wells	Physical presence	P												F					F	
Existing metocean buoy on location	Physical presence	P												S						Screened out during preliminary assessment: Sensitivity of receptor: 'Very Low'; Severity of effect: 'Slight' Overall Impact: 'Very Low'
Submerged turret buoy - 50 m below surface - in exclusion zone	Physical presence	P												F					F	Section 11.1: Disruption to other users of the sea offshore
Water returns through restricted orifice at entrance to caisson will lead to	Underwater noise / non-	P					S			S							S			Screened out: Native marine

Action required:	
F	Further assessment required
S	Screened out of EIA

Project activities	Environmental Aspects	Planned / Unplanned / Accidental	Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users, residents, livestock)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological	Cumulative Impact	Comments
Offshore operations: Subsea installation, drilling, production, offloading of crude from FPSO to CTT																				
Walk-through of planned activities and unplanned events offshore																				
aeration of discharge assisting marine growth, creating noise and requiring cleaning	native species																			growth will have no discernible impact and underwater noise will not be discernible over other sources assessed in Section 10.12
Topside release of reservoir hydrocarbon	Oil spill	A	F	F	F	F	F		F	F			F	F					F	Section 12.1: Accidental and chronic oil pollution offshore
Well blow-out	Oil spill	A	F	F	F	F	F		F	F			F	F	F	F			F	
Damage to infrastructure leading to leaks e.g. rupture of flowlines	Oil spill	A		F	F	F	F			F						F			F	Section 12.1: Accidental and chronic oil pollution offshore
Loss of diesel inventory of vessel	Oil spill	A	F	F	F	F	F		F	F			F	F					F	
Loss of inventory of reservoir hydrocarbon on vessel	Oil spill	A	F	F	F	F	F		F	F			F	F	F	F			F	

PremierOil

Action required:	
F	Further assessment required
S	Screened out of EIA

Project activities	Environmental Aspects	Planned / Unplanned / Accidental	Receptors which may be impacted by the activities: Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users, residents, livestock)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological	Cumulative Impact	Comments
Offshore operations: Subsea installation, drilling, production, offloading of crude from FPSO to CTT																				
Walk-through of planned activities and unplanned events offshore																				
Subsea leak of reservoir hydrocarbon	Oil spill	A	F	F	F	F	F		F	F					F	F			F	
Potential for chronic impact from small volume releases of oil e.g. rupture of hoses, malfunction in couplings / valves, human error.	Oil spill	A	F	F	F	F	F		F	F			F	F					F	Section 12.1: Accidental and chronic oil pollution offshore
Build-up of oil in the top of the PW discharge caisson	Oil spill	A		F	F	F				F									F	
Collision between vessels leading to loss of third party vessel	Oil spill	A	F	F	F	F	F		F	F				F	F	F		S	F	Section 11.1: Disruption to other users of the sea offshore Section 12.1: Accidental and chronic oil pollution offshore
Loss of station of MODU and potential for loss of riser contents	Oil spill	A	S	S	S				S	S										Screened out: MODU will be held in position by

Action required:	
F	Further assessment required
S	Screened out of EIA

Project activities	Environmental Aspects	Planned / Unplanned / Accidental	Receptors which may be impacted by the activities																Cumulative Impact	Comments
			Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users, residents, livestock)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological		
Offshore operations: Subsea installation, drilling, production, offloading of crude from FPSO to CTT																				
Walk-through of planned activities and unplanned events offshore																				
																				anchor, rather than dynamic positioning. Note other causes of loss of riser contents have been assessed in Section 12.1
Leaks of oil or chemical to deck	Oil spill	A								S					S					Screened out: Leaks and small spills to deck will be contained within the hazardous drains system.
Alternative export route, directly offloading the crude from the FPSO to the purchaser's CTT at the Sea Lion location.	Not assessed during ENVIID																			Note: this operation was not assessed at the ENVIID but was added retrospectively as the project plan progressed. It has however been

Project activities (Action required: F – Further assessment required; S – Screened out of EIA)	Environmental Aspects	Planned / Unplanned / Accidental	Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users, residents, livestock)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological	Cumulative Impact	Comments
Offshore operations: Subsea installation, drilling, production, offloading of crude from FPSO to CTT																				
Walk-through of planned activities and unplanned events offshore																				
																				included within this assessment.

Receptors which may be impacted by the activities: Benthos to Archaeological.

Table 9.3: Summary of the outcomes of the inshore ENVIID and the preliminary assessment, which was used to determine those environmental and social aspects, impacts and risks that required further investigation in the EIA

Action required:	
F	Further assessment required
S	Screened out of EIA

Project Activity	Environmental Aspect	Planned / Unplanned / Accidental	Receptors which may be impacted by the activities																Cumulative Impact	Comment
			Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological		
Inshore operations: Use of Berkeley Sound as a logistics base during the subsea installation campaign																				
Walk-through of planned activities and unplanned events inshore																				
Presence of LTVs	Underwater noise, Artificial light																			Not assessed at ENVIID
Presence of oil spill infrastructure e.g. if permanent moorings or a clump weight are placed for boom deployment[a]	Placement of objects	P							F					F					F	Section 11.2: Disruption to other users of the sea inshore Section 11.11: Disturbance to human population from visual impacts

Action required:	
F	Further assessment required
S	Screened out of EIA

Project Activity	Environmental Aspect	Planned / Unplanned / Accidental	Receptors which may be impacted by the activities																Cumulative Impact	Comment
			Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological		
Inshore operations: Use of Berkeley Sound as a logistics base during the subsea installation campaign																				
Walk-through of planned activities and unplanned events inshore																				
Use of artificial lighting on vessels inshore	Artificial light	P				F								F					F	Section 10.1: Artificial light inshore Section 11.8 Disturbance to human population from light
Underwater noise generated by all vessels during all inshore operations	Underwater noise	P		F	F	F	F												F	Section 10.5: Underwater noise inshore
Fuel combustion for power generation by all vessels during all activities	Atmospheric emissions	P							F	F	F	F							F	Section 10.9: Atmospheric emissions
Fugitive emissions during fuel transfer operations[a]	Atmospheric emissions	P									F	S							F	

Action required:	
F	Further assessment required
S	Screened out of EIA

Project Activity	Environmental Aspect	Planned / Unplanned / Accidental	Receptors which may be impacted by the activities																Cumulative Impact	Comment
			Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological		
Inshore operations: Use of Berkeley Sound as a logistics base during the subsea installation campaign																				
Walk-through of planned activities and unplanned events inshore																				
Generation of solid hazardous and non-hazardous solid or liquid waste	Waste	P													F				F	Section 10.10: Waste Management
Management of liquid / solid waste streams when inshore e.g. macerated food, drainage, bilge, hypersaline, black and grey water	Waste	P												F					F	
Discharge of liquid waste streams to sea e.g. macerated food, drainage, bilge, hypersaline, black and grey water	Waste	P		F	F	F				F									F	
Loss of containment of solid waste inshore	Waste	U				F	F						F							
Loss of containment of liquid waste to sea	Waste	U		F	F				F	F										
Collision of a vessel with a marine mammal offshore	Marine mammal collision	U					F												F	Section 10.11: Collision with marine mammals.

Action required:	
F	Further assessment required
S	Screened out of EIA

Project Activity	Environmental Aspect	Planned / Unplanned / Accidental	Receptors which may be impacted by the activities: Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological	Cumulative Impact	Comment
Inshore operations: Use of Berkeley Sound as a logistics base during the subsea installation campaign																				
Walk-through of planned activities and unplanned events inshore																				
Introduction of marine invasive species to Berkeley Sound from vessel ballast water / biofouling	Non-native species	U	F	F	F	F	F										F		F	Section 10.12: Introduction of marine invasive species
Spread of marine invasive species from Stanley Harbour to Berkeley Sound from biofouling	Non-native species	U	F	F	F	F	F										F		F	Section 10.5: Underwater noise inshore
Fuel bunkering for support vessels[a]	Physical presence	P							F				F	F					F	Section 11.2 : Increased vessel presence and other sea users
Use of Large Transport Vessel (LTVs) as a ‘floating logistics vessels’ for the offshore installation activities e.g. in Berkeley Sound	Physical presence	P											F	F					F	Section 11.10 and 11.11: Disturbance to human population from light, noise odour and visual impact

Action required:	
F	Further assessment required
S	Screened out of EIA

Project Activity	Environmental Aspect	Planned / Unplanned / Accidental	Receptors which may be impacted by the activities: Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological	Cumulative Impact	Comment
Inshore operations: Use of Berkeley Sound as a logistics base during the subsea installation campaign																				
Walk-through of planned activities and unplanned events inshore																				
																				Section 11.12 Air quality inshore
Generation of airborne noise by inshore operations[a]	Physical presence	P												F					F	Section 11.9: Disturbance to human population from noise
Fuel spill from OSV due to collision, power grounding, drift grounding, non-accidental structural failure and foundering, fire / explosion[a]	Oil spill	A	F	F	F	F	F	F	F	F			F	F	F	F			F	Section 12.2: Accidental and chronic oil pollution inshore
Potential for chronic impact from small volume releases of oil e.g. rupture of hoses, malfunction in couplings / valves, human error	Oil spill	A	F	F	F	F	F	F	F	F			F	F	F	F			F	Section 12.2: Accidental and chronic oil pollution inshore

Table 9.4: Summary of the outcomes of the onshore, at-shore and logistics ENVIID, which describes all the activities required to support the offshore and inshore activities associated with the project and the aspects, impacts and risks that required further investigation in the EIA

Action required:	
F	Further assessment required
S	Screened out of EIA

Project Activities	Environmental Aspects	Planned / Unplanned / Accidental	Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users, residents, livestock)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological	Cumulative Impact	Comments
			Receptors that may be impacted by the activities																	
Onshore and at-shore operations required in support of all offshore and inshore activities described above: Presence and use of onshore supply base and use of port facilities																				
Walk-through of planned activities and unplanned events onshore and at-shore																				
Fuel combustion in vessel use e.g. ships, cars, forklift etc.	Atmospheric emissions	P							F	F	F	F								Section 10.9: Atmospheric emissions
Generation of waste at supply base	Waste	P													F					Section 10.10: Waste management
Domestic and office waste at supply base	Waste	P													F					
Presence of additional personnel on Falkland Islands and domestic waste	Waste	P													F					
Loss of containment of solid waste at supply base	Waste	U				F	F						F							

Action required:	
F	Further assessment required
S	Screened out of EIA

Project Activities	Environmental Aspects	Planned / Unplanned / Accidental	Receptors that may be impacted by the activities																Cumulative Impact	Comments
			Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users, residents, livestock)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological		
Onshore and at-shore operations required in support of all offshore and inshore activities described above: Presence and use of onshore supply base and use of port facilities																				
Walk-through of planned activities and unplanned events onshore and at-shore																				
Loss of containment of liquid waste at supply base - discharge to drainage	Waste	U							F											
Loss of containment of liquid waste at supply base - discharge to soil	Waste	U							F											
Use of the Existing TDF offloading of cargo and loading of supply vessels	Physical presence	P												F						Section 11.1: Increased vessel presence and other sea users
Use of FIPASS (freshwater & fuel supply only)	Physical presence	P												F						
Use of diesel to support all activities	Competition for resource	P												S					S	Screened out: need met according to basic market forces

Action required:	
F	Further assessment required
S	Screened out of EIA

Project Activities	Environmental Aspects	Planned / Unplanned / Accidental	Receptors that may be impacted by the activities															Cumulative Impact	Comments
			Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users, residents, livestock)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological		
Onshore and at-shore operations required in support of all offshore and inshore activities described above: Presence and use of onshore supply base and use of port facilities																				
Walk-through of planned activities and unplanned events onshore and at-shore																				
Use of freshwater to support all activities	Competition for resource	P												F	F				F	Section 11.4 Competition for freshwater
Use of food to support all activities	Competition for resource	P												S						Screened out: need met according to basic market forces
Use of accommodation to support all activities	Competition for resource	P												F	F				F	Section 11.3 Competition for accommodation
Use of electricity to support all activities	Competition for resource	P												F	F				F	Section 11.5 Competition for electricity
Use of FIPASS and, port facilities to support all activities	Competition for resource	P												F	F				F	Section Other users inshore

Action required:	
F	Further assessment required
S	Screened out of EIA

Project Activities	Environmental Aspects	Planned / Unplanned / Accidental	Receptors that may be impacted by the activities: Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users, residents, livestock)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological	Cumulative Impact	Comments
Onshore and at-shore operations required in support of all offshore and inshore activities described above: Presence and use of onshore supply base and use of port facilities																				
Walk-through of planned activities and unplanned events onshore and at-shore																				
Use of flights to support all activities	Competition for resource	P												F					F	Section 11.6 Competition for resources – air links
Use of sewage infrastructure to support all activities	Competition for resource	P												F	F				F	Section 10.10 Waste
Use of roads to support all activities	Competition for resource	P												F	F				F	Section 11.6 Competition for resources – air links
Lighting on TDF and supply base	Physical presence	P			F									F					F	Section 10.1: Artificial light Section 11.8: Disturbance to human population from light
Presence of vessels in port facilities	Physical presence	P												F					F	

Action required:	
F	Further assessment required
S	Screened out of EIA

Project Activities	Environmental Aspects	Planned / Unplanned / Accidental	Receptors that may be impacted by the activities																Cumulative Impact	Comments
			Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users, residents, livestock)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological		
Onshore and at-shore operations required in support of all offshore and inshore activities described above: Presence and use of onshore supply base and use of port facilities																				
Walk-through of planned activities and unplanned events onshore and at-shore																				
Physical presence and use of laydown and storage bases in supply base	Physical presence	P												F					F	
Introduction of non-native marine species from vessel ballast water / biofouling	Non-native species	U	F	F	F	F	F										F		F	Section 10.12: Introduction of marine invasive species
Delivery of cargo and potential introduction of non-native terrestrial species on cargo	Non-native species	U													F		F		F	
Spillage of liquid cargo e.g. chemical containers at TDF during loading to supply vessels	Spill	A	F	F	F	F	F	F	F	F			F	F	F	F			F	Section 12.3: Accidental and chronic oil pollution at-shore
Spillage of fuel at TDF / FIPASS	Oil spill	A	F	F	F	F	F	F	F	F			F	F	F	F			F	

Action required:	
F	Further assessment required
S	Screened out of EIA

Project Activities	Environmental Aspects	Planned / Unplanned / Accidental	Receptors that may be impacted by the activities																Cumulative Impact	Comments
			Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users, residents, livestock)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological		
Onshore and at-shore operations required in support of all offshore and inshore activities described above: Presence and use of onshore supply base and use of port facilities																				
Walk-through of planned activities and unplanned events onshore and at-shore																				
Fuel combustion by all shipping, vessel, land transport, fixed wing and helicopter use	Atmospheric emissions	P							F	F	F	F							F	Section 10.9: Atmospheric emissions
Use of vessels offshore, inshore and at port facilities	Physical presence	P												F					F	Section 11.2: Increased vessel presence and other sea users inshore
At-shore collision between Premier vessels	Physical presence	U												F					F	
At-shore collision between a Premier and third party vessel	Physical presence	U												F					F	
Airborne noise from use of helicopters for transporting personnel to and from the Islands' to the MODU / FPSO and CTT	Noise disturbance	P				F	F							F					F	Section 10.2: Disturbance to wildlife from helicopter use

Action required:	
F	Further assessment required
S	Screened out of EIA

Project Activities	Environmental Aspects	Planned / Unplanned / Accidental	Receptors that may be impacted by the activities																Cumulative Impact	Comments
			Benthos	Plankton	Fish / cephalopods	Seabirds	Marine mammals	Designated sites	Seabed and soil	Water quality	Regional air quality	Global atmosphere	Landscape / seascape	Human population (e.g. other sea users, residents, livestock)	Tangible property	Commercial fisheries	Biosecurity / Biodiversity	Archaeological		
Onshore and at-shore operations required in support of all offshore and inshore activities described above: Presence and use of onshore supply base and use of port facilities																				
Walk-through of planned activities and unplanned events onshore and at-shore																				
																				Section 11.9: Disturbance to human population noise
The potential for nuisance caused by dust and odour from the onshore supply base and TDF, e.g. yard surfacing, dry bulk chemicals and storage and mixing of other chemicals.	Dust / odour nuisance													S						Screened out: Design, operation and management of the yard and TDF will minimise any dust and odour. Additionally, predominant westerly winds will direct dust an odour away from Stanley.

10 ENVIRONMENTAL ASPECT & RISK ASSESSMENT

Table of Contents

10.1 Artificial light

Table of Contents

10.1.1 Introduction

Numerous vessels and offshore installations will be used throughout the three Stages of the Phase 1 Development each of which requires the use of artificial light and flaring may be required to clean-up four wells from the Mobile Offshore Drilling Unit (MODU) (section 5.4.9). The level of anthropogenic light in the night-time sky has increased dramatically in recent decades and is increasingly becoming an issue relating to impacts on biodiversity (Hölker *et al*., 2010). Additionally, light was raised as a concern by stakeholders during consultations in 2014, 2015 and 2016 (section 6.0). Where this has an adverse effect on humans or other animals, this is referred to as light pollution (see Davies *et al*., 2014 for review). Most ecological studies take place during day-light hours and therefore the ecological consequences of light pollution are only just beginning to be appreciated.

Artificial light and flares can affect the natural behaviour of animals in several ways such as disturbance to activity patterns and hormone-regulated processes dictated by the internal clock. A more obvious effect however, is the attraction of animals and seabirds to man-made light sources and their subsequent disorientation. This phenomenon is known as positive phototaxis.

Positive phototaxis is exploited to catch species of squid (FAO, 2014), with approximately 63-89 % of the global squid catch being made by light-fishing vessels (jiggers). Equally, it has long been known that seabirds are attracted to lights at-sea (Murphy, 1936), which has also been exploited as a technique for capturing seabirds. There is a growing awareness of the impact that anthropogenic sources of light are having on seabirds (Montevecchi, 2006), although quantitative studies are few in number.

This chapter assesses the potential impacts and risks associated with anthropogenic light arising from the Phase 1 Development of the Sea Lion Field, which include:

- Attraction of marine life, e.g. plankton, fish and squid; and
- Attraction of seabirds and subsequent collision risk with vessels or flares.

Note: Large Transport Vessels (LTVs) will be the only project related vessels anchored in Berkely Sound , this is in support of the subsea construction activity. Thereafter there will be no project related vessels anchored in Berkeley Sound. And thus is a temporary situation. The following chapter asseses the impacts of the planned offshore installation and the inshore vessels, while anchored inshore, with regard to artificial light.

Note: A further 18 wells may be cleaned up to the MODU depending on the quantity and characteristics of solids in the initial produced fluids.

Note: the other impacts associated with vessel use are described elsewhere in this document, as are the impacts of artificial light on humans, as described in section 9.2.

10.1.1.1 Legislation relevant to the management of artificial light

Outside the EIA process for major projects, no legislation is in place in the Falkland Islands to govern the environmental impact of artificial light, although offshore industry guidelines are in place (see section 10.1.5 below).

While not directly related to the environmental impact of artificial light, it is important to understand during this assessment that mitigation measures will be limited by the need to ensure the use of sufficient lighting for safety reasons. Specifically, offshore installations are required to be lit in line with the:

- International Regulations for the Prevention of Collisions at Sea (ColRegs) (Rule 22 and Annex 1).

Lighting of the FPSO and MODU deck, walkways and process areas will be an outcome of compliance with occupational safety requirements and process safety requirements. For example, the FPSO design requires that luminance levels for general and emergency operating conditions shall be in accordance with IEC 61892-2 which follows from compliance with Falkland Islands health and safety legislation for the offshore industry.

Lighting of helicopter landing areas (FPSO, MODU and Commercial Trading Tanker (CTT)) is a requirement of CAP 437 (CAA, 2013).

Offshore flaring (i.e. flaring associated with well testing, well clean-up operations and pressure relief) is regulated in the Falklands by the Department of Mineral Resources (DMR) under the:

- Offshore Mineral Ordinance 1994 (1997 and 2011 Amendments).

10.1.2 Sources of artificial light

Offshore operations associated with the Development will introduce several sources of artificial light into the offshore waters of the North Falkland Basin (NFB), and in Berkeley Sound, all of which will add to the existing ambient light (section 10.1.9).

As a worst case, the Phase 1 Development sources of artificial light and flaring will include the following:

- Within the Sea Lion Field:
  - The Mobile Offshore Drilling Unit (MODU);
  - Installation vessels;
  - The Floating Production Storage Offloading vessel (FPSO);
  - Supply / support vessels;
  - An Emergency Response and Rescue Vessel (ERRV); and
  - Oil export CTT and Offshore Support Vessel (OSV) (for Direct Offtake).
- In transit (passing a few kilometres away):
  - Coaster vessels; and
  - Large Transport Vessels / fast transit carriers.
- Within Berkeley Sound:
  - Up to three Large Transport Vessels (LTVs) and Subsea Construction Vessel during subsea construction; and
  - Multi-Role Support Vessel (MRSV).

The number and type of vessels present at the Sea Lion Development site will vary with the Stage of the Field's development and the activities undertaken (section 5.11.2). Away from the Development site, support vessels will regularly steam to and from the supply base in Stanley throughout all Stages. Throughout the life of the Development, activities will operate for 24 hours a day and to do this safely, all working areas will have to be well illuminated.

In Stage 1 of the subsea construction campaign, three LTVs will be used over a twelve month period although the current schedule expects that a maximum of two LTVs are present in Berkeley Sound for only eight months (c. August-2022 to end March-2023), which supports the target of avoiding competing for sea room during the peak fishing period. The phasing of the subsea installation campaign results in a maximum of two of the three LTVs being anchored in Berkeley Sound at any one time during this period. Stage 2 - which will provide the drilling and subsea infrastructure in support of the Southern Drill Centre (DC) - only requires one LTV to be anchored for a duration of approximately four months from c. mid December-2025.

The only sources of inshore light emissions are those from the LTVs anchored in Berkeley Sound and c. 14 trips by a Subsea Construction vessel transiting to and from the Sound as subsea equipment is loaded onto its decks for installation offshore.

Offshore, Direct Offtake to the CTT from the FPSO requires an Offshore Support Vessel (OSV) - to be present to manoeuvre and hold the CTT in place during the offtake operation.

Sources of light on the Phase 1 vessels will include:

- Navigational lights;
- Illuminated living spaces within all vessels;
- Floodlighting to provide a safe working environment on the decks of ships and MODU;
- Small permanent pilot flare of associated gas from the FPSO; and
- Periodic high-pressure (HP) flaring of gas, only in the event of a blowdown.

10.1.2.1 Navigational lights

Vessels are required to display navigational lights when at-sea. These are relatively small coloured lights (white, red and green) that are of low intensity to avoid glare. Alone, these lights are unlikely to cause impacts or pose any risk (see Poot *et al*., 2008).

10.1.2.2 Living spaces

Light can be emitted from living spaces (accommodation, mess rooms etc.) through uncovered portholes and windows on the rig and other vessels (Figure 10.1:).

10.1.2.3 Deck lights

Deck lighting is required to provide a safe working environment. These lights are usually very bright floodlights, designed to illuminate a wide area. It is these light sources that are most difficult to manage as they are outside and are essential for safe working practices (Figure 10.1:).

10.1.2.4 Flaring

During steady state production from the Phase 1 Sea Lion Development, there will be no routine flaring of gas with the majority of excess gas being reinjected into the GPI well(s) (section 5.8.5.3). However, for safety reasons, there will be a small constant gas fed pilot flare at the end of the flare boom. Periodically, excess gas and hydrocarbons may be burned off by flaring during start-up and shut-downs (both planned and unplanned), or during emergency blowdowns.

Well clean up via the MODU may be required to provide early production flow information to support the field development, although this is not confirmed, it is included in this assessment. Up to four wells will be tested from the MODU, with flaring for one day for each well (section 5.4.9). Further, depending on the results of the clean ups, a further 18 production wells may require clean up.

a) Lighting arrangement for a representative MODU

b) Lighting arrangement for a representative FPSO

Figure 10.1: Photographs of representative offshore lighting arrangements

10.1.3 Potential environmental receptors

The ENVironmental Impact IDentification (ENVIID) workshop was used to identify those environmental receptors upon which the impacts and / or risks of artificial light warranted further investigation (Chapter 9). These include:

- Zooplankton (section 7.4.1);
- Fish and squid offshore and inshore (section 7.4.4);
- Seabirds offshore and inshore (section 7.4.5); and
- Marine mammals offshore and inshore (section 7.4.6).

The offshore marine environment is essentially dark at night, except for moonlight and sources of bio-luminescence. The above receptors have evolved to function in accordance with a diurnal cycle where, over any 24 hour period, there are predictable periods of daylight and darkness. The introduction of artificial light during the hours of darkness therefore has the potential to confuse the circadian rhythms (the body clock) followed by the receptors over the 24 hour cycle leading to impacts on normal behaviour and the risk of collision for seabirds.

10.1.4 Characterising and quantifying the impacts and risks of artificial light

When characterising and quantifying the impacts and risks of artificial light it is necessary to consider the:

- Influencing factors;
- The impact of attraction to artificial light and flares; and
- The risk of collision caused by artificial lights and flares.

10.1.4.1 Influencing factors

The potential impact of artificial light from the project's Phase 1 Development on marine life is influenced by the:

- Number of Phase 1 light sources and duration of light exposure;
- Location of light sources;
- Intensity of light;
- Orientation of light;
- Season of activity (occurrence of receptors); and
- Local weather conditions.

10.1.4.1.1 Number of Phase 1 light sources and duration of light exposure

The number of light sources and the duration of light exposure during each different stage of the operation is summarised in Table 10.1.

Table 10.1: Number, source and duration of lights during the Phase 1 Development

Phase 1 Development Stage	Duration of Stage	Light sources
Offshore		
Stage 1: Mobilisation and installation of materials and equipment, pre-first oil drilling by MODU (13 wells), installation, HUC of the FPSO and 'first oil'	42 months	(including installation vessels, MODU, FPSO, support vessels, oil export vessels and potential flaring)
Stage 2: Post first-oil drilling by the MODU (17 wells), and concurrent production operations by the FPSO and oil export	29 months	(including MODU, FPSO, support vessels, oil export vessels and potential flaring)
Stage 3: Steady phase production	17.5 years	(including FPSO, support vessels, potential flaring and oil export vessels)
Inshore		
Stage 1: Anchoring and operation of floating logistics vessels (LTVs)	Intermittently for a total of up to 12 months	Up to four separate LTVs, Installation vessels

10.1.4.1.2 Location of light sources

Initial well clean up flaring will take place from the MODU, whereas any flaring carried out during production (Stage 3) will take place from the FPSO.

Most of the vessel activity that requires deck lighting will be based offshore at the site of the Phase 1 Development, which represents a fixed / permanent source of light.

Inshore, up to two Large Transport Vessels (LTVs) would be temporarily anchored in Berkeley Sound in support of the subsea construction campaign.

Deck lighting will have to be maintained by all vessels to provide a safe working environment.

When in transit to and from inshore waters, light will be limited to navigation lights in accordance with ColRegs (section 10.1.1.1).

10.1.4.1.3 Intensity of light

Luminous intensity is the amount of light emitted in a given direction and is the most useful measure of 'brightness' with regards to environmental impact. It is measured in candelas, which are a measure of light emission (lumens) per 'solid angle' (steradian), which gives an indication of light intensity received at a receptor. Candelas are used to describe navigation standards for shipping and aviation. There is generally a positive relationship between the power consumption of a light source (in kilowatts) and the amount of light emitted, which is known as 'luminous efficacy' and is measured in 'lumens per watt' (lm/W).

The intensity of light emitted by each vessel will vary depending on activity. At the time of writing the exact identity of the specific vessels involved is unknown; however, some good representative comparisons can be made with vessels operating elsewhere (Figure 10.1: above) and with reference to regulatory requirements.

Marguenie and van de Laar (2004) experimented with the lighting of a gas-production platform (gas production platform L5) in the North Sea to investigate the relationship between light intensity and bird attraction (reported in Poot *et al*., 2008). By disconnecting different sources of light, they were able to show that bird attraction was influenced by light intensity, although they were more concerned with migratory land birds than seabirds.

For illustrative purposes, Table 10.2: shows the power consumption of different lights on the L5 platform in Danish waters; this can provide a rough guide for light intensity as an increase in power consumption results in an increase in light intensity. It was thought that, at full intensity (30 kW) the light's influence extended 3-5 km from the platform. By way of comparison in the squid fishing industry, each jigger is equipped with lights totalling 300 kW and the fleet may contain up to 100 vessels within Falkland Islands waters.

The lights used on the MODU and large vessels are likely to differ from those on the L5 platform; however, it has been used as an example as information regarding the specific lighting specifications of the MODU or other vessels, are not yet available.

All vessels in the field (including the MODU, FPSO, standby vessel, and supply vessels) will, as a minimum, comply with the Collision at Sea Regulations (ColRegs) requirements for visibility. This requires vessels to maintain lighting that is visible over certain ranges. The lights in vessels of 50 m or more in length must be visible at the following minimum ranges:

- Masthead lights - six miles;
- Sidelights, sternlights and towing lights - three miles; and
- White, red, green or yellow all-round lights - three miles (Figure 10.2:).

The intensity of a light visible over 6 nautical miles will typically be 94 candelas (ColRegs Annex 1).

For helicopter landing, some key requirements of CAA standards for offshore helicopter landing areas (CAP 437) are as follows:

- The periphery of the landing area should be delineated by omni-directional green perimeter lights visible from up to 1.5 nm in good visibility with a minimum intensity of three candelas in the horizontal plane going up to thirty candelas from above;
- The touchdown circle must be yellow light with a minimum intensity of 15 candelas in the horizontal plane up to 60 candelas from above; and
- The green 'H' heliport marking must have a minimum intensity of 10 candelas in the horizontal plane up to 60 candelas from above.

Table 10.2: Examples of the power required by different light sources on gas production platform L5

Source	Source power consumption (kW)
Navigational lights (red and green)	0.3
Sodium floodlights of crane	1.5
Helicopter platform	0.16
Landing lights	0.48
Platform total mostly tube lights (400 x 36 W) and sodium floodlights (20 x 400 W)	30

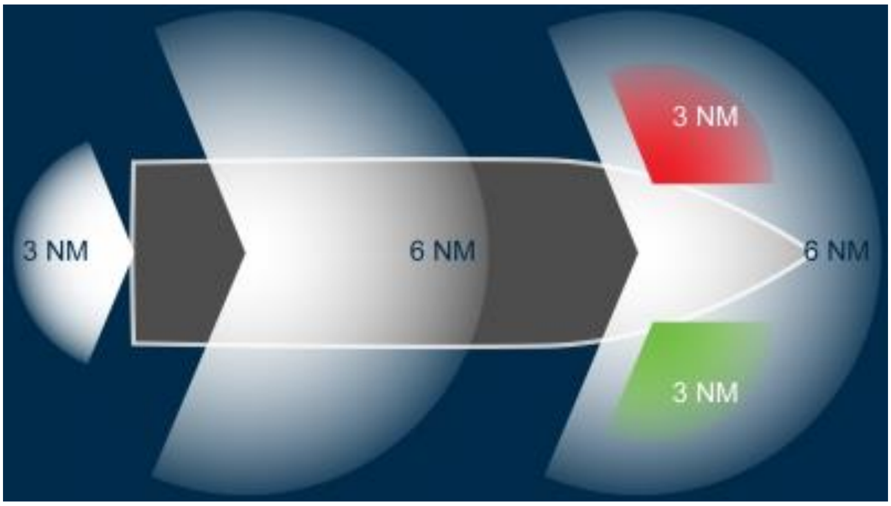


Figure 10.2: Navigational lighting requirements for a vessel over 50 m in length

10.1.4.1.4 Orientation of lights

Some lights, such as navigation lights, are designed to be seen by other vessels and therefore are orientated to face out-board. However, these are usually low intensity lights (Table 10.2: above; ColRegs, 2005). Helicopter platform and landing lights also face outwards, or upwards, to guide incoming aircraft; intensity is required to be highest near the horizontal plane and lowest in the vertical. These are also usually of relatively low intensity (Table 10.2: above).

The highest intensity lights are the deck or crane floodlights, which are generally orientated to illuminate any operational activity being undertaken on the deck of the vessel and surrounding water e.g. during supply boat transfers but can vary in orientation if following a moving load suspended on the crane.

Lights for escape purposes e.g. lifeboat positions must shine overside but their use is limited to actual use of the lifeboats or exercises.

During flaring the flame is emitted from the flare stack, the highest point on the rig or FPSO (away from any other infrastructure), and would be vertically orientated, with a possible flame height of approximately five metres.

10.1.4.2 Impacts of attraction to artificial light

10.1.4.2.1 Zooplankton, fish and squid

It is well documented that marine zooplankton are attracted to artificial light (Davies *et al*., 2014). Aggregations of zooplankton may then attract small fish, which in turn attract larger predatory fish or squid. This effect appears to be more pronounced with static light sources. This principle is very successfully exploited by jigger fishing vessels to catch Illex squid (Argentine shortfin squid, *Illex argentinus*; section 7.7.3.1.1).

Inshore, lobster krill is the 'species' most likely to be attracted to ships' lights that illuminate the water. These animals can form very dense shoals, which can attract predators and even interfere with a ship's ability to work by blocking water intake filters. Other species that may be attracted to ships' lights include squid (in the spawning season), and potentially rock cod, at the beginning of the calendar year through to March (P. Brickle pers. obs.).

Experimental trials to investigate the impacts on abundance and behaviour of fish in response to artificial light indicated that nocturnal lighting created conditions that potentially benefit larger, piscivorous (fish-eating) fish. This outcome was believed to result from both the concentration of prey and the foraging advantage afforded to visual predators (Becker *et al*., 2013).

There are relatively few commercially exploitable pelagic (water-column) fish species in the deeper waters of the NFB or inshore waters. Catch statistics indicate that hoki is the most abundant species in the NFB (FIG, 2014b); however, it is likely that unexploited species such as lantern fish (*Myctophidae*) are also likely to be present. Inshore, species such as Falkland sprat, tessellated rock cod and smelt are known to be present. section 7.4.4 contains further details regarding the distribution of fish in the NFB and inshore waters.

The spread of *Illex* squid catches indicates that there is considerable inter-annual variation in the distribution of this species. However, the distribution of fishing effort in some years indicates that a small proportion of the stock is likely to be near the Sea Lion Field during April and May (Waluda *et al*., 2008).

There are numerous other species of squid that are found within Falkland Islands waters. The most numerous of these is likely to be *Onykia ingens* (greater hooked squid), which is widespread at low density throughout the NFB but shows seasonal movement on and off the Shelf (Jackson *et al*., 1998; Arkhipkin *et al*., 2012b).

Inshore, loligo are very abundant off the east coast of the Islands. This species spawns inshore, animals migrate into deeper waters (to the edge of the Patagonian Shelf) as they grow before migrating inshore to spawn as they mature (section 7.7.3.2.1.1).

10.1.4.2.2 Seabirds

Seabirds take advantage of natural sources of light to find prey and to navigate. Both these essential life functions may be impacted by disorientation caused by artificial lights and flares. Seabirds may circle an artificial light source for prolonged periods using valuable energy reserves in a process which leads neither to feeding nor effective navigation, and both of which may result in exhaustion (c.f. NAM, 2007). Nonetheless, the greater impacts to seabirds result from the risk of collision with the light or flare, or landing on the vessel, both of which are characterised and quantified in section 10.1.4.3.1.

10.1.4.2.3 Marine Mammals

Literature reviews for this assessment have found no evidence that marine mammals would be attracted to artificial light directly. There may, however, be indirect impacts on marine mammals if they are attracted to feed on prey that are concentrated due to the presence of artificial light (section 10.1.6.3).

10.1.4.3 Risks associated with artificial light

10.1.4.3.1 Seabird collisions

Globally, there are issues regarding the interaction between birds and anthropogenic light sources. Birds can be impacted directly by a wide range of artificial light sources within marine environments. Of relevance to this assessment, they are often attracted to and collide with offshore hydrocarbon platforms (Ortego, 1978; Hope-Jones, 1980; Tasker *et al*., 1986; Baird, 1990; Wiese *et al*. 2001; Burke *et al*., 2005; NAM, 2007) and commercial fishing vessels and other boats using lights (Dick and Donaldson, 1978; Ryan, 1991; Arcos and Oro, 2002; Black, 2005a; Merkel and Johansen, 2011; Glass and Ryan, 2013).

The receptors can be broadly split into migratory land birds and seabirds. Although there is some seasonal movement of birds between the Falklands and South America, the location of the Sea Lion Field and Berkeley Sound are not regarded to be on the route of migrating land birds and therefore the potential risk to seabirds is of greatest concern.

Light generated by the Oil and Gas (O&G) industry, and other marine users, has the potential to lead to direct and indirect mortality from:

- The impact of a collision (OSPAR, 2012);
- Incineration in the flare - flaring is the most problematic form of artificial light at-sea, with a high risk of mortality posed to any birds flying too close to the flame (Hope-Jones, 1980; Montevecchi, 2006); and / or
- Loss of feather condition and hypothermia due to contact with the decks of vessels (Black, 2005a; Glass and Ryan, 2013).

Collisions between birds and vessels (known as bird-strikes) are episodic events that, in addition to influencing factors such as the amount and orientation of light (section 10.1.4.1), are related to a number of other variables including:

- Weather conditions (e.g. reduced visibility due to mist, fog or snow, and moon phase);
- Seabird behaviour (e.g. activity patterns, fledging); and
- Seabird abundance (e.g. large aggregations close to a breeding site)

The number of variables makes the risk of bird-strikes difficult to quantify. Nonetheless, when all of these factors align, hundreds of birds can collide with a vessel on a single night. Although the Sea Lion Field is not located near breeding colonies or areas of notably high seabird density, the impact of lighting has been estimated to extend to 3-5 km around offshore installations

(Marquenie, 2007) and therefore there is a risk of episodic bird-strikes throughout the life of the Development.

Berkeley Sound contains the largest known colonies of sooty shearwaters and white-chinned petrels in the Falklands and a large number of birds congregate at the entrance to the Sound throughout the breeding season (September to May) (section 7.4.5.3.2).

10.1.4.3.1.1 Direct and indirect mortality

With regard to the above, some individuals will be killed outright by a collision or contact with a flare, others may be injured, and others still may survive the initial impact.

The likelihood of direct mortality is species specific and relates to flight style, with species like diving-petrels colliding at great speed being more likely to be killed outright by the impact than larger petrels and shearwaters that have a gentler landing (Glass and Ryan, 2013).

Once on the deck however, petrels, in particular, find it difficult to become airborne as these birds only come to land to breed in burrows and, unlike land birds or gulls, are not well adapted to walking. Therefore, petrels will often seek shelter under gratings, containers etc. This behaviour can potentially lead to indirect impacts in two ways:

- Hypothermia and death caused by contamination of feathers given that the decks of ships can be covered with oily, greasy residues and hazards such as save-alls (devices intended to catch waste products and / or prevent losses) or detergents (MMS, 2010); and
- Condition loss and / or starvation caused by the time spent hidden away in nooks and crannies where they may stay for prolonged periods.

10.1.4.3.1.2 Seabird behaviour and susceptibility to artificial light and collision

Seabirds of all species can collide with any vessel at-sea whether at night or day. However, not all species are equally susceptible to light induced bird-strike. Diurnal albatrosses and petrels (i.e. active during the daytime) seem less likely to be involved in light induced bird-strikes than birds that are active at night (Wiese *et al*., 2001; Black, 2005a). However, fledglings of most species tend to depart from colonies at night and may be more vulnerable at this time. Attraction to artificial lights is particularly strong in small, planktivorous (plankton eating) procellariiform seabirds (i.e. petrels, shearwaters and storm-petrels) that remain active at night (Ryan, 1991; Black, 2005a).

It is unclear what exactly attracts birds to light but there are several theories:

- The most susceptible species feed on bioluminescent planktonic organisms that migrate close to the surface at night, and are therefore attracted to light sources (Imber, 1975).
- Light from the moon may be a navigational cue for some species of seabird (Montevecchi, 2006).
- In the absence of celestial light, on overcast nights, Poot *et al*. (2008) propose that artificial lights interfere with a bird’s magnetic compass. It is thought that the magnetic compass is linked to light receptors in the eye that require light of blue wavelengths to function; red light appears to impair this function (Poot *et al*., 2008).

Whatever the reason, it is clear that small petrels can collide with anthropogenic structures at-sea and die as a consequence (for examples see Ryan, 1991; Wiese *et al*., 2001; Black, 2005a; Glass and Ryan, 2013).

It is safe to assume that where artificial light exists at-sea there will be some interaction between vessels and seabirds, which will usually involve small numbers of individuals. However, in conditions of poor visibility (due to fog, snow or rain) the problem is exacerbated and more individuals are likely to interact with vessels emitting light.

Where artificial light, poor visibility and high seabird numbers coincide, 1,000's of birds may collide with a vessel on a single night. While there are no published records, light induced bird collisions with vessels, with varying numbers of birds affected, are a regular occurrence around the Falkland Islands (A. Black pers. obs.), elsewhere in the South Atlantic (Ryan, 1991; Black, 2005; Glass and Ryan, 2013) and elsewhere in the world (e.g. Wiese *et al*., 2001; Merkel, 2010).

10.1.4.3.1.3 Weather conditions and moon phase

Virtually every reported large bird-strike associated with artificial light at-sea is linked to weather conditions (e.g. Ryan, 1991; Black, 2005a; Merkel, 2010; Glass and Ryan, 2013). The probability that snow will fall on any given day is higher during the winter months than the summer months, so there may be a seasonal component to bird-strike statistics. Fog is generally related to wind direction and in the Falklands is more frequently observed during periods of north or north-easterly winds, which can be experienced at any time.

Additionally, the influence of artificial light appears to be greatest on moonless nights when there is limited ambient natural light (Montevecchi, 2006). The longer nights and poorer weather experienced during the winter months are therefore more conducive to bird-strikes.

10.1.4.3.1.4 Susceptible seabirds and their abundance

Bird-strikes reported by Ryan (1991), Black (2005a) and Glass and Ryan (2013) and observations on vessels in Falkland Islands waters (A. Black pers. obs.) indicate that the most vulnerable species groups in the South Atlantic are; prions, blue petrels, storm-petrels, diving-petrels, gadfly (Pterodroma) petrels and shearwaters. Most of these birds are migratory or widely dispersed during the non-breeding season, which results in seasonal patterns of abundance in the region of the Sea Lion Field. These species generally have very large population sizes, are found over extensive ranges and are mostly regarded as being of 'Least Concern' status by IUCN; however, sooty shearwaters are Near Threatened and some of the gadfly petrels (such as Atlantic petrel) are regarded as 'Endangered', due to a restricted breeding distribution and land-based threats.

With regard to abundance, it has been suggested that a mortality rate of >1 % of the natural mortality rate has the potential to have an impact at the population level (OSPAR, 2012). However, this approach can be problematic, not least because it is not possible to determine the size of many / any of the populations of the species most likely to be impacted. The impact of individual mortality is likely to be greater in species that are classified nationally or internationally as 'Declining', 'Threatened' or 'Endangered', in the NFB at Sea Lion these species include black-browed albatross, white-chinned petrel, sooty shearwater, southern royal albatross, northern royal albatross, Magellanic penguin, grey-headed albatross, wandering albatross, Atlantic petrel and rockhopper penguin (section 7.4.5.2.3).

Sea Lion Field

Data from the JNCC seabirds at-sea surveys was used to indicate the seasonal abundance of the most susceptible species near the Sea Lion Field and Berkeley Sound. Table 10.3: shows the relative abundance of each species recorded during JNCC seabird surveys (see White *et al*., 2002), the darker the colour the more abundant the species (each colour change represents an order of magnitude difference in bird density).

In the NFB, prions were generally the most numerous 'species' recorded in all months, although they were never encountered in very large numbers. Relatively high prion numbers were recorded during the winter months when the likelihood of snow (poor visibility) is also highest.

In addition to prions, small numbers of other potentially vulnerable species, such as blue, Atlantic and Kerguelen petrels may be present during the winter months. For example, Kerguelen petrels have been recorded as striking vessels (Premier, 2015d; Ryan, 1991; A. Black pers. obs.). This species is present, in relatively low numbers, within Falkland Islands waters during the winter months but absent during the summer months (Table 10.3: ; White *et al*., 2002).

Berkeley Sound

The waters near Berkeley Sound are numerically dominated by sooty shearwaters during the spring, summer and autumn months. The relative abundance of susceptible species is generally highest during the summer months (Table 10.3:), however, the shorter nights and lower likelihood of poor weather conditions at this time act to counter higher seabird numbers.

There is evidence to suggest that fledgling birds on their maiden flight are more susceptible to disorientation by lights than other birds (Troy *et al*., 2011; Rodriguez *et al*., 2015a and b) and therefore the sooty shearwater fledging period is likely to be the most critical time. The breeding phenology of sooty shearwaters has not been studied in-depth in the Falklands but young birds fledge (depart from the colony) throughout April and early May (Woods, 1988). Sooty shearwater mortality has been observed on a jigger departing from Berkeley Sound in early May 2014, when six out of 11 birds striking the vessel suffered broken wings or necks and died as a consequence (R. James pers. comm.).

Table 10.3: Relative species abundance within approximately 15 nautical miles of the Sea Lion Field (shaded areas indicate relative abundance)

Species	IUCN status	Relative seasonal abundance (see key below)							
		North Falkland Basin				Berkeley Sound			
		Sum	Aut	Win	Spr	Sum	Aut	Win	Spr
Prion species	LC								
Diving-petrel species	LC								
Wilson's storm-petrel	LC								
Grey-backed storm-petrel	LC								
Black-bellied storm-petrel	LC								
Great shearwater	LC								
Sooty shearwater	NT								
Little shearwater	LC								
Soft-plumaged petrel	LC								
Atlantic petrel	EN								
Kerguelen petrel	LC								
Blue petrel	LC								

Key: Relative abundance of seabirds (Data from JNCC database)

Not recorded	Very Low	Low	Moderate	High

10.1.4.3.2 Historical observations associated with O&G in the Falkland Islands

During the 2011 exploration drilling campaign in the NFB carried out by Rockhopper Exploration plc, observations from the ERRV recorded birds associating with the MODU but did not record any negative interactions (Munro, 2011). Most observations were made from a support vessel some distance from the MODU. In order to be able to detect small petrels at night, observations would ideally be carried out on board the vessel concerned (the MODU in this case); although for reasons of bed space and health and safety this can be difficult. Statistically, significantly more birds were recorded during the morning than the afternoon and it was suggested that this was due to attraction to lights during the night (Munro, 2011).

During the 2015 exploration campaign, Premier developed and implemented a Bird-Strike Management Plan (BSMP; Premier, 2015b) to monitor, record, report and mitigate (if required) bird strikes on the MODU and associated vessels. During Premier's 2015 exploration drilling campaign in the NFB there were no reports from the MODU but there were five records from supply vessels (Table 10.4:). All of these incidents were reported from supply vessels and at least three of the incidents were reported as having occurred in Stanley Harbour.

Given all that is described above, it is not possible to estimate the number of birds at risk from light induced bird-strikes during the life of the Phase 1 Development. However, from experience gained on vessels that operate in South Atlantic waters (Ryan, 1991; Black, 2005a; Glass and Ryan, 2013; A. Black pers. obs.) and on O&G platforms elsewhere (Hope-Jones, 1980; Tasker *et al*., 1986; Wiese *et al*., 2001), it is considered likely that some birds will collide with vessels involved with the Development.

Table 10.4: Bird-strikes reported during the 2015 Premier Exploration Drilling Campaign

Date	Species	Number	Weather	Location	Outcome
30th April	Sooty shearwater	1	Overcast / foggy	TDF	Injured
1st May	Sooty shearwater	1	Overcast / foggy	TDF	Injured
13th June	Kerguelen petrel	1	Occasional snow	52° 09' S, 55° 42' W	Released OK
14th June	Grey-backed storm-petrel	1	Not recorded	Not recorded	Oiled
31st August	Snipe	1	Clear	Stanley Harbour	Dead

10.1.5 Industry-standard mitigation measures

Good working practice and design will help to limit the amount of light pollution and reduce the risk of bird-strikes. However, as light is required to maintain a safe working environment, it is not possible to eliminate all sources of light (black-out) which must remain compliant with ColRegs (section 10.1.1.1).

Nonetheless, the Convention for the Protection of the Marine Environment of the North-East Atlantic (the 'OSPAR Convention') has published the following guidelines based on discussions at the 2012 OSPAR Workshop aimed at reducing potential lighting impacts on migrating birds and seabirds:

Guidelines to reduce the impact of offshore installations lighting on birds in the OSPAR maritime area (OSPAR Agreement 2015-08).

These guidelines recommend:

- Assessment of light sources:
  - All lighting equipment on offshore installations potentially emitting light outside the physical boundary of an installation should be assessed to determine whether the light is essential for safety reasons and whether there is the potential for reducing external emissions. As part of this process, photographs taken in the dark from outside the offshore installations can be used to detect significant light sources, including stray and spurious light sources, emitting light to the surrounding environment.
- Reduction of light emissions:
  - The lighting on offshore installations should be reduced to a minimum compatible with safe operations whenever and wherever possible. This includes the use of black out blinds, minimising the number of lights and the intensity of the lights and / or adapting the spectrum of the lights to bird-friendly lighting systems;
  - Unnecessary light sources should be removed, as far as possible;
  - In areas where lighting is not a continuous requirement, light sources should be automatically or manually controlled through the process control system. Normally unmanned platforms should have switches installed and during unmanned periods lights should be switched off apart from lighting requirement to comply with national and international regulations on aviation and shipping navigation; and

  - Where the use of automatic or manual light controls is impractical, the installation of light barriers (shielding) should be considered. This could be used, for example, in areas external to living quarters in order to ensure that adequate lighting is available on external steps but there are limited emissions outside the structure.
- Optimum alignment and light shields:
  - Light sources should, if possible and consistent with safe working practices, be positioned in places where emissions to the surrounding environment can be minimised. Additional shielding should also be installed, where practicable.

There are no industry standard mitigations available for initial well clean up from the MODU in terms of reduction of light impacts (but see also section 10.9).

During production, flaring will be minimised and the base case is for all excess gas to either be used as fuel on the FPSO or to be re-injected into the reservoir (sections 5.8.3.3 and 5.8.5.6.2).

10.1.6 Impact and risk assessment

The following section draws upon all the information provided above to assess the 'Sensitivity of the Receptor' and the 'Severity of Effect' in order to determine the overall 'Impact' of planned activities. Assessment of unplanned events includes an assessment of the 'Likelihood of Occurrence' to determine the 'Risk'.

A summary of the impact and risk assessment outcomes is tabulated in section 10.1.11 (Table 10.7:), which shows the worst case impact / risk for each activity and receptor.

10.1.6.1 Impact assessment of attraction to offshore artificial light

10.1.6.1.1 Attraction of marine life (zooplankton, fish and squid)

Any impact of the project's Phase 1 Development on zooplankton, fish and squid is expected to be very small and localised. Vessels in transit should only be displaying navigation lights, which are of low light intensity (section 10.1.4.1.3). Additionally, relatively slow moving plankton, fish and squid would be unable to maintain position alongside a moving vessel. Therefore, the impact on this group of receptors is likely to be greatest around the MODU, FPSO and stationary vessels; where the surface of the water may be illuminated. These animals may be attracted to the lights of the vessels but there is nothing to suggest that this should be regarded as a significant impact on these organisms, although there could be some indirect impacts. For example, squid and fish may be attracted to the vessels to feed on zooplankton and may in turn be an easier target for larger squid, fish, seabirds or marine mammals. Nonetheless, given that there is likely to be 'negligible numbers of any species of geographical importance' present within the 'zone of influence', **the sensitivity of this receptor group** is considered to be **'Very Low'**.

It is anticipated that the impact on zooplankton, fish and squid will be very localised (in the immediate vicinity of the vessels) and any impacts resulting from changing predation patterns will 'not be detectable above background variability' and / or will be 'reversible once activity ceases'. Therefore, the **severity of the impact** is assessed as **'Slight'**.

Therefore, the overall **significance of the impact** of artificial light on zooplankton, fish and squid is assessed as **'Very Low (1)'**.

10.1.6.1.2 Attraction of seabirds in the Sea Lion Field

As indicated in section 10.1.4.3.1.4, not all seabirds are susceptible to the impacts and risks associated with artificial light and flares. The available survey data indicate that there will be a low number of individuals of all of the potentially susceptible species present within the zone of influence of the Development (section 10.1.4.3.1.4). Although accurate population estimates are not available for all species, the biogeographical populations are known to be very large. Therefore, it is anticipated that the assemblage of birds within the zone of influence of the Development, at any given time, will not be of geographical importance (i.e. <1 % of the local population). As shown in Table 10.3: above, the species that are typically impacted in the southwest Atlantic have an IUCN status of 'Least Concern'. Atlantic petrels (IUCN 'Endangered') are occasionally sighted in the NFB but they are not considered to be a notable presence within the zone of influence of the Development. Therefore, the **sensitivity of the receptor** is considered to be **'Low'**.

In the absence of collision, mortality after contact with a flare or oiling of feathers (section 10.1.4.3.1.1), the severity of effect on seabirds from simple attraction to artificial lights or flares is expected to be minimal. While seabirds may be distracted from natural feeding behaviour, or may expend energy flying in circles around the vessel which has the potential to affect the body condition of the birds, the impact will be short-lived (a matter of hours) and should not have long-term consequences provided there is no contact between the birds and the vessel. Any effect will be localised and it is unlikely that impacts will be detectable above background variability. Therefore, the **severity of effect** of distraction by artificial light or flares (i.e. with no resultant contact with the vessel) to seabirds is considered to be **'Slight'**.

Therefore, the overall **significance of the impact** of distraction of seabirds by artificial light or flares (i.e. the birds do not come into contact with the vessel or flare) is assessed as **'Very Low (2)'**.

10.1.6.1.3 Attraction of seabirds in Berkeley Sound

As indicated in section 10.1.4.3.1.4, not all seabirds are susceptible to the impacts and risks associated with artificial light. Within Berkeley Sound, sooty shearwater is the species of greatest concern, although other species; such as, great shearwater, common diving-petrel, Wilson's and grey-backed storm-petrel are also thought to breed on Kidney Island and are present in the waters adjacent to the Sound. The colony of the IUCN 'Near Threatened' sooty shearwaters on Kidney Island is situated approximately 10 km from the proposed LTV anchorage location. The IUCN status indicates that the sensitivity of the receptor is 'Moderate'. However, Kidney Island is the largest of the known colonies in the Falkland Islands and represents a significant proportion of the biogeographic population (i.e. >1 % of the South Atlantic population). Although the shearwaters are only present for part of the year (September to May), the worst case **sensitivity of the receptor** is considered to be **'High'**.

In the absence of collision or oiling of feathers (section 10.1.4.3.1.1), the severity of effect on seabirds from simple attraction to artificial lights is expected to be minimal. Although sooty shearwaters do feed inshore, these birds gather in large numbers at the entrance to Berkeley Sound late in the day (between September and May) but do not return ashore to visit nest burrows until dusk. Experience from elsewhere in the world, suggests that lights do not prevent adult shearwaters from returning to their colonies and impact on fledglings is of greater concern (Rodriguez *et al*., 2015a and b). Therefore, the **severity of effect** of distraction by artificial light (i.e. with no resultant contact with the vessel) to seabirds is considered to be **'Slight'**.

Overall the **significance of the impact** of distraction of seabirds by artificial light (i.e. the birds do not come into contact with the vessel) is assessed as **'Low (4)'**.

10.1.6.2 Risk assessment of artificial light use

Given the number of variables that influence the potential for bird-strikes it is challenging to assess the risk of bird strikes with the Phase 1 vessels (section 10.1.4.1). It can be stated however, that collision with a vessel or installation, and then landing on a deck, may result in injury to a wild bird that is likely to have implications for the survival of the individuals concerned (section 10.1.4.3.1). Additionally, collision with a flare may result in mortality (10.1.4.3.1.1).

10.1.6.2.1 Risk of small scale seabird strikes in the Sea Lion Field

The sensitivity of the receptors in the Sea Lion Field is as described above in section 10.1.6.1.2. Therefore, the **sensitivity of the seabird receptors** impacted by artificial light has been assessed as **'Low'**.

Where a single bird-strike occurs, the effect is localised and it is unlikely that any impact will be detectable above background variability and therefore will not pose a threat to the populations of the species involved. Although birds may be killed, which is clearly undesirable, the **severity of effect** of artificial light at this scale is considered to be **'Slight'**.

The overall **significance of the impact** of small scale seabird strikes in response to artificial light and flares is considered to be **'Very Low (2)'**.

With regard to the likelihood of a single bird-strike event occurring, observations on other vessels operating within Falkland Islands waters indicate that these small scale events occur on a regular basis. Although the results of observations during the 2015 exploration drilling campaign suggest that these events occur less frequently, small scale bird-strike events, concerning low numbers of birds, are likely to occur on multiple occasions per year. Therefore, **the likelihood of a single bird-strike** is considered to be **'Likely'**.

The overall significance of the **risk of single bird-strike events** is therefore assessed as **'Low (4)'**.

10.1.6.2.2 Risk of multiple (large scale) seabird strikes in the Sea Lion Field

The sensitivity of the receptors in the Sea Lion Field is as described above in section 10.1.6.1.2. Therefore, the **sensitivity of the seabird receptors** impacted by artificial light and flares has been assessed as **'Low'**.

Multiple bird strike events can result in hundreds of bird mortalities in a single night, however, these events usually occur close to land (i.e. breeding sites) where some birds congregate at dusk. The Sea Lion Development is 200 km offshore, in an area that supports relatively low seabird densities throughout the year, and therefore it is not considered likely that multiple bird strikes will occur on a regular basis. The biogeographic populations of the most susceptible species are very large (millions of individuals). Like all seabirds, these species are relatively long-lived, reproduce slowly and have low natural adult mortality rates and so it is not anticipated that the impact of light induced bird-strikes from the Sea Lion Development will affect the local populations. Losses at this scale however, may add cumulatively to mortality caused by other sources of anthropogenic light. Additionally, stakeholder concern regarding this issue was expressed during scoping and has been raised as an issue within the Falkland Islands' Offshore Hydrocarbons Environmental Forum (FIOHEF, 2013); therefore, there is a need to identify opportunities for improvement through mitigation and controls, and to consult with project stakeholders. Therefore, the severity of effect of multiple seabird strikes caused by artificial light or flares is considered to be **'Moderate'**.

The overall **significance of the impact** of multiple seabird strikes in response to artificial light or flares is considered to be **'Moderate (6)'**.

With regard to the likelihood of a multiple bird-strike event occurring, such a strike is likely to occur less than once per year but more than once in 10 years. Therefore, the **likelihood of a multiple bird-strike** is considered to be **'Possible'**.

Therefore, the overall significance of the **risk of multiple bird-strike events** is assessed as **'Moderate (9)'**.

10.1.6.2.3 Risk of small scale seabird strikes in Berkeley Sound

The sensitivity of the receptors in Berkeley Sound is as described above in section 10.1.6.1.3. Therefore, the **sensitivity of the seabird receptors** is considered to be **'High'**.

Where a single bird-strike occurs, the effect is localised and it is unlikely that any impact will be detectable above background variability (considering the area is already subject to a high degree of light pollution from fishing vessels), and will not pose a threat to the populations of the species involved. The LTVs will only be present within Berkeley Sound for a limited amount of time (i.e. for up to twelve months). Therefore, the **severity of effect** of artificial light and losses of this scale is considered to be **'Slight'**.

The overall **significance of the impact** of single seabird strikes in response to artificial light is considered to be **'Low (4)'**.

With regard to the likelihood of a single bird-strike event occurring, observations on other vessels operating within Berkeley Sound indicate that these small scale events occur on a regular basis. Therefore, the **likelihood of a single bird-strike** is considered to be **'Likely'**.

Therefore, the overall significance of the **risk of single bird-strike events** is assessed as **'Moderate (8)'**.

10.1.6.2.4 Risk of multiple seabird strikes in Berkeley Sound

The sensitivity of the receptors in Berkeley Sound is as described above in section 10.1.6.1.3. Therefore, the **sensitivity of the seabird receptors** is considered to be **'High'**.

Multiple bird strike events can result in hundreds of bird mortalities in a single night, these events usually occur close to land (i.e. breeding sites) where birds congregate at dusk. However, the situation in Berkeley Sound is unusual in that the LTV anchorage location is situated approximately 10 km inshore of the breeding colony, so birds do not pass the site en route to the colony. This is significant as multiple seabird strikes are closely linked to weather conditions and occur when visibility is reduced due to fog or snow. Under these conditions, the deck lights of vessels may not be visible at a range of 10 km (i.e. the zone of influence is reduced). The severity of the impact would be higher for vessels entering or departing from the Sound, which would pass close to the colony on Kidney Island.

The greatest impact is likely to affect fledglings, which seem to be more susceptible to disorientation by artificial light than adults regardless of weather conditions. Fledging is a once in a life-time event that occurs over a period of several weeks for the entire population (during April and May). However, the overlap between LTV activity, and fledging is expected to be limited to the arrival of the last LTV to be anchored for approximately four months from c. mid Feb-2026.

There are records of bird-strikes in Berkeley Sound at this time (R. James pers. comm.), although this issue has not been investigated in great detail. However, the Sound has been the focus of shipping activity for many years and is a significant source of light pollution (section 10.1.9), nonetheless, the population of sooty shearwaters on Kidney has apparently increased (Woods and Woods, 1997; Clark *et al.,* 2019). Currently, there is considerable light pollution in Berkeley Sound from vessels engaged in transhipment, although this can vary considerably from year-to-year depending on squid (Illex) catches. However, the current impact is not thought to be a threat to the population of sooty shearwaters and therefore the **severity of the impact** of the additional light from LTVs is considered to be **'Minor'**.

The overall **significance of the impact** of multiple seabird strikes in response to artificial light from Inshore vessels is considered to be **'Moderate (8)'**.

The floating storage vessels (LTVs) will be present in the Sound for a combined period of up to twelve months for all LTVs. Nonetheless, it is likely that more than one multiple bird-strike may occur during this intermittent period and therefore the **likelihood of a multiple bird-strike** is considered to be **'Possible'**.

The overall significance of the **risk of multiple bird-strike events** is therefore assessed as **'Moderate (9)'**.

10.1.6.3 Indirect impacts and impact interactions

Other marine life may be indirectly impacted by artificial light and flares if it is attracted to food sources clustering beneath vessels. For example, where marine mammals are attracted to food sources which were initially attracted by the light, this may render marine mammals more vulnerable to underwater noise. Equally, diurnal birds may be attracted to additional food sources and, once attracted there is the risk of these birds colliding with the structure, flare or becoming contaminated from any minor oil spills.

Further, 'additive or synergistic' impact interactions (section 8.10) may occur where attraction of marine life and seabirds to artificial light or flares then increases the likelihood of other impacts, such as those associated with underwater noise (sections 10.4 and 10.5), operational discharges (section 10.7) or accidental spills (Chapter 12). An overview of the potential for impact interactions is provided in Chapter 13.

10.1.7 Project-specific mitigation measures

It is best practice to minimise any impacts to the marine environment and the amount of light spilling horizontally into the environment will be minimised where practical and possible.

10.1.7.1 Reducing light pollution

During the design process, the number of lights and light levels, on the FPSO topsides, and other external areas, must meet the requirements stated in the FPSO Field Design Specification. Specifically, '*the minimum and maximum luminance levels for general and emergency operating conditions shall be in accordance with IEC 61892-2*' (Premier, 2016e). OSPAR Agreement 2015/08 will also be followed in the Best Practical Environmental Option (BPEO) process during FPSO design.

Likewise, during the Direct Offtake the decks and water around vessels will be illuminated to provide a safe working environment and to facilitate monitoring of spills, leaks or other potential hazards.

Premier recognise there is a driver to minimise light pollution from all project vessels particularly in the South Atlantic region, to limit the incidence of bird strikes. A summary of the design and auditing procedures associated with the project vessels is provide in Table 10.5. However, while lighting will be minimised from a cost / maintenance perspective, there is limited opportunity to implement additional measures specifically designed to reduce the risk of bird strike.

Shielding of light is a possible method of limiting the intensity of light emissions in certain directions but, if done without proper thought or analysis, it can actually increase overall light emissions. For example, applying shielding after lighting has been designed can increase the illumination of the work area, whereas if it is applied as part of the lighting design it can reduce the required output of the lighting units. Intelligent shielding at the design stage can reduce attraction of birds to lighted structures and significantly reduce associated mortality (MMS, 2007). Lights can also be designed to minimise upward emissions where these are not required.

As shown in Figure 10.3 the issue of bird-strikes is recognised by the cruise ship industry in the Southern Ocean and the International Association of Antarctic Tour Operators (IAATO) has guidelines for their vessels, which have been adopted by other operators in the region. Some of these measures are practical for use on the FPSO, supply and installation vessels, the ERRV and the MODU. These include:

- Dousing of deck lighting on supply vessels when not in use, necessity and emergencies notwithstanding; and
- Dousing of helideck landing lights when not in use and at night, if this is permissible (e.g. helidecks may need to be kept available to third-party aircraft in distress).

Elsewhere in the South Atlantic, the issue of bird-strikes on fishing vessels operating around Tristan da Cunha has been managed through a strike policy of blacking-out at night (Glass and Ryan, 2013). However, this is clearly not feasible in an industry that operates 24 hours a day.

As far as possible without increasing safety risks, it should be an aim to coincide planned flaring, such as blowdowns in preparation for periods of maintenance, with daylight hours. This intent will be carried forward into the flaring policy in the FPSO operating procedures. Monitoring of light-related impacts forms a part of the EMMP and further mitigation will be discussed should adverse impacts be identified.

Table 10.5: The design and auditing procedures associated with lighting on project vessels

Vessel	Design / auditing procedure
FPSO	There is the opportunity to focus on lighting at the design stage of FPSO, which may help to reduce the lighting output. Overall, the design intent will be to ensure the right level of light coverage to extend to the edges of structures (where there are often walkways and escape routes). Attempting to shield individual lights onto focused areas will likely lead to neighbouring areas not meeting the specified minimum values and hence, additional lights would be required, which may ultimately serve to increase the overall level of light pollution. Application of OSPAR 2012.
MODU	The MODU will undergo a strict regime of acceptance audits in line with Premier's rig acceptance processes. Part of these audits, albeit primarily for safety, will include a lighting survey which may identify unwanted light emissions and recommend practical shielding and operational practices to minimise unwanted light taking account of safety and operational requirements (application of OSPAR, 2012). The outputs of this survey will be incorporated into the Master Corrective Actions Register for the rig along with all other HSE actions. Crew inductions will include information about the risks of unnecessary light alongside other HSE priorities. The BSMP will feed back into ongoing operational adjustments and incident resolution.
Contracted third-party vessels	Premier has limited control over third-party vessels; nevertheless the importance of minimising light will be communicated to contractors tendering for the work and they will be asked to make a statement on their proposals to minimise unwanted light as part of their tender evaluation. Ongoing operational reviews and crew inductions will include information about the risks of unnecessary light. Premier vessels representatives will be responsible for ensuring bird-strikes are recorded and incidents resolved satisfactorily.
CTT	Site-specific HSE priorities including unwanted lighting will be communicated to incoming CTTs and all vessels hired by Premier. Support vessels will communicate directly with any vessel that appears to be emitting unnecessary light to minimise sources.

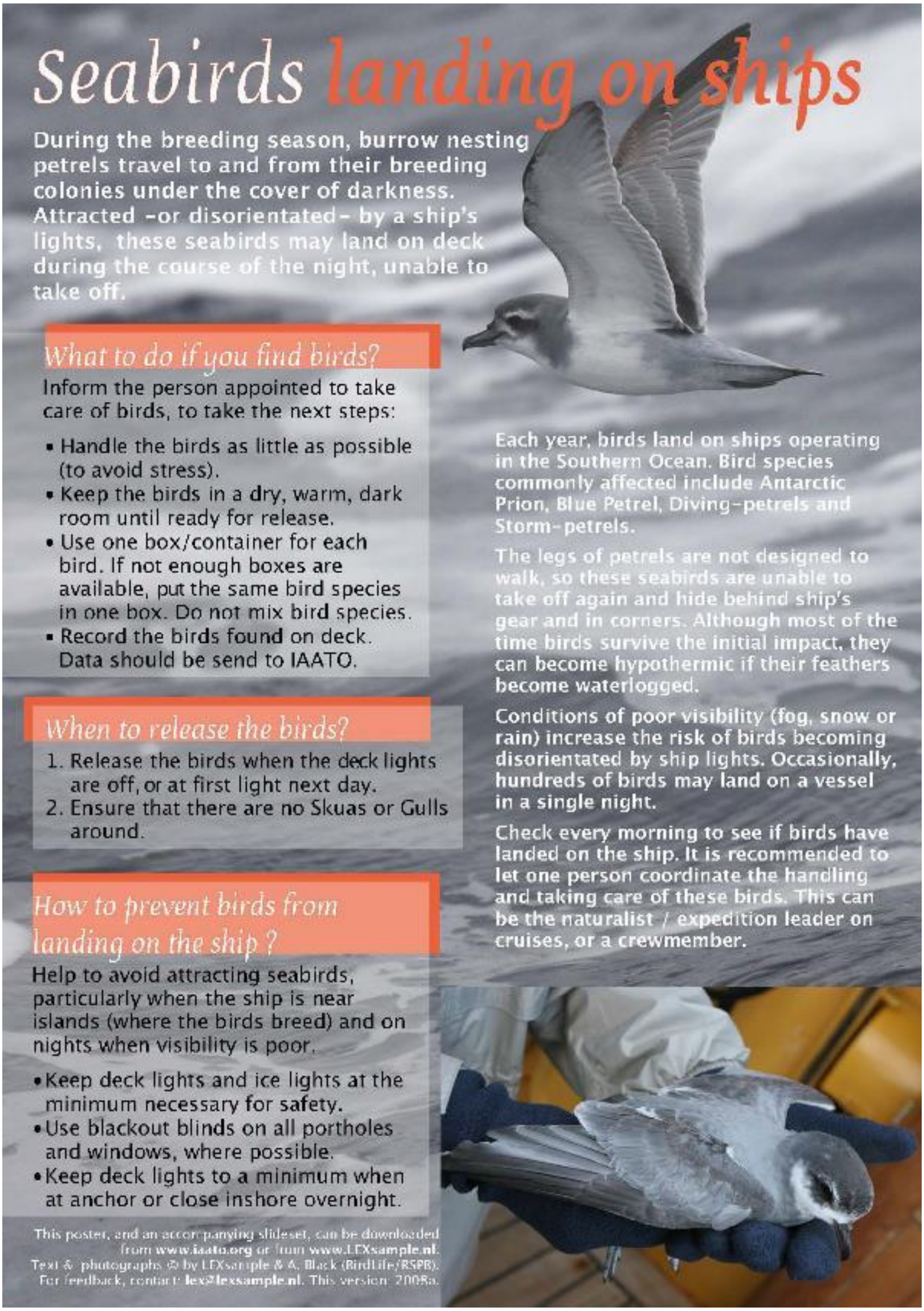


Figure 10.3: Example of an educational poster for the management of birds on deck (source: www.LEXsample.nl)

10.1.8 Residual impact

The impacts on zooplankton, invertebrates, fish and seabirds associated with artificial light offshore are considered to be of **'Very Low'** or **'Low'** significance such that no mitigation measures are considered necessary.

However, the risk of large scale seabird collisions in offshore waters of the NFB and both small and large scale seabird collisions in Berkeley Sound is **'Moderate'**. While numerous mitigation options exist that may be incorporated into the design of vessels, until independent monitoring data indicate that these are effective, the risk of collisions must remain the same as described above.

10.1.9 Cumulative impacts

Under natural conditions, the only sources of light at-sea are moonlight, starlight and bioluminescence. In addition to the artificial lights from the Phase 1 Development, there are currently several other sources of anthropogenic light in the wider area of the NFB and in Berkeley Sound which can lead to cumulative impacts from increased 'concentration' and increased 'extent and proportion' (section 8.10.1).

10.1.9.1 Sea Lion Field

The most significant source of artificial light in the southwest Atlantic is the Illex (Argentine shortfin squid) jigging fleet (Table 10.6 ; Figure 10.4 and Figure 10.5). Over recent years, the number of jiggers fishing within the Falkland Islands EEZ peaked at about 100 vessels (FIG, 2013c, 2014b and 2015u). The distribution of these vessels can be followed via satellite images (Rodhouse *et al*., 2001; Waluda *et al*., 2008), which have been used to quantify fishing effort. The presence of Argentine shortfin squid, and the vessels that fish for them, within Falklands waters is seasonal and the licence period extends from February to June (FIG, 2014b). Therefore, jigger fishing vessels represent a seasonal high intensity source of anthropogenic light in the NFB (Table 10.6).

A small number of jiggers have Falkland Islands Fisheries Department observers deployed on board every year, which has provided some evidence of interactions between these vessels and seabirds inshore. For a short period, dedicated seabird observers were deployed on jiggers to assess the degree of seabird bycatch on these vessels. Although the focus of these observations was interactions between seabirds and fishing gear, there was no evidence to suggest that these vessels had a significant bird-strike problem (Wolfaardt *et al*., 2010). It is not clear why bird-strikes are not a more significant issue on jigger vessels. It could be that the lights are so bright that birds are able to see the superstructure of the vessels and therefore avoid collisions; however, this remains unproven. Some jiggers (especially Korean vessels) use lights that are tinted green. Studies in the North Sea (Poot *et al*., 2008) have shown that the wavelength of light emitted influences the behaviour of birds. However, many jiggers appear to use white light so this would not mitigate the fleet as a whole.

The additional light of the MODU and supporting vessels will add to light emitted by other vessels in the NFB and therefore adds to the extent of artificial light and proportion of seabird populations exposed to artificial light in the NFB. However, it is not anticipated that this will constitute a significant cumulative effect due to the overwhelming influence of the jigging fleet. Nonetheless, the Sea Lion Development vessels will be operating year-round, whereas the presence of fishing vessels is seasonal. Additionally, the effect of artificial light attracting birds to the Development site may expose these birds to other impacts, such as accidental spills, that they would otherwise not be exposed to, although it is noted that accidental spills are not solely related to O&G operations.

10.1.9.2 Berkeley Sound

Places of human settlement and industry ashore represent permanent sources of light pollution. In the Falklands, these are primarily associated with the two major population centres, Stanley and Mount Pleasant Complex (MPC). Additionally, Berkeley Sound is used as an anchorage for the trans-shipment of fish and is also a significance seasonal source of light pollution.

Sources of existing anthropogenic light within Berkeley Sound are summarised in Table 10.6 . Notably, the jiggers described above utilise Berkeley Sound to tranship their catches to refrigerated cargo ships known as ‘reefer’ vessels and to refuel. Although the full rig of jigging lights are not deployed in Berkeley Sound, there is a considerable amount of light emitted from these vessels, the glow from which can be seen from Stanley (A. Black pers. obs.) and can also be seen from space, resembling a small town (Figure 10.6). In addition to the jiggers, other vessels use Berkeley Sound as an anchorage, primarily for the transhipment fish catches.

Although vessels can be present in all months of the year, activity peaks between March and June when tens of vessels can be present. Combined, these vessels represent a large source of anthropogenic light. The inshore floating storage vessels (LTVs) will add to this with varying degrees of significance depending on timing / season. The period of greatest conservation concern is linked to the sooty shearwater fledging, which occurs in April and early May. This period also coincides with one period of LTV activity (i.e. one LTV to be anchored for approximately four months from c. mid Feb-2026) and will therefore have the least impact on cumulative light pollution.

At other times of the year, there may be very few vessels using Berkeley Sound and therefore the LTVs will add considerably to the ambient level of light pollution but these are likely to be periods when very few susceptible receptors are present.

The data presented in Figure 10.5 and Figure 10.6 are a composite of the data collected over the period of a year (2007 in this case) to display the average light intensity. Vessel activity within Berkeley Sound is highly seasonal and therefore the light intensity within the Sound during the period of peak vessel activity (March to May) will be considerably higher than illustrated (For example, the value for a light only detected half the time is discounted by 50 %). The year 2007 was chosen as this represents an ‘average’ fishing year within the available data range.

Table 10.6 Other sources of artificial light in the NFB

Source	Light source	Seasonality / frequency	Description
NFB			
Coasters / Freighters / Tankers	Navigation lights; Accommodation lights.	Year round	Several shipping routes pass close to the Sea Lion Field (see section 11.1.4.4.1)
Finfish trawl fleet	Navigation lights; Accommodation lights; Deck lights.	During two fishing seasons (Feb to May and Aug to Nov)	Operates along the edge of the continental slope (200 m depth contour) approximately 50 km to the south and west of the Sea Lion Field (section 11.1.4.4.1). Although these vessels often stop fishing at night, deck lighting may remain on throughout the night.
Illex jigging fleet	Navigation lights; Accommodation lights; Deck lights; Squid jigging lights.	Between February and June	Operates over the continental shelf to the south and west of the Sea Lion Field. These vessels use powerful arrays of lights (up to 150 bulbs totalling 300 kW per vessel) to attract squid to jigging lures. The size of the jigger fleet and distribution of fishing effort are related to squid abundance, which can vary considerably from year-to-year.
Berkeley Sound			
Reefers	Navigation lights; Accommodation lights; Deck lights.	Peak activity during the Illex season (March to June)	The number of reefers varies considerably from year-to-year and is closely linked to the amount of Illex squid caught each year.
Finfish trawl fleet	Navigation lights; Accommodation lights; Deck lights.	During two fishing seasons (Feb to May and Aug to Nov)	Trawlers are licensed to fish in two seasons and can be present in small numbers in most months of the year. However, due to the generally small catch these vessels visit Berkeley Sound far less frequently than jiggers
Illex jigging fleet	Navigation lights; Accommodation lights; Deck lights; Squid jigging lights.	Between February and June	During periods of good fishing, each jigger, in a fleet of approximately 100 vessels, may visit Berkeley Sound on a weekly basis. However, catches show very high inter-annual variation (section 7.7.3.1.1). Jiggers tend to use 4-6 of the fishing lights to illuminate the deck when transhipping.

Figure 10.4: Jigging vessel fishing at-sea in Falkland Islands waters

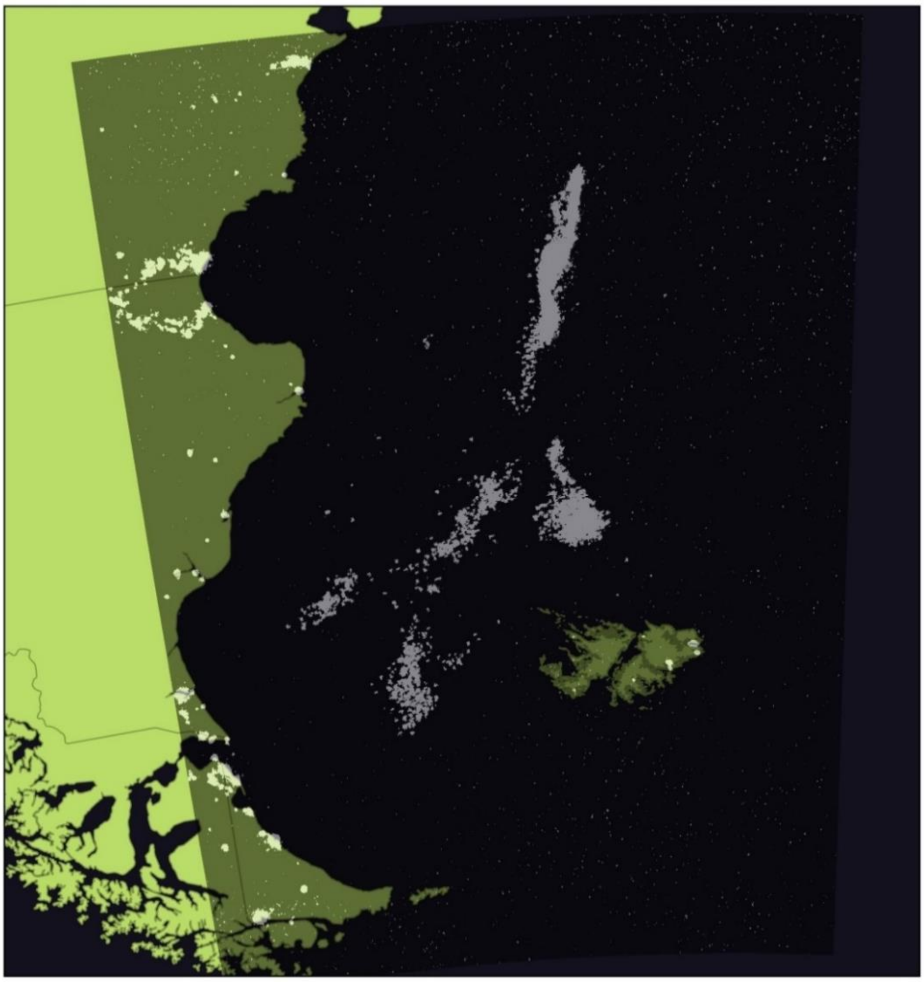


Figure 10.5: The distribution of anthropogenic light in the southwest Atlantic, 2007 (Credit: Earth Observation Group, NOAA National Geophysical Data Center)

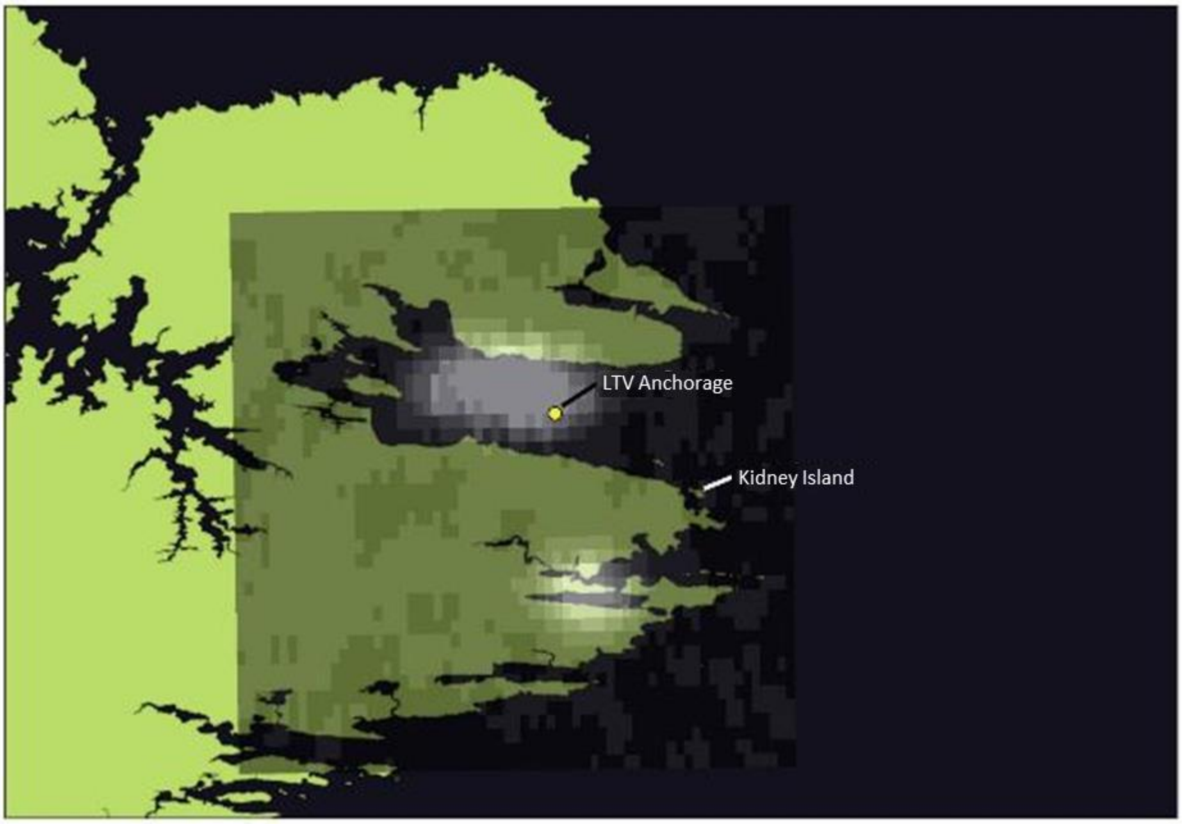


Figure 10.6: The distribution of anthropogenic light in the region of Berkeley Sound, 2007 (Credit: Earth Observation Group, NOAA National Geophysical Data Center)

10.1.10 Confidence

While the approximate timing and type of vessels used during the Phase 1 Development of the Sea Lion Field is known, the intensity and orientation of lights on the FPSO, MODU, and other vessels are not quantified, although representative, analogous examples have been used in this assessment. Additionally, there is the potential that flaring may be undertaken on up to four well clean ups, and will be undertaken periodically during planned / unplanned shutdowns, during commissioning and in the event of emergency blowdowns.

The nature of the impact on the environmental receptor is understood, however, the scale of the potential impacts and risks are difficult to predict due to their episodic nature; this is acknowledged as a data gap. Some monitoring data exist from previous Falklands campaigns and although short-term, this did not directly record a significant issue with bird-strikes. While some specific survey data exist for seabirds in the wider NFB and the area around the Sea Lion Field, these data are limited to very short time points and lack good spatial coverage over several years that would take into account the temporal and spatial variability of such mobile species. Therefore, although it can be assumed that some birds may be killed as a result of bird-strikes, it is not possible to predict the potential impact in quantitative terms.

The use of deck lighting, occurrence of potentially susceptible species (albeit in low numbers offshore) and the likelihood of poor weather conditions (reduced visibility) combined suggest that some incidents of bird-strike are likely to occur throughout the life of the Development. Premier's BSMP will help to determine the accuracy of this assessment and inform future management plans. The initial focus of the BSMP is monitoring, but also includes awareness training for workers on the rig and other vessels. The information collected should help to better assess whether bird-strikes associated with the O&G industry are an issue in the Falklands and prompt additional mitigation, if required.

With the available data, the level of confidence in the impact predictions (in terms of the nature of the impact and its level of significance) is considered to be **'Probable'**. Additionally, the data gaps are not considered to have the potential to significantly change the outcome of the assessment.

10.1.10.1 Monitoring required

As during the 2015 exploration drilling campaign, Premier will develop and implement a BSMP, which describes the processes required to monitor, record and report seabird interactions during the Development.

The Bird Collision Observation Form will be submitted to FIG on a monthly basis (at a minimum) and the contributing factors for the events that result in bird-strikes will be reviewed. If it is determined that any bird-strike events have similar contributing factors, or a trend is identified, the most appropriate mitigation measure will be identified and implemented.

Opportunistic observations of rare events have highlighted the potentially deleterious nature of bird-vessel interactions (e.g. Ryan, 1991; Black, 2005a) and observations were made of bird-strikes during the previous exploration campaign. However, systematic observations by trained independent observers would provide more valuable data towards better understanding of bird / vessel interactions.

Offshore, Premier will use independent Seabird and Marine Mammal Observers (SMMOs) on support vessels and investigate the possibility of a collaborative survey with Falkland Islands Fisheries Department (FIFD), potentially using the fisheries patrol vessel as a platform. A seabird distribution monitoring programme will be developed over several years with an understanding of ongoing work and in collaboration with FIFD, if possible. This will cover the offshore area, transit zones and targeted onshore colonies. Dedicated seabird observers will be deployed offshore during any initial well test and commissioning flaring to quantify any impacts.

Detailed monitoring requirements have been established during the Environmental Monitoring and Management Plan (EMMP) workshop (Chapter 15).

The practicalities of adopting the OSPAR green lighting strategy will be investigated during the project engineering phases as a potential mitigation against bird-strikes. Premier will also investigate a pilot-free flare design using an automated ignition system.

All monitoring requirements agreed by Premier and FIG will be recorded and managed via the project-specific Phase 1 EMMP (an outline EMMP is provided in Chapter 15).

10.1.11 Offsetting

For significant residual and impact and risks (Moderate or above), offsetting via an Environmental Fund is proposed, see section 8.9 for further details.

10.1.12 Findings summary

Table 10.7: Summary of the impacts and risks associated with artificial light offshore and inshore arising from the Phase 1 Sea Lion Development

Activity	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Presence of all vessels / MODU / FPSO	Deck and accommodation lights and flaring during shutdowns	Attraction of plankton, invertebrates and fish	Planned	1, 2 & 3	Very Low	Slight	n/a	Very Low (1)	n/a	Probable	Industry-standard: Use of blackout blinds Project-specific: None proposed
		Attraction and disorientation of seabirds offshore			Low	Slight	n/a	Very Low (2)	n/a	Probable	
Presence of all vessels in Berkeley Sound	Deck and accommodation lights	Attraction and disorientation of seabirds inshore	Planned	1 & 2	High	Slight	n/a	Low (4)	n/a	Probable	
Small scale bird collisions offshore	Deck and accommodation lights Flaring	Injury or fatality to single / handful of birds	Unplanned	1, 2 & 3	Low	Slight	Likely	Low (4)	n/a	Probable	Industry-standard: Use of blackout blinds; Project-specific:

Activity	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Large scale bird collisions offshore	Vessel deck and accommodation lights Flaring	Injury or fatality to multiple (dozens) birds	Unplanned	1, 2 & 3	Low	Moderate	Possible	Moderate (9)	Moderate (9)	Probable	Reduce light pollution by: Design and auditing; and Dousing of unrequired lights.
Small scale bird collision inshore	Deck and accommodation lights	Injury or fatality to single / handful of birds	Unplanned	2 & 3	High	Slight	Likely	Moderate (8)	Moderate (8)	Probable	Industry-standard: Use of blackout blinds; Project-specific: Reduce light pollution by: Design and auditing; and Dousing of unrequired lights
Large scale bird collision inshore	Deck and accommodation lights	Injury or fatality to multiple (dozens) birds	Unplanned	2 & 3	High	Minor	Possible	Moderate (9)	Moderate (9)	Probable	

a See Chapter 8 for definitions of sensitivity, severity, likelihood and significance.

10.2 Onshore disturbance to wildlife from helicopter use

Table of Contents

10.2 Onshore disturbance to wildlife from helicopter use

10.2.1 Introduction

There is the potential for aircraft noise to impact upon colonies of penguins and seals (Hughes *et al*., 2008) and also to impact upon livestock and the human population. Concern over such impacts was raised by stakeholders during the scoping consultation (section 6.3).

This chapter investigates the potential for disturbance caused by the use of helicopters on penguins and other wildlife during the transport of personnel to and from the offshore Sea Lion Field. The potential for disturbance to livestock and the human population from helicopter noise and other sources of noise is described in section 11.8.

Note: the other impacts associated with helicopter use e.g. atmospheric emissions, are described elsewhere in this document, as described in 9.2.

10.2.1.1 Relevant legislation

There are numerous pieces of International and Overseas Territory legislation in place to govern air safety which are out with the scope of this EIA which is only concerned with environmental impact and risk.

Aviation activities within the Falklands specifically are overseen by Falkland Islands Civil Aviation Department (FICAD). Their work is principally governed by the following:

- Air Navigation (Overseas Territories) Order (AN(OT)O) (2013); and
- International Conventions and Standards ('Rules of the Air').

While no legislation is in place specifically with regards to the environmental impacts of disturbance, guidelines have been developed in the Falklands, and elsewhere, to minimise the impact due to concerns over disturbance to wildlife and livestock from low flying aircraft. Detail on these guidelines are provided in section 10.2.5 below under Industry-Standard mitigations.

10.2.2 Sources of helicopter noise during the Phase 1 Development

During the Phase 1 Development the use of helicopters will be required:

- To carry personnel and / or equipment to and from the Mobile Offshore Drilling Unit (MODU) and the Floating Production, Storage and Offloading (FPSO) vessel in Stages 1 and 2;
- To carry personnel and / or equipment to and from the FPSO in stage 3;
- To carry a Falklands marine berthing crew to and from the purchaser's Conventional Trading Tanker (CTT) prior to each Direct Offtake operation; and
- For Search and Rescue (SAR) exercises and test flights.

10.2.3 Potential receptors

The ENVironmental Impact IDentification (ENVIID) workshop was used to identify the specific receptors upon which the impacts and / or risks associated with helicopter use warranted further investigation (Chapter 9). The specific receptors that may be impacted include:

- Seabirds (section 7.4.5); and
- Marine mammals (seals) (section 7.4.6).

In the Falklands, the most vulnerable receptors are breeding and moulting penguins; a number of species of which will be present on land throughout the year. Similarly, seals haul-out regularly throughout the year on the Falkland Islands to rest and breed.

10.2.4 Characterising and quantifying the impact of helicopter noise on wildlife

10.2.4.1 Nature of potential impact to wildlife

10.2.4.1.1 Seabirds

Aircraft are increasingly used to support research and other operations in remote environments, such as the Arctic and Antarctic. Although there has been little dedicated research into the effects of disturbance on wildlife, with most evidence coming from opportunistic observations, there is a strong suggestion that low flying aircraft result in both behavioural and physiological changes in penguins and seals (Culik *et al*., 1990; Cooper *et al*., 1994; Southwell, 2005).

Low flying aircraft may invoke particularly strong behavioural responses in penguins, which could lead to trampling of adults, chicks and eggs, and / or the loss of exposed eggs and chicks to predators. Indeed, one well publicised (though unverified) incident of mass mortality of approximately 7,000 king penguins on Macquarie Island was linked to panic caused by the over-flight of a C-130 Hercules aircraft (Rounsevell and Binns, 1991; Cooper *et al*., 1994). While a few studies have already linked helicopter activity with local population declines (Thomson, 1977; Wilson *et al*., 1990), incidents such as that on Macquarie Island have led to more dedicated research.

The most comprehensive study of the impacts of aircraft noise on penguins was carried out by Hughes *et al*. (2008) at a king penguin colony on South Georgia. This study aimed to quantify the short-term effects of helicopter overflights, with emphasis on:

- The relative effects of different overflight altitudes on behaviour;
- Whether noise levels are associated with specific levels of disturbance; and
- Whether penguin responses change with repeated overflights.

Although no mortality was recorded, the results of the study found significant changes in penguin behaviour during all overflights (at altitudes between 230 and 1,768 m). Differences in behavioural response were recorded between incubating and non-incubating birds with birds sitting on eggs tending to remain in place and non-incubators moving away from the approaching helicopter. Pre-overflight behaviour resumed within 15 minutes of the aircraft passing overhead and no chicks or eggs were taken by predators as a consequence of the behavioural response to the overflights.

In terms of the specific cause of the impact, no relationship was observed between helicopter *noise level* and penguin behavioural response in this study. Although the sound of the helicopter is likely to be an important factor, it is understood that the visual disturbance is the greater contributor to the changes in the penguins' behaviour. As a helicopter approaches, the colony becomes silent and penguins, and other birds, look upwards and follow the aircraft as it passes (A. Black pers. obs.). Cooper *et al*. (1994) suggested that penguins react to the visual appearance and size of the helicopter as they would do a natural aerial predator, such as skua or gull. However, as the study of Hughes *et al*. (2008) progressed, the penguins exhibited a reduced behavioural response to overflights suggesting a degree of habituation to aircraft.

In conclusion, to minimise disturbance to king penguins, Hughes *et al*. (2008) recommended a precautionary approach and suggested that overflights occur at the maximum altitude that is operationally practical, or preferably, that colonies are avoided altogether.

With regard to physiological impacts, a number of studies have investigated the relationship between behavioural response and physiological stress in penguins (for example, Ellenberg *et al*., 2006; Ellenberg *et al*., 2007). The results indicate that even in the absence of a behavioural response, in incubating birds for example, the animal is still subjected to stress as is evidenced by changes in physiological indicators, such as heart rate, and increased body temperature (Sladen *et al*., 1966; Regel and Pütz, 1997). Therefore, the fact that incubating birds did not move from their nest sites does not necessarily indicate the absence of an impact from helicopter overflights. Breeding and other activities, such as moulting, all have associated energy costs and disturbances from helicopter overflights that cause animals to move, or induce a physiological stress response at this time would incur an additional burden in terms of energetic cost. Such physiological stress has been linked to reduced breeding success in penguins and other seabirds (Regel and Pütz, 1997). Moulting penguins fast for about a month and during this time birds lose over 40 % of their body weight (Williams *et al*., 1992) such that additional energy expenditure could lead to starvation or have chronic impacts on the survival of individuals (Regel and Pütz, 1997).

10.2.4.1.2 Seals

Seals haul-out throughout the year to rest and to aid thermoregulation and digestion, and therefore this behaviour is an essential part of the animal’s routine. If disturbed while on land, seals will usually depart for the water thus escaping the perceived threat. If seals are continually disturbed, the physical exertion and energy expended to haul-out repeatedly, combined with inefficient digestion of food, could disturb the balance of the animal’s energy budget and have chronic impacts on survival and reproduction.

Although seen onshore throughout the year, the most sensitive period for these animals is the breeding season. Fur seals and sea lions display complex territorial or harem behaviour, which helps to maintain the genetic fitness of the population. Continual disturbance could interfere with the breeding behaviour of these animals leading to unforeseen consequences for population fitness (French *et al*., 2011). Additionally, young animals can become separated from their mothers and therefore from their source of food.

There has been some dedicated research to investigate the impact of disturbance to lactating southern elephant seals. Arnbom *et al.* (1997) found that lactating bouts were shorter in stressful environments, which resulted in pups with lower weaning weights than found in undisturbed pups. Given that elephant seal pup weight at weaning is directly related to its chances of survival in its first year (McMahon *et al*., 2000) there is a direct link between disturbance and pup survival rate.

As a worst case, it is apparent that some responses of seals to disturbance can be associated with reduced survival and reproduction. However, other less severe responses, such as increased alertness, can be temporary and have little or no impacts on fitness. As with seabirds, the degree of response is linked to the proximity of the aircraft to the animal (Southall, 2005).

10.2.4.2 Quantifying the impact of helicopter disturbance on wildlife

When quantifying the potential impacts of helicopter disturbance on wildlife, it is necessary to consider the following:

- The proposed helicopter activity during the Development;
- Helicopter noise levels;
- The distribution of helicopter-sensitive wildlife; and
- The overlap between helicopter flight paths and seal, sealion and penguin distribution.

10.2.4.2.1 Proposed helicopter activity during the Phase 1 Sea Lion Development

As detailed in the project description (section 5.11.3.1), helicopter flights will occur most frequently during Stage 2 of the Development when routine flights to the MODU and FPSO may occur up to three times per week and crew changes will occur every two weeks, along with SAR test flights and exercises.

It is likely that crews arriving at Mount Pleasant Airport (MPN) on the fixed-wing flight will be transported by road to Stanley airport, where the helicopters are based, prior to being taken offshore. However, in some instances, the helicopters will collect crews directly from MPN before transporting them offshore, and crews returning will be taken directly to MPN. At the time of writing, it is possible that the SAR aircraft will be based at MPN rather than at Stanley Airport and that the test flights will be conducted in the vicinity of MPN. A summary of the estimated number of helicopter flights that will occur is provided in Table 10.8 .

Detail on the proposed flight paths are provided in section 10.2.4.2.4 below.

10.2.4.2.2 Helicopter noise levels

The noise received by a receptor on the ground is related to a helicopter's altitude and prevailing weather conditions at the time. Disturbance to wildlife is not purely due to noise (as explained in section 10.2.4.1) but is an important contributor to disturbance. Note that there are no sound level thresholds for disturbance in terrestrial wildlife (or marine animals when on land) and research indicates that there is no direct relationship between noise level and behavioural response (Hughes *et al*., 2008).

While helicopters are widely used in the oil and gas (O&G) industry, there is little data available regarding the sound level generated in-flight. Sound levels are measured in decibels (dB), which is a logarithmic scale and, in effect, an increase in sound level of 10 dB is equivalent to a doubling in the perceived sound level.

Table 10.8 Number of helicopter flights during the Phase 1 Development

Helicopter activity [a]	Stage 1 (39 months)		Stage 2 (30 months)		Stage 3 (17.5 years)	
	Frequency of flights	Number of flights	Frequency of flights	Number of flights	Frequency of flights	Number of flights
Crew change to MODU / FPSO	8 / fortnight	456	8 / fortnight	592	5 / fortnight	2,600
Berthing crew transfer to CTT	n/a	n/a	1 / fortnight	74	15 per year	300 [a]
Routine flights	2 / week	226	3 / week	444	n/a	n/a
SAR training	17 / month	442	17 / month	578	17 / month	4,080
Total number of flights per Stage	-	1,124	-	1,762	-	7,500
Total	10,386					

a Averaged over the 17.5 year production life

The noise experienced on the ground will be directly related to the distance between the helicopter and the listener. One study, looking at the impact on human health, reported sound levels of 110-115 dB as passengers boarded an idling Sikorsky S92 aircraft (Ognedal, 2012). The same helicopter would be considerably louder when in-flight. BMT (2005) contains measurements of a Eurocopter EC155 B1, a type commonly used for oil and gas shuttle purposes, and reports 88.9 dB at a horizontal distance of 150 m with an overflight at 150 m height (a straight line distance of 212 m). By applying a simple ISO9613-2 attenuation calculation to the scenario, it is likely that the source level was around 144 dB (sound power level) which approximates to 133 dB sound pressure level at 1 m for a spherically spreading source. This allows the sound pressure level at other distances to be estimated. A similar calculation has been undertaken for two other common types of helicopter: Super Puma EC225 and a Sikorsky S-92 (Norske Olje & Gass, 2014). The anticipated levels of sound experienced at different distances from the source are shown in Table 10.9 along with noise levels of actual recordings of flights in the Falklands and day-to-day activities for comparison.

It is important to note however, that environmental factors, especially wind, will influence the propagation of sound and far more sophisticated models would be required to accurately predict the noise level experienced by different receptors at any given point under a range of environmental conditions. Therefore, the values given here should be regarded as a rough guide to sound perceived under still conditions.

Table 10.9 Sound level from helicopter and flight activity experienced at ground level (adapted from Norske Olje & Gass (2014) and BMT, 2005))

Activity	Maximum sound level at distance from sound source (dB(A))[b]			
	Equivalent at 1 m	Approx. 100 m	600 m	3,500 m
Super Puma EC225 (idling)	>114	-	c. 68	c. 43
Sikorsky S92 (idling)	>110	-	c. 54	c. 39
EC155 (overflight)	133	-	77	48
Sikorsky S61 taking off (recorded at MPN)	-	145	-	-
FIGAS Britten-Norman Islander (recorded at Stanley Airport)	-	148	-	-
Comparison with typical noise levels experienced by the public[a]	Chainsaw (120 dB)	-	Conversation (60 dB) Small penguin colony (65 – 69 dB)	Street in the evening (41 dB)

a After NoMEPorts, 2008.

b An 'A-weighting' is normally applied to sounds measured by instruments in an effort to account for the 'loudness' as it is perceived by the human ear. Essentially, between 500 Hz and 6 kHz the human ear is much more sensitive, but below and above these frequencies the human ear is not particularly sensitive and the 'A-weighting' takes these sensitivities into account.

10.2.4.2.3 The distribution of helicopter-sensitive receptors

The wildlife receptors likely to be most vulnerable to helicopter noise are mostly coastal in distribution. Wildlife colonies of note in north East Falkland include:

- The king penguin colony at Volunteer Point. The unusual breeding strategy of this species means that breeding birds will be present year-round, as it takes over a year to raise a chick. This colony supports virtually the entire Falklands' breeding population of this species.
- Gentoo penguins breed between October and February on the coasts of northern East Falkland (e.g. at Seal Bay), but also return to shore to rest at other times throughout the year when they may congregate away from breeding colonies. The number of breeding birds on the coasts of northern East Falkland is approximately 23 % of the Islands' population (Baylis, 2012).
- Magellanic and rockhopper penguins will be on land between September and April while they moult and breed and are at-sea between May and August. When breeding, Magellanic penguins are dispersed around much of the coastline and there are no population estimates although there are colonies at Seal Bay. Rockhopper penguins are relatively uncommon in the north of East Falkland, which supports approximately 2.3 % of the Islands' population.

- There are several small southern giant petrel colonies in the north of East Falkland, at Black Point (Volunteer Lagoon) and Rincon Grande. Generally, the birds return to colonies in September but do not lay until late October with the chicks fledging in late March.
- Eddystone and Volunteer Rocks are used by South American fur seals which favour the seclusion of isolated offshore rocks / small islands (Campagna, 2008). Fur seals are at their most vulnerable during the pupping, which takes place between October and December.
- There are several locations on the north coast of East Falkland where South American sea lions breed or haul-out (including Diamond Cove, Big Shag Island and Cape Bougainville). Sea lions pup during December and January and are likely to be more susceptible to impacts associated with disturbance at this time.

A visual summary of the above, showing the temporal distribution of colonies on the north coast of East Falkland is provided in Table 10.10 , which indicates that colonies of penguins and seals will be present year round and most predominantly in the austral summer when breeding and moulting occur.

It is likely that other species of seabird and seals would also be disturbed by helicopter over flights. In the Falkland Islands, areas with notably high wildlife significance are designated as National Nature Reserves (NNRs) (e.g. Volunteer Point), Important Bird Areas (IBAs) (e.g. Kidney and Cochon Islands, Volunteer Point, Seal Bay and Cow Bay and Cape Dolphin) or Ramsar sites (e.g. Bertha's Beach) (section 7.5.2).

Table 10.10 Temporal distribution of colonies and / or haul outs on and around the northern coast of East Falkland

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
King penguins	Breeding at Volunteer Point											
Gentoo penguins	Breeding		Occasional return to shore to rest							Breeding		
Magellanic / rockhopper penguins	Breeding and moulting				-	-	-	-	Breeding and moulting			
Southern giant petrel	Breeding			-	-	-	-	-	Return to shore for breeding			
South American fur seals	Haul-out throughout year									Pupping		
South American sea lions	Pupping	Haul-out throughout year										pupping

10.2.4.2.4 Overlap between helicopter flight paths and wildlife aggregations

Figure 10.7 below shows the spatial distribution of sensitive environmental receptors and community settlements in the north of East Falkland.

10.2.4.2.4.1 Flights to the Sea Lion Field

Direct flightpaths between the two main heliports and the Sea Lion Field are indicated by the arrows in Figure 10.7. The flightpath from Stanley Airport to the Sea Lion Field is on a bearing of 340° (Ian Ewen pers. comm.).

Flights from MPN directly to the Sea Lion Field will pass close to gentoo breeding colonies on the north coast but this area is not designated as an NNR, IBA or Ramsar site (Figure 10.7).

Helicopters flying between Stanley and the Phase 1 Development would pass approximately 5.5 km to the west of the king penguin colony at the Volunteer Point NNR / IBA and directly over Seal Bay on the north coast of East Falkland. Seal Bay is designated an IBA due to the populations of breeding rockhopper, gentoo and Magellanic penguins and sooty shearwaters (section 7.5.2.3.1). Additionally, there are a number of small rockhopper penguin colonies in Berkeley Sound, which are undesignated.

10.2.4.2.4.2 Flights to the CTT

During the Direct Offtake operation of crude from the FPSO to the CTT, a Berthing Crew would be transported from Stanley Airport by helicopter to the CTT at an offshore location close to the Sea Lion Field. Importantly, the approach used will be mostly over the sea and should not pose a significant risk to wildlife aggregations onshore.

10.2.4.2.4.3 SAR Test Flights

SAR test flights may occur from MPN or from Stanley Airport, as occurred during the 2015 exploration campaign.

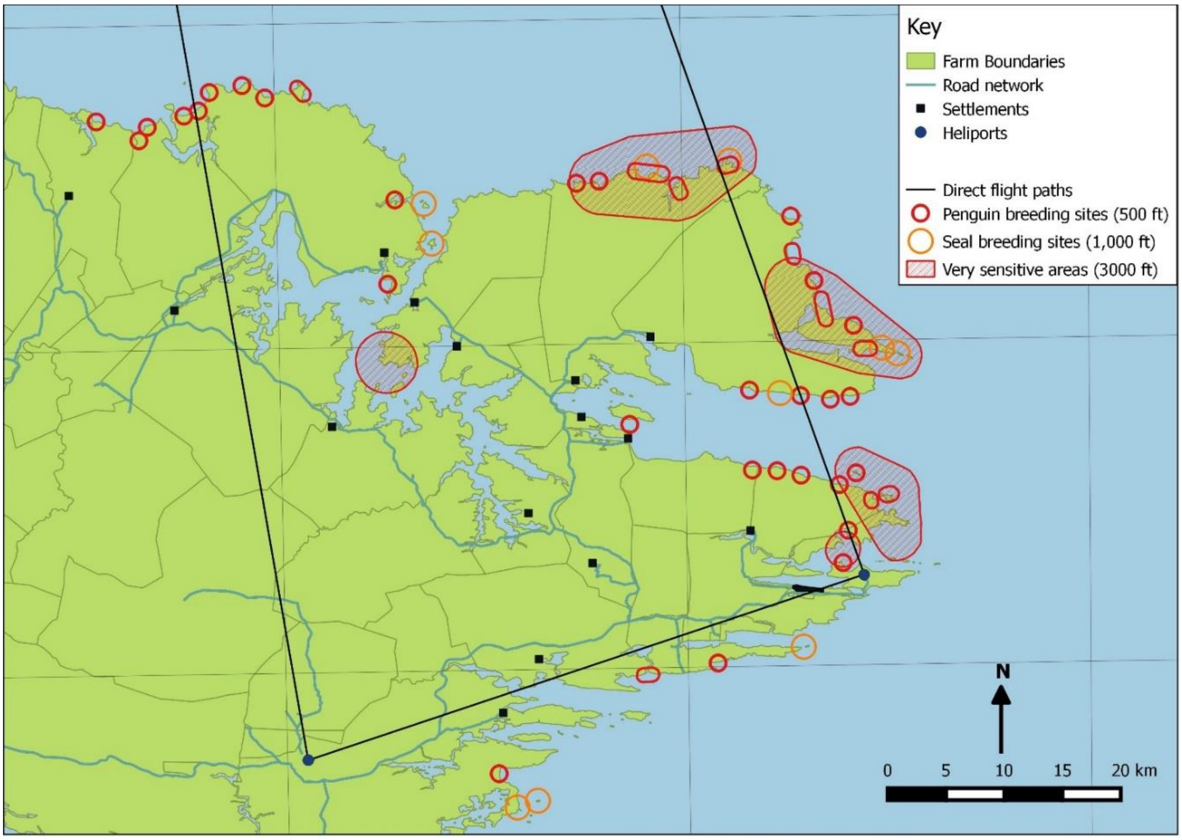


Figure 10.7: The distribution of sensitive wildlife receptors and settlements in relation to the most direct helicopter flightpaths.

Note: the arrows heading out to sea ultimately converge at the Sea Lion Field 200 km offshore.

Note: the sensitive areas shown in Figure 147 are taken from the Ministry of Defence's Falkland Islands Range and Avoidance Areas (5-GSGS) map (MoD, 2014)

10.2.5 Industry-standard mitigation

While no industry-standard mitigations exist for the O&G industry specifically, guidelines have been developed in the Falklands, and elsewhere, to minimise the environmental impacts of disturbance from helicopters. These include:

- The Ministry of Defence's (MoD's) Falkland Islands Range and Avoidance Areas (5-GSGS) map (MoD, 2014);
- The Falkland Islands Low Flying Handbook (FILFH, 2017); and
- South Georgia Low Flight Avoidance Map (GSGSSI, 2009).

The simplest and most effective way to mitigate the effects of disturbance from helicopter overflights is to route helicopters away from colonies of penguins, other seabirds and seals. Following the example set by the MoD (MoD, 2014) and on other islands such as South Georgia, impact reduction methods (e.g. flight avoidance maps) can be used, which generally have a history of successful use and acceptance.

In addition to guidance on the avoidance of bird activity with regard to flight safety etc., the key avoidance areas are marked on the FIFLH avoidance maps. Specifically, the FILFH (2017) lists the following guidance:

- Sensitive areas with increased risk of birdstrike - not to be over flown by any aircraft below 3,000 ft unless landing or taking off. Full details are provided on the Falkland Island Range and Avoidance Areas, GSGS 5563, Ed 5/6;
- National Nature Reserves - to be avoided by 1000 ft above ground level (AGL) vertically and 0.25 nm laterally unless otherwise specified. See Falkland Island Range and Avoidance Areas, GSGS 5563, Ed 5/6 for more details;
- Sensitive breeding sites - to be avoided by 1000 ft AGL vertically and 0.25 nm laterally unless otherwise specified. See Falkland Island Range and Avoidance Areas, GSGS 5563, Ed 5/6 for more details; and
- Penguin and Seal Avoids - areas listed as 'known sensitive breeding sites of penguins or seals' are not to be over flown by any aircraft below 1000 ft AGL. See Falkland Island Range and Avoidance Areas, GSGS 5563, Ed 5/6 for more details.

Importantly, according to the FIFLH (2017), the source data for the 'avoid areas' above is unknown. Both the Falkland Islands Director of Civil Aviation and Environmental Departments have been consulted but they do not have a record of the origin. Until a full review can be completed, the GSGS 5563 is to be used as the source document.

In addition to the restricted areas identified on the MoD map and the guidance in FILFH (2017), the following additional recommendations are made in the GSGSSI (2009):

- When following the coastline, maintain a vertical separation distance of 600 m and a horizontal separation of about 500 m from the coastline where possible;
- Cross coasts at right angles and above an altitude of 600 m where possible;
- Never hover or make repeated passes over wildlife concentrations or fly lower than necessary; and
- At all times, the number of animals exposed to disturbance will be reduced to as low as reasonably practical taking account of safety, weather conditions etc.

As the above is considered standard practice within the Falklands, Premier will develop an approved project-specific flight plan, which should be sufficient to mitigate the impact of helicopter disturbance on wildlife. Premier will use the flight avoidance map as the basis for flight planning, following the Falkland Islands Low Flying Handbook Guidance (FILFH, 2015). All helicopter pilots will:

- Be briefed on flight avoidance protocols for sensitive areas prior to flying;
- Sign a document indicting that that the FILFH (2017) has been read and understood;
- Be accompanied by a pilot experienced in the area on their first flight; and
- Be issued with an approved flight path.

The above mitigation measures are taken into account during the initial impact assessment described below.

10.2.6 Impact assessment

The following section draws upon all the information provided above to assess the ‘Sensitivity of the Receptor’ and the ‘Severity of Effect’ in order to determine the overall ‘Impact’ of planned activities.

A summary of the impact assessment outcomes for this Development is tabulated in section 10.2.12 (Table 10.11), which shows the worst case impact for each activity.

10.2.6.1 Disturbance to wildlife

Of all the helicopter-sensitive wildlife described, the species of greatest concern is the king penguin as these birds breed year-round onshore, and virtually the entire Falklands’ population is in one location at the Volunteer Point NNR / IBA (section 10.2.4.2.3). As well as passing cc. 5.5 km away from the Volunteer Point IBA, direct flight lines from Stanley to the Sea Lion Field would also pass directly over, or close to, a number of small rockhopper penguin colonies at Seal Bay (Figure 10.7). Further, other undesignated but significant penguin colonies and are on (or close to) the direct flight paths between the Sea Lion Field and the Stanley and MPN heliports (Figure 10.7). The national importance of these areas and the species they support means that the sensitivity of the receptors could be considered to be ‘Very High’. However, as a flight plan will be in place, in line with the FILFH (section 10.2.5), the exposure time and the frequency / level of exposure that these colonies will experience is greatly reduced. As the colonies will not actually be exposed to the helicopter noise, the **sensitivity of the receptor** to the impact of helicopter noise can be considered to be **‘Low’**.

The impact of a single helicopter overflight on any population of penguins is likely to be short-term and rapidly reversible. However, the combined impact of numerous (potentially daily) disturbances could have serious implications for the survival of moulting birds or chicks. If this were to continue over a number of years, it could result in a reduction in the local populations or redistribution of known colonies (section 10.2.4.1.1). Nonetheless, as the FILFH compliant flight plan will prevent such chronic exposure, the **severity of effect** of helicopter over-flights is considered to be **'Minor'**.

Therefore, the overall **significance of the impact** of helicopter disturbance on wildlife is considered to be **'Low (4)'**.

10.2.7 Project-specific mitigation measures

As the impact is considered to be **'Low (4)'**, there is no need to consider any additional project-specific mitigation measures.

10.2.8 Residual impact

No residual assessment was carried out as the initial impact was considered to be **'Low (4)'** owing to the use of the FILFH compliant flight plan.

10.2.9 Cumulative impacts

Low flying aircraft are a common sight around the Falkland Islands and therefore there is the potential for cumulative impacts in the form of increased 'concentration', 'extent and proportion' and 'duration' (section 8.10.1).

The Government Air Service (FIGAS) operates a small fleet of Britten-Norman Islander fixed-wing aircraft that transport passengers and small quantities of freight around the Islands, most of which have an airstrip. Additionally, there are a number of military fixed-wing aircraft (from Typhoon jets to A400N Atlas) that regularly practice low-level flying around the Islands.

In addition to the Premier helicopters, there are a number of helicopters based at MPN that are used for SAR and transporting military personnel and cargo around the Islands. Additionally, helicopters fly visitors to some of the offshore islands that support concentrations of wildlife and occasionally overfly Stanley. SAR helicopters occasionally undertake exercises in Stanley Harbour and deliver patients to the King Edwards Memorial Hospital (KEMH), landing on the school's football pitch.

In recognition of the threat posed by low-flying aircraft to wildlife, and also the risk of bird strikes and damage to aircraft, all flights within the Falkland Islands adhere to the MoD flight avoidance map (MoD, 2014). Although, notably, MoD aircraft may breach the guidelines if operationally necessary.

Under normal operating conditions, helicopter activity during the Phase 1 Development will follow the project-specific flight plan (section 10.2.5) and will have no need to land anywhere other than Stanley airport or MPN. Therefore, with the impact considered to be **'Low'**, the Development should not result in any additional impact on wildlife.

10.2.10 Confidence

The project activities are clearly defined in terms of the:

- Start and end points of flights;
- Frequency of flights; and
- Adherence to project-specific flight plans.

Equally, the locations of vulnerable receptors are known. While the long-term consequences of the impact of noise on wildlife are not fully understood, the application of the Falkland Islands Low Flying Handbook and associated guidance will take account of tried and tested mitigation measures such that the confidence in the assessment is considered to be **'Certain'**.

10.2.10.1 Monitoring required

No specific monitoring over and above any legal or Premier's corporate standards have currently been identified. Detailed monitoring requirements have been established during the Environmental Monitoring and Management Plan (EMMP) workshop. All monitoring requirements agreed by Premier and FIG will be recorded and managed via the project-specific Phase 1 EMMP (an outline EMMP is provided in Chapter 15).

10.2.11 Offsetting

As no residual impacts identified in this section are considered significant, i.e. Moderate or above, offsetting is not considered (see section 8.9).

10.2.12 Findings summary

Table 10.11 Summary of the assessment of impacts to wildlife associated with helicopter disturbance during the Phase 1 Sea Lion Development

Activity / Event	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Helicopter use	Disturbance to wildlife	Behavioural and physiological stress reactions to helicopter over-flights, leading to trampling, increased vulnerability to predation, increased energy demands and possible reduced breeding success.	Planned	1, 2 & 3	Low	Minor	n/a	Low (4)	n/a	Certain	Industry-standard: Use of project-specific flight plan in line with the flight avoidance map as the basis for flight planning, following the Falkland Islands Low Flying Handbook Guidance (FILFH, 2017). Project-specific: None

a See Chapter 8.0 for definitions of sensitivity, severity, likelihood and significance.

10.3 Disturbance to the seabed / placement and removal of objects

Table of Contents

10.3 Disturbance to the seabed / placement and removal of objects

10.3.1 Introduction

The Phase 1 Development will require the short-term and long-term placement of objects on the seabed both at the offshore location and in Berkeley Sound. Both the installation and removal of subsea structures can cause disturbance to the seabed, potentially affecting the benthos and habitats. Additionally, the introduction of hard substrates to the subsea environment may present the opportunity for marine growth and for 'artificial reefs' to form.

This chapter assesses the potential impacts associated with the installation and presence of structures and the removal of temporary structures, as well the risk associated with accidentally dropped objects.

All long-term structures will be installed in anticipation of full removal at the time of decommissioning (Section 5.12) and the impacts of removing these will be assessed in a dedicated EIA in support of the Decommissioning Programme (Section 5.12.3).

Note: the impacts to other users of the sea from the placement of objects on the seabed are assessed elsewhere in the document as described in Section 9.2.

10.3.1.1 Legislation regarding seabed disturbance

Currently there is no legislation enacted in the Falkland Islands which governs the placement (or removal) of objects on the seabed or any associated disturbance of the seabed.

However, UK Legislation which may be relevant from the environmental perspective are the:

- Petroleum Act 1998;
- Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1999 (and all associated amendments);
- Offshore Marine Conservation Regulations (Natural Habitats, &c) 2007 (as amended) (which implement the Habitats Directive);
- The Marine and Coastal Access Act 2009 and The Marine (Scotland) Act 2010, which introduced the requirement for marine licences for objects placed on the seabed and for disturbance of the seabed (normally applies to objects not directly related to drilling, production or pipelines); and
- Energy Act 2008 (Part 4A) which covers navigational issues and the consent to locate.

10.3.2 Sources of seabed disturbance / placement of objects

The following chapter assesses the impacts of the offshore and inshore sea bed disturbance required in support of the Sea Lion Phase 1 development. As described in section 5.1.1, the Sea Lion project offshore subsea layout and location of wells has been optimised. As a result of the optimisation, the sources of offshore seabed disturbance include:

- Offshore:
  - Mooring systems:

  - The installation and removal of the temporary Mobile Offshore Drilling Unit (MODU) mooring system (estimated to be in place for 69 months); and
  - Installation of the long-term Floating Production, Storage and Offloading (FPSO) mooring system (in place for field-life);
- Installation of well infrastructure:
  - Conductors; and
  - Wellheads for drilling (with X-mas trees placed on top of the wellhead during production).
- The Subsea Production System (SPS) and Subsea Umbilical's, Risers and Flowlines (SURF):
  - Up to six manifolds and two tee-structures;
  - Production, water injection, diesel service and gas flowlines / risers;
  - Riser clump weights;
  - Flexible jumpers and flying leads;
  - Umbilicals;
  - Sandbags, grout bags and gravel bags used as markers and construction aids; and
  - Temporary clump weights for installation of equipment and for downlines for hydrotesting.
- Survey equipment, transponders and sampling equipment.
- Accidentally dropped objects e.g. subsea infrastructure during installation.

Note: the MODU will either be moored by anchors or by pre-installed suction anchors. The exact number of anchors used will not be known until the rig is selected, it is assumed for the purposes of assessment that approximately ten anchors will be used with different lengths of chain required in order for the rig to maintain position.

Note: smaller dropped objects such as tools etc. are considered to have negligible impact to the seabed and were screened out as indicated in Chapter 9.0. The risks associated with large potential dropped objects are assessed below.

The inshore impacts will relate to the:

- Use of temporary anchors by up to four Large Transport Vessels (LTVs) anchored in Berkeley Sound. The phasing of the LTV arrival and exit dates means that a maximum of two LTVs will be present at anyone time.

Note: The oil spill boom buoys may still be required in the event that IFO is brought in to Berkeley Sound on the LTVs.

10.3.3 Potential receptors

The ENVironmental Impact IDentification (ENVIID) workshop was used to identify those receptors upon which the impacts and risks of seabed disturbance warranted further investigation (Chapter 9.0). These include:

- Benthic fauna and habitats at the Sea Lion Field (Section 7.4.3.2); and
- Benthic fauna and habitats in Berkeley Sound (section 7.4.3.3).

Note: impacts to sites of archaeological interest were screened out during the ENVIID (Chapter 9.0) as there are no known shipwrecks in the vicinity of the Phase 1 Development locations (Section 7.7.6). In Berkeley Sound, the location of the LTV's and associated anchors has been chosen to avoid known wrecks, the location of which has been confirmed through sidescan sonar survey (BSL, 2015a)..

10.3.4 Characterising and quantifying the impacts and risks

When characterising and quantifying the potential impacts and risks associated with placing and removing objects on the seabed it is necessary to consider the:

- Nature of the impact from the installation and presence of objects on the seabed;
- Potential impacts at the Phase 1 Development locations including:
  - Fauna and habitats in the Sea Lion Field; and
  - Fauna and habitats Berkeley Sound.
- Quantification of the subsea infrastructure including the dimensions and footprint of the:
  - FPSO and MODU mooring systems;
  - Well infrastructure, SPS and SURF; and
  - Temporary inshore anchors used by the LTVs during the early construction stages.
- Risk of dropped objects and associated impacts on benthic fauna.

10.3.4.1 Nature of the impact from installation, presence and removal of structures

Placement and / or removal of objects on the seabed may directly and / or indirectly impact upon:

- Benthic fauna; and
- Biodiversity via habitat modification and marine growth.

10.3.4.1.1 Impacts to benthic fauna

Benthic fauna are primarily impacted by:

- Direct crushing of sessile or sedentary organisms; and
- Indirect smothering of organisms with re-settling suspended sediments.

Direct impacts include the crushing of sessile or sedentary organisms which cannot move away. These effects will be immediate, very localised and will affect the area directly covered by the structure, and possibly the immediate vicinity in which the activity occurs. During installation processes however, seabed sediments will be stirred up and become suspended, which can lead to indirect impacts.

While larger, more mobile animals, such as crabs, fish, shrimps and prawns may be able to avoid these impacts, the suspension of sediment can cause clogging, smothering or abrasion of sensitive feeding and respiratory apparatus in sedentary or slow moving organisms (Nicholls *et* *al*., 2003). These impacts are of greatest concern for filter feeders such as the saltwater clams (*Thyasira* spp.) found at the offshore Development site.

One study (Carlmark, 1971) involved laboratory testing of objects falling into sediments in test conditions and contains notes on the behaviour of the sediments on impact. Overwhelmingly, there was displacement of solids either side of the impact and an elevated 'lip' forming to the impact depression, but very little material was visibly ejected into the water column.

However, and importantly, the degree of the impact upon filter feeders depends upon the duration of exposure to suspended sediments. For instance, experiments have shown that the filter feeding scallop *Pecten novaezelandiae* was unaffected by exposure to 250 mg/l of sediment in suspension for a single week, but decreased growth was observed in individuals exposed to lower density suspensions for periods longer than one week (Nicholls *et al*., 2003).

10.3.4.1.2 Impacts to biodiversity from habitat modification and marine growth

Habitat modification can result from the placement of hard substrates on the seabed and can have direct and indirect impacts on biodiversity as follows:

- The anthropogenic installation of new habitat in an area leading indirectly to:
  - The settlement and growth of native marine fauna not otherwise present in the immediate area;
  - Provision of a ‘stepping stone’ for species with only moderate dispersal abilities (BAS, 2014); and
  - The establishment of non-native species.
  - Direct damage to existing habitats.

10.3.4.1.3 Anthropogenic installation of new habitats

When hard substrates are placed on the seabed in an area where such platforms are naturally sparse, there is the potential that these structures may become colonised by species which prefer hard substrates and would not ordinarily be in the area. Further, such habitats may enable the spread of species with moderate dispersal abilities by providing ‘stepping stones’ which create interconnectivity with other regions (BAS, 2014).

It is observed that installations in the North Sea are predictably colonised with numerous epifauna groups which wouldn’t otherwise be present in the area (OSPAR, 2009a). For example, seaweeds, mussels, anemones, sponges, hydroids and cold-water corals are frequently recorded on Oil and Gas (O&G) structures (e.g. jackets, risers and seabed infrastructure) (Coolen *et al*., 2015). A very specific example of the settlement of fauna which is otherwise not found in an area is the presence of the cold-water coral *Lophelia pertusa* in the North Sea. This species was most frequently reported on the shelf-edge and the offshore banks of the northeast Atlantic (Roberts, 2002) and is now found in the North Sea where it had not previously been recorded (Gass and Roberts, 2006). Importantly, these colonised ‘habitats’ can then attract the more mobile fauna which are attracted by the shelter and food source provided.

While the likelihood of colonisation, and the composition of marine growth on a particular structure depends on a variety of factors (such as water temperature, water depth, wave action, the indigenous and / or non-native species present in the area and the season in which the structure was installed (Fortreath *et al*., 1982; OGUK, 2011)), it is generally recognised that the presence of marine growth on artificial hard substrates can impact upon biodiversity and species abundance in an area.

Indeed, in order to better understand the extent to which artificial substrates associated with the O&G industry affect biodiversity, and to examine the impact of habitat creation by O&G activities in the North Sea in general, O&G UK recently launched a scientifically-led and long-term environmental Joint Industry Project to assess the 'INfluence of man-made Structures In The Ecosystem' (INSITE, 2016).

While it is debatable as to whether the impact of 'artificial reefs' is positive, negative or negligible in the immediate location, there may be the potential for broader reaching negative effects. For example, based on laboratory work, Holst and Jarms (2007) suggest that one reason for a worldwide increase in mass occurrences of scyphozoan jellyfish may be due to increases in artificial substrates and marine litter in coastal and offshore regions, owing to the increased settlement opportunities for larval stages. Although the cause is unlikely to be directly related to artificial substrates or litter, jellyfish blooms are already experienced in Falklands waters, with peaks in jellyfish catch approximately every ten years and long-term trend of growing catches (J. Pompert *pers. comm*).

With regard to non-native species, there is the potential for the creation of new habitats to enable such species to settle and become established. The potential for this may be enhanced where the surfaces of the artificial 'habitat' are heated, which may increase the range of species able to survive in the region, growth rates and maturation times (BAS, 2014). An overview of the potential for such impact interactions (i.e. the combined effect of species introduction and artificial habitat provision) is provided in Chapter 13.0.

10.3.4.1.4 Damage to existing habitats

Damage to existing habitats can result directly from the placement of objects on the seabed. The significance of such damage will depend upon the extent of the damage, the importance of the habitat with regard to its ecological value and whether or not the habitat is ubiquitous, rare or isolated.

10.3.4.2 Potential impacts at the Phase 1 Development locations

10.3.4.2.1 Impacts in the Sea Lion Field

10.3.4.2.1.1 Existing habitats and fauna

The sediment at the Sea Lion site is classed as medium to coarse silt with a high percentage of fine material (61-80 %) (Section 7.3.7.1.1) which is likely to become suspended during the installation processes with the potential to impact the fauna present.

With regard to fauna present, an 'area-wide' seabed survey of the Sea Lion development area was carried out in 2012 (Gardline 2013a, b), and several surveys were carried out in support of the 2015 exploration drilling campaign (section 7.2.2). These surveys indicated that the benthic communities in the area were:

- Typical of the sediment type and were rich in species assemblages, diversity and abundance (Gardline 2013a, b); and
- Relatively homogeneous throughout the surveyed area (section 7.3.7.1.1).

Nonetheless, hard substrates do occur in the North Falklands Basin (NFB) and these areas have been colonised. For example, about 40 km to the south of the Sea Lion Field, in the region of the Isobel Deep well, seabed photography revealed the presence of hard substrates in the form of clay outcrops, boulders and drop-stones associated with glacial and iceberg groundings (Premier, 2014g). Assessment of the epifaunal assemblages within these habitats, confirmed the presence of a relatively well populated community of species. Brittlestars, sea urchins, starfish, hard and soft corals, bryozoans, hydroids, ascidians and anemones were frequently encountered. In turn, this colonisation has led to the presence of demersal fish (notably Notothenidae spp.), pelagic fish and cephalopods. An example of the growth found on erratic glacial rocks is shown in Figure 10.8.

Figure 10.8: Example of marine growth on seabed boulder in the Isobel Deep area of the NFB (Source: MG3, 2015)

10.3.4.2.1.2 Habitats of importance

There are no habitats in the region of the Sea Lion Field that are equivalent to those of conservation significance in the UK as defined by the Offshore Marine Conservation of Habitats Regulations (which implement the EC Habitats Directive) (section 7.4.3.2.2).

10.3.4.2.1.3 Anticipated marine growth

With regard to marine growth opportunities, in the upper water column, colonisation by seaweeds and mussels may occur quite quickly on the upper lengths of risers and FPSO anchors chains as is observed in similar latitudes. At the depths of approximately 450 m however, it is likely that colonisation and growth on the subsea infrastructure will be slower.

In order to obtain a firmer estimate of marine growth potential, British Antarctic Survey (BAS) were commissioned by Premier to estimate the type of marine growth that could occur in the Sea Lion Field (BAS, 2014).

Existing oceanographic data and models suggest predominant currents at the location of the proposed Sea Lion Development come from East Falkland and north of Tierra del Fuego with the current speed generally being less than 15 cm/s. Following biofilm development in the initial weeks of deployment, *Ectocarpus* and *Enteromorpha* algae, tubicolous polychaete worms and acorn barnacles are likely to establish. These will be followed by a complex succession of fouling types. Ultimately, barnacles, oysters or mussels (probably the latter) are likely to dominate.

The study indicated that, by far, most growth should occur in the top 40 m, as is seen in the North Sea. Thicknesses of marine growth are predicted to be less, overall, than that seen the North Sea, and comparative estimates are shown in Table 10.12: . The most unpredictable element with regard to marine growth, is the chance establishment of the occasional giant kelp.

The roughness of fouling growth is generally expected to peak at 2-6 cm in the top 20 m depth within 3-9 years (BAS, 2014).

In the event that marine growth on risers / anchor chains exceeds safety parameters with regard to structural integrity, the marine growth will be cleaned off to sea. This process will destroy all native, and any non-native, marine growth and the organic matter will fall to the seabed as natural detritus.

Table 10.12: Summary of terminal marine growth estimates in the UK versus Sea Lion (BAS, 2014)

Area	Depth	Type of growth		
		Hard (m)	Soft (m)	Algae / kelps (m)
UK	0 - 15 m	0.2	0.07	3
	15 - 30 m	0.2	0.3	Unknown
	30 m to seabed	0.01	0.3	No growth
Sea Lion	0 - 15 m	0.15	0.1	Unknown
	15 - 30 m	0.12	0.1	Unknown
	30 m to seabed	0.04	0.01	No growth

10.3.4.2.2 Impacts in Berkeley Sound

The area that may be affected in Berkeley Sound is limited to the location of the LTVs' anchor site (at a location to be agreed with FIG / Fisheries within Berkeley Sound).

The following sections describe what is known of the species and habitats in the area.

10.3.4.2.2.1 Existing habitats and fauna

Full detail on the flora, fauna and habitats of Berkeley Sound are provided in section 7.4 of the Environmental Baseline chapter. The following section provides a summary of the results of surveys which were carried out for the project.

Within the Sound, the dominant sediment type was slightly gravelly sand. Finer sediments occurred more in the inner bays to the west with sediments generally becoming coarser toward the east end. The nearest sampling station to the LTV anchorage was found to contain slightly gravelly sand with some hard substrates located approximately 4 km to the west.

The flora and fauna throughout Berkeley Sound is highly variable in terms of species abundance, richness and composition, as would be expected given the highly variable nature of the sediment and the large scale of survey area. Samples taken nearest to the LTV anchorage indicated comparatively average species richness with low abundance but high diversity.

Overall, the habitats found within Berkeley Sound are widespread and the seabed is scarred from historic and ongoing ship anchoring.

10.3.4.2.2.2 Habitats of importance

As is detailed in Section 7.4.3.3.3, a number of habitats were identified within the surveyed area of Berkeley Sound that could potentially qualify as those of conservation significance under the UK's Offshore Marine Conservation Regulations 2010 (which implements the EU Habitats Directive). One of these (at BS_ENV_42) locations was found to carry the mottled sea star, *Glabraster antarctica*, amongst the coralline algae encrusted bedrock exposures which is described as 'a primarily Antarctic and Sub-Antarctic species only rarely seen inshore in the Falklands' by SMSG (Neely and Brickle, 2013).

10.3.4.2.2.3 Anticipated marine growth

As described above, Berkeley Sound contains varied habitats, and hard substrates are already found in the area. As such, marine growth on LTV anchors is likely to be typical of fauna and flora already in the area. However as the anchors are temporary, marine grown on introduced hard substrates in Berkeley Sound is not considered further.

Nonetheless, the potential for the LTV anchors to provide added hard substrate for the settlement of any non-native species which may be introduced by biofouling on the LTVs is considered in Section 10.12.

10.3.4.3 Quantification of the subsea infrastructure

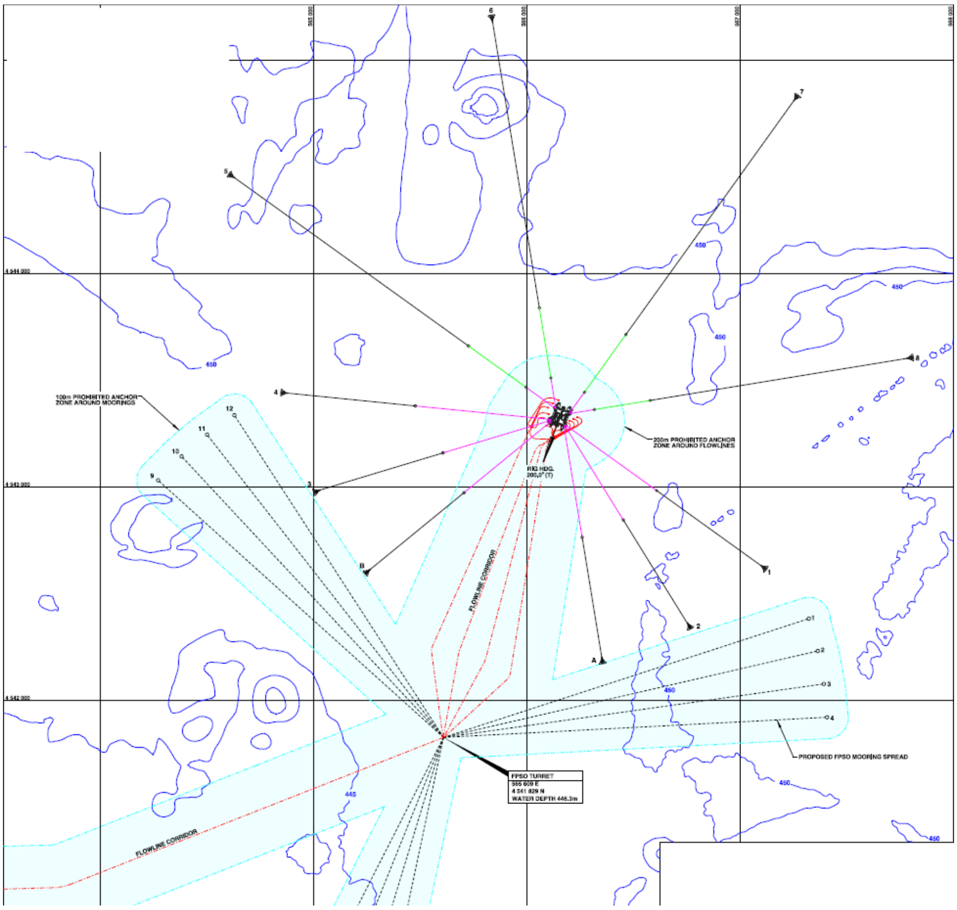
10.3.4.3.1 FPSO and MODU mooring systems

During Stage 2 of the Development, both the MODU and the FPSO will be in the field, carrying out simultaneous operations (SIMOPS). An example anticipated SIMOPS anchor array is shown in Figure 10.9. It is expected that the greatest disturbance to the seabed will result from the installation of the mooring systems.

The mooring system for the FPSO will be installed during Stage 1 of the Phase 1 Development and will remain in place for the duration of the field life (Section 5.5.2). The mooring system will comprise of 12 suction-piled anchors distributed in clusters of four. Each cylindrical anchor will be six and a half metres in diameter and will be flush with the seabed following installation. It is anticipated that 300 m of chain will be laid upon the seabed for each anchor.

The dimensions of the FPSO mooring system, and a summary of the assumptions made with regard to estimation of the impacted area, are provided in Table 10.13: . The area that may be disturbed during the installation of the FPSO mooring system is estimated to be 0.037 km^2 while the long-term footprint of the mooring system is 0.0007 km^2 (Table 10.13:).

For the purpose of this EIA, a ten anchor spread has been assessed for the MODU using ‘15T Stevpris MK6 anchors’ and the same assumptions as were made as for the FPSO anchors (Table 10.13:). The temporary MODU anchor array will be installed and removed on up to eight different occasions in four locations over the course of the drilling campaign and each activity will cause seabed disturbance. As a result, the total area disturbed by the MODU mooring system throughout the drilling campaign is estimated at 0.264 km^2 (Table 10.13:).



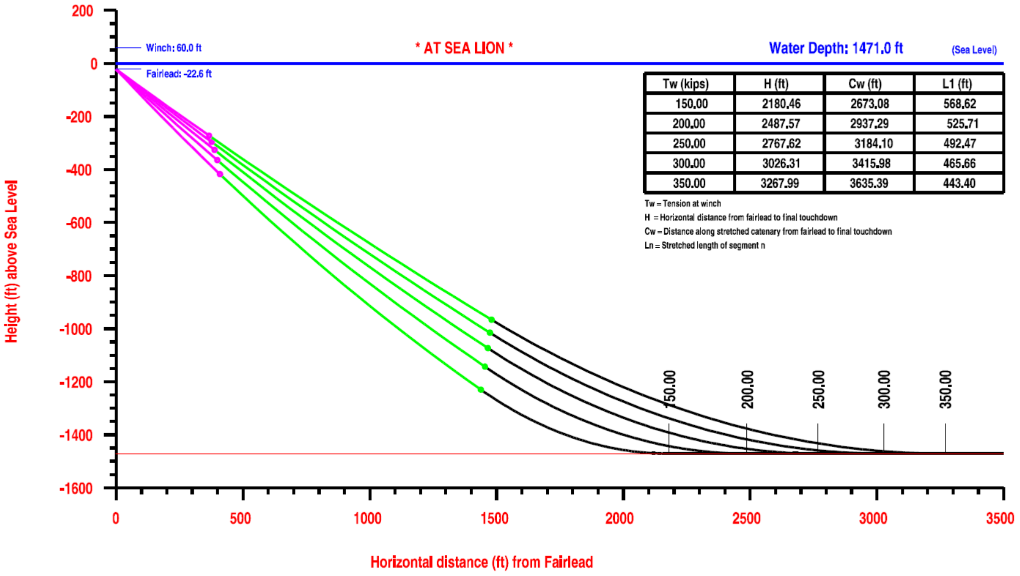


Figure 10.9: Layout of long-term FPSO anchors and temporary MODU anchors during SIMOPS

Table 10.13: Dimensions and footprints of the FPSO and MODU anchor layouts

Installation	Structure	Quantity	Dimensions			Worst case assumptions	Seabed disturbance (m^2)	Infrastructure footprint (m^2) [b]
			Outer diameter (m)	Length (m)	Width (m)			
FPSO (Permanent [a])	Anchor chains	12	n/a	1,371	0.08	300 m in contact with seabed and impact corridor width 10 m	36,000	288
	Cylindrical suction anchors	12	6.5	n/a	n/a	Disturbance zone of 100 m^2 per anchor	1,200	398
	Total						37,200	686
							0.037 km^2	0.0007 km^2
MODU (temporary)	Anchor chains	10	n/a	1,371	0.08	300 m in contact with seabed and impact corridor width 10 m	30,000	n/a
	15 tonne Stevpris MK6 Anchors	10	n/a	6.7	6	Disturbance zone of 300 m^2 per anchor	3,000	n/a
	Total area of disturbance for each MODU placement						33,000	n/a
	Total for all MODU anchor placements and removals (8 anchor placement and removal events)						264,000	n/a
							0.264 km^2	n/a
Total FPSO and MODU disturbance							0.301km^2	0.0007 km^2

[a] The FPSO moorings will be installed in Stage 1 and will therefore be in place for approximately 23 years.

[b] Areas for unconventional shapes are calculated by assuming an oblong / square according to the longest dimensions as a worst case.

[c] The MODU will be in situ for a total of 69 months during Stages 1 and 2 of the Phase 1 Development.

10.3.4.3.2 SPS and SURF

The dimensions of the SPS, SURF and associated supports are summarised in Table 135, as are the assumptions made with regard to the area impacted. The SURF will be installed directly on the seabed and no mechanical trenching, burial or support (e.g. rock dumping or concrete mattresses) will be required for the permanent infrastructure. However, it is standard practice to temporarily install protective materials (e.g. concrete mattresses or reinforced rubber mats) on the seabed for the storage of equipment and materials used during installation operations, such as pile hammers, hydrotest equipment etc. An allowance is added for this and for other construction-related deposits such as sandbags. Temporary storage areas may also be required to store jumpers, umbilical's, anchor wires etc. prior to installation. Including allowance for the above, the total seabed disturbance from the SPS and SURF installation is estimated to be 0.205 km^2. The long-term footprint is estimated to be 0.022 km^2.

Table 10.14: Estimated dimensions of subsea equipment

Equipment	Quantity	Dimensions			Worst case assumption	Seabed disturbance (m^2)	Infra-structure footprint (m^2)
		Outer diameter (m)	Length (m)	Width (m)			
Well infrastructure							
Pile driven 36" conductor casings	30	0.914	n/a	n/a	Area of disturbance extends 1 m around the structure to account for piling activity	200	20
Subsea Wellhead	30	n/a	5.25	4.1	Area of disturbance when positioning extends 1 m around the structure	1327	646
Subsea Production System (SPS)							
Manifolds	3	n/a	21.7	13.7	Area of disturbance when positioning extends 1 m around the structure	1116	892
	3	n/a	10.0	9.6		417.6	288.0
	1	n/a	10.3	5.7		94.7	58.7
	1	n/a	10.7	6.5		108.0	69.6
Subsea Umbilicals, Risers and Flowlines (SURF)							
Main Drill Centre Umbilical	1	0.237	1,754	n/a	Assume 100 % of length in contact with seabed and 1 m disturbance corridor	3,924	416
Main DC To West Flank Remote Gas Well Umbilical	1	0.084	5,524	n/a		11,512	464
West Flank To Casper Umbilical (Contingent)	1	0.084	2,892	n/a		6,027	243
Main DC To South DC Umbilical	1	0.128	3,892	n/a		8,282	498
Main DC To East DC Umbilical	1	0.1	5,665	n/a		11,897	567
Production Flowlines / Risers	3	0.47	6,796	n/a		16,786	3194
WI Flowline / Risers	1	0.501	10,295	n/a		25,748	5158
Gas Lift Flowline / Risers	2	0.372	5,976	n/a		14,175	2223

Equipment	Quantity	Dimensions			Worst case assumption	Seabed disturbance (m^2)	Infra-structure footprint (m^2)
		Outer diameter (m)	Length (m)	Width (m)			
West Flank Gas Production & Injection Flowline / Riser	1	0.255	7,511	n/a		16,937	1915
Casper Gas Production & Injection Flowline	1	0.191	2,716	n/a		5,951	519
Diesel Service Flowlines / Riser	2	0.402	7,000	n/a	Assume 100 % of length in contact with seabed and 1 m disturbance corridor	16,814	2,814
Flexible Jumpers	37	0.19	4,070	n/a	100 % of length in contact with seabed and 1 m disturbance corridor	8,913	773
	824	0.1	2,640	n/a		5,544	264
Bridge Crossing	1	n/a	14	7		140	95
Flying Lead	0.12	-	7,120	n/a		15,094	854
10 % contingency for laydown and storage areas during installation						17,101	-
10 % contingency for miscellaneous deposits and equipment e.g. survey equipment, sand bags, transponders, mattresses for installation equipment, additional clump weights, tethers						17,101	-
Total						205,209	21,971
						0.205 km^2	0.022 km^2

10.3.4.3.3 Inshore LTV anchors

Four temporary LTVs are being used as floating storage barges however, only two are anticipated to be anchored within Berkeley Sound at any one time.

The dimensions of the anchoring systems used are summarised in Table 10.15, as are the assumptions made with regard to the seabed area impacted. The assumptions are based on the worst case disturbance that could be caused during installation and / or use e.g. anchor placement and disturbance as the vessels weather vane around the anchors.

The overall seabed disturbance is estimated at 0.035 km^2 which amounts to about 0.12 % of area of Berkeley Sound (Table 10.15).

Table 10.15: Estimated dimensions of inshore LTV anchoring

Installation	Structure	Quantity	Dimensions Length (m)	Dimensions Width (m)	Worst case assumptions	Seabed disturbance (m^2)	Infrastructure footprint (m^2)
Up to four Large Transport Vessels (LTVs) used but only three anchorages required	Anchor chains	3 (1 per vessel)	100	0.08	75 m [a] radius circular disturbance zone	35,343	n/a
	Drag embedment anchors	3 (1 per vessel)	5	4	Disturbance zone of 300 m^2 per anchor	900	n/a
Overall total						35,343	n/a
						0.035 km^2	n/a

[a] Assuming 75 % of chain in on the seabed.

10.3.4.4 Risk of dropped objects

Throughout the entire Phase 1 Development there is the potential for subsea infrastructure to be accidentally dropped during the installation process.

In the event that a large object is dropped, impacts will be the same as for intentionally placed objects via direct crushing benthic fauna and suspension of sediments (section 10.3.4.1.1). Owing to the uncontrolled nature of a dropped object it is possible that such an event could lead to substantial suspension of sediment and the associated impacts.

Equally, there is the potential that subsea infrastructure already in place could be damaged leading to spills or leaks. The environmental impact of oil leaks and spills is assessed in Chapter 12.

10.3.5 Industry-standard mitigation measures

10.3.5.1 Seabed disturbance

Over and above an EIA of potential effects, there are few industry-standard mitigation requirements with regard to the disturbance of the seabed from the placement of objects. Those that do exist, e.g. the use of chain mats deployed from bottom-trawl fishing vessels in the North Sea to flatten the profile of raised clay berms (and thus reduce the future risk to fishermen), do not apply in the Sea Lion location as the lines are not being trenched or buried.

However, during all vessel anchoring, preparation and management, good operational practices e.g. optimal tensioning of anchor chains will be used to minimise anchor scouring and damage to the seabed.

10.3.5.2 Marine growth on hard substrates

In the North Sea, the composition of marine growth and the depth of each marine growth layer (e.g. seaweed, mussels etc.) is periodically surveyed and the growth is removed if the structural integrity of the asset is compromised by the added weight of marine growth. This applies less for an FPSO than for fixed structures. However, if the FPSO risers become fouled to a point where they fall out with design safety parameters, the marine growth may be cleaned off into the sea. The FPSO will be treated with antifoulants to minimise the potential for growth. However, seabed surveys / inspections throughout the Development will inform the level of growth on the seabed structures and mooring systems.

10.3.5.3 Dropped objects

Good oilfield practice will be observed such that all dropped objects will be reported to FIG and retrieved, where possible, as soon as is reasonably practicable. Any remaining debris will be retrieved in the decommissioning process and checked with a seabed clearance survey (section 5.12).

10.3.6 Impact and risk assessment

The following section draws upon all the information provided above to assess the 'Sensitivity of the Receptor' and the 'Severity of Effect' in order to determine the overall impact of planned activities. Assessment of unplanned events includes an assessment of the 'Likelihood of Occurrence' to determine the 'Risk'.

A summary of the impact and risk assessment outcomes is tabulated in section 10.3.12, which shows the worst case impact / risk for each activity and receptor.

10.3.6.1 Impact assessment of disturbance to the seabed

10.3.6.1.1 Sea Lion Field

10.3.6.1.1.1 Disturbance to fauna and existing habitats

It is assumed at this time that the benthic species diversity and abundance in the area of the DC(s) and the GPI well(s) will be similar to that recorded in the previous benthic surveys across the Sea Lion Field area and that the benthic communities are typical of the area (section 7.4.3.2).

Whilst optimisation of the seabed layout results in an increase in offshore seabed footprint compared with previous estimates, the area likely to be disturbed during the installation of subsea infrastructure is relatively small (section 10.3.4.2) as the equipment is laid directly onto the seabed without the need for trenching or burial operations. Furthermore, the seabed area is likely to contain 'negligible numbers of any species of geographical importance' and no habitats have been identified that would be equivalent to designated sites under UK legislation (section 10.3.4.2.1.2). Should any species or habitats be identified in site-specific surveys which are of ecological importance, the zone of influence is sufficiently small that the **sensitivity of the receptor** is considered to be '**Very Low'**.

While direct impacts will be fatal to a small number of individuals, the area likely to be impacted by direct crushing or smothering is small. Similarly, the suspension of sediments following one-off installation processes will be very short-lived and therefore un-likely to result in any impact (section 10.3.4.1.2). Therefore, any changes will be barely detectable above background variability. At the population level, any impacts will be fully reversible once the installation activity ceases and therefore the **severity of effect** is considered to be 'Slight'.

The overall **significance of impact** is assessed as 'Very Low (1)'.

10.3.6.1.1.2 Habitat modification and marine growth

Assessing the sensitivity of the receptor and severity of effect of marine growth on hard substrates is a challenge as the impact of 'artificial reefs' on biodiversity may be considered positive or negative (section 10.3.4.1.3). For the purposes of this assessment, it assumed that any anthropogenic contribution to the environment is 'negative'.

The main receptors that may be impacted by marine growth are flora and fauna. The biodiversity of the local area may be affected should any species not common to the area be able to settle, or that of the broader region should species use the substrate as a stepping stone (section 10.3.4.1.2). However, species diversity and abundance in the NFB is relatively uniform, and the species are not considered to be of geographical or conservation importance. Therefore, the **sensitivity of the receptors** in the existing Sea Lion baseline is estimated to be **'Very Low'**.

There are not believed to be any habitats of particular ecological importance that could be damaged in the Sea Lion Field (section 10.3.4.2.1.1). However, given the homogenous nature of the seabed and sediments at the Sea Lion Field, and the relative absence of hard substrates in the region, the installation of infrastructure will effectively create a new habitat in the area. The small surface area of the artificial substrate and the isolated location indicate that the colonisation of seabed infrastructure will be slow. Although, as is shown in section 10.3.4.2.1.3 above, it is likely that the hard substrate will become colonised and this change to the benthic community in the area will be detectable against the background environment. Nonetheless, this impact will be very localised and reversible once the infrastructure is removed such that, on balance, the **severity of effect** is considered to be **'Moderate'**.

The overall **significance of impact** is assessed as **'Low (3)'**.

10.3.6.1.2 Berkeley Sound

10.3.6.1.2.1 Disturbance to fauna and existing habitats

Berkeley Sound supports a wide range of habitat types and benthic species. Most of these are widespread and commonly found elsewhere in the Falklands archipelago. However, the mottled sea star which was found at the BS_ENV_42 location is considered to be rare in inshore waters (section 7.4.3.3.3.1) and the identification of habitats that could potentially qualify as geogenic reefs, also at BS_ENV_42, indicates that a precautionary approach should be taken. Given that these habitats are 'currently undesignated but could be of local importance', the **sensitivity of the receptor** to crushing / smothering (should it be present at the LTV anchoring site which is currently unknown) is, on balance, considered to be **'Moderate'**.

. The area that will be disturbed by the anchoring LTVs is very small (section 10.3.4.3.3) and is likely to be in an area that has frequently been subject to anchor placement before, as has much of Berkeley Sound. While the previous scarring of the area does not directly affect this assessment, it does indicate that the disturbance caused by the use of anchors is unlikely to stand out over and above the existing baseline and therefore, the **severity of effect** is considered to be **'Slight'**.

The overall **significance of impact** is assessed as 'Very Low (3)'.

10.3.6.2 Risk assessment of unplanned and accidental events

10.3.6.2.1 Risk of dropped objects

Given that dropped objects would be an unplanned event, it is not possible to predict what might fall or what the extent of any impacts may be. Although a dropped object may result in the suspension of sediment, even if a large object was dropped, a relatively small area would be affected. It is likely that negligible numbers of any species of geographical importance will be present within the zone of influence and therefore the **sensitivity of the receptor** is considered to be **'Very Low'**.

Equally, the duration of sediment suspension will be very short such that the **severity of effect** is considered to be **'Slight'**.

Therefore, the overall **significance of impact** is assessed as **'Very Low (1)'**.

With regard to the likelihood of objects being dropped, data gathered between 1980 - 1999 indicate that in a yearly average of 24,480 lifts from mobile unit crane decks, only 0.034 losses per year occurred (OGP, 2010). Given the ongoing developments that have occurred in the industry since 1999 with regard to improvements in safety, the loss of a larger object during the installation in Stage 1 would require the failure of numerous engineering and procedural controls and therefore the **likelihood of occurrence** is considered to be **'Unlikely'**.

Therefore, the **overall risk** associated with disturbance to the seabed from dropped objects considered to be **'Very Low (2)'**.

10.3.7 Project-specific mitigation measures

The impacts and risks are considered to be 'Low' or 'Very Low' such that there is no need for any further project-specific mitigation measures.

Note: please see also the mitigation measures described in section 10.12 with regard to the introduction / spread of non-native marine species.

10.3.8 Residual impacts and risks

Not applicable.

10.3.9 Cumulative impact

10.3.9.1 Sea Lion Field

Given the absence of any other O&G activities in the NFB, there is no potential for cumulative effects at this time, or for the interconnectivity of 'created habitats'. In the event that additional infrastructure is laid upon the seabed in future however, the potential for cumulative effects and interconnectivity with regard to the potential 'stepping-stone' effect of marine growth on hard infrastructure (BAS, 2014) would need to be re-examined in the EIA carried out by future operators.

10.3.9.2 Berkeley Sound

Scarring on the seabed in Berkeley Sound is widespread and extensive owing to the extent of historical and ongoing vessel activity and anchoring (section 7.4.3.3.3.7). While the LTVs will anchor during the initial construction phase, and will weather vane around the anchors, this will occur in one location causing damage to only a very small area. Therefore, the LTV anchors are not expected to make a significant contribution to cumulative impacts on biodiversity.

10.3.10 Confidence

The uncertainties within this assessment include:

- Confirmation on which MODU anchor array will be used;
- The absence of site-specific offshore benthic surveys and detail on the diversity and abundance of benthic fauna around the DC(s) and the GPI well(s);
- Final location of the LTV anchorages ; and
- The absence of samples at the specific LTV anchoring locations.

The use of a different MODU anchor array is not considered to affect the impact assessment because of the contingencies included in the calculations.

While the wider survey of the Sea Lion Development area has provided sufficient information on which to base the current assessment, the specific benthic habitats and fauna at the Sea Lion location have not yet been surveyed and this is acknowledged as a data gap.

Beyond the above, the subsea infrastructure requirements are well understood and the data used for the assessment assume the worst case with regard to equipment dimensions and the local environment. Overall, the **confidence** in the seabed disturbance and marine growth assessments is **'Probable'**.

10.3.10.1 Monitoring required

As noted in, seabed surveys will be required prior to, and throughout, the Development for numerous reasons and will be used to:

- Further inform the environmental baseline;
- Enable validation of this EIA in future years; and
- Assess any needs for remediation.

The Premier monitoring strategy has been established at the Environmental Monitoring and Management Plan (EMMP) workshop. All monitoring requirements agreed by Premier and FIG will be recorded and managed via the project-specific Phase 1 EMMP (an outline EMMP is provided in Chapter 15).

10.3.11 Offsetting

As no residual impacts or risks identified in this section are considered significant, i.e. Moderate or above, offsetting is not considered (see section 8.9).

PremierOil

10.3.12 Findings summary

Table 10.16: Summary of the impact and risk assessment for the placement and removal of objects on the seabed

Activity	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Placement of objects on the seabed	Installation of MODU / FPSO mooring systems, SPS and SURF at Sea Lion Field	Disturbance to the seabed, benthic fauna and habitats offshore	Planned	1	Very Low	Slight	n/a	Very Low (1)	n/a	Probable	Industry-standard: Good operational practices. Marine growth removal. Seabed surveys / inspections. Project-specific: None proposed.
		Habitat modification and marine growth	Planned	1, 2 & 3	Very Low	Moderate	n/a	Low (3)	n/a	Probable	
	Anchoring of the LTVs, in Berkeley Sound for a combined period of up to 12 months for the complete subsea campaign	Disturbance to the seabed, benthic fauna and habitats	Planned	1 & 2	Moderate	Slight	n/a	Very Low (3)	n/a	Probable	
Dropped objects	Loss of equipment or infrastructure to the seabed	Disturbance to the seabed and benthic fauna	Unplanned	1, 2 & 3	Very Low	Slight	Unlikely	Very Low (2)	n/a	Probable	Industry-standard: Reporting and retrieval of dropped objects Project-specific: None proposed.

[a] See Chapter 8.0 for definitions of sensitivity, severity, likelihood and significance.

10.4 Underwater noise offshore

Table of Contents

10.4 Underwater noise offshore

10.4.1 Introduction

Underwater noise will be generated in the Sea Lion Field throughout the development and will result primarily from piling associated with conductor installation activities and the use of vessels.

The properties of sound in water (range and speed of travel) are exploited by many marine animals as a means of communication, navigation and detecting prey or predators. Sound travels at approximately 1,500 m/s in water (about five times faster than in air) and low frequency sound can propagate over hundreds to thousands of kilometres, although the effective range of most biological functions is tens of kilometres. Man-made (anthropogenic) noise in the marine environment can interfere with these processes and is recognised as having the potential to cause harm to marine animals. Consequently, underwater noise is regarded as a form of pollution.

In recent years, a number of comprehensive reviews have investigated the sources of underwater noise generated by the oil and gas (O&G) industry (Genesis, 2011) and the implications of anthropogenic noise for marine animals (Wartzok *et al*., 2004; Gordon *et al*., 2004; Southall *et al*., 2007; OSPAR, 2009b; NOAA, 2013). Despite the growing volume of research this remains an area that is poorly understood, largely due to the difficulties of observing and measuring the impact of noise on animals in the marine environment. Therefore, a precautionary approach is required during any impact assessment.

This chapter provides an assessment of the potential impacts of underwater noise generated during the offshore components of the Phase 1 Sea Lion Development. When assessing the impact of sound on any animal, it is necessary to compare the sounds being made with the thresholds above which the animal may experience injury or may exhibit behavioural reactions to disturbance. It is also necessary to consider how close the animal needs to be to the source of the noise for it to experience the sound at levels above the injury and disturbance thresholds. Therefore, to inform the assessment, Premier commissioned Genesis (2016) to conduct underwater noise modelling to identify and characterise the sources of underwater noise that will be generated during the Phase 1 Development, and their potential impacts. Since this was completed, more recent guidelines on acoustic injury for marine mammals have been published (NMFS, 2016) and received noise levels have been updated accordingly while retaining the same framework of transmission loss calculation dependent on frequency.

The Direct Offtake Conventional Trading Tanker (CTT) will not use Dynamic Positioning (DP) during the offshore offtake operation. The Direct Offtake CTT will be attached to a DP-capable tug throughout but overall, noise levels produced by the CTT/tug offtake will be lower than with the previous OLST option. Noise source levels from large vessels have a high uncertainty and will be measured under the EMMP (section 15).

The impact of underwater noise from any vessels used inshore (i.e. LTVs in support of the subsea construction campaign) are assessed in section 10.5.

Note: the other impacts associated with vessel use are described elsewhere in this document, as described in section 9.2.

10.4.1.1 Relevant legislation

The following legislation is relevant to the management of underwater noise:

- European legislation:
  - EC Habitats Directive (Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora).
- UK legislation:
  - Offshore Marine Conservation (Natural Habitats & Conservation) Regulations 2001 (OMR) (and all associated amendments) - and the potential need for a Disturbance Licence; and
  - Conservation (Natural Habitats) Regulations 1994 listing of all European Protected Species (EPS).
- Falkland Islands legislation:
  - Marine Mammals Protection Ordinance 1992;
  - Conservation of Wildlife and Nature Ordinance 1999; and
  - Fisheries (Conservation and Management) Ordinance 2005.

10.4.1.1.1 Offences against marine mammals

The Falkland Islands' Marine Mammals Ordinance 1992 states that it is an offence to:

- Intentionally take, wound, or kill any marine mammal in Falkland Islands waters.

However, what constitutes a wound is not clearly defined. Therefore, following the definitions used by the EC Habitats Directive, injury to a marine mammal (assumed to be analogous to wounding) is assumed to include:

- The creation of a 'Permanent Threshold Shift (PTS)' in hearing.

Further the Ordinance does not cover disturbance to marine mammals. Therefore, again, the EC Habitats Directive guidelines are followed in this assessment whereby it is an offence to intentionally or deliberately disturb any marine mammal in a way which is likely to:

- Impair its ability to:
  - Survive, reproduce or rear / nurture their young; and / or
  - Migrate;
- Significantly affect the local distribution or abundance of the species to which it belongs.

Note: in the UK, it is not an appropriate defence to claim that an impact upon a protected species was an 'incidental result of an otherwise lawful activity'. Therefore, in the UK, the potential for injury and / or disturbance must now be assessed prior to commencement of relevant activities to determine the need for mitigation measures, or the need for a 'Disturbance License' where impacts may occur and cannot be mitigated. No such equivalent currently exists in the Falkland Islands.

10.4.2 Sources of underwater noise

Anthropogenic sources of underwater noise associated with the Phase 1 Development include:

- High intensity pulsed sounds:
  - Pile-driving of the well conductors (if carried out, see section 5.4.5.1).
- Moderate intensity continuous (non-pulsed) sounds:
  - Drilling by a Mobile Offshore Drilling Unit (MODU);
  - Machinery noise (from the FPSO);
  - Vessel engine / thruster noise from the oil export tankers; and
  - Helicopter flights operating between Stanley airport / MPN and the MODU, FPSO, and the CTT.

10.4.2.1 Pile-driving

Although suction piling can be used in soft sediments, pile-driving most commonly refers to an object being forcibly driven into the seabed using a hydraulic hammer. Pile-driving can generate substantial levels of pulsed underwater noise. The level of this noise will depend on the size and maximum operating energy level of the hammer, the diameter and length of the piles, seabed conditions, and the physical factors that will influence sound propagation (such as water depth, bathymetry and salinity).

It is still uncertain whether piling will be employed during Phase 1 to install the well conductors from a vessel, or whether these will be drilled into place by the MODU (section 5.4.5.1). However, for the purposes of assessing the potential impacts of underwater noise, the worst case scenario of pile-driving the well conductors has been assumed, as well as suitable monitoring and measurement. It is understood that piling may occur for a relatively short period (nine days in total) during early Stage 1 of Development.

10.4.2.2 Drilling

Sound associated with drilling from the MODU will be created by rotating equipment; such as generators, pumps and the drill string.

Drilling will occur during Stages 1 and 2 of the Phase 1 Development and noise will be continuously generated for sustained periods throughout the drilling operations.

10.4.2.3 Vessel noise

Noise from vessels is generated by propeller cavitation, thrusters such as those used in DP systems, and noise transferred to the ship's hull from the engine and other systems. Numerous vessels will be used during the Phase 1 Development (see section 10.4.4.3.4.4).

Detail on the type and purpose of all the vessels used throughout the Development are provided in section 5.11.2.

The sources of vessel noise will be reasonably constant throughout Stages 1, 2 and 3 of the Phase 1 Development (> 20 years). However, the frequency of vessel visits to the (FPSO by the CTT will decrease over the life of the Field.

The constant nature of the sound generated by the FPSO and Direct Offtake CTT vessels means that animals are not subjected to sudden bursts (pulses) of noise as they are with piling noise.

As the vessels, or animals, move through the water the sound intensity will increase, or decrease, gradually.

The modelling below is considered to be worst case as it uses the previous (i.e. noisier) OLST option attending the FPSO. Whilst this is no longer the case, the modelling results are included as they are a useful worst case benchmark of offshore underwater noise impacts.

In reality, however, the assessment within this section recognises that the source sound level will vary depending on activity. Although there is already a degree of vessel noise in the area during the course of the year (which is near a route taken by numerous fishing and trade vessels), the static nature of the FPSO and associated vessels represents a permanent source of anthropogenic noise.

The approach of either the CTT to the FPSO will be at low speed under its own propulsion, as The CTT will have behind it a support vessel (tug) under low power that is holding the stern of the CTT under tension, sufficient to control heading. During close approach, the CTT-tug combination would not operate on DP, although the tug would be DP-capable if required in an emergency. During offtake, the CTT-tug combination would again operate under relatively low power and low noise levels. On departure the CTT would move away at low speed under its own propulsion. When full, tankers would then either depart to market under main propulsion or remain in field maintaining position until the FPSO had a second cargo to offload and the sequence would be repeated.

10.4.2.4 Helicopter flights

Underwater sound resulting from helicopter overflights is not well quantified, but is primarily generated by the rotation rate of the propellers and the number of blades. The main contribution to underwater sound from helicopters is on the approach to, and take-off from, installations. The level of sound received underwater depends on the altitude and aspect of the helicopter, with the peak level received as the helicopter passes overhead. The duration of underwater sound from helicopters is usually brief (in the order of tens of seconds). The sound source spectra, which have been used in the modelling for vessels and the helicopter, are shown in Figure 10.12 (Page 711). Helicopters will be used throughout all phases of the Sea Lion Development (see section 5.11.3); however, it is clear that helicopters will contribute little to the combined sound pressure level. Although included in the modelling, helicopters are not considered further, in isolation, as a significant source of underwater noise.

10.4.3 Potential receptors

The ENVironmental Impact IDentification (ENVIID) workshop was used to identify those receptors upon which the impacts of underwater noise offshore warranted further investigation (Chapter 9). These include:

- Invertebrates in the North Falkland Basin (NFB) and around the Sea Lion Field (e.g. cephalopods and crustaceans) (section 7.4.4.2);
- Fish in the NFB and around the Sea Lion Field (section 7.4.4.2);
- Seabirds in the NFB and around the Sea Lion Field (section 7.4.5.2); and

- Marine mammals in the NFB and around the Sea Lion Field (e.g. whales, dolphins and seals) (section 7.4.6.2).

The above may be impacted upon as they either exist in, or spend time in, the zone influenced by anthropogenic sound. To varying degrees, all the above may use, or rely on, sound for various life functions and / or may be impacted upon directly by sound.

10.4.4 Characterising and quantifying the impact of underwater noise

When characterising and quantifying the impacts of underwater noise, it is necessary to consider:

- The behaviour of sound and how it is measured;
- The concept of hearing thresholds in receptors (e.g. fish, seabirds and marine mammals);
- The nature of the impact on receptors; and
- Quantification of sound propagation - sound modelling.

10.4.4.1 The behaviour of sound and how it is measured and described

All sound travels in waves, Figure 10.10 illustrates a sound wave and the relationship between ‘peak pressure’ and ‘root mean squared pressure’. In understanding this chapter it is important to understand that:

- ‘Peak sound level’ (PK) indicates the highest sound pressure (loudness) experienced, which is of greatest significance when assessing pulsed sounds such as piling; and
- ‘Root mean squared’ (rms) is a means of displaying the average sound pressure (loudness) over a period of time and is of greater use when assessing the potential for disturbance.

Although continuous non-pulsed sounds (e.g. vessels noise) are often represented by an average, it should be noted that there will always be variability inherent in the sound source (i.e. peaks in sound output). Therefore, the root mean squared value should be averaged over sufficient time to smooth out variations in output.

When reading this chapter, it is important to appreciate that the field of underwater acoustics utilises a great deal of technical terminology and to enable greater understanding of this chapter, the key terminology is defined in Table 10.17:

.

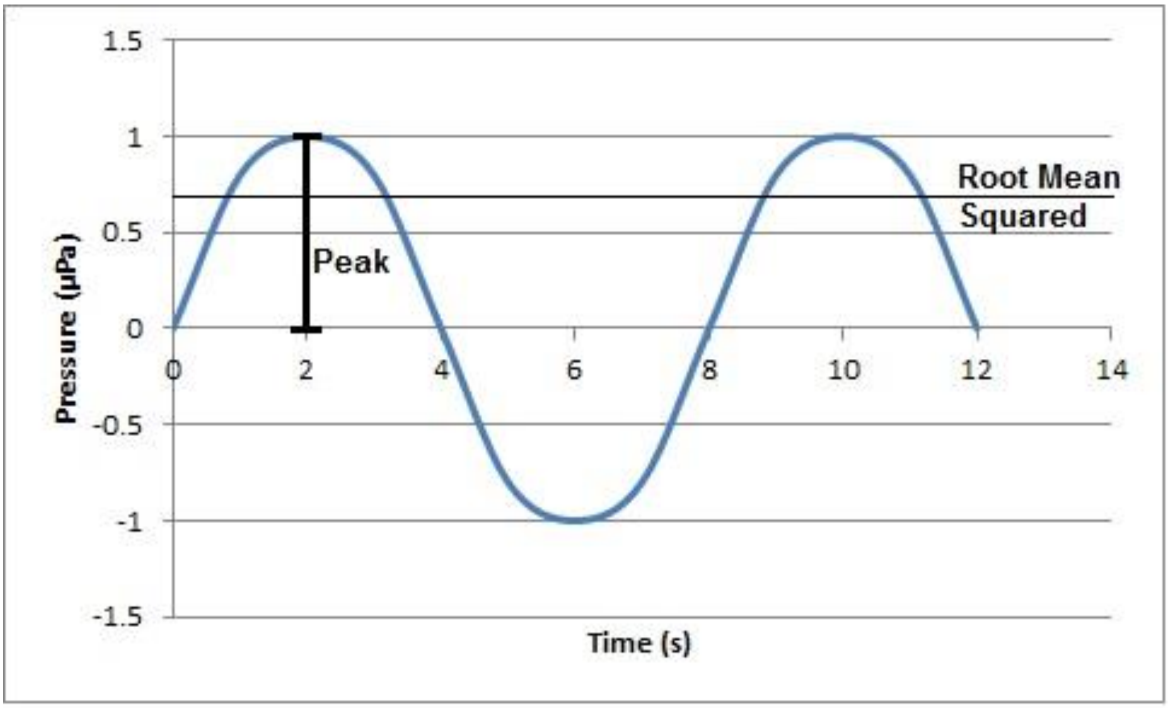


Figure 10.10: Sinusoidal wave showing changes in pressure over time, illustrating measurement parameters for Peak pressure and Root Mean Squared pressure

Table 10.17: Definitions of terms found in the text

Term	Definition
Hz	Hertz; measurement of sound frequency (in cycles / waves per second). Differences in sound frequency are experienced by the listener as changes in pitch (a high frequency is high pitched whereas a low frequency is low pitched). Marine mammals have evolved to hear sounds over a specific range of frequencies, which are used to describe different hearing groups (e.g. low, moderate and high frequency cetaceans).
Recoverable injury	Recoverable injury, refers to injuries, including hair cell damage, minor internal or external bleeding. None of these injuries are likely to cause direct mortality.
TTS	Temporary Threshold Shift, a temporary, reversible increase in the threshold of audibility (i.e. a reduction in sensitivity) at a specified frequency or portion of an individual's hearing range (i.e. temporary deafness).
PTS	Permanent Threshold Shift; a permanent, irreversible increase in the threshold of audibility (i.e. a reduction in sensitivity) at a specified frequency or portion of an individual's hearing range (i.e. permanent, but not necessarily complete, deafness).
dB (re. 1µPa)	deciBel; The unit used to measure the intensity of a sound. re. 1µPa indicates a reference pressure for underwater sound. In order to cover the range of hearing sensitivity from just audible to unbearably loud, the deciBel (dB) is measured on a logarithmic scale. For example, the smallest audible sound (near total silence) is 0 dB. a sound 10 times more powerful is 10 dB. a sound 100 times more powerful than near total silence is 20 dB. a sound 1,000 times more powerful than near total silence is 30 dB.
Impulse sound	Sound sources that are typically short (less than 1 second) and of high intensity. Impulse sounds characteristically have high peak sound pressure with rapid rise and rapid decay. They can occur in repetition or as a single event. For example, pile driving.
Non-impulse sound	Generally, a continuous noise with little variation in sound intensity. Examples of non-impulse sound sources include: marine vessels, aircraft, machinery operations / construction

Term	Definition
rms	Root mean squared; is the average of the squared sound pressure over some duration of time (Figure 10.10). This gives a measure of the average sound pressure received per unit time and is often used as a measure of intensity of non-impulse sounds.
Source level (zero-peak)	Refers to the level of sound measured at a nominal distance of one metre from the sound source, expressed as dB re. 1 µPa @ 1m in water.
Sound Pressure Level (SPL)	Intensity of a sound at any given point, expressed in dB re. 1 µPa.
Peak Sound Pressure Level (PK)	Peak Sound Pressure is defined as the greatest absolute instantaneous sound pressure within a specified time interval and frequency band. Although relevant to all sources of sound, peak sound pressure is most relevant to impulsive sounds (e.g., short duration and high amplitude), which can create a greater risk of causing direct mechanical fatigue to the inner ear in comparison to sounds that are strictly non-impulsive
Cumulative Sound Exposure Level (SEL(cum))	A measure of the energy of a sound, and is therefore related to Sound Pressure Level and time (exposure). SEL(cum)s are considered useful when making predictions about the physiological impact of noise: hearing damage can be modelled as a function of the acoustic energy of a stimulus, and the onset of temporary hearing damage depends on the SPL and exposure time (e.g. a subject can be safely exposed to a weaker stimulus for a longer time, but exposure to a loud stimulus would only be acceptable for a short time). SEL(cum) is expressed as dB re 1µPa^{2}s.
Hearing threshold	The average sound level, at a specific frequency, that is just audible to a subject (e.g. a human or a marine mammal) under quiet conditions.
Injury threshold	The sound threshold (intensity) at which a receptor may experience hearing injury, which would lead to a permanent shift in the receptors hearing ability (i.e. deafness as defined in section 10.4.1.1.1).
Disturbance threshold	The sound threshold (intensity) at which a receptor may experience disturbance due to an inability to hear biologically significant sounds (such as communication calls) or may change its behaviour.
Avoidance / displacement threshold	The sound threshold (intensity) below the injury threshold but sufficient for an animal to depart from an area to avoid disturbance. This can result in a cessation of feeding or mating behaviour.

10.4.4.2 Hearing thresholds in receptors - the concept

It is important to acknowledge that the sound perceived by different species, and individuals within species, is not necessarily the same as the sound actually made. In other words, not all receptors (e.g. humans, marine mammals, seabirds) will perceive the same sound in the same way and to one it may be very loud while another cannot hear it at all. Similarly, hearing thresholds can differ between individuals and / or can change within an individual's lifetime.

For example, hearing sensitivity usually declines with age, particularly in the high frequency range. Such changes can occur naturally as a result of aging and associated wear and tear or as a result of hearing injury caused by exposure to high intensity noise.

Irreparable damage to an individual receptor's hearing apparatus, and the associated shift in hearing sensitivity, is referred to as a 'Permanent Threshold Shift' (PTS). Shorter-term reversible changes to an individual's hearing ability (e.g. temporary tinnitus following exposure to loud music) is referred to as a 'Temporary Threshold Shift' (TTS) which can be experienced when individuals are exposed to sound levels below the PTS threshold.

Therefore, although perceived loudness is proportional to the 'Sound Pressure Level' (SPL) in dB, an SPL value in isolation would be meaningless if one wanted to predict how loud another animal has perceived a sound, or whether a sound is likely to elicit a response or inflict injury. In part, this is because the hearing systems of animals are not equally sensitive to all frequencies of sound (Hz). Therefore, in light of the above, an important concept is that of the 'hearing threshold'. The hearing threshold is the average sound pressure level that is just audible to a subject under quiet conditions (Table 10.17: above). When the hearing threshold is plotted as a function of the frequency of sound (Hz), the plot is called an 'audiogram'. Figure 10.11 shows the audiograms for a range of receptor species.

The audiogram plot indicates the average hearing threshold for a range of frequencies for each species. Note however, that the audiograms for most marine species remain unknown and those that have been published are often derived from a few individuals under artificial conditions.

Importantly, SPLs below the hearing threshold will not be detected at all and the higher an SPL is above the threshold, the greater the perceived intensity (volume) will be.

To work through an example in order to understand the audiograms, as shown in Figure 10.11, at a frequency of 1,000 Hz, humpback whale has a hearing threshold of 42 dB re 1 μPa. This means that if a sound at 1,000 Hz was made in quiet conditions, a humpback whale would not hear the sound until it was loud enough, or intense enough, to be at 42 dB re 1 μPa. The variables which affect whether or not, a sound may be this loud, or intense, include the intensity of the sound source and the distance of the receptor from the sound.

When an animal experiences hearing loss due to excessive sound, the line displayed on the audiogram shifts upward (i.e. the animal would become less sensitive to sound at a given frequency).

This has resulted in the accepted use of weighting functions for some animal groups such as marine mammals that are applied to received noise levels to adjust them in relation to their hearing sensitivities, which is discussed further below.

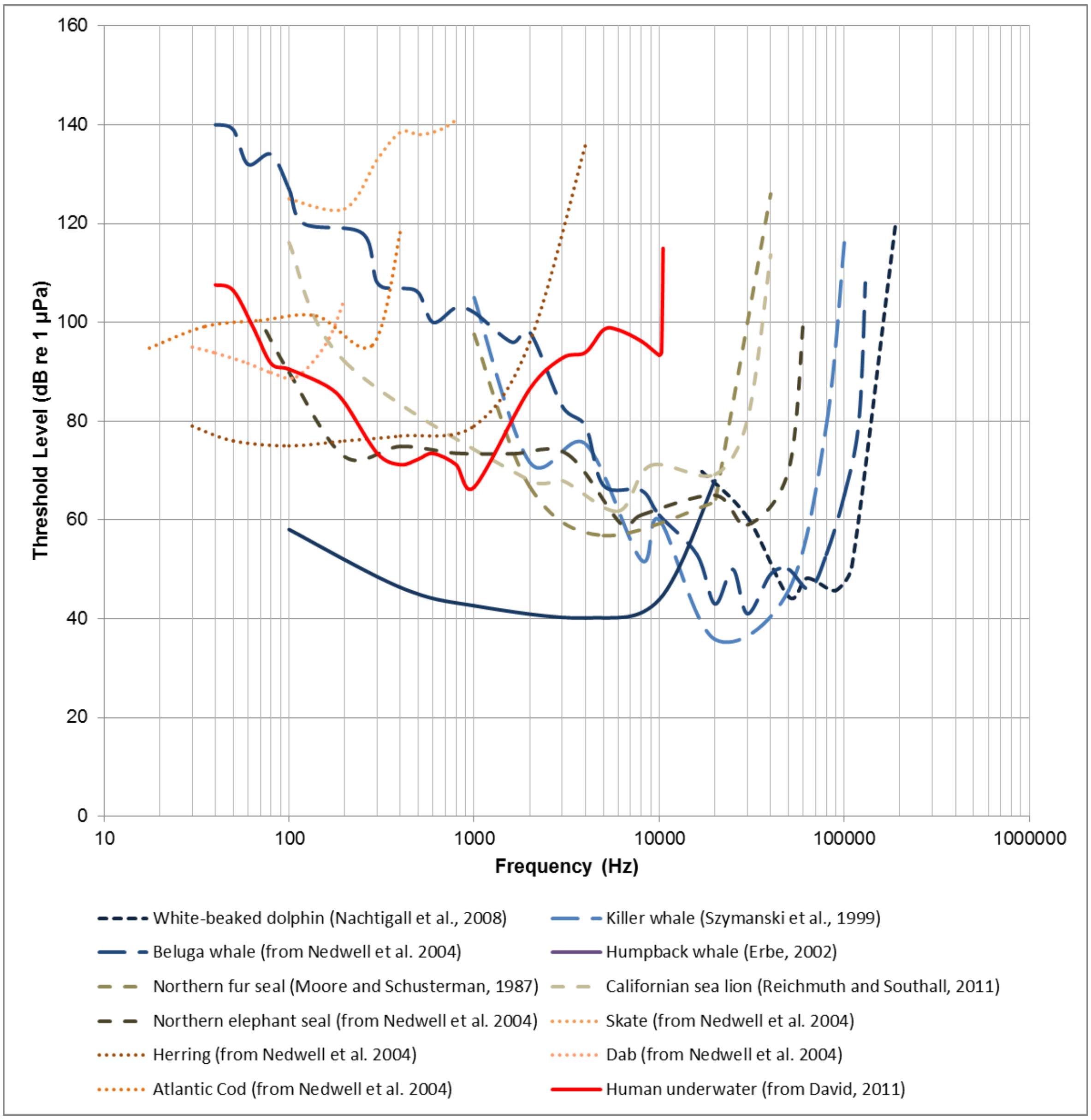


Figure 10.11: Audiograms covering a range of fish and marine mammal hearing groups and humans (underwater)

10.4.4.3 Nature of the impact and the hearing thresholds of each receptor group

When assessing the impact of underwater noise on a given receptor there are two important considerations to make:

- Whether, and how, the sound will impact upon individual animals; and / or
- Whether, and how, the sound will impact upon the long-term viability of populations.

An action or activity becomes biologically significant to an individual animal when it interferes with normal behaviour and activity, or affects the animal's ability to grow, survive, and reproduce. Where a biologically significant proportion of a population is impacted, such effects may have consequences at the population-level and may affect the viability of the species (NRC, 2005). For receptor groups that are generally very numerous and reproduce often (such as fish) the impact at the population level is the key consideration. Where a species has a relatively small population size, and / or long generation time (e.g. marine mammals) the impact on individuals is more significant and may have direct implications for the local population.

10.4.4.3.1 Invertebrates

There is scant information on the effect of underwater noise on the behaviour of marine invertebrates. The available evidence suggests that some species of cephalopod (e.g. squid and octopus) and crustaceans (e.g. crabs, lobsters and shrimps) are capable of detecting sound within the low frequency range, less than 3 kHz (OSPAR, 2009b).

A little work on sound detection in cephalopods has been conducted. Hu *et al*. (2009) discovered experimentally that common octopus (*Octopus vulgaris*) can detect sounds between 400 Hz and 1,000 Hz. The bigfin reef squid (*Sepiotheutis lessoniana*) can detect a wider range of frequencies from 400 Hz to 1,500 Hz. The thresholds of *S. lessoniana* were generally lower than those of *O. vulgaris*, indicating greater sensitivity over a wider range of frequencies. The lowest thresholds for both species were at 600 Hz. Other research has shown that some species of squid are similar to fish in their ability to detect sound (Mooney *et al*., 2010; OSPAR, 2009b) and are able to detect sounds of the types and frequency produced during O&G related activities. Further, studies have shown a potential behavioural response in squid, albeit to very high intensity underwater noise (seismic airguns) (McCauley *et al*., 2001). Note that in the following assessment, cephalopods are assumed to be similar to non-swim bladder fish in their ability to detect sound and are thus assessed alongside fish.

While commercially exploitable aggregations of squid are not known to occur within the area of the Sea Lion Field (section 7.7.3.1.1), it is necessary, from an ecosystem perspective, to assess the potential impact upon these animals.

Regarding other invertebrate groups, Wale *et al*. (2016) observed the effects of the playback of six hours of vessel noise to blue mussel *Mytilus edulis* in laboratory conditions. Algal clearance rates of noise-exposed mussels were significantly lower, and oxygen consumption rates higher than those of control animals, reflecting stress. DNA damage in the gills and haemolymph was also observed.

10.4.4.3.1.1 Invertebrate injury / disturbance thresholds

There are no widely accepted criteria for the levels of sound likely to cause injury or disturbance to invertebrates.

10.4.4.3.2 Fish

There have been some experimental investigations into the impacts of sound on fish but most of these investigations only concern a few fish species (and sometimes only a few individuals of these species). In many cases, the experimental design is flawed and the results vary widely (reviewed in Popper and Hastings, 2009). Nonetheless, it is understood that fish are able to both generate and detect sound which is used to communicate, sense their environment, and detect predators and prey (Popper *et al*., 2014).

10.4.4.3.2.1 Fish hearing thresholds

Relatively little is known about sound perception in fish, however, it is likely that particle motion is equally important as sound pressure in fish, and invertebrate, perception of sound. It is known that otoliths (ear bones) and gas-filled bladders are both used to detect sound and fish can be broadly categorised according to the structures used for hearing (Table 10.18:).

The presence of a gas bladder is likely to increase the ability of many species of fish to detect sounds over a broader frequency range and at greater distances from the source than fishes without such structures (Popper *et al*., 2014). Further, gas bladders, and their anatomical location within the body, make fish more susceptible to pressure-mediated injury to the ears and general body tissues than species lacking gas bladders.

In addition to the 'hearing' structures used, a number of other factors are likely to influence the impact of sound on any given fish species. These include:

- The hearing capabilities, whether generalist or specialist, and the lateral line structures of the fish;
- Life styles (e.g. bottom vs. mid-water fishes);
- The size of the individuals; and
- Behavioural responses to potential 'fright' stimuli (e.g. fishes that stay in one location vs. species that swim away).

Most fish can hear, or detect, sound within the low range of 100 Hz to 1 kHz, with some able to detect even lower frequencies. This range of frequencies overlaps with most anthropogenic sound sources in the marine environment and fish are known to react to approaching vessels at distances of 0.1 km to 1.0 km (Mitson, 1995). Many species of fish also produce sounds for communication that are typically emitted at low frequencies below 1 kHz (Montgomery *et al*., 2006).

This information suggests that sound from piling and vessels, which is primarily between 10 Hz and 10 kHz (strongest at 50 Hz to 1 kHz), is likely to be within the frequency range of sound use or detection for most fish species.

Mueller-Blenkle *et al*. noted significant movement response to the playback of pile-driving stimulus in two fish species under laboratory conditions, at relatively low received sound pressure levels (sole: 144 – 156 dB re 1µPa Peak; cod: 140 – 161 dB re 1 µPa Peak). Sole showed a significant increase in swimming speed during the playback period compared to before and after playback. Cod exhibited a similar reaction, yet results were not significant. Cod showed a significant freezing response at onset and cessation of playback. There were also indications of directional movements away from the sound source in both species. The results further showed a high variability in behavioural reactions across individuals and a decrease of response with multiple exposures.

While higher predators such as many marine mammals and seabirds are considered of conservation importance, no specific marine fish species are listed in the 1999 or 2011 Falkland Islands Biodiversity Snapshots (Procter and Fleming, 1999 and FIG, 2011) nor in the Falkland

Islands Biodiversity Strategy 2008-2018. Nonetheless, several species are important for commercial fishing.

Data are limited concerning the effects of sound on developing eggs and larvae. A study by Banner and Hyatt (1973) quoted in Buehler *et al*. (2015) found increased mortality was found in eggs and embryos of sheepshead minnow (*Cyprinodon variegates*) exposed to broadband noise (100–1,000 Hz) that was about 15 dB above ambient sound level. However, the same study found that hatched fry of sheepshead minnow and fry of longnose killifish (*Fundulus similes*) were not affected by the same exposure.

Table 10.18: Categorisation of fish hearing groups

Hearing Group	Characteristics
Fish with no swim bladder or other gas chamber (e.g. flatfish, skate)	These species are less susceptible to barotrauma and only detect particle motion, not sound pressure. However, some barotrauma may result from exposure to sound pressure.
Fish with swim bladders in which hearing does not involve the swim bladder or other gas volume (e.g. Atlantic salmon)	These species are susceptible to barotrauma although hearing only involves particle motion, not sound pressure.
Fish in which hearing involves a swim bladder or other gas volume (e.g. Atlantic cod, herring and relatives)	These species are susceptible to barotrauma and detect sound pressure as well as particle motion.
Fish eggs and larvae	For eggs and developing larvae, which may contain gas filled spaces, the inability to rapidly move away from sound sources make them susceptible to barotrauma

(Source: Popper *et al*., 2014)

10.4.4.3.2.2 Responses of fish to anthropogenic sounds

The effect of exposure to excessive sound in fish can result in:

- Behavioural responses e.g. avoidance, absence of responses owing to masking of ambient sounds;
- Stress and other physiological responses;
- Hearing loss and damage to auditory tissue;
- Damage to non-auditory tissue e.g. damage to non-auditory swim-bladder and muscle tissue, and enhanced gas bubble growth and traumatic brain injury (see Richardson *et al*., 1995a; Hastings and Popper, 2005 for reviews);
- Mortality;
- Effects on the developing larvae and young fish in the presence of sound and / or after termination of sound; and / or
- Effects on larval behaviour and longer-term survival (Popper and Hastings, 2009).

There is evidence that fish react to vessel noise, which can be an issue for survey vessels conducting stock assessment research (Mitson, 1995). However, there is no suggestion that disturbance due to vessel noise causes long-term impacts on fish populations. Fish in the early stages of life are considered to be most vulnerable to sound (OSPAR, 2009b; Popper *et al*., 2014). Planktonic eggs and larvae may be more vulnerable than adult fish simply because they are unable to actively move away from a sound source. Further, eggs and larvae appear to be susceptible to barotrauma (pressure trauma) caused by rapid pressure changes resulting from impulse sounds (such as pile driving); however, the available data suggests that mortality of eggs and larvae would only occur within a few metres of such sound sources (Popper and Hastings, 2009).

10.4.4.3.2.3 Fish injury and disturbance thresholds

Although data regarding the impact on fish is extremely patchy, a working group has recently published guideline thresholds for noise induced injury and disturbance in fish (Popper *et al*., 2014). The disturbance and injury thresholds for piling and vessel noise are shown in Table 10.19: for fish grouped by their different hearing structures. In some cases numerical guidelines are provided, expressed in appropriate metrics (for example, the threshold for mortality or potential mortal injury in fish without a swim bladder is set at 219 dB SEL or 213 dB PK). In the context of fish injury thresholds, 'recoverable injury' refers to injuries, including hair cell damage, minor internal or external bleeding. None of these injuries are likely to cause direct mortality. Although TTS injury is also by definition recoverable, TTS refers to changes in hearing sensitivity.

When there were insufficient data to support numerical values, the relative likelihood of effects occurring was evaluated at a range of distances from the source, although the actual likelihood of effects depends on the received level. These sound exposure guidelines, which are based on the best scientific information at the time, should be treated as interim (Popper *et al*. 2014).

Table 10.19: Criteria for noise induced disturbance and injury in fish

Fish type [a]	Thresholds for mortality and potential mortal injury	Impairment thresholds			Behaviour [b]
		Recoverable injury	Temporary Threshold Shift	Masking effect [b]	
Pile driving					
No swim bladder	>219 dB SELcum or >213 dB peak	>216 dB SEL cum or >213 dB peak	>186 dB SEL cum	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Swim bladder not involved in hearing	210 dB SELcum or >207 dB peak	203 dB SEL cum or >207 dB peak	>186 dB SEL cum	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Swim bladder involved in hearing	207 dB SELcum or >207 dB peak	203 dB SEL cum or >207 dB peak	186 dB SEL cum	(N) High (I) High (F) Moderate	(N) High (I) High (F) Moderate
Eggs and larvae	>210 dB SELcum or >207 dB peak	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low

Fish type [a]	Thresholds for mortality and potential mortal injury	Impairment thresholds			Behaviour [b]
		Recoverable injury	Temporary Threshold Shift	Masking effect [b]	
Shipping and continuous Sounds					
No swim bladder	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Swim bladder not involved in hearing	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Swim bladder involved in hearing	(N) Low (I) Low (F) Low	170 dB rms for 48 hrs	158 dB rms for 12 hrs	(N) High (I) High (F) High	(N) High (I) Moderate (F) Low
Eggs and larvae	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low	(N) Moderate (I) Moderate (F) Low

a See Table 10.18: .

b Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near (N), intermediate (I) and far (F).

10.4.4.3.3 Seabirds

The majority of seabirds do not spend prolonged periods underwater and are therefore not subjected to, or impacted by, anthropogenic underwater noise. However, some species; particularly penguins but also diving-petrels and shearwaters (many of which are recorded as present within the Sea Lion area (section 7.4.5.2.1)), do spend considerable periods underwater.

Penguins are known to use contact calls to communicate when on the surface, however, there is little evidence to suggest that they vocalise underwater (O'Brian, 2002). There is however some evidence to show that penguins are able to detect sound underwater and may use sound to detect predators or prey (O'Brian, 2002). Although there has been very limited dedicated research on these species, the presence of gas filled spaces in these animals (i.e. lungs, inner ears) leads to the assumption that the impact of high intensity sound could result in barotrauma similar to that experienced by marine mammals and fish. Indeed, Cooper (1982) reports mortality of over 1,000 penguins and cormorants over a period of six months during which underwater blasting was carried out. In addition, a recent study showed that African Penguins, *Spheniscus demersus*, were temporarily displaced from their favoured fishing areas during seismic survey operations in South Africa, fishing significantly further from the seismic survey vessel during the operations, and returning to the area once the operations ceased (Pichegru *et al*. 2017). Although the circumstances and intensity of the sound source during these observations were significantly higher than those predicted with the activities associated with the Sea Lion Development, these observations highlight the potential for underwater noise to impact seabirds.

In addition, diving seabirds, such as penguins, are frequently observed reacting at close range (< 100 m) to an approaching vessel (A. Black pers. obs.). These birds abruptly change direction, swimming speed and dive duration, and are observed to flee (as if reacting to a predator) in a direction perpendicular to the vessel's course. However, it seems that these birds primarily react to the presence of the vessel rather than the sound, as the sound would be audible at a greater range.

In summary, while seabirds may not utilise underwater sounds in the same way as marine mammals, they certainly rely on sound to communicate in air, both at-sea and on land and any sub-lethal impairment of hearing in these birds could impact their survival or breeding success.

10.4.4.3.3.1 Seabird injury thresholds

There is very little data available regarding thresholds for sound injury or disturbance for seabirds. However, a proposed pile driving operation with potential to impact the protected marbled murrelet (*Brachyramphus marmoratus*) prompted the formation of a multi-disciplinary panel to determine an SEL threshold for this species. An SEL threshold of injury of 202 dB re 1µPa^{2}s was agreed on by the panel (SAIC, 2011). The threshold found for the marbled murrelet was applied here to assess to estimate the impacts to diving seabirds.

10.4.4.3.4 Marine mammals

Man-made sources of sound in the ocean can disturb marine mammals, evoking behavioural responses, similar to the response to predator risk, and can trigger physiological stress responses (Tyack, 2008; Rolland *et al*., 2012). Marine mammals (cetaceans and pinnipeds) are generally considered to be of the greatest conservation concern in relation to underwater noise pollution as they are protected species that are known to use sound to communicate over large distances, to navigate, and to detect potential prey or predators. Equally, the diving capacity of some marine mammals means that even sound energy emitted close to the seabed (e.g. piling) may be accessible to these receptors.

10.4.4.3.4.1 Marine mammal hearing thresholds

Cetaceans are known to emit sound over a large range of frequencies; from low frequencies (10 Hz) in the blue whale to higher frequencies (200 kHz) in some dolphins (OSPAR, 2009b). The hearing range of species however, is likely to extend beyond the known emitted sound range.

The auditory range of species can only be determined through field observations, which are extremely difficult for free-ranging animals in the marine environment; furthermore, the full range of vocalisations used by many species encountered in the southwest Atlantic are poorly understood (Hipsey *et al*., 2013). Nonetheless, it is understood that different species of marine mammal are sensitive to different frequency ranges (Table 10.20:) and animals can be categorised into one of five groups (Table 10.20:). Inclusively, the range of frequencies utilised by an assemblage of marine mammal species can therefore be very extensive.

Whales are known to produce some of the loudest sounds in the natural world. Although the sound emitted is not the same as that perceived, the recorded sound levels may give an indication of the normal hearing range of these species. Table 10.21: shows the sound intensity of some cetacean calls. It should be noted that the nature of sperm and baleen (fin, blue, grey and bowhead) whale calls are different. Sperm whales produce pulsed clicks whereas baleen whale calls are more sustained.

Table 10.20: Marine mammal hearing groups (from NMFS, 2016)

Functional hearing group	Estimated auditory bandwidth[a]	Species occurring in the development area (Hipsey *et al*., 2013)
Low-frequency cetacean	7 Hz – 35 kHz b	Southern right whale, humpback whale, fin whale, sei whale and minke whale
Mid-frequency cetacean	150 Hz – 160 kHz	Sperm whale, southern bottlenose whale, long-finned pilot whale, killer whale and southern right whale dolphin
High-frequency cetacean	275 Hz – 160 kHz	Hourglass dolphin b, Peale's dolphin b and Commerson's dolphin
Phocid pinniped, (true seals, underwater)	50 Hz – 86 kHz b	Southern elephant seal and leopard seal
Otrariid pinniped, (eared seals, underwater)	60 Hz – 39 kHz b	Fur seal species and South American sea lion

a Represents frequency band of hearing for entire group as a composite, individual hearing ranges are typically not as broad.

b Grouping based on the NOAA guidelines (NOAA, 2015).

Table 10.21: Range of sound emitted by cetaceans

Whale species	Call type	Frequency (kHz)	Intensity dB re 1 μPa[a]	Audible range (km)	Purpose
Sperm [a]	Usual	15	230 (RMS)	16	Searching for prey
	Creak	15	205 (RMS)	6	Homing in on prey
	Coda	5	180 (RMS)	c. 2	Social
	Slow	0.5	190 (RMS)	60	Male communication
Fin [b]	Moan	0.01 to 31	155-186	Unknown	Social and navigation
Blue [b]			155-188		
Grey [b]			142-185		
Bowhead [b]			128-189		

a Whitehead, 2003.

b Kuperman and Roux, 2007.

10.4.4.3.4.2 Diving capabilities of marine mammals

The diving capability of marine mammals is relevant because it indicates the potential for animals to be close to the source of the sounds made below the surface of the sea during the Phase 1 Development (for example those made by piling).

The water depth where the piling will take place is in the region of 450 m. However, the sound pressure level will be highest at the source (where the hammer strikes the pile), which may be some distance above the seabed. While 450 m is deeper than the maximum diving range of fur seals and is on the limits of sea lion diving abilities (Reidman, 1990), this depth is well within the capabilities of southern elephant seals, which repeatedly dive to depths between 400 and 1,000 m (McIntyre *et al*., 2010). Therefore, southern elephant seals may be more vulnerable (i.e. more likely to be close to the source of sound) than other species of pinnipeds. Furthermore, Massie *et al*. (2016) recorded an average dive duration of 33 minutes for adult female elephant seals (maximum duration 95 minutes), which makes it difficult to visually track of these animals.

Of the species of cetacean present in the NFB, many are capable of diving to depths in excess of 450 m, although due to the difficulties of working with these animals in an oceanic environment, the maximum dive depths of many species remain unknown.

10.4.4.3.4.3 Responses of marine mammals to anthropogenic sounds

Underwater noise may result in a number of different impacts on marine mammals, as described in Table 10.22: .

The strength of the effect on a marine mammal is affected by the intensity of the sound experienced by the animal, which is related to the:

- Intensity of the sound source level;
- Distance of the receptor from the sound source;
- Frequency of the sound; and
- Length of exposure to the sound.

However, although marine mammals will react to noise, the response between species and individuals also varies with context and is not only related to the intensity of the sound. For example, animals engaged in feeding may be reluctant to leave an area or animals that are accustomed to vessel noise may react to a lesser extent.

Further, it should be noted that behavioural changes in response to anthropogenic noise, such as moving away from an area for a short period of time, changes in dive-time, masking of communication signals or echolocation clicks for short periods, do not necessarily result in detrimental effects on the animals involved. A reaction lasting less than 24 hours, and not recurring on subsequent days, was not regarded as particularly severe by Southall *et al*. (2007).

Table 10.22: The nature of potential impacts of sound upon marine mammals

Potential impact upon marine mammal	Nature of the impact
Masking	Masking occurs when anthropogenic sounds impair the ability of marine mammals to detect biologically significant sounds, such as communication calls, echolocation clicks or passive environmental sounds used in navigation or prey detection.
Behavioural disturbance – Avoidance / displacement	Behavioural disturbance is usually detected by changes in activity due to sound. This can range from strong avoidance behaviour (displacement) to subtle changes in vocalisations. The degree of behavioural change is very difficult to measure in the field and is likely to differ between, and within, individuals depending on their motivational state. For example, animals that are engaged in feeding may be more reluctant to change their behaviour and move away from a food source despite being subjected to noise.
Discomfort / stress	While Rolland *et al*. (2012) have recently published results that correlate changes in stress related hormones with changes in the density of shipping traffic, there is

Potential impact upon marine mammal	Nature of the impact
	limited information regarding stress in marine mammals as it is very difficult to measure. Consequently, the long-term impacts of noise induced stress are unknown.
Hearing loss	In more extreme cases, underwater noise may result in hearing loss, which could have severe consequences for animals through impaired communication and navigation skills and impaired prey / predator detection. Hearing loss can be classified as either: TTS (Temporary Threshold Shift); or PTS (Permanent Threshold Shift). Recovery from TTS can occur over a relatively short period i.e. hours or days, whereas, PTS results from tissue or structural damage and is permanent. It is likely that behavioural changes will occur at thresholds below the TTS.
Tissue damage	Research on the non-auditory effects of sound on marine mammals (i.e. tissue damage) is in its infancy (OSPAR, 2012). However, there is evidence of enhanced gas bubble growth and traumatic brain injury (see Richardson *et al*., 1995a; Hastings and Popper, 2005 for reviews). It has been proposed that avoidance / displacement behaviour, induced by anthropogenic sound, may cause some deep-diving species (such as beaked whales) to surface rapidly or remain on the surface for extended periods. This can induce a condition similar to decompression sickness and has been proposed as a potential cause of stranding in these animals (Crum & Mao, 1996 in OSPAR, 2009b).

10.4.4.3.4.4 Marine mammal injury thresholds

The injury thresholds for each marine mammal group have recently been reviewed and updated by NMFS (2016) and are summarised in Table 10.23: .

For cetaceans, published TTS data are limited to the bottlenose dolphin and beluga whale (both medium frequency cetaceans) and precautionary thresholds for all marine mammals are derived from this data (Southall *et al*., 2007). In all cases, the PTS threshold is interpolated from the TTS threshold value (Southall *et al*., 2007, NMFS, 2016).

The pressure criteria for injury are defined as 'those peak SPLs above which tissue injury is predicted to occur, irrespective of exposure duration'. For marine mammals these thresholds vary between hearing groups, as indicated by the PK values shown in Table 10.23: . Any single exposure at, or above, these peak pressures is considered to cause tissue injury, regardless of the length of exposure.

Cumulative Sound Exposure Level (SEL(cum)) is a measure of energy, summed over multiple exposures or a stated period of time. It can be an extremely useful metric for assessing cumulative exposure because it enables sounds of differing duration, sometimes involving multiple exposures, to be compared in terms of total energy. NMFS (2016) used known TTS values to infer PTS values for each marine mammal hearing group. These values are weighted to account for the variable sensitivity to specific frequencies across these groups (Table 10.20:).

Table 10.23: NMFS (2016) marine mammal TTS and PTS injury criteria for impulsive and non-impulsive sounds.

Criterion	TTS thresholds		PTS Thresholds	
Level A: Hearing Groups a	Impulsive	Non-Impulsive	Impulsive	Non-Impulsive
Low-Frequency Cetaceans (LF)	PK: 213 dB SELcum: 168 dB	SELcum: 179 dB	PK: 219 dB SELcum: 183 dB	SELcum: 199 dB
Mid-Frequency Cetaceans (MF)	PK: 224 dB SELcum: 170 dB	SELcum: 178 dB	PK: 230 dB SELcum: 185 dB	SELcum: 198 dB
High-Frequency Cetaceans (HF)	PK: 196 dB SELcum: 140 dB	SELcum: 153 dB	PK: 202 dB SELcum: 155 dB	SELcum: 173 dB
Phocid Pinnipeds (PW)	PK: 185 dB SELcum: 170 dB	SELcum: 181 dB	PK: 218 dB SELcum: 185 dB	SELcum: 201 dB
Otariid Pinnipeds (OW)	PK: 203 dB SELcum: 188 dB	SELcum: 199 dB	PK: 232 dB SELcum: 203 dB	SELcum: 219 dB

a See Table 10.20: .

10.4.4.3.4.5 Marine mammal displacement and disturbance thresholds

The SPL thresholds for disturbance of marine mammals are as follows:

- Avoidance / displacement behaviour may occur at, or above, 160 dB re 1 μPa (rms); and
- Behavioural disturbance may occur at, or above, 120 dB re 1 μPa(rms).

These thresholds are given in Southall *et al*. (2007) and are unchanged by NMFS (2016).

Behavioural responses of each marine mammal hearing group (section 10.4.4.3.4.1) to different types of sound were reviewed by Southall *et al*. (2007). Each of the reported responses were then ranked according to a 'behavioural response severity' scale summarised in Table 10.24: .

This scale was used by JNCC (2010a) to produce guidelines for assessing the risk of disturbance to marine mammals in UK waters. These guidelines interpret a disturbance as 'sustained or chronic disruption of behaviour scoring 5 or more in the Southall *et al*. (2007) behavioural response severity scale' (JNCC, 2010a) (Table 10.24:).

The more severe the response on the Southall *et al*. (2007) scale, the less time an animal will tolerate it before significant negative effects on their life functions occur, which would constitute disturbance. Conversely, less severe reactions could constitute disturbance if there is low-level, but chronic disruption of behaviour. This could happen for certain activities that expose the same animals to noise for many weeks, months, or years.

Table 10.24: Behavioural response severity scale from Southall *et al*. (2007)

Score	Definition
0	No observable response
1	Brief orientation response (investigation / visual orientation) – No observable response
2	Moderate or multiple orientation behaviours; may approach sounds as a novel object
3	Prolonged orientation behaviour; minor changes in locomotion speed, direction, and / or dive profile but no avoidance of sound source
4	Moderate changes in locomotion speed, direction, and / or dive profile but no avoidance of sound source
5	Extensive or prolonged changes in locomotion speed, direction, and / or dive profile but no avoidance of sound source
6	Minor or moderate individual and / or group avoidance of sound source
7	Extensive or prolonged aggressive behaviour; severe and / or sustained avoidance of sound source
8	Obvious aversion and / or progressive sensitisation; long-term avoidance of area
9	Outright panic, flight, stampede, attack of conspecifics, or stranding events

10.4.4.4 Quantification of the impacts - sound modelling

In order to quantify the potential impacts of underwater noise on fish, seabirds and marine mammals, the sound generated by the different activities associated with the Phase 1 Development was modelled and compared with published thresholds for injury and disturbance (section 10.4.4.3). Note however that there are currently no injury thresholds or disturbance guidelines for invertebrates and therefore the impacts of underwater noise on these species are not specifically modelled. Nonetheless, there are indications in the literature that squid have a similar hearing range to fish (Mooney *et al*., 2010; OSPAR, 2009b) and the potential for underwater noise to impact these species is, therefore, assumed to be similar. The modelling was carried out by Genesis Oil and Gas Consultants Ltd. using an interpretation of the Marsh and Schulkin (1962) 'semi-empirical' model (Genesis, 2016).

The modelling process was carried out in three main steps:

1) Identification of the levels of sound likely to be made by the Phase 1 sources of underwater noise (i.e. how much noise is each activity likely to make). These are estimated using published data on sound levels from similar activities;
2) Use of Sound Propagation Modelling which assesses the way these sounds are likely to travel out from the sources thus enabling determination of the sphere of influence of a sound source.

3) Comparison between the Phase 1 noise levels predicted by the models and the internationally recognised injury and disturbance thresholds for each receptor. As described in (section 10.4.4.3), published data are available for:
   - Injury thresholds:
     - Fish (Popper *et al*., 2014);
     - Seabirds (SAIC, 2011); and
     - Marine mammals (NMFS, 2016).
   - Disturbance and behavioural response thresholds:
     - Fish (Popper *et al*., 2014); and
     - Marine mammals (Southall *et al*., 2007).

Three Scenarios were identified and modelled to assess the impacts of underwater noise associated with the highest sound generating activities associated with the different stages of the Phase 1 Development (Table 10.25:).

To enable brevity in this section, the following provides only the information required to ensure appreciation and understanding of the modelling results and the impact assessments. Additional detail on the modelling methodology and results are provided in the following report:

- Genesis, 2016. Sea Lion Development - Underwater Noise Modelling. Document Number: J73700A-Y-TN-24005/B4. Prepared for Premier.

Table 10.25: Modelled scenarios

Scenarios	Associated sound sources	Timing	Description
Scenario 1: Installation of FPSO mooring system and well conductors	Installation vessel noise from engines / thrusters and pile-driving of inner well conductors	Early Stage 1	The FPSO suction caissons, mooring system and chains will be installed along with the pre-first oil well conductors (13 x 36” diameter), which will be driven into place using a subsea hammer system from an installation vessel. As a worst case scenario all the vessels and pile-driving has been assumed to take place in the same location and at the same time.a
Scenario 2: Installation of subsea infrastructure and drilling of wells	Installation vessels; 3 x anchor handling tugs (AHT); helicopter flights; and MODU drilling	Late Stage 1	The Subsea Production System (SPS) and Subsea, Umbilicals, Risers and Flowlines (SURF) will be installed during this time while drilling is ongoing. All sound sources have been modelled at the FPSO turret with the drilling rig at the drill centre.
Scenario 3: Steady state production	FPSO; non-dynamically positioned CTT; and 2 x support vessels	Stage 3	An FPSO will be used during production with regular CTT offloading. The FPSO will be moored using 12 suction caissons. For this scenario, the FPSO, CTT and two support vessels have all been modelled at the FPSO turret location.

a At the time of writing, it is uncertain whether the well conductors will be pile-driven as it is possible that the well will be drilled prior to inserting the conductors (section 5.4.5). Pile-driving is assumed here to ensure the worst case from a noise perspective.

10.4.4.4.1 Step 1: Identification of source sound levels

The sound source levels for the Phase 1 activities were estimated using published data as shown in Figure 10.12 and described in Table 10.26: . In order to ensure that the outcomes of the Sound Propagation Model (Step 2) were comparable with the published data used, it was necessary to convert the published data on sound levels into similar sound metrics. Details of this conversion are provided in Genesis (2016). Helicopter noise, taken from Richardson *et al*. (1995a) is a much lower contribution than the vessel noise sources (Figure 10.12).

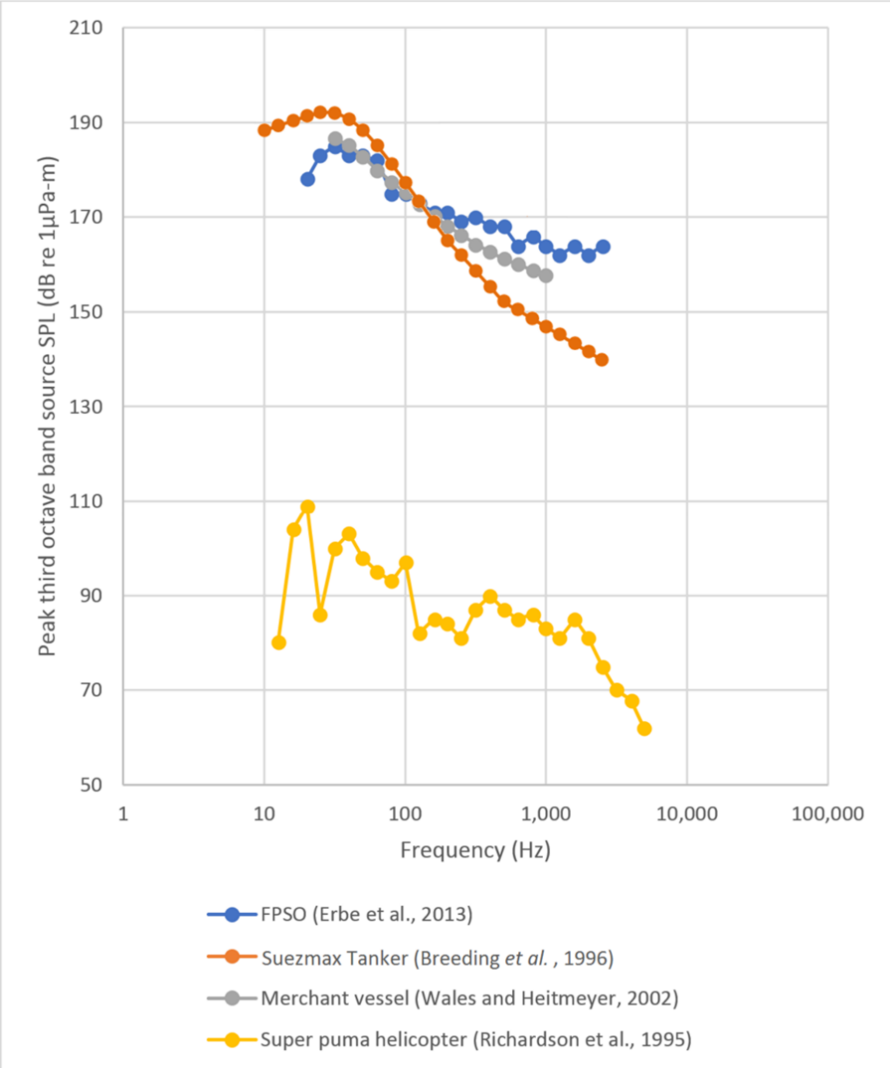


Figure 10.12: Source spectra used in the modelling to represent vessels and helicopter

Table 10.26: Summary of source sound pressure levels used to estimate the source levels associated with the Phase 1 Development activities

Sea Lion Sound Source	Representative source spectrum used for modelling	Reference	Broadband source SPL (dB re 1 µPa at 1 m)	
			Rms [a]	Zero-peak [a]
Supply ship	Merchant vessel	Wales and Heitmeyer, 2002	189	191
Installation vessel	Merchant vessel	Wales and Heitmeyer, 2002	189	191
Driving of inner well conductors	Pile driving of a 1.5 m pile, scaled	Sound spectrum ITAP to broadband SPL from McHugh *et al*., 2005	202	217
Anchor handling tug	Merchant vessel	Wales and Heitmeyer, 2002	189	191
FPSO	FPSO [b]	Erbe *et al*., 2013	189	191
DP Shuttle tanker	Suezmax tanker	Breeding *et al*., 1996	198	201

a See Table 10.22: above.

b This estimate is based on an FPSO with DP capabilities (thrusters) and is the closest analogue available to the Sea Lion FPSO.

10.4.4.4.2 Step 2: Sound propagation modelling

The results of the sound propagation models used in this assessment determine:

- The Peak Sound Pressure Level (PK), which indicates the highest level of instantaneous sound received by a receptor at a given distance from the source. This information is used to determine the distance at which injury and disturbance thresholds are exceeded; and
- The cumulative Sound Exposure Level (SELcum), which is a standardised measure of the overall sound energy that an animal will be exposed to (i.e. related to SPL and exposure time) over a specified length of time (a 24 hour period in this assessment).

As described in NMFS (2016), the SELcum was weighted according to the marine mammal hearing types (i.e. low-frequency, mid-frequency, high-frequency and otariid and phocid pinniped hearing as described in Table 10.20: above). This accounts for the differences in the sensitivity of these groups to different frequencies.

10.4.4.4.3 Step 3a: Comparison of model results with injury thresholds

Here it may be useful to reiterate that:

- All sounds, whatever the source, will have an PK and an SEL;
- Three different sound source combinations are considered (Scenarios 1, 2 and 3) with the primary differentiation being between piling noise (i.e. high intensity but short-term pulsed sounds) and vessel noise (moderate intensity but longer-term noise); and
- Sounds may inflict injury and / or elicit behavioural disturbance responses.

The purpose of the model is to determine whether or not the Phase 1 Development will emit sounds which can exceed the injury or disturbance thresholds described in section 10.4.4.3 and the distances at which animals need to be from the sound source in order to experience these effects.

The descriptions below indicate where the relevant injury and disturbance thresholds for each receptor have been breached.

10.4.4.4.3.1 Peak Sound Pressure Level (PK) results (Scenarios 1, 2 and 3)

The PKs predicted by the modelling for each of the three Scenarios (Table 10.25: above) were compared to:

- The Popper *et al*., (2014) data on fish injury levels (Table 10.19:); and
- The NMFS (2016) data on marine mammal injury thresholds (Table 10.23:).

Note again that there are no thresholds for PK available for seabirds and therefore an assessment of the impact of PK on seabirds was not possible.

Table 10.27: summarises whether PTS injury thresholds were breached and, where appropriate, the distance from the source where animals would be exposed to injurious sound. For example, a fish with no swim bladder would have to be closer than 1.8 m to the piling operation carried out in Scenario 1 to suffer a PTS injury (Table 10.27:).

The PTS threshold (the point of irreversible damage) was exceeded for HF cetaceans (threshold 202 dB re 1 μPa) in Scenario 1, to a distance of 12 m, and was at or close to the threshold at source for Scenarios 2 and 3. For all other marine mammals PTS thresholds were not exceeded (Table 10.28:).

TTS thresholds are exceeded for HF cetaceans in all three Scenarios (threshold 196 dB re 1 μPa) and for LF cetaceans in Scenario 1 (threshold 213 dB re 1 μPa). The model also predicted that the TTS for Phocid pinnipeds (threshold of 212 dB re 1 μPa) would be exceeded within approximately 76 m of the source of piling noise (Scenario 1).

Table 10.27: The distance to the Sound Pressure Level PTS injury thresholds for fish

Scenario	PK dB re 1µPa	Distance to injury (PTS) threshold (m)			
		Fish no swim bladder [a]	Fish with swim bladder not involved in hearing [a]	Fish with swim bladder involved in hearing [a]	Fish eggs and larvae [a]
Scenario 1: Vessels and pile-driving	217	1.8	4.6	4.6	4.6
Scenario 2: Vessels, helicopters and drilling	201	Not exceeded	Not exceeded	Not exceeded	Not exceeded
Scenario 3: Vessels and dynamically positioned Offshore Loading Shuttle Tanker	202	Not exceeded	Not exceeded	Not exceeded	Not exceeded

a Popper *et al*. (2014).

Table 10.28: The distance to the Sound Pressure Level PTS injury thresholds for marine mammals

Scenario	PK dB re 1µPa	Distance to injury (PTS) threshold (m)				
		LF Cetaceans[a]	MF Cetaceans[a]	HF Cetaceans[a]	Phocid Pinnipeds[a]	Otariid Pinnipeds[a]
Scenario 1: Vessels and pile-driving	217	Not exceeded	Not exceeded	12 m	Not exceeded	Not exceeded
Scenario 2: Vessels, helicopters and drilling	201	Not exceeded	Not exceeded	Not exceeded	Not exceeded	Not exceeded
Scenario 3: Vessels and dynamically positioned Offshore Loading Shuttle Tanker	202	Not exceeded	Not exceeded	1 m	Not exceeded	Not exceeded

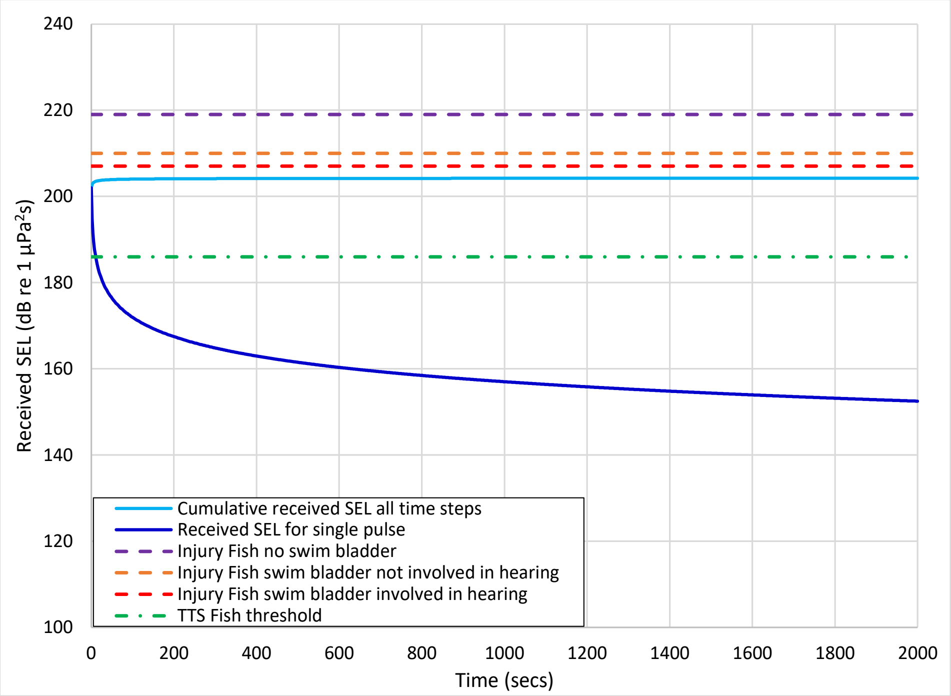
a NMFS (2016).

10.4.4.4.3.2 Sound Exposure Level (SEL) results and injury from pile driving (Scenario 1)

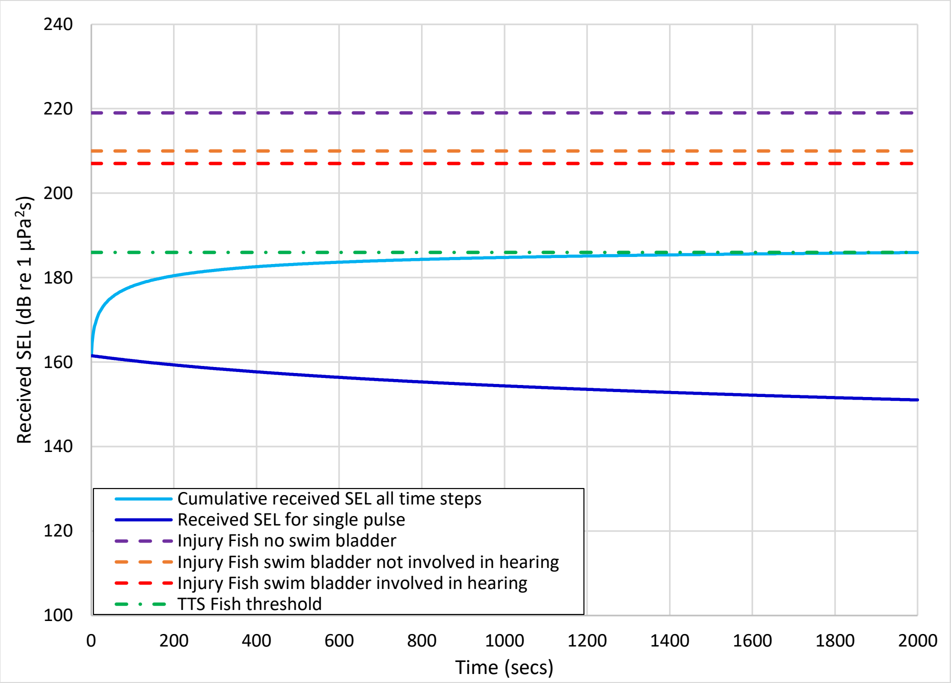
Fish and injury

Comparison between the modelled SEL results for the Phase 1 Development and the published fish injury thresholds indicated that the injury thresholds (PTS) for fish of different hearing types will not be exceeded at any point (Figure 10.13a). The model assumes that fish will swim away from the sound source at a steady 1 m/s.

Fish with a starting distance of less than 500 m from the source will experience TTS (Figure 10.13b).



a) Travelling at 1 m/s, initially 1 m from sound source



b) Travelling at 1 m/s, initially 500 m from sound source

Figure 10.13: Received SEL for a fish for one pile strike and over 24 hours of piling operations (two piles installed).

Seabirds and injury

Penguins are regarded as the most sensitive seabird receptor due to their diving ability (the proportion of time spent below the surface), priority conservation status and their recorded presence in the Sea Lion Field (section 7.4.5.2.1). Species of penguin that are potentially in the area, their diving capability and the maximum cumulative SEL(cum) per dive are shown in Table 10.29: Data on injury thresholds from underwater noise in birds are insufficient to enable plotting of the thresholds as was done for fish and marine mammals. However, the calculated received SEL was compared to an injury threshold of 202 dB re 1 Pa^{2}s (SAIC, 2011). This threshold was not exceeded for any of the species investigated (Table 10.29:).

Table 10.29: Predicted cumulative SEL for four species of penguin during a single dive

Species	Maximum dive depth (m)	Maximum dive duration (sec)	No. of pulses received	Distance from piling (m)	SEL for one pile strike (dB re 1μPa)	SEL(cum)	Injury threshold
Magellanic penguin	148 [a]	127 [a]	63.5	344	164.0	182.0	Not exceeded
Gentoo penguin	105 [b]	210 [b]	105	387	163.2	183.4	Not exceeded
Rockhopper penguin	101 [c]	184 [c]	92	391	163.1	182.8	Not exceeded
King penguin	304 [d]	462 [d]	231	188	167.9	191.5	Not exceeded

a Gómez-Liach *et al*., 2015. b Williams *et al*. 1992.

c Pütz *et al*. 2006. d Kooyman *et al*., 1992.

Marine mammals and injury

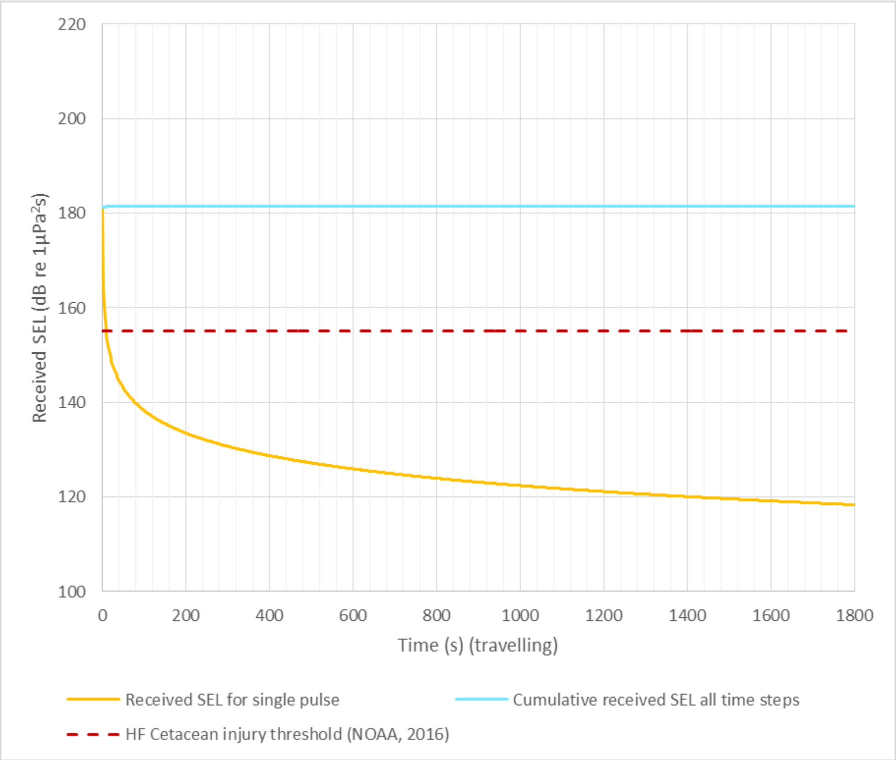
The model was run for animals which were at varying distances from the sound source at the point of the sound commencing (1 – 1,000 m). Table 10.30: shows the cumulative SEL(cum) received by a marine mammal as it moves away from the pile-driving operation at 5 m/s. However, a swimming speed of 5 m/s, which is typical of routine swimming speeds in cetaceans (e.g. Fish and Hui, 1991), is a conservative model, as 'escape' speeds used to avoid disturbance would be expected to be higher. Generally, it is predicted that most receptors will minimise the amount of time they remain in the closest ranges of a sound source (NMFS, 2016). The assumption that animals will move away from a sound disturbance is inherent in the disturbance categories described in section 10.4.4.3.4.5.

Figure 10.14 shows both the received SEL(cum) from one pile strike, and the cumulative SEL, for a high frequency cetacean as it travels away from the sound source. Again, the model was run for animals which were at varying distances from the sound source at the point of the sound commencing (this time 1 and 500 m). SEL(cum)s are also shown for pinnipeds in Table 10.22: from the same starting distances. On all figures the injury threshold (NMFS, 2016) is also shown by a dashed line.

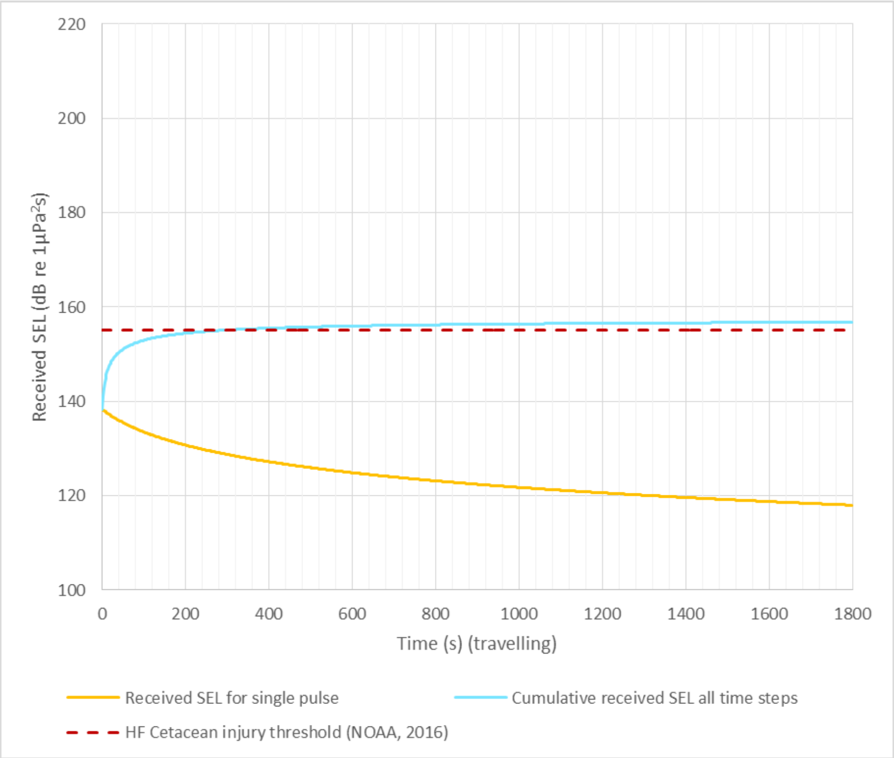
Table 10.30: Cumulative SEL(cum) at distances from the inner well conductor installation (Scenario 1). Shaded cells indicate SEL(cum)s above the PTS threshold

Initial distance from source (m)	Cumulative SEL(cum) (dB re 1μPa^{2}s) for two well conductor installations (Pile driving, Scenario 1)					
	Unweighted	Low frequency cetacean[a]	Mid frequency cetacean[a]	High frequency cetacean[a]	Phocid pinniped[a]	Otariid pinniped[a]
1	205	204	185	181	198	198
5	197	195	177	173	189	190
10	195	192	174	170	185	187
15	194	191	172	168	184	185
20	193	190	171	167	>183	184
25	192	189	171	167	<183	183
50	190	186	167	164	180	180
75	188	185	166	162	178	179
100	187	184	165	162	178	178
250	184	181	163	159	175	176
500	181	179	161	157	173	173
750	179	178	159	156	172	172
800	179	178	159	>155	171	172
900	178	177	159	<155	171	172
1000	178	177	158	154	171	171

a SEL(cum) values are weighted according to hearing group, as described in NMFS (2016)

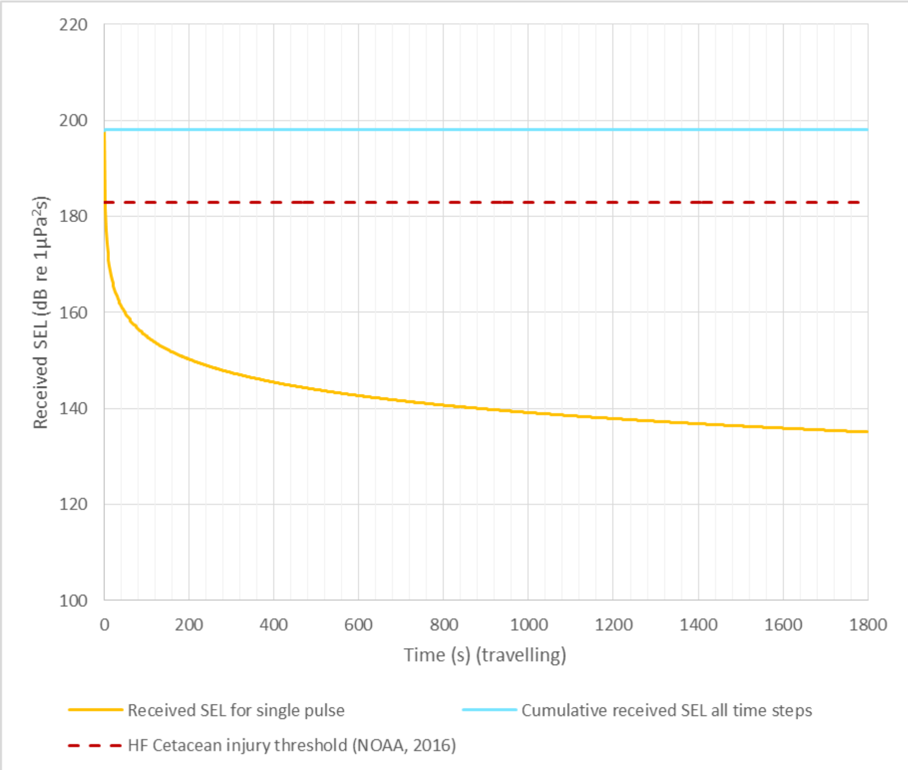


a) Travelling at 5 m/s, initially 1 m from sound source

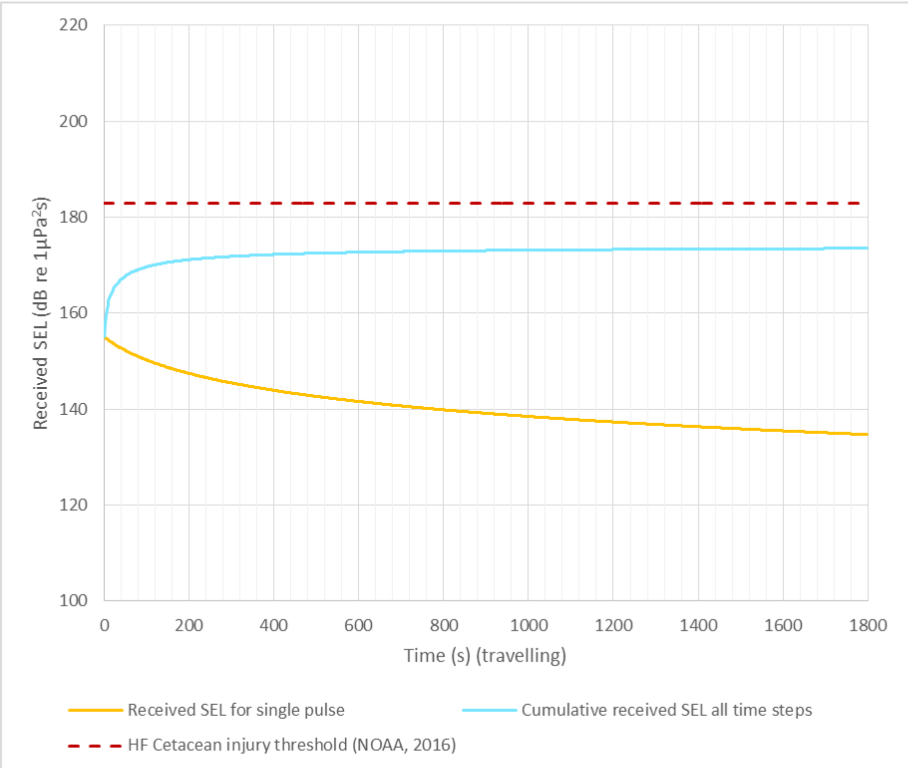


b) Travelling at 5 m/s, initially 500 m from sound source

Figure 10.14: Received SEL(cum) for a high-frequency cetacean for one pile strike over 24 hours of piling operations (two piles installed).



a) Travelling at 5 m/s, initially 1 m from sound source



b) Travelling at 5 m/s, initially 500 m from sound source

Figure 15: Received SEL(cum) for Phocid pinnipeds for one pile strike and cumulative SEL(cum) over 24 hours of piling operations (two piles installed). Animal is travelling at 5 m/s and is initially a) 1 m and b) 500 m from the sound source.

10.4.4.4.3.3 SEL results and injury from vessel noise (Scenario 3)

Marine mammals and injury

The cumulative Sound Exposure Level resulting from continuous vessel noise could also lead to injury if an animal is subject to noise for a long enough period of time. If the source SPLrms is known, a rough calculation will indicate the exposure time necessary to cause injury to a receptor (with a known SEL(cum) threshold) at specified distance from the source. This assumes that animals in the area are stationary and results in a very precautionary estimate.

The results for HF cetaceans, the most sensitive group, are plotted in Figure 10.16. The blue line indicates the threshold of injury (i.e. the exposure time, in seconds, required to cause PTS at distance, in metres, from the source). The source is assumed to be a Suezmax shuttle tanker with a source SPLrms of 198 dB re 1 μPa (Table 10.26: above). For example, the graph (Figure 10.16) indicates that a cetacean would have to remain at 3.7 km of the source for a period of more than one hour (3,600 seconds) or at 500 m for two minutes to exceed the PTS threshold.

For other groups, stationary animals outwith the following distances would not experience SEL(cum) above the threshold: LF cetaceans - 125 m; MF cetaceans - 110 m; PW pinnipeds - 80 m; OW pinnipeds - 8 m.

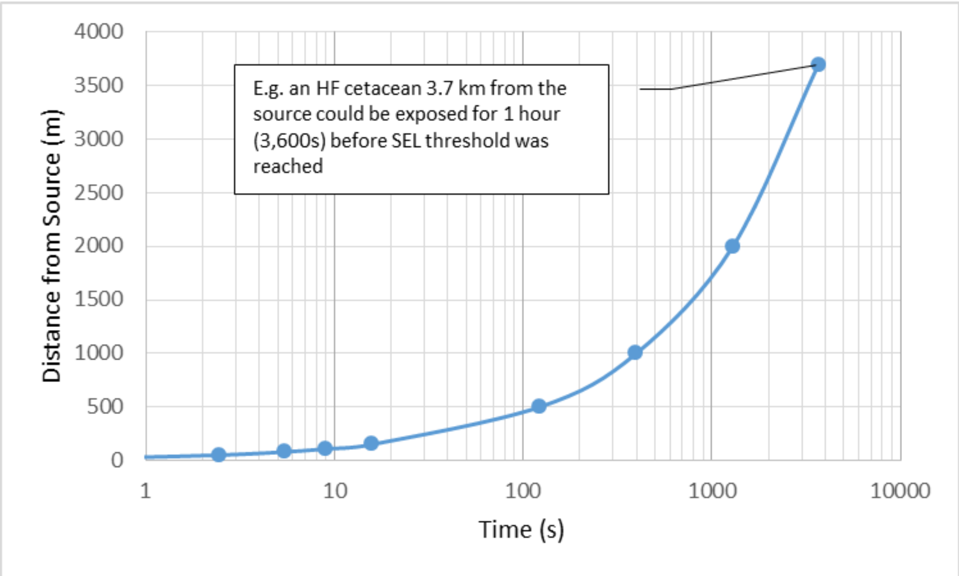


Figure 10.16: Injury threshold SEL (blue line) for HF cetaceans

10.4.4.4.4 Step 3b: Comparison of model results with disturbance and behavioural response thresholds

The SPL, or the loudest instantaneous sound, is lower for vessel, drilling and helicopter noise than it is for short-term, high impact pile-driving activity and falls below the SPL injury threshold. Where SPL and SEL(cum) values fall below injury thresholds, animals exposed to long-term and continuous vessel noise are more likely to invoke acute and / or chronic behavioural responses, rather than injury.

JNCC (2010), in the context of the Habitats Directive implementation in the UK, states that disturbance 'is unlikely to result from single, short-term operations, e.g. a seismic vessel operating in an area for 4-6 weeks, or the driving of a dozen small diameter piles. Such activities would most likely result in temporary sporadic disturbance, which on its own would not be likely to impair the ability of an animal to survive, reproduce, etc, nor result in significant effects on the local abundance or distribution. Non-trivial disturbance … would most likely result from more prevalent activities in an area, chronically exposing the same animals to disturbance or displacing animals from large areas for long periods of time. Examples of activities for which the risk of a disturbance offence should be assessed include commercial whale-watching and pile driving in one area for a long period of time.'

Graham *et al*. (2017) noted some changes in behavior in bottlenose dolphins and harbor porpoise (HF cetaceans) which spent a reduced period of time in the vicinity of coastal construction works during both impact and vibration piling. However there was a lack of a strong behavioral response to both types of piling by either species observed.

Piling will only occur for a short-time and is therefore not considered to represent a source of long-term disturbance, therefore the following sections relate to vessel noise only.

10.4.4.4.4.1 Fish disturbance from vessels

For fish there are very broad qualitative guidelines to determine the risk of injury or behavioural disturbance from vessel noise and other continuous sounds (Table 10.19: above). Popper *et al*. (2014) suggest that all fish are at high risk of masking (section 10.4.4.3.2) when they are close to continuous low frequency sources of noise, and fish that use the swim bladder to detect sound are also at high risk at long range. Fish that use the swim bladder are also at high risk of behavioural change when near to the source of noise (Table 10.19: above).

Using the criterion for behavioural disturbance of fish of 150 dB re 1µPa (RMS, Popper *et al*. (2014)), this implies a disturbance radius of 0.87 km and an area of impact of 2.4 km2, which includes vessels and piling noise. This is very small in relation to the available area and the likely distribution of fish species. While the threshold proposed by Popper (2014) is interim, more recent data have not contradicted this, and given the scale of the impact against the scales of the species and offshore environment, this is not considered a significant impact.

10.4.4.4.4.2 Seabirds disturbance from vessels

For seabirds, there are no guidelines to determine what constitutes a behavioural disturbance or threshold sound level.

10.4.4.4.4.3 Marine mammal disturbance from vessels

The PKs of vessel noise are insufficient to cause instantaneous permanent injury in marine mammals (Table 10.27: b Scenario 3 above), although they may cause TTS in the high-frequency cetacean group at close range. There is the potential for the SEL(cum) from vessel noise alone to exceed injury thresholds, although for this to occur, an animal would have to remain within close range of the source for a period of time (Figure 10.16 above). Therefore, while injury is unlikely, there is the potential for long-term continuous vessel noise to cause behavioural disturbance. Although marine mammals will react to noise, the response between species and individuals varies with context and is not simply related to the intensity of the sound. For example, animals engaged in feeding may be reluctant to leave an area or animals that are accustomed to vessel noise may react to a lesser extent.

Behavioural changes, such as moving away from an area for a short period of time, changes in dive-time, masking of communication signals or echolocation clicks for short periods, do not necessarily result in detrimental effects on the animals involved. A reaction lasting less than 24 hours, and not recurring on subsequent days, was not regarded as particularly severe by Southall *et al*. (2007). Therefore, it is considered unlikely that a transiting vessel, such as those steaming to and from Stanley, would cause more than trivial disturbance that would be rapidly recoverable once the vessel passes (JNCC, 2010a).

Importantly, it is the repeated or chronic exposure to vessel noise that could cause disturbance (JNCC, 2010a) which could, in extreme circumstances, effectively exclude animals from an area. The vessels associated with Phase 1 Development (all Stages) offshore represent a relatively static continuous source of noise, which has the potential to cause chronic disturbance over a long period (i.e. the 20+ year life of the Development).

The disturbance zones for all three scenarios were assessed. Due to the different sound types within each Scenario e.g. pulsed pile-driving vs. continuous vessel noise, different disturbance thresholds, based on data from Southall *et al*. (2007) were applied for cetaceans and pinnipeds in each Scenario (Table 10.31). The sound propagation of noise against the minimum disturbance thresholds for cetaceans and pinnipeds are shown for Scenarios 1, 2 and 3 in Figure 10.17, Figure 10.18 and Figure 10.19 respectively. The JNCC guidelines recommend that the proportion of the marine mammal population which could potentially be disturbed is assessed. Although there are sightings from various surveys and recordings from an acoustic monitoring study, there are currently no population estimates for any cetacean species in Falkland Islands waters. However, the available data does not indicate that the area surrounding the Sea Lion Field is home to resident populations of marine mammals or is a feeding area of overriding importance for any species.

Given the lack of population estimates, the proportion of the available habitat within the area of disturbance and avoidance / displacement could be used as a proxy to assess the potential impact on marine mammals. However, the habitat is not uniform throughout Falkland Islands waters and the available information indicates that many species show clear distribution patterns (section 7.4.6.2). Therefore, the assessment is necessarily precautionary to account for the data gaps associated with marine mammal distribution and behaviour.

The distances and areas of the calculated disturbance zones for the three scenarios are shown in Table 10.31. These results are not affected by the revised TTS and PTS values in NMFS (2016), which relate to injury criteria rather than disturbance.

Table 10.31: Behavioural response disturbance thresholds and distances, within which animals were expected to, elicit a behavioural response to the SEL (Genesis, 2016)

Scenario	Marine mammal hearing group	Disturbance threshold (rms dB re 1 µPa)	Distance to threshold (km)	Area of impact (km2)
Disturbance				
1	Cetaceans	140	2.72	23.2
	Pinnipeds	150	0.87	2.4

Scenario	Marine mammal hearing group	Disturbance threshold (rms dB re 1 µPa)	Distance to threshold (km)	Area of impact (km2)
2	Cetaceans	120	17.5	962
	Pinnipeds	120	17.5	962
3	Cetaceans	120	21.5	1,452
	Pinnipeds	120	21.5	1,452
Avoidance / displacement				
1	Cetaceans	160	0.28	0.25
	Pinnipeds	180	0.03	0.003
2	Cetaceans	160	0.17	0.09
	Pinnipeds	160	0.17	0.09
3	Cetaceans	160	0.22	0.15
	Pinnipeds	160	0.22	0.15

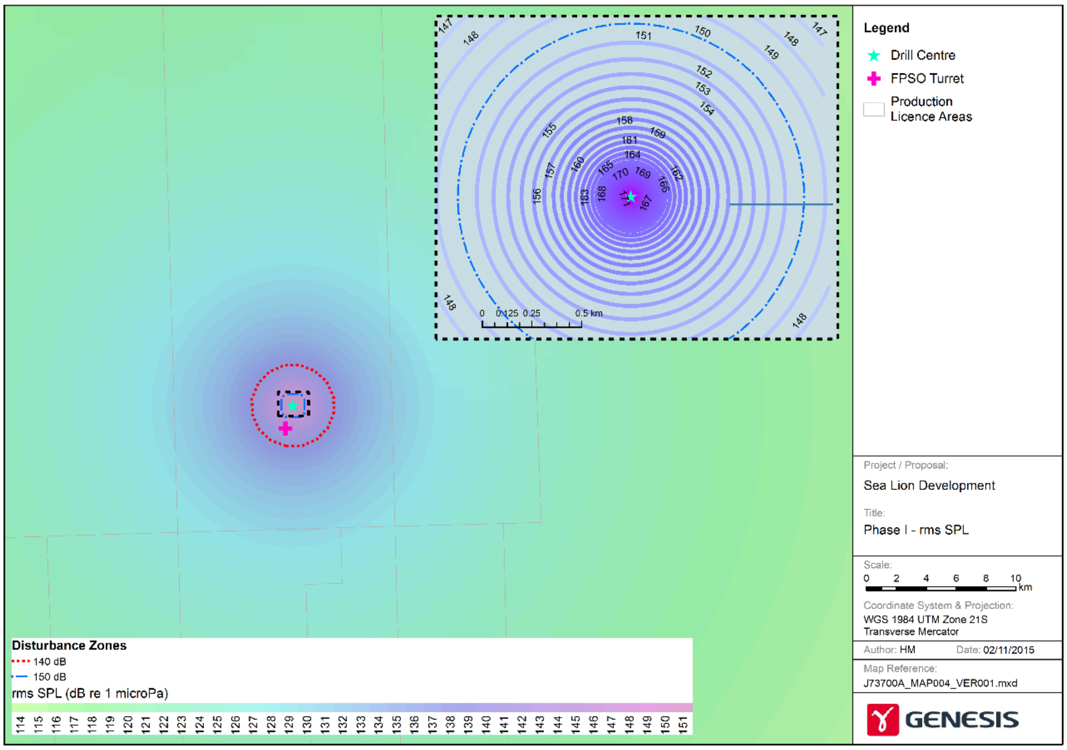


Figure 10.17: Showing the sound propagation of noise generated during Scenario 1 (including pile driving). The minimum disturbance zones for cetaceans (140 dB re 1 µPa) and pinnipeds (150 dB re 1 µPa) are shown.

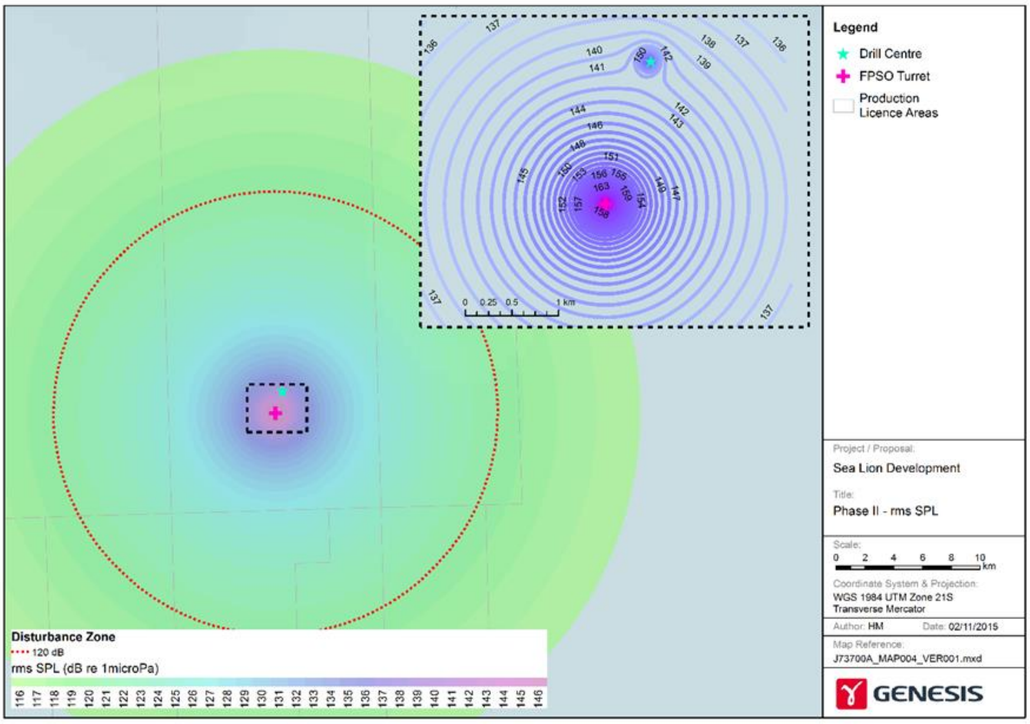


Figure 10.18: Showing the sound propagation of noise generated during Scenario 2 (vessels, drilling and helicopters). The minimum disturbance zone for cetaceans and pinnipeds (120 dB re 1 µPa) is shown.

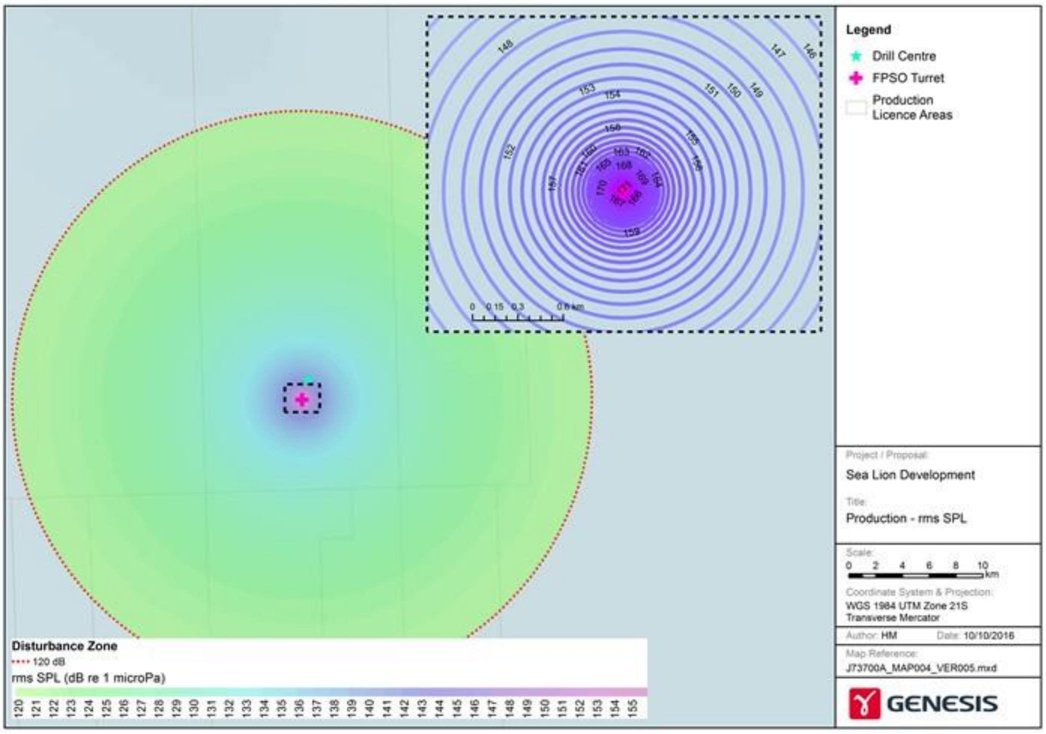


Figure 10.19: Showing the sound propagation of noise generated during Scenario 3 (vessels and dynamically positioned shuttle tanker). The minimum disturbance zone for cetaceans and pinnipeds (120 dB re 1 µPa) is shown.

10.4.5 Industry-standard mitigation

10.4.5.1 Pile-driving

With regard to underwater noise, a key industry-standard is provided by the JNCC Guideline (2010b) on how to manage activities which generate pulsed sounds. It is important to note that, while the modelling results described above do not take account of these guidelines, they are factored in to the initial impact assessment (section 10.4.6 below). The predictions regarding PTS from piling, using the criteria both of PK and SEL(cum), indicate that a mitigation zone of 800 - 900 m is appropriate.

Premier will apply the JNCC Guidelines (2010b) during the piling operations. In summary, this includes:

- Surveillance using dedicated Marine Mammal Observers (MMOs);
- Passive Acoustic Monitoring (PAM) to help detect HF cetaceans at greater ranges and when observing conditions are poor;
- A pre-start watch of 60 minutes (in line with the JNCC guidelines for seismic surveys and taking account of the water depth and dive cycles of local animals);
- A 20-minute delay after the last visual or acoustic detection;
- Soft-start to piling that lasts 20 minutes;
- A repeat of the pre-start watch and soft-start when piling is stopped for a period greater than 10 minutes; and
- Reporting of activities and observations using the JNCC format.

Acoustic Deterrent Devices (ADD) were considered (as required by the guidelines) but not seen to offer a significant extra mitigation in this case. Given that the risks to mammals here are modest, the introduction of a deliberately disturbing noise into the project is not seen as outweighing the potential benefits in reducing mammal exposure to project sound sources.

10.4.5.2 Vessel noise

There are no industry-standard mitigation measures specifically designed to reduce the impact of vessel noise on fauna. However, standard operating procedures, such as maintenance schedules, will help to minimise the noise generated by propeller cavitation. For fixed pitch propellors, sound generated is relative to vessel speed, whereas for variable pitch propellors the relationship between vessel speed and propeller speed (and the inception of cavitation) is more complex. At present, it is not clear whether vessels operating offshore will be equipped with fixed or variable pitch propellors. Although speed restrictions are not proposed offshore, vessels operating in the vicinity of the Sea Lion Field are likely to be operating at low speed.

10.4.6 Impact assessment

The following section draws upon all the information provided above to assess the ‘Sensitivity of the Receptor’ and the ‘Severity of Effect’ in order to determine the overall ‘Impact’ of planned activities.

A summary of the impact assessment outcomes for this Development is tabulated in section 10.4.12 (Table 10.32:), which shows the worst case impact for each activity and receptor and details are provided below.

10.4.6.1 Impact of piling noise (high intensity pulsed sounds - Modelling Scenario 1)

10.4.6.1.1 Invertebrates and fish - piling

Sound from piling can propagate through the water column, and at the interface of the seabed substrate. Sound waves at the seabed interface travel slower than they do in the water column and their peak energy is at lower frequencies (Hawkins and Popper, 2014) so that they are more likely to affect the bottom-living fishes and invertebrates.

The modelling predicts that the PK of 217 dB re.1µPa during piling activities falls above the threshold for mortality or potential mortal injury for all fish hearing groups (section 10.4.4.4.3.2). However, for all fish hearing groups, fish at a distance of 4.6 m or more from the sound source would not be exposed to sound that could cause mortal injury (section 10.4.4.4.3.1). It is unlikely that many individuals will be within this distance.

However, the modelling also predicts that fish close to the piling operation (within 600 m) may be subjected to cumulative SELs above the TTS threshold (section 10.4.4.4.3.2). Given that fish are very mobile however, it is expected that they would temporarily move away from the noise source. Studies have shown that fish move back into an area once piling operations are finished (Slabbekoorn *et al*., 2010).

As well as sound pressure, invertebrates and fish are also susceptible to injury due to particle motion (Hawkins and Popper, 2017). The thresholds for injury described above (Table 10.19:) refer to sound pressure, rather than particle motion; however, the classification of fish into different hearing groups does take account of this to some extent.

It is considered unlikely that fish within the zone of influence of the piling operation (within 600 m) will be present in 'geographically important' numbers (section 7.4.4.2). There are no known spawning aggregations in the area, although it is likely that small numbers of dispersed asynchronous (protracted) spawners, such as skate and non-commercial species (such as myctophids) will be present. Nonetheless the **sensitivity of the receptor** is considered to be **'Low'**.

Piling will take about half a day per pile and therefore the entire operation will be completed within a short period of time (fifteen days). Although it is possible that fish will suffer TTS, which might increase the risk of predation for the individuals concerned, by its nature the impact will be 'short-term and reversible' and is unlikely to lead to cumulative effects at the population level. It is unknown whether the JNCC guidelines (i.e. soft-start) will have a mitigating effect on invertebrates and fish and therefore the **severity of the effect** is considered to be **'Minor'**.

The **overall significance** of the impact of piling noise on fish is therefore assessed as **'Low (4)'**.

10.4.6.1.2 Seabirds - piling

For all diving bird species investigated, the received SEL(cum)s did not exceed the injury threshold (Table 10.29:). Nonetheless, piling noise may cause some behavioural disturbance and will add cumulatively to the noise emitted by vessels. Although the number of individuals within the zone of influence of piling noise is likely to be small, the priority conservation status of penguins in the Falklands and IUCN status of some species (such as the 'Vulnerable' rockhopper penguin) means that the **sensitivity of the receptor** is considered to be **'High'**.

In the event that a penguin is behaviourally disturbed by the sound however, the impact of piling noise is short-term and effects are considered to be 'reversible once the activity ceases'. Therefore, the **severity of the effect** of piling noise has initially been assessed as **'Minor'**. However, assuming seabirds will react to noise disturbance in a similar way as marine mammals, the industry-standard mitigation measures (JNCC Guidelines, primarily soft-start) associated with pile-driving (which were not considered in the modelling) should separate animals from the piling activity and therefore result in a **severity of the effect** on seabirds of **'Slight'**.

Therefore, the overall **significance of the impact** of piling noise on seabirds is assessed as **'Low (4)'**.

10.4.6.1.3 Marine mammals - piling

Generally, the sound sources of greatest concern regarding impact on marine mammals are high intensity intermittent / impulse sounds, such as seismic surveys, underwater explosions and high intensity sonar. During the Phase 1 Sea Lion Development, the only sound source that falls into this category is piling noise, which will only occur during early Stage 1 of the Development as described in Section 5.5.1. The following assessment separates out the impacts with regard to injury and disturbance.

10.4.6.1.3.1 Marine mammal injury and pile noise

The PK associated with this activity is below the injury threshold for permanent (PTS) trauma for LF and MF cetacean hearing groups (section 10.4.4.4.3.1; Table 10.27: ,). However, the PTS threshold is exceeded for HF cetaceans, to approximately 12 m. The PK is also below PTS threshold for Phocid and Otariid pinnipeds.

PK during piling will exceed the TTS threshold for LF and HF cetaceans, to a distance of 3 m and 21 m respectively, and for Phocid pinnipeds to a distance of approximately 76 m from the source (section 10.4.4.4.3.1). This indicates that these species groups within close proximity to the piling activity may be temporarily affected by exposure to a single hammer strike.

Analysis of the cumulative SEL indicates that all marine mammal hearing groups except Otariid pinnipeds would be susceptible to PTS at varying ranges from the sound source at the start of piling (LF 250 m, MF 1 m, HF 800 – 900 m and Phocids to 20 m) (Table 10.30:), assuming that the animals swim away from the sound source. This indicates that; LF and HF cetaceans may be permanently affected by the cumulative exposure to the sounds of piling if they are within 250 m and 800 - 900 m respectively of the activity when it commences, and that Phocid pinnipeds may be permanently affected if they are within 20 m when piling commences.

Phocid seals are very difficult to observe at-sea, and animals on the surface are outwith the area where injury might occur (i.e. more than 200 m from the source). Elephant seals may spend over 90 % of their time at-sea below the surface and dive for up to two hours (McIntyre *et al.*, 2010).

Additionally, they are not known to use sound for navigation or prey detection so acoustic monitoring is not a viable alternative.

LF cetaceans are relatively conspicuous to observers within the 250 m range that corresponds with potential PTS.

Given the range at which there is potential for injury to HF cetaceans and the issues around visibility of relatively small and inconspicuous marine mammals at this range, the use of PAM is recommended as an additional safeguard. However, in many cases PAM is not as accurate as visual observation for determining range, and this will mean that the mitigation zone will reflect the range accuracy of the system (JNCC, 2010b)..

There is a risk that marine mammals could suffer PTS at close range to the sound source (up to 800 - 900 m for HF cetaceans). Hourglass dolphins are classified as HF cetaceans and are known to frequent the waters surrounding the Sea Lion Field, although due to low density the probability that this species would be present within the PTS range at the time of piling is low. However, as well as being legally protected under the Marine Mammals Ordinance 1992, all marine mammals are regarded as high conservation priority species under the Falklands Biodiversity Framework (FIG, 2016a). Therefore, following the guidelines set out in section 8.5.2.1, the **sensitivity of receptor** (regardless of species), is considered to be **'High'**.

According to the modelling results, the potential permanent injury to marine mammals from piling noise are largely associated with exposure time (SEL(cum)) rather than intensity (PK), although HF cetaceans are also at risk from peak levels if they are within 12 m of the source. The range over which this impact occurs is up to 800 - 900 m for cetaceans and 20 m for pinnipeds. The number of animals within the zone of influence at any one time is likely to be low; however, the consequences would be permanent to the individuals concerned. Therefore, the severity of the effect of piling noise has initially been assessed as 'Minor'. However, industry-standard mitigation measures (JNCC Guidelines) associated with pile-driving, which were not considered in the modelling, should separate animals from the piling activity and therefore result in a **severity of the effect** on marine mammals of **'Slight'**. The assumption is made here that PAM is undertaken and is included as industry-standard mitigation since it is recommended under some circumstances such as those here.

Therefore, the overall **significance of the impact** of piling noise on HF cetaceans has been assessed as **'Low (4)'**.

10.4.6.1.3.2 Marine mammal disturbance and pile noise

Along with the potential for injury, pile noise and associated vessels will result in a degree of disturbance. As described above, all marine mammal receptors are protected and therefore the **sensitivity of the receptor** is considered to be **'High'**.

The model used here to assess the potential impact of piling assumes that marine mammals will move away from the immediate area when piling commences. Therefore, we must assume that all marine mammals will vacate the zone of disturbance. Modelling suggests that disturbance will extend to a distance of 2.72 km for cetaceans and 0.87 km for pinnipeds during the piling operations (Table 10.31). The impact of disturbance from piling alone is short-lived (the piling of each casing will take 0.5 days) and is rapidly reversible once the activity ceases, although this will add cumulatively to disturbance from vessel noise. Therefore, the **severity of the impact** of disturbance caused by piling is assessed as **'Slight'**.

Therefore, the **significance of the disturbance** caused by piling is considered to be **'Low (4)'**.

10.4.6.2 Impact of vessel noise (non-pulsed sounds - Modelling Scenarios 2 and 3)

10.4.6.2.1 Invertebrates and Fish - vessel noise

The sound modelling indicates that the thresholds for potential mortality set by Popper *et al*. (2014) are not exceeded by the loudest vessels employed (Scenario 3; section 10.4.4.4.3.1)

Although the influence of vessel noise may be detectable within a 21.5 km radius of the Development (section 10.4.4.4.4.1) this area is unlikely to contain significant populations of any species of fish (i.e. unlikely to contain >1 % of the Falklands population). Therefore, the **sensitivity of the receptor** is considered to be **'Low'**.

As described in section 10.4.4.3.2.2, there is no suggestion that disturbance due to vessel noise causes long-term impacts on fish populations. Equally, most species of fish in Falkland Islands waters are subject to commercial fisheries and any impact due to vessel noise from the Sea Lion Development will be insignificant in comparison. Therefore, the **severity of the impact** of vessel noise on fish is assessed as **'Slight'**.

Overall the significance of the **impact of disturbance** caused by vessel noise to fish is therefore assessed as **'Very Low (2)'**.

10.4.6.2.2 Seabirds - vessel noise

The presence of two of the four principle breeding species of penguin (rockhopper and Magellanic penguins) is highly seasonal within Falkland Islands waters, being far less numerous between May and September. However, the other two species (gentoo and king penguins) are present year-round and are more numerous in the NFB in the winter months. Therefore, it is possible to encounter penguins in the NFB throughout the year (section 7.4.5.2.1). All of the species of penguin breeding in the Falklands (except king penguin) are listed as priority conservation species and rockhopper penguins are classified as IUCN 'Vulnerable'. The Falklands population has shown a long-term decline in numbers and is the subject of a dedicated management plan. Therefore, the worst case **sensitivity of receptor** (penguins) is considered to be **'High'**.

There is nothing to suggest that vessel sound has any more than a very short-term and completely reversible impact on penguins. Indeed, it has been observed that some species of penguin, clearly evident in chinstrap penguins, are positively attracted to research vessels (up to 100 m in length) operating on DP control (A. Black *pers. obs*.). Although anecdotal, these observations indicate that penguins do not strongly avoid areas where vessel noise is prevalent. While this does not mean there is not an impact, it is expected that any impact would be transitory and therefore the **severity of the effect** on seabirds of disturbance due to vessel noise is assessed as **'Slight'**.

Primarily due to the high **sensitivity of the receptor**, the overall **significance of the impact** of disturbance due to underwater noise is assessed as **'Low (4)'**.

10.4.6.2.3 Marine mammals - vessel noise

10.4.6.2.3.1 Marine mammal injury and vessel noise

This is not considered to be applicable given that animals would need to stay close to the source for longer than one hour to be affected, as is described in section 10.4.4.4.3.3. It is assumed that animals would move away from the source of noise before being subject to a sound exposure level that would cause injury and therefore the impact of vessel noise is assessed as disturbance (below) rather than the potential for injury.

10.4.6.2.3.2 Marine mammal disturbance and vessel noise

Although the SPL of vessel noise is lower than piling noise, the long-term continuous nature of this source of sound pollution could result in chronic impacts on a number of marine mammal species (Rolland *et al*., 2012; Hatch *et al*., 2008).

Available evidence suggests that marine mammals are present within the zone of influence of vessel noise (within 30 km of the Development site) albeit with seasonal variation (section 7.4.6.2.3). Although it is unlikely that the area under the influence of vessel noise around the Development site supports resident populations of cetaceans, it is likely that the area is traversed by numerous animals on migration (section 7.4.6.2.3).

In terms of species sensitivity, the low-frequency cetaceans, such as fin and sei whales, are considered the most sensitive receptors, due to their IUCN 'Endangered' status and the overlap in their hearing range with vessel noise. To take a precautionary approach, it is assumed that the 'Endangered' fin whale, known to be in the area year-round, and the sei whale, known to be seasonally abundant (section 7.4.6.2.3), are the main receptor species. Additionally, within Falkland Islands waters all marine mammals are protected under the Marine Mammals Ordinance 1992 and all pelagic cetaceans, fur seals and sea lions are highlighted as Falkland Islands conservation priority species (section 7.5.3). Therefore, the **sensitivity of the receptor** is considered to be **'High'**.

Operations during the Phase 1 Sea Lion Development will add considerably to the ambient noise levels in an area that normally experiences little anthropogenic sound (section 7.4.6.2.1.2). Development activities will produce predominantly low frequency (<1,000 Hz) continuous sounds that are less than 201 dB re.1μPa at source. Sound of this intensity could induce avoidance behaviour / displacement of marine mammals at close range (< 220 m), and disturbance within a radius of 21.5 km (section 10.4.4.4.4.3).

However, the sound propagation modelled assumes that all vessels are present at the same location. In reality, the offloading tanker (project will use Direct Offload to a CTT) is only present sporadically, twice in a 14 day cycle initially but reducing in frequency as the field matures. Therefore, the sphere of influence will fluctuate and only reach the area predicted in Scenario 3 periodically.

Underwater vessel noise will occur throughout the life of the Development's 23.5 years, although it has been suggested that cetaceans can adapt to ambient noise and the area concerned is relatively small compared with the amount of available habitat. While a small increase in vessel noise around animals already subject to, and possibly accustomed to, vessel noise may disrupt feeding and cause short-term stress, these impacts are very hard to measure. The constant nature of vessel noise means that marine mammals are gradually exposed to higher sound levels as they move closer to the source, hence marine mammals are able to change direction (i.e. move away from the sound source) before the impact causes any long-term effects.

It is expected that any negative impact would be readily reversible once the animals move away from the source (as found by Rolland *et al*., 2012). However, if the source was located in an area that was regarded as an important feeding or breeding ground (not believed to be the case here) the impact would be more significant. Globally, disturbance to marine mammals due to vessel noise is becoming a bigger issue (NOAA, 2004; Hatch *et al*. 2008), as the volume of vessel traffic increases year-on-year and the populations of these species (notably large baleen whales) increase following partial recovery from human exploitation. There is little information regarding the long-term implications of vessel noise on marine mammal populations and therefore a precautionary approach has been taken and the **severity of effect** has been assessed as **'Minor'**.

The overall **significance of the impact** caused by vessel noise emanating from the Development site has therefore been assessed as **'Moderate (8)'**.

10.4.7 Project-specific mitigation measures

10.4.7.1 Pile-driving

This assessment assumes that JNCC guidelines regarding piling will be followed as industry-standard practice and the resulting significance of the impact of piling noise is 'Low' for all receptors. As described above, this includes the use of trained and dedicated MMOs; a pre-start watch period; a delay after the last detection of an animal in the mitigation zone; a soft-start to piling; and in this situation, the use of PAM to detect vocalising animals (section 10.4.5.1.).

In addition, Premier will use an automated animal recognition device that supports and enhances the MMO observations by using infra-red signals and artificial intelligence and which covers a wider field of view than an MMO. These methods are in development but early results suggest an improvement in animal recognition is possible to reduce the risks present.

10.4.7.1.1 Reporting on piling activity

Reports detailing the piling activity and marine mammal mitigation, i.e. the 'MMO and PAM reports', will be sent to FIG after the end of the piling activity.

10.4.7.2 Disturbance due to vessel noise

Although the impact of moderate intensity sound (e.g. from vessel noise) is considered to be of 'Moderate' significance (mainly owing to the protected nature of the receptors and the precautionary assessment of the severity of effect) there are currently no guidelines governing anthropogenic noise that does not exceed the PTS threshold.

In some circumstances, a reduction in ship speed may reduce the level of underwater noise. However, this applies only to vessels with fixed pitch propellers when the speed becomes lower than the cavitation inception speed (i.e. it does not result in a lower sound with all vessels). Therefore, for ships equipped with controllable pitch propellers, there may be no reduction in noise with reduced speed (IMO, 2014).

10.4.8 Residual impacts and risks

10.4.8.1 Piling noise

The initial assessment indicates that when industry-standard mitigation is applied the **significance of the impact** of piling noise on invertebrates and fish, seabirds and marine mammals is **'Low'**. Project-specific mitigation is therefore not proposed and an assessment of residual impact is not applicable.

10.4.8.2 Vessel noise

Disturbance due to vessel noise will continue throughout the 20 year field life of the Development and is the most significant impact associated with underwater noise. While there are means of reducing the amount of noise emitted by vessels, as described above, the most effective of these need to be built-into the design of the vessels concerned.

The degree of residual impact will therefore depend on the vessels contracted / built to work on the Sea Lion Development and, at the time of writing, these details are unknown. Therefore, as a precautionary approach at this pre-FEED stage in the process, the **residual impacts** from vessel noise, to all receptors, remain the same. Therefore, the worst case impact remains as **'Moderate'** with regard to behavioural disturbance to marine mammals.

10.4.9 Cumulative impacts

Commercial shipping is a major contributor of low frequency (5 - 500 Hz) background noise in the world's oceans and therefore there is the potential for cumulative impacts from increased 'concentration', increased 'extent and proportion' and increased 'duration' of underwater noise (section 8.10.1).

Globally, the number of ships in operation has tripled in the last 50 years and shipping noise levels have increased at the rate of approximately 3 dB per decade (OSPAR, 2009b). Indeed, disturbance from vessel noise is becoming an issue in areas where high shipping density and cetaceans coexist (Hatch *et al*., 2008).

Acoustic recordings indicate that the Sea Lion Field is subject to low ambient anthropogenic noise (section 7.4.6.2.1.2) and therefore there will be little cumulative impact near the Field. Shipping routes around the Falkland Islands converge on Stanley and Berkeley Sound. Therefore, vessels associated with the Development travelling to and from Stanley have greater potential to add cumulatively to the existing vessel noise in inshore waters off the east coast of the Falklands (see section 10.5).

The cumulative impact of underwater noise from other users of the NFB would fall under category 2 (see section 8.10) whereby the extent and proportion of the impact may be increased. The edge of the continental shelf to the south of the Development (along the 200 m isobath) is heavily fished by demersal trawlers. Although these vessels are not static and individually may not have a significant impact, where several vessels are fishing in the same general area or a single vessel is fishing the same area for consecutive days they could contribute to the disturbance impact.

In comparison to the impact of commercial fisheries on fish and cephalopod species in Falkland Islands waters, the impact of vessel sound during the Phase 1 Development is considered to be negligible.

10.4.10 Confidence

The impact of impulse sounds, such as piling, has been subject to some research and the use of precautionary threshold values widely accepted. However, the model used here relies on many assumptions regarding the sound source levels of O&G related activity and the auditory sensitivity of receptors. The changes between Southall *et al*. (2007) and NMFS (2016) in interpretation of the sensitivities of species groups and the threshold levels for potential impacts demonstrate that knowledge is still evolving in this area and may change again in a timescale of years. Confidence in the assessment of piling noise is therefore considered to be 'Uncertain'.

There is greater uncertainty over the long-term impact of less intense continuous underwater noise such as that from vessels and also over the marine mammal distribution on the NFB.

The uncertainty over the potential impact of noise disturbance on individual marine mammals and populations is acknowledged as a data gap. Furthermore, there is very little data available regarding the intensity of sound produced by vessels and activities associated with the O&G industry under operational conditions. Accurate input parameters are vital for modelling purposes.

With regard to the uncertainty over marine mammal distribution, previous observational and acoustic surveys give a reasonable indication of the species present but further surveys would help to determine the inter-annual variation in marine mammal abundance in the area and help to resolve the status of rare species. Further acoustic surveys would help to evaluate the vocal range of the species encountered within Falkland Islands waters. The inter-annual distribution and abundance of marine mammals in the NFB is acknowledged as a data gap.

Therefore, the **confidence in the assessment** of noise disturbance is assessed as **'Uncertain'**.

10.4.10.1 Monitoring required

It is clear that disturbance due to vessel noise is becoming an increasingly significant issue and yet there is very little hard evidence to support the precautionary conclusions of this assessment and therefore monitoring will be required.

The JNCC guidelines will be followed, including during any piling, and there will be Seabird and Marine Mammal Observers (SMMOs) on board vessels to provide ongoing monitoring. Monitoring of day-to-day operational noise, including during activation of thrusters as well as various vessel scenarios will also be undertaken to understand baseline noise levels during operations.

A review of SMMO reports will be carried out after five years of implementation to improve knowledge of locations and behaviour of marine mammals.

Premier will investigate the use of noise minimisation in the design of vessels, where possible.

Detailed monitoring requirements has been established during the Environmental Monitoring and Management Plan (EMMP) workshop. All monitoring requirements agreed by Premier and FIG will be recorded and managed via the project-specific Phase 1 EMMP (an outline EMMP is provided in Chapter 15).

10.4.11 Offsetting

For significant residual impact and risks (Moderate or above), offsetting via an Environmental Fund is proposed, see section 8.9 for further details.

10.4.12 Findings summary

Table 10.32: Summary of the impact assessment for underwater noise offshore [a]

Activity / Event	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance[a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Underwater Piling noise	Impulse high intensity noise	Injury to invertebrates and fish	Planned	1	Low	Minor	n/a	Low (4)	n/a	Uncertain	Industry-standard: JNCC guidelines will be followed, including; Dedicated Marine Mammal Observers (MMO); Soft-start to piling operations; and Passive Acoustic Monitoring (PAM) Project-specific: Use of automated animal detection device
		Injury to seabirds		1	High	Slight	n/a	Low (4)	n/a		
		Injury to marine mammals		1	High	Slight	n/a	Low (4)	n/a		
		Behavioural disturbance to marine mammals		1	High	Slight	n/a	Low (4)	n/a		
Underwater Vessel noise	Continuous moderate intensity noise	Injury and disturbance to invertebrates and fish	Planned	1,2, & 3	Low	Slight	n/a	Very Low (2)	n/a	Uncertain	Industry-standard: None. Project-specific: None proposed.
		Injury to seabirds		1,2, & 3	High	Slight	n/a	Low (4)	n/a		
		Behavioural disturbance to marine mammals		1,2, & 3	High	Minor	n/a	Moderate (8)	Moderate (8)		

a See Chapter 8 for definitions of sensitivity, severity, likelihood and significance.

10.5 Underwater noise inshore

Table of Contents

10.5.1 Introduction

Underwater noise will be generated by vessels operating in Berkeley Sound during two relatively short periods in the early years of field development.

Note: Large Transport Vessels (LTVs), used for floating storage will be anchored for up to twelve months to support the offshore construction stages of the Development, but thereafter there will be no project related vessels anchored in Berkeley Sound .

Note: The other impacts associated with vessel use are described elsewhere in this document, e.g. section 9.2, and the impact of noise from any vessels used offshore during the oil export process are assessed in section 10.4.

Note: Owing to the complexity of language used when assessing the impact of sound, it is advised that section 10.4 be read first as many sections in the following chapter refer back to sections that provide common information to avoid repetition.

10.5.1.1 Legislation relevant to underwater noise

A summary of the key pieces of legislation relating to environmental impact from underwater noise is given in section 10.4.1.1.

10.5.2 Sources and types of underwater noise associated with LTVs

Anthropogenic sources of underwater noise associated with the inshore activities of the Phase 1 Development include:

- Moderate intensity continuous (non-pulsed) sounds from vessels:
  - Use of LTV's during the offshore construction phase; and
  - Vessel engine / thruster noise generated by visiting Offshore Construction Vessels (OCVs).

10.5.2.1 Use of Large Transport Vessels (LTVs)

Large Transport Vessels (LTVs) will be used to transport drilling, SPS / SURF, FPSO mooring infrastructure, equipment and bulks to the Falkland Islands. On arrival in the Islands, the LTVs will anchor in Berkeley Sound and function as floating storage / logistics barges. Materials and equipment will be collected from the LTVs and transported offshore to Sea Lion for installation.

During Stages 1 and 2 of development, the LTVs will be anchored in the Sound (maximum of two vessels at any one time); each vessel will have its own individual 500 m exclusion zone. LTVs may be present during two distinct installation campaigns:

- Campaign 1, Main Drill Centre (MDC), – two vessels from Q3 2022 to Q2 2023; and
- Campaign 2, Southern Drill Centre (SDC), – one vessel from Q4 2025 to Q2 2026.

Premier will work with FIG / Fisheries to identify optimum locations within Berkeley Sound that will cause the least disruption to other users during periods of high marine traffic in the Sound however, the proposed anchorages are shown in Figure 5.5. The LTVs will be present for eight to twelve months.

The LTV vessels are considerably smaller than the Suezmax tankers that were previously modelled for inshore noise. The LTVs (and Offshore Construction Vessels) are similar in size to the reefers that currently use the Sound (approximately 160 m in length). As such the underwater noise levels from the LTVs (and OCVs) are considered to be covered within the envelope of the modelling described below.

10.5.2.2 Use of Offshore Construction Vessels (OCVs)

During the offshore installation campaigns the Offshore Construction Vessels (OCVs) will visit the LTVs in Berkeley Sound to collect equipment required for the offshore installation. It is anticipated that during:

- Campaign 1 – OCVs will visit Berkeley Sound 11 times; and
- Campaign 2 – OCVs will visit Berkeley Sound four times.

10.5.2.3 Bunkering of LTVs

As required, Stanley Services' tanker will supply MGO to the LTVs.

Following the offshore installation campaigns, vessel presence within Berkeley Sound is predicted to occur infrequently and, for the majority of time, there will be no vessels associated with the proposed project within Berkeley Sound.

10.5.3 Potential environmental receptors

The ENVironmental Impact IDentification (ENVIID) workshop was used to identify those receptors upon which the impacts of underwater noise warranted further investigation (Chapter 9). These include:

- Invertebrates (e.g. cephalopods and crustaceans) in Berkeley Sound (section 7.4.4);
- Fish in Berkeley Sound (section 7.4.4);
- Seabirds in Berkeley Sound (section 7.4.5); and
- Marine mammals in Berkeley Sound (e.g. whales, dolphins and seals) (section 7.4.6).

The above may be impacted upon as they either exist in, or spend time in, the zone influenced by anthropogenic sound. To varying degrees, all the above may use, or rely on, sound for various life functions and / or may be impacted upon directly by sound.

10.5.4 Characterising and quantifying the impact of underwater noise

When characterising and quantifying the impacts of underwater noise, it is necessary to consider:

- The behaviour of sound and how it is measured;
- The concept of hearing thresholds in receptors (e.g. invertebrates, fish, seabirds and marine mammals);
- The nature of the impact on receptors; and
- Quantification of sound propagation - sound modelling.

10.5.4.1 The behaviour of sound and how it is measured

The behaviour of sound and how it is measured is described in section 10.4.4.1 of the offshore underwater noise chapter, along with a description of the key terminology used. However, sound propagation in shallow inshore waters is further influenced by factors such as seabed absorption and reflection, and by thermoclines. These factors are incorporated into the model used below to describe sound propagation inshore.

10.5.4.2 The concept of hearing thresholds

The concept of hearing thresholds is described in section 10.4.4.2 of the offshore underwater noise chapter.

10.5.4.3 The nature of the impacts on receptors

The nature of the impact of underwater noise on different receptor groups, along with details on their hearing thresholds and injury, displacement and disturbance thresholds, is described in section 10.4.4.3 of the offshore underwater noise chapter.

Note again that there are very few data on the impact of noise on invertebrates although there is some evidence that cephalopods may be similar to fish in their ability to detect sound (Hu *et al*., 2009).

10.5.4.4 Quantification of sound impacts - noise modelling

As was carried out for the offshore noise impact assessment (section 10.4.4.4), the sound generated by the different activities associated with LTV operations was modelled and compared with published thresholds for injury, displacement and disturbance (section 10.4.4.3). Again, the modelling was carried out by Genesis Oil and Gas Consultants Ltd. using an interpretation of the Marsh and Schulkin (1962) 'semi-empirical' model (Genesis, 2015c).

To enable brevity, the following sections provide only the information required to ensure appreciation and understanding of the modelling results and the impact assessments. Additional detail on the modelling methodology and results are provided in the following report:

Genesis, 2016. Sea Lion Development - Underwater Noise Modelling. Document Number: J73700A-Y-TN-24005/B4. Prepared for Premier.

Anchoring of the LTVs is not considered in the modelling as the noise from navigating vessels is considered to be greater, thus representing the worst case.

As with the offshore noise modelling in section 10.4, the modelling process was carried out in three main steps:

1) Identification of the levels of sound likely to be made by the underwater noise sources inshore (i.e. how much noise is each activity likely to make). These are estimated using published data on sound levels from similar activities; and
2) Use of Sound Propagation Modelling which assesses the way these sounds are likely to travel out from the sources, thus enabling determination of the sphere of influence of a sound source. This provides outputs for:

- The peak Sound Pressure Level (PK), which indicates the highest level of instantaneous sound received by a receptor at a given distance from the source. This information is used to determine the distance at which injury and displacement / disturbance thresholds are exceeded; and
- The cumulative Sound Exposure Level (SELcum), which is a standardised measure of the overall sound energy that an animal will be exposed to (i.e. related to SPL and exposure time) over a specified length of time (a 24 hour period in this assessment).

3) Comparison between the Phase 1 noise levels predicted by the models and the internationally recognised injury and disturbance thresholds for each receptor.

As summarised in Table 10.33: three different scenarios were modelled providing outputs on the potential extent of vessel noise across a broad range of operational activities:

- Two scenarios were modelled to assess the impacts associated with different steps of the inshore operations; and
- One scenario was chosen to indicate the baseline background level of noise from other users of Berkeley Sound, which was used to assess cumulative impacts.

Table 10.33: Modelled LTV and baseline scenarios

Scenarios	Description	Associated sound sources	Timing
Scenario 1: Arrival of vessels	LTV anchored; and OCV entering the Sound	LTV anchored; and OCV travelling at 8 knots.	One hour, twice per transfer
Scenario 2: LTV at anchor, OCV Loading	LTV at anchor, on low power	LTV anchored, OCV Moored on low power	Constant for duration of SURF installation
Scenario 3: Background vessels	Typical background vessel noise	Fishing vessel; Tanker; and Reefer (all travelling at 9 knots, an average from AIS data).	Variable

10.5.4.4.1 Step 1: Identification of source sound levels

Vessel noise is continuous and varies depending on the type of vessel being used. Larger vessels tend to produce lower frequency noise than smaller vessels (OSPAR, 2009b). However, the level of noise will vary depending on the vessel's speed and activity, with vessels using thrusters generally producing higher sound levels (OSPAR, 2009b). Vessels within Berkeley Sound will be travelling at reduced speeds of no more than eight knots.

Specifically, sound source levels and frequencies of vessels vary as follows:

- Large vessels produce source levels that can exceed 185 dB re 1 µPa @1m when operating at full speed (Malme *et al*., 1989). However, in restricted waters when their speed is reduced to below 10 knots, source levels decrease with measured levels of 179 - 181 dB re 1 µPa @1m reported (McKenna *et al*., 2012), and 174 dB 1 µPa at around 8 knots (after Breeding *et al*., 1996);

- Greatest sound levels occur at low frequencies typically between 10 – 300 Hz with broadband sounds predominantly below 150 Hz and in some cases below 40 Hz (Ross, 1993; McKenna *et al*., 2012);
- Supply and maintenance vessels produce sound source levels of 130 - 160 dB re 1 µPa @1m, with frequencies of between 20 Hz and 10 kHz; and
- Conventional tugs produce sound with a dominant frequency of 1,000 Hz and reported source levels range from 160 - 187 dB re 1 µPa @1m while typically being around 170 dB re 1 µPa @1m (Richardson *et al*., 1995a; Genesis, 2011).

Most of the acoustic energy from vessels is below 1 kHz, typically within 50-300 Hz (Genesis, 2011) and thruster noise from DP vessels has been recorded to increase sound levels in the spectrum from 3 Hz to 30 Hz (Nedwell and Edwards, 2004).

Consequently, vessels have greater potential to impact seals and baleen whales that are more sensitive to low frequency sounds rather than dolphins and porpoises, which utilise higher frequency sounds (Okeanos, 2008).

The model used to estimate the noise from vessels undertaking different activities is based on experimental work that has shown a good level of agreement between the results of the model and experimental data (Breeding *et al*., 1996; Wagstaff, 1973). The model has been designed for ships ranging in length from approximately 15 m up to 370 m and the CTT, OCV and MRSV are all within this range. The broadband SPL and vessel frequency spectrums used to estimate source sound levels from vessel activity for each modelled scenario are presented in Table 10.34: and Figure 10.20 to Figure 10.22.

Baseline underwater noise levels within Berkeley Sound were assessed based on the historical vessel data within the Sound. There are periods during the year when vessel noise is largely absent for many days per month. Between July and December, relatively few vessels occur with between one and 17 vessel days per month. However, between January and June the number of vessels present increases, with between 56 and 313 vessel days per month. The average vessel speed for the ‘baseline vessels’, as interpreted from AIS data, is around 9 knots, while top speeds of 14 knots are observed.

Table 10.34: Summary of source SPLs for each scenario within Berkeley Sound.

Vessel	Length (m)	PK (dB re 1 µPa @ 1m) in each scenario		
		1	2	3
LTV	160	120	120b	n/a
OCV	160	174	120	n/a
Fishing vessel	79	n/a	n/a	162
Tanker	127	n/a	n/a	167
Reefer	160	n/a	n/a	170

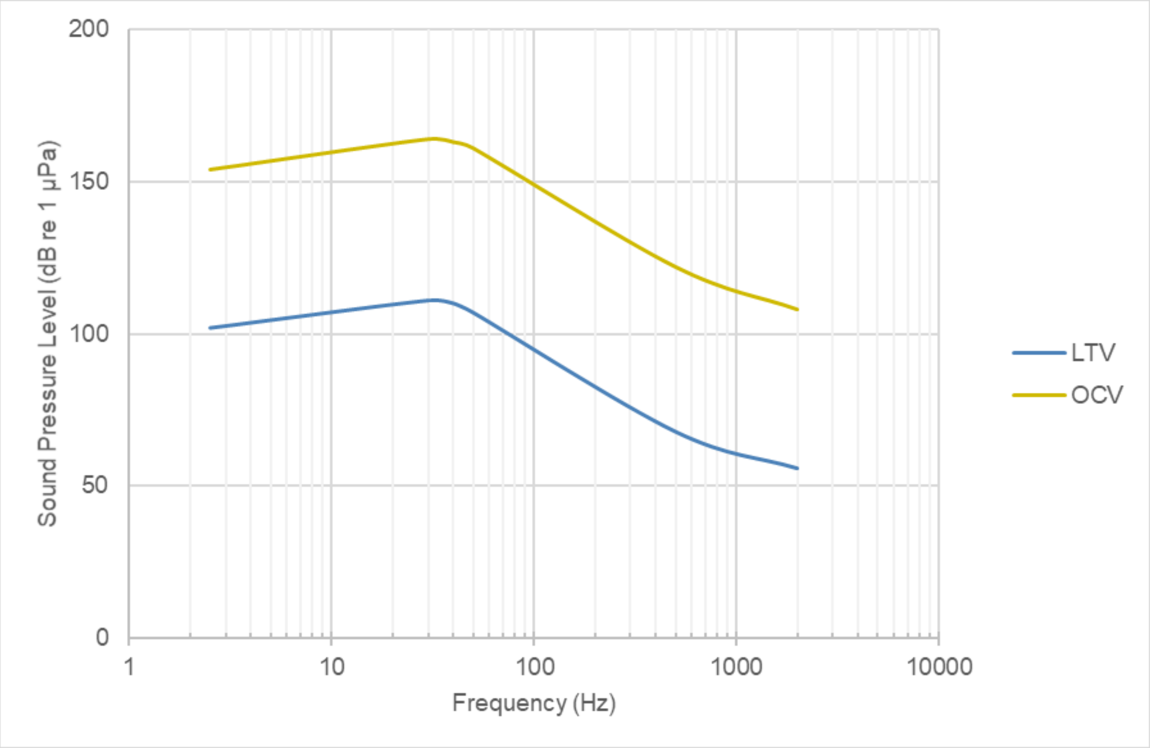


Figure 10.20: Vessel frequency spectrums used in noise modelling for Scenario 1

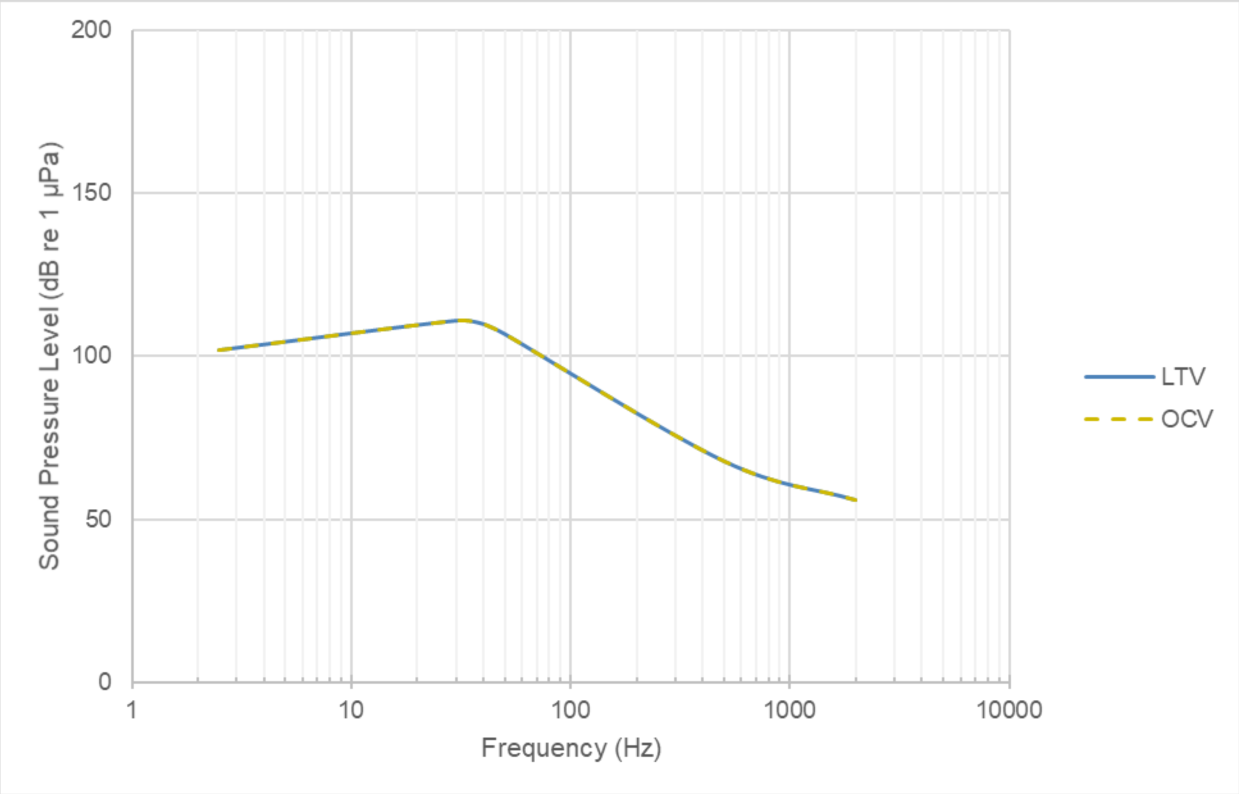


Figure 10.21: Vessel frequency spectrums used in noise modelling for Scenario 2

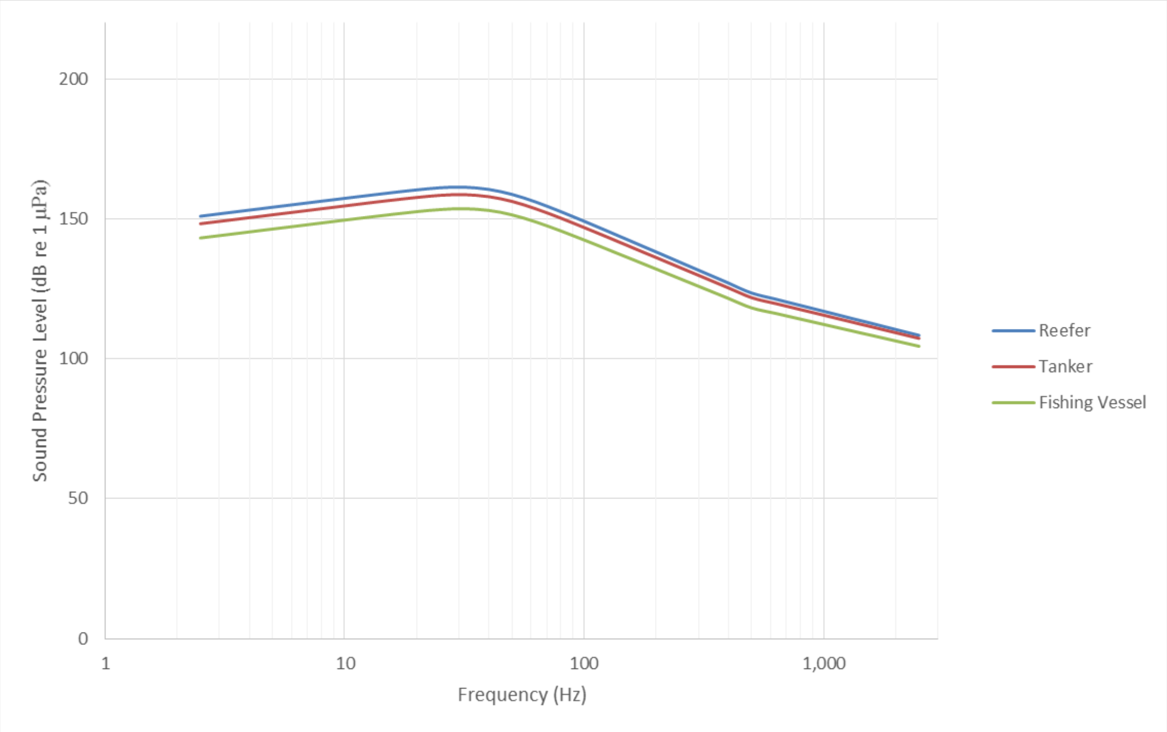


Figure 10.22: Vessel frequency spectrums used in noise modelling for Scenario 3

10.5.4.4.2 Step 2: Sound propagation modelling

The results of the sound propagation models used in this assessment determine:

- The Peak Sound Pressure Level (PK), which indicates the highest level of instantaneous sound received by a receptor at a given distance from the source. This information is used to determine the distance at which injury and disturbance thresholds are exceeded; and
- The cumulative Sound Exposure Level (SELcum), which is a standardised measure of the overall sound energy that an animal will be exposed to (i.e. related to SPL and exposure time) over a specified length of time (a 24 hour period in this assessment).

As described in NMFS (2016), the SELcum was weighted according to the marine mammal hearing types (i.e. low-frequency, mid-frequency, high-frequency and otariid and phocid pinniped hearing as described in Table 10.20: above). This accounts for the differences in the sensitivity of these groups to different frequencies.

10.5.4.4.2.1 Scenarios 1 – 3: the Inshore Operations

For illustrative purposes, the SPL outputs from the modelling undertaken for Scenarios 1 and 2 are presented in to and are used to inform the comparison sections below (summarised in Table 10.35). Data on the SEL(cum) with regard to injury are provided in section 10.5.4.4.3.

The results indicate that the noise levels generated by the different inshore activities vary and however, they are largely similar to the background levels (see Scenario 3 below).

As is shown in , a small area of disturbance is predicted to occur during Scenario 1 when the LTV is at anchor and the OCV is entering Berkeley Sound. For context; shows the model outputs with the marine mammal disturbance threshold (120 dB re 1µPa(rms)) highlighted. The model output indicates that during Scenario 1, sound levels exceeding the disturbance threshold extend to 0.984 km from the OCV (Table 10.35) as the vessels enter the Sound and about 0.450 km from the LTV anchorage. Noise levels exceeding the avoidance threshold for marine mammals (160 dB re 1µPa(rms)) extend to only 5 m from the OCV as it enters the Sound but are not exceeded for the LTV at anchor and this is similar to the levels of background noise already experienced within Berkeley Sound (see Scenario 3 below).

Figure 10.23 illustrates that the cumulative noise level, from all vessels present, is lowest when the LTVs are the only vessels present (Scenario 2). Figure 10.24 illustrates that a small zone of disturbance (i.e. noise levels exceed the disturbance threshold) will exist, which extends 0.490 km from the anchorage (Table 10.35). Noise levels exceeding the higher avoidance threshold are not predicted. As can be seen from Scenario 3 below, these noise levels are within those already experienced in Berkeley Sound.

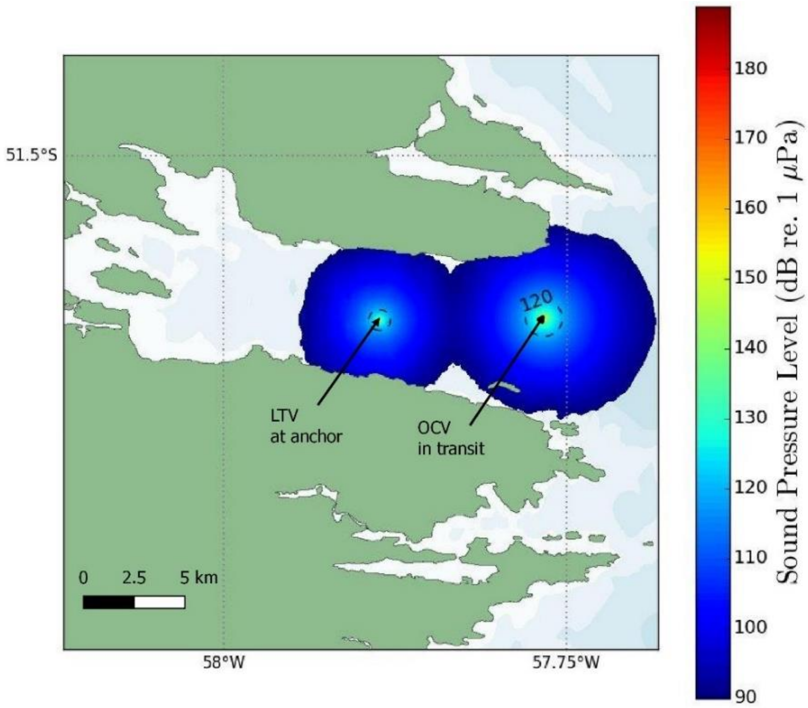


Figure 10.23: Scenario 1 noise modelling output (OCV in transit and the LTV at the anchorage)
Note: The dashed line indicates the point at which the disturbance threshold (120 dB re 1µPa(rms)) is exceeded

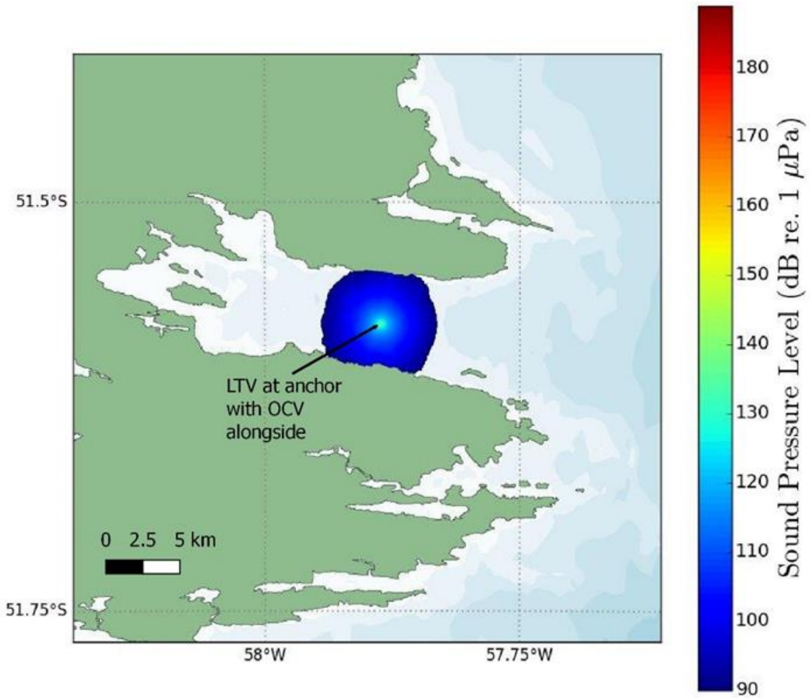


Figure 10.24: Scenario 2 noise modelling output (LTV at Anchor) Note: The dashed line indicates the point at which the disturbance threshold (120 dB re 1µPa(rms)) is exceeded

10.5.4.4.2.2 Scenario 3: Berkeley Sound background noise modelling outputs

The results from the modelling undertaken for Scenario 3 are presented in Figure 10.25 and indicate that the background noise levels in Berkeley Sound are similar to those during the inshore operations.

Again, for context, the cumulative noise levels exceeding the disturbance threshold for marine mammals (120 dB re 1µPa(rms)) extend to approximately 0.590 km from the tanker and the higher avoidance threshold is not reached.

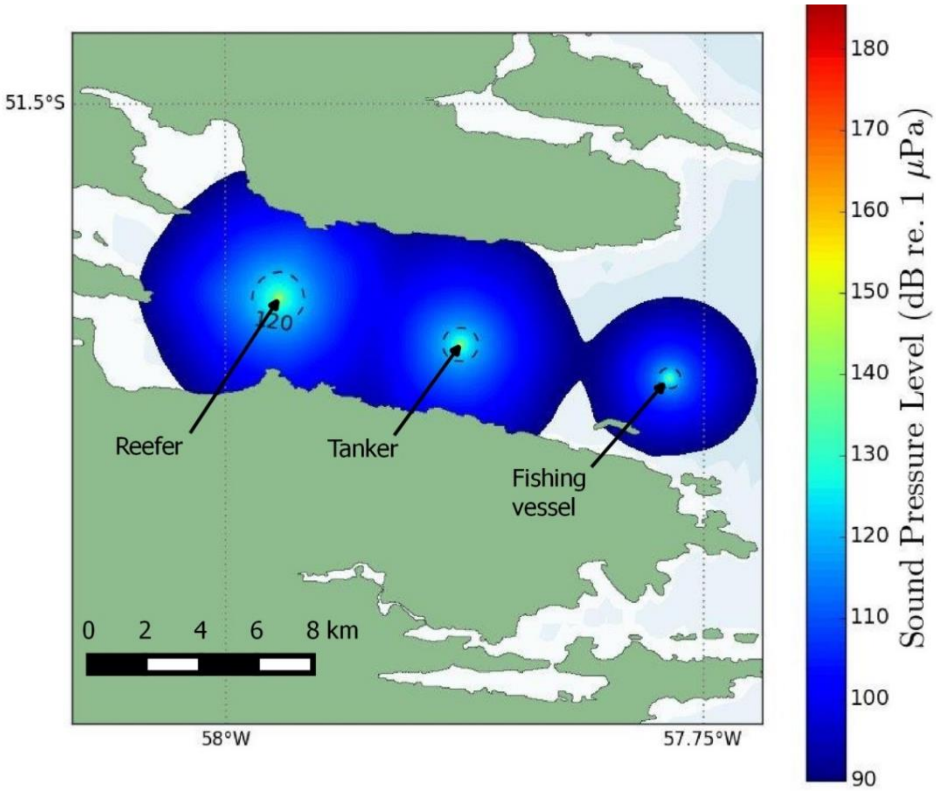


Figure 10.25: Scenario 3 noise modelling SPL outputs Note: The dashed line indicates the point at which the disturbance threshold (120 dB re 1µPa(rms)) is exceeded

10.5.4.4.2.3 Cumulative Sound Exposure Level modelling

The sound produced during LTV operations is non-pulsed and continuous in nature and is below the thresholds for instantaneous injury. However, exposure to a lower sound pressure for an extended period can result in injury. Cumulative Sound Exposure Level (SEL(cum)) was modelled to investigate the potential for exposure above the thresholds for injury. An example, based on the worst case scenario (Scenario 1), of received SEL(cum) for marine mammals and fish moving away from the sound source at 1 m/s over a 14 hour period is presented in Figure 10.26. The vast majority of the SEL(cum) is accumulated at the beginning of the exposure period, and after 14 hours, the increase in SEL(cum) is negligible, such that this is equal to a 24-hour exposure level.

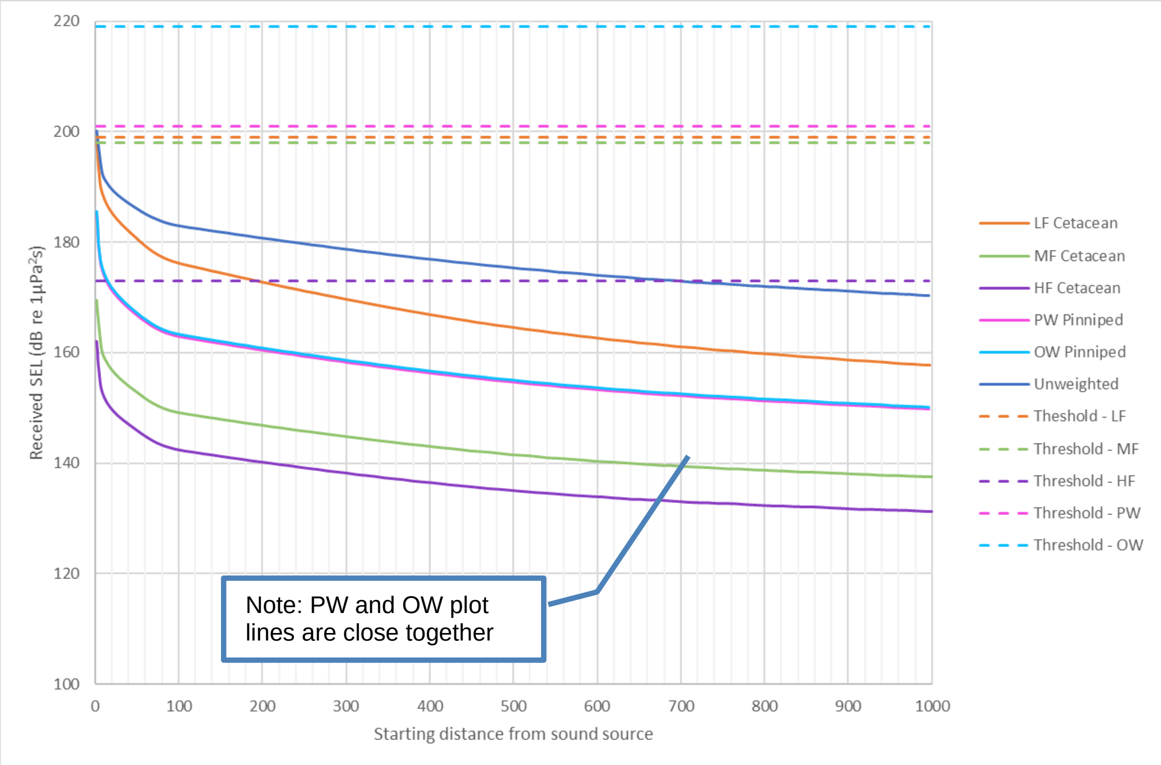


Figure 10.26: Received SEL(cum) for fish (see the blue 'unweighted line') and marine mammals moving away from the sound source at 1 m/s over a 14 hour period.

10.5.4.4.3 Comparison of model results with injury thresholds

The internationally recognised thresholds for injury and disturbance to invertebrates, fish, seabirds and marine mammals are described in section 10.4.4.3. Note again that in this assessment, cephalopods are assumed to be similar to non-swim bladder fish in their ability to detect sound and are thus assessed alongside fish in section 10.5.6.1.1.1 to assume the worst case.

10.5.4.4.3.1 Fish injury

The impairment thresholds for hearing-sensitive fish (e.g. those with a swim bladder involved in hearing such as the Falkland sprat) in response to vessel noise, is 170 dB re 1 µPa (rms) (over 48 hours) for a 'Recoverable Injury' while a Temporary Threshold Shift (TTS) may occur at noise levels of 158 dB re 1 µPa (rms) (over 12 hours) (section 10.4.4.3.2.3). The potential for injury to eggs and larvae from vessel noise is considered to be low at near, intermediate and far locations from the sound source.

During Scenario 2, when the OCV is steaming into the Sound, the SPL thresholds for impairment injury are exceeded very close to the sound source (approximately within a few metres of the vessels as illustrated in Figure 10.24). Importantly however, the thresholds quoted are based on the assumption of continuous noise occurring over a period of either 12 or 48 hours and assume that there is no avoidance behaviour (i.e. assuming the fish do not swim away from the sound source). Additionally, the vessels will be in transit and therefore any receptors passing close by the vessel (witin metres) will be exposed to sound above the SPL for a very short period of time.

It is therefore predicted that injury to adult fish and cephalopods, eggs or larvae will not result from any of the vessel activities involved in the inshore operations.

10.5.4.4.3.2 Seabird injury

The SEL(cum) injury threshold for diving seabirds is 202 dB re 1 μPa^{2}s (section 10.4.4.3.3.1). Although not specifically modelled, data indicates that at no time during the inshore activity does the unweighted SEL(cum) exceed this level.

10.5.4.4.3.3 Marine mammal injury

For non-pulsed sounds such as vessel noise, the SEL(cum) injury thresholds for cetacean and pinniped hearing groups have recently been updated by NMFS (2016) and are shown in Table 10.23: . The received SEL(cum) for all marine mammal hearing groups moving away from the worst case sound source (greater than that predicted during inshore operations) at 1 m/s over a 14 hour period is presented in Figure 10.26 which shows that the SEL(cum) injury threshold is not exceeded for any marine mammal type.

The PK injury thresholds for each marine mammal hearing group are shown in Table 10.23: . The lowest threshold for PK induced PTS is set at 202 dB re 1 μPa for HF cetaceans but is greater for all other marine mammal hearing groups (section 10.4.4.3.4.4). Table 10.34: above shows that the PK produced during Scenario 1 is 174 dB re 1 μPa directly at the source. Therefore, at no time during the inshore activities does noise occur at a level that will cause instantaneous physical injury to marine mammals (Figure 10.24).

Given that the sound sources associated with inshore operations does not exceed internationally recognised thresholds for injury, the remainder of the assessment focusses on the potential for vessel noise to induce avoidance behaviour or disturbance.

10.5.4.4.4 Comparison of model results with disturbance and behavioural response thresholds

10.5.4.4.4.1 Invertebrate and fish disturbance from vessels

There is limited information available regarding the sensitivity of fish (and cephalopods) to sound and the noise levels that could result in avoidance / displacement or disturbance, with many gaps in scientific knowledge e.g. Hawkins *et al*. (2015). Nonetheless, it is understood that fish are able to both generate and detect sound which is used to communicate, sense their environment, and detect predators and prey (Popper *et al*., 2014). Popper *et al*. (2014) suggest that all fish are at high risk of masking (section 10.4.4.3.2.3) when they are close to continuous low frequency sources of noise, and those that use the swim bladder to detect sound are also at high risk at long range. Fish that use the swim bladder are also at high risk of behavioural change when near to the source of noise (section 10.4.4.3.2.3 above).

10.5.4.4.4.2 Seabirds disturbance from vessels

For seabirds, there are no guidelines to determine what constitutes a behavioural disturbance or threshold sound level.

10.5.4.4.4.3 Marine mammal disturbance from vessels

While modelling has indicated that injury is very unlikely in marine mammals, there is the potential for long-term continuous vessel noise to cause behavioural disturbance. However, as described in section 10.4.4.3.4.3, reactions to infrequent noise lasting <24 hours is unlikely to have any lasting effect (Southall *et al*., 2007). Therefore, it is considered unlikely that vessels engaged in inshore operations would cause more than trivial disturbance that would be rapidly recoverable once the operation is complete (JNCC, 2010a).

The threshold for displacement in marine mammals is set at 160 dB re 1 µPa(rms) (section 10.4.4.3.4.5). Noise levels capable of causing displacement may occur in a very localised area around the vessel activity. As shown in Figure 10.24 above, the most significant area in which displacement may result occurs during Scenario 1, when th OCV steams towards the LTV anchorage and could cause displacement of marine mammals out to five metres from the vessel, which equates to 0.1 % of the area within Berkeley Sound (Table 10.35).

There is potential for a wider area of disturbance to marine mammals based on the lower disturbance threshold of 120 dB re 1 µPa(rms) (Table 10.35). The lowest level of disturbance impact occurs when the LTVs are at anchor and the OCVs moored, during cargo exchange, i.e. in Scenario 2. The area of potential disturbance during the majority of the time that the LTVs will be anchored within Berkeley Sound is similar to that produced by existing commercial mid-sized vessels operating in the Sound (Scenario 3).

Table 10.35 Noise modelling results showing distances from the sound source at which displacement / disturbance of marine mammals may occur, and the areas above which the thresholds are exceeded in which an impact may be observed

Scenario	Threshold (rms dB re 1 µPa) [b]	Distance to threshold (km)	Area of impact (km^2)	Percentage of Berkeley Sound area above noise level
Displacement threshold				
1	160	0.005	<0.001	<0.001
2	160	Not exceeded	n/a	n/a
3	160	Not exceeded	n/a	n/a
Disturbance threshold				
1	120	0.984	3.04	2.2
2	120	0.488	0.74	0.53
3	120	0.594	1.11	0.79

a The average area of influence of the vessels modelled is presented - i.e. this represents one 'existing' vessel travelling at average speed.

b Southall *et al*. (2007).

10.5.5 Industry-standard mitigation measures

10.5.5.1 Vessel noise

As stated in section 10.4.5.2, there are no industry-standard mitigation measures specifically designed to reduce the impact of vessel noise on fauna. However, standard operating procedures, such as maintenance schedules, will help to minimise the noise generated by propeller cavitation.

10.5.6 Impact assessment

The following section draws upon all the information provided above to assess the 'Sensitivity of the Receptor' and the 'Severity of Effect' in order to determine the overall 'Impact' of planned activities.

A summary of the impact assessment outcomes for this Development is tabulated in section 10.5.12 (Table 10.36:), which shows the worst case impact for each activity.

10.5.6.1 Displacement and Disturbance

10.5.6.1.1.1 Invertebrate and fish displacement and disturbance

Berkeley Sound does support spawning loligo squid but the size of the local population and distribution of spawning sites are poorly known (section 7.4.4.3.2.1). However, there are unlikely to be any significant aggregations within the zone of influence of underwater noise generated by inshore operations. Nonetheless, fish do occur in low numbers of geographical importance and therefore as described in section 10.5.6.1.1.1 above, the **sensitivity of the receptor** is considered to be '**Low'**.

Noise modelling indicates that levels of sound during the inshore operations will be similar to the noise levels currently predicted to occur within the area (section 10.5.4.4.2). While Popper *et al*., (2014) recognise that masking effects may be high at any distance from the sound source and behavioural changes may be moderate in the near and intermediate area of the sound source (section 10.5.4.4.4.1), any impacts during the manoeuvring of the OCV will be intermittent and very short-term. Therefore, it is expected that any impact will be fully reversible such that the level of disturbance would be barely detectable above background variability and the **severity of the effect** is considered to be '**Slight'**.

The **overall significance of the impact** of vessel noise on fish is considered to be '**Very Low (2)**'.

10.5.6.1.1.2 Bird displacement and disturbance

There are no quantified thresholds for assessing impacts of displacement or disturbance to seabirds.

Berkeley Sound contains significant populations of breeding seabirds, including 4.9% of the Falkland Islands Gentoo penguin breeding population, 1.8% of the Islands' rockhopper penguin population and close to 100% of the king penguin population (at Volunteer Point) (see section 7.4.5.3.1.4). The rockhopper penguin is described as 'Vulnerable' by the IUCN and is on the Falkland Islands list of priority species. Consequently, the sensitivity of the receptor is considered to be 'High'.

Noise modelling indicates that levels of sound during inshore operations will be similar to the noise levels currently occurring within the Sound and therefore, there will be little or no additional impact from underwater noise on seabirds present in the area. However, the period of inshore activity will extend throughout the summer months (August to March), which extends the period of 'normal' shipping activity in the Sound. While there are no published disturbance thresholds for birds, if loud enough, the levels of noise could cause birds to temporarily relocate, reduce feeding activity underwater or remain above water for the time operating vessels pass by.

The potential for impacts from underwater noise during the manoeuvring of the project vessels will be localised, infrequent, very short-term and fully reversible such that the level of disturbance would be barely detectable above background variability. Therefore, **the severity of the effect** is considered to be **'Slight'**.

The **overall significance of the impact** of vessel noise on seabirds is considered to be **'Low (4)'**.

10.5.6.1.1.3 Marine mammal displacement and disturbance

Although a number of marine mammal species may occasionally occur within Berkeley Sound, the most regularly recorded are sei, southern right and Antarctic minke whales, Commerson's and Peale's dolphins, South American sea lions and fur seals. All marine mammals are conservation priority species in the Falkland Islands and therefore the **sensitivity of the receptor** is considered to be **'High'**.

The SPL threshold for displacement behaviour by marine mammals is 160 dB re 1 μPa (rms) and that for disturbance is 120 dB re 1 μPa(rms). Noise modelling undertaken indicates that the displacement threshold is exceeded out to five metres during Scenario 1, when the LTV is at anchor and an OCV is entering Berkeley Sound. This is a very localised area of displacement and will not cause any impact on marine mammals.

A wider area of disturbance is predicted to occur when the OCV is entering the Sound (Scenario 1) with noise capable of causing disturbance extending out to 984 m from the OCV as it enters the Sound (Table 10.35). This is similar in extent to the current level of disturbance, (estimated to be 594 m for a mid-size tanker), caused by existing shipping in the area.

Noise generated by the transiting vessels could lead to disturbance via reduced communication and reduced feeding, swim speeds and dive intervals (section 10.4.4.3.4.3). Berkeley Sound is known to be a feeding site for sei whales and other marine mammals (section 7.4.6.3). Importantly however, noise from transiting vessels will be intermittent and very short duration (section 1.1.1) and once the vessels have stopped, noise levels will reduce to background levels such that any additional disturbance impacts will quickly return to existing background levels.

It is thus expected that the level of disturbance would be barely detectable above background variability and, therefore, the **severity of the effect** is considered to be **'Slight'**.

The **overall significance of the impact** of vessel noise on marine mammals is considered to be **'Low (4)'**.

10.5.7 Project-specific mitigation

The significance of the impact of underwater noise associated with inshore operations within Berkeley Sound is assessed as **'Low'** or **'Very Low'** for all receptors and therefore project-specific mitigation is not required.

10.5.8 Residual impacts

Not applicable.

10.5.9 Cumulative impact

All vessel use during the Phase 1 Development will contribute to the existing vessel activity and background noise in Berkeley Sound and, therefore, may lead to cumulative impacts via increased 'concentration', increased 'extent and proportion' and increased 'duration' (section 8.10.1).

The noise generated by vessels engaged in inshore operations will add to the noise generated by other vessels using Berkeley Sound. The baseline number of vessels using Berkeley Sound varies considerably from one year to the next, which is linked to the amount of squid caught in any particular year. A total of 957 vessels were recorded in the Sound over a 12 month period between May 2014 and May 2015, which is considered to be a busy year. Fishing vessels were the most frequent vessel with 620 recorded over the 12 month period. A further 171 Reefer vessels, 97 tankers and 68 other assorted vessels were also recorded over the same period.

There are also considerable month-to-month differences in the number of vessel visits, with the highest number of visits between March and June (section 7.7.3.2.1.2). Additionally, there are seasonal and potentially inter-annual variations in the number of receptors present (such as sei and southern right whales). Therefore, the cumulative impact will be highly variable.

Noise arising from the Phase 1 vessels is similar to the current levels of noise within the Sound. Although there will be an increase in vessel activity, and the inshore operations will increase the spatial and temporal spread of vessel disturbance within the Sound, the overall level of noise is not predicted to rise significantly above the current levels, which may already cause a degree of disturbance.

10.5.10 Confidence

Sound propagation in water is relatively well understood and models used to determine this are used extensively but there is limited information on vessel noise. The vessels used in the modelling described above are considerably larger than the proposed project vessels and therefore it is assumed that the noise generated by project vessels will be below that modelled. This assessment is thus considered to be precautionary.

The status of the potential receptors in Berkeley Sound is relatively well understood, although the influx of southern right whales in the winter of 2017 (section Cetaceans recorded during JNCC seabirds at-sea surveys) highlights that unusual years do occur and long-term trends can change. The seasonal distributions of the regularly occurring marine mammals, birds and fish are broadly known, although, with the exception of the breeding seabirds, there is limited information on their population sizes. The inter-annual distribution and abundance of marine mammals are acknowledged as a data gap, as is the distribution of loligo spawning sites.

Less is known on the sensitivity of the receptors to noise. Studies on physiological effects or behavioural responses to underwater noise are limited to a relatively few species of marine mammal and fish and very little is known on the ability of cephalopods or birds to detect sound underwater and, again, this is acknowledged as a data gap.

Based on the predicted severity of effect from vessel noise, there is enough information to have a **'Probable'** degree of confidence in the conclusions of this assessment. However, due to the gaps in our understanding, in particular relating to the physiological and behavioural responses to noise by species likely to be present within the Sound, the confidence in the assessment is precautionarily assessed as **'Uncertain'**.

10.5.10.1 Monitoring

Disturbance to marine mammals due to vessel noise is becoming an increasingly significant issue globally. It is known that Berkeley Sound supports a significant assemblage of marine mammals and therefore monitoring of the impacts of vessel activity on these animals will be undertaken. Premier will deploy hydrophones in the Sound to record marine mammal vocalisations for 1-2 years to establish the baseline. Marine Mammal Observers (MMOs) will be placed on the OCVs and records of animal behaviour will be kept for subsequent analysis.

A review of the MMO reports will be conducted after 5 years and used to improve knowledge of locations and behaviour of marine mammals.

Populations of sea lions in Berkeley Sound and fur seals at Volunteer rocks will be monitored with counts undertaken from land. Haul out sites will also be recorded.

Hydrophones recordings will be used to validate the results of noise modelling.

Two projects studying the inshore cetaceans of the Falklands, with a focus on Berkeley Sound, have recently concluded. The results from these studies have helped to better understand the Falkland Islands' cetacean populations and may focus future monitoring.

Premier will investigate the use of noise minimisation in the design of vessels, where possible.

Detailed monitoring requirements will be established during the Environmental Monitoring and Management Plan (EMMP) workshop. All monitoring requirements agreed by Premier and FIG will be recorded and managed via the project-specific Phase 1 EMMP (an outline EMMP is provided in Chapter 15).

10.5.11 Offsetting

As no residual impacts or risks identified in this section are considered significant, i.e. Moderate or above, offsetting is not considered (see section 8.9).

10.5.12 Findings summary

Table 10.36: Summary of the impacts from vessel noise during inshore operations.

Activity / Event	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Vessel operations within Berkeley Sound	Intermittent moderate intensity noise during inshore operations	Displacement and behavioural disturbance b to invertebrates and fish	Planned	1 & 2	Low	Slight	n/a	Very Low (2)	n/a	Uncertain	Industry-standard: None. Project-specific: None proposed
		Displacement and behavioural disturbance b to seabirds		1 & 2	High	Slight	n/a	Low (4)	n/a	Uncertain	
		Displacement and behavioural disturbance b to marine mammals		1 & 2	High	Slight	n/a	Low (4)	n/a	Uncertain	

a See Chapter 8 for definitions of sensitivity, severity, likelihood and significance.

b Noise modelling results indicate that noise levels do not occur during any stage of Phase 1 Sea Lion development within Berkeley Sound that will cause injury (as opposed to disturbance) to any of the receptors

10.6 Discharge of drilling mud and cuttings

Table of Contents

10.6.1 Introduction

Drilling muds will be used during all Phase 1 drilling operations and will consist of a liquid phase into which various chemicals and solids have been added to modify the operational properties of the drilling system (section 5.4.6). The wells will be drilled in sections and will generate drill cuttings as a waste product. Both the used mud and the cuttings must be disposed of responsibly as with any other waste product. The use of chemicals during the Phase 1 Development was raised as a concern by stakeholders during scoping consultations (Chapter 6.0).

This chapter assesses the impacts associated with the discharge of solid and liquid drilling wastes. Modelling was carried out to enable greater understanding of the impacts.

Note: the impacts of associated with other sources of disturbance to the seabed and liquid waste discharges are described elsewhere in this document, as described in section 9.2.

10.6.1.1 Relevant legislation

Conventions and legislation relevant to drilling discharges to sea include:

- EU legislation and Conventions:
- Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora (The Habitats Directive).
- OSPAR Decision 2000/2 on a Harmonised Mandatory Control System (HMCS) for the Use and Reduction of the Discharge of Offshore Chemicals.
- OSPAR Decision 2000/3 on the Use of Organic-Phase Drilling Fluids (OPF) and the Discharge of OPF-Contaminated Cuttings (16 January 2001).
- UK legislation:
- Offshore Chemical Regulations (OCR) 2002 (and all amendments).
- Offshore Petroleum Activities (Oil Pollution Prevention and Control) (OPPC) Regulations 2005 (and all amendments).
- Falkland Islands requirements:
- Petroleum Operations Notice (PON) No.10 - Application to Use and Discharge Non-Aqueous Drilling Fluids (NADF) and Associated Cuttings.

Under the above, there are numerous compliance requirements with regard to the receiving habitat, oil content on cuttings and chemical selection.

10.6.1.1.1 The PON 10 and oil on cuttings compliance

The discharge of cuttings contaminated with High Performance Oil Based Mud (OBM), which is a Non-Aqueous Drilling Fluid (NADF), must be managed in accordance with the FIG PON 10 to ensure best practice. The FIG PON 10 reflects the requirement of OSPAR Decision 2000/3 and prohibits the following:

- The discharge of whole Organic Phase Fluids (OPF) e.g. NADF;
- The discharge of whole OPF when drilling tophole sections; and

- The discharge of cuttings contaminated with OPF at a concentration greater than 1 % by weight on dry cuttings.

Appendix I of OSPAR Decision 2000/3 also states that Best Available Techniques (BAT) and Best Environmental Practice (BEP) must be utilised to minimise oil concentration on discharged cuttings.

10.6.1.1.2 Chemical compliance

Premier proposes to manage offshore chemicals in a similar way to the UK system whereby offshore chemicals have been controlled since 1979 via the Offshore Chemical Notification Scheme (OCNS). This has developed into an OSPAR-wide control scheme via the Harmonised Mandatory Control System (HMCS) which is an outcome of OSPAR Decision 2000/2 and Recommendations 2010/3 and 2010/4. This contains requirements for chemicals to be pre-screened by applying standardised laboratory tests in an application or standard known as the Harmonised Offshore Chemical Notification Format (HOCNF). Those with acceptable properties are given rankings as to their potential risk in typical usage are added to the Cefas Definitive Ranked List of Registered Products. Only chemicals from this list may be used or discharged offshore for O&G purposes.

Chemicals with the best performance (lowest toxicity, lowest bioaccumulation and lowest persistence) are given a classification of ‘Gold’. Chemical discharge must be subject to a risk assessment unless they are categorised as posing little or no risk to the environment according to OSPAR Agreement 2013/6 (PLONOR, including e.g. inert minerals, nut fibres, methanol and monoethylene glycol). In the UK and Netherlands, the risks are assessed at 500 m from the discharge using a dispersion calculation known as the Chemical Hazard and Risk Model (CHARM). For those chemicals that cannot be assessed using CHARM, such as inorganic or PLONOR chemicals, a separate OCNS classification is given from ‘A’ to ‘E’, with ‘E’ being the best environmental performance.

For any chemicals that have specific undesirable properties around biodegradation, toxicity and bioaccumulation, these are given a ‘substitution warning’ which means that their use must be justified and replacements sought. The goal was a phase out of discharge of these chemicals by 1st January 2017. Chemicals with traces of certain undesirable substances such as particular metals, including those on a list for priority action (OSPAR 2004/12 revised 2013) are given a ‘warning’ code and their use must be specifically justified in applications.

All chemicals dosed into the drilling muds will be selected to minimise the potential environmental impacts as much as possible in line with the OSPAR Decision 2000/2.

During the Phase 1 Development, chemicals with the best environmental rating (e.g. PLONOR (Pose Little Or No Risk), HQ (Hazard Quotient) ‘Gold’ or OCNS ‘E’ will be selected where possible. Where technical feasibility issues dictate otherwise, full justification of the chemical use will be provided as instructed by FIG with options to substitute for less harmful chemicals over the course of the drilling campaign kept under review.

10.6.2 Sources of drill cuttings and fluids discharges

For the Phase 1 Development a maximum of 30 wells, drilled by the MODU, will be connected ('tied-back') to the FPSO. The maximum 30 development well configuration comprises up to:

- 20 oil production wells (hereafter referred to as just 'production' wells);
- 8 Water Injection (WI) wells; and
- A maximum of two remote and dual purpose (i.e. gas injection / gas re-injection) GPI wells.

The production and WI wells will be drilled across three (clustered) Drill Centres (DC) and the two GPI well(s) will be drilled as remote wells. The distribution of the wells over the DC's is as follows:

- Main Drill Centre (MDC):
  - 14 production wells; and
  - 3 WI wells
- Eastern Drill Centre:
  - 3 WI wells
- Southern Drill Centre (SDC):
  - 6 production wells; and
  - 2 WI wells
- 1 remote GPI well to the west of the DC's, with the potential for a second GPI if necessary (i.e. potential for a maximum of 2 GPI wells.

Details on the well profiles with regard to section diameters and lengths are provided in the Project Description (section 5.4.5.1).

Note: to ensure that a conservative worst case is assessed with regard to spatial extent, concentration and thickness of cuttings, the modelling described in section 10.6.4.3.4 covers the maximum number of wells (30) being drilled over the three DC's (28), and the two remote GPI wells.

Specifically, the discharges will include:

- Tophole sections: seabed discharges of seawater, bentonite mud and associated drill cuttings;
- Bottomhole sections: surface discharges of drill cuttings contaminated with OBM at a target average concentration of <0.5 % by weight on dry cuttings; and
- Resuspension of cuttings during clearing of equipment.

Note: the project base case is for the bottom hole sections of the GPI well(s) i.e. the 17 ½" and 12 $^{1}/_{4}$" sections, to be drilled with WBM (section 5.4.5.1). However, as described in section 5.4.5.1, the potential exists that these lower sections of the GPI wells may be drilled using OBM if the rig is configured for OBM at that time. To account for the worst case scenario of OBM being used to drill the GPI lower well sections, for the modelling of GPI the wells two bottom hole sections have been assumed to have been drilled with OBM. This assumption presents the worst case scenario with regard to environmental impact.

10.6.2.1 Tophole discharges

At the time of writing, it was undecided whether or not the topholes will be drilled to enable installation of the well conductors, or whether the conductor casings will be pile-driven into place (section 5.4.4.3). In terms of the volume of drill cuttings generated, it is assumed that the topholes will be drilled rather than piled to ensure assessment of the worst case.

Note: with regard to the impacts of underwater noise offshore (section 10.4), the opposite option is assumed where the conductors will be pile driven into place, again to assess the worse environmental case.

Therefore, for this chapter it is assumed that the two tophole sections of each well will be drilled with seawater and bentonite sweeps followed by a displacement mud. All tophole mud and cuttings will be discharged directly to the seabed as no marine riser will be in place to enable cuttings to be returned to surface.

10.6.2.2 Bottomhole discharges

The oil production wells will each comprise three lower sections, whilst the WI wells and the GPI wells will comprise only two. The lower sections of the oil and water injection wells will all be drilled using OBM. However, for the GPI wells, the final decision with regard to the choice of drilling mud (i.e. WBM or OBM) used for the lower 17 ½", 12 ¼" well sections will depend upon the success of the batch drilling process and which mud type of mud the MODU is configured to at that time (section 5.5.3.1 and 5.5.3.2). The use of OBM for the lower hole sections of the oil and water injection wells provides much improved control of hole stability and shale performance when drilling at highly deviated angles (section 5.4.4.3).

The OBM cuttings will be returned to the rig and treated by shale-shakers to recover most of the mud for re-use. The remaining cuttings will then be treated by a Thermomechanical Cuttings Cleaner (TCC) to remove most of the base oil, with recovered base oil returned to the OBM system on the rig. leaving <0.5 % oil on cuttings by dry weight to ensure compliance with legislation (section 10.6.1.1.1). The TCC unit also grinds the cuttings to a finer grain material in the process.

The treated OBM cuttings will then be discharged from a cuttings chute extending up to 20 m below the sea surface after re-mixing with the recovered water which allows a slurry to be formed, which will flow and descend in the water column. The exact depth of discharge is dependent on the rig and equipment and may be shallower than 20 m, but cuttings modelling based on a 20 m depth is conservative as a shallower discharge will provide more opportunity for dispersion of the cuttings before reaching the seabed.

In the event that it is not possible to treat and discharge the OBM cuttings offshore, it would be necessary to transfer the cuttings to shore for storage and / or eventual treatment and disposal. However, it is understood that onshore treatment and disposal of OBM cuttings in the Falkland Islands is unavailable (section 10.110.10). Therefore, it is necessary to ensure that a high availability of the offshore treatment process is maintained and the following measures will be in place:

- The successful TCC supplier will need to be able to demonstrate a high level of uptime and reliability for the TCC e.g. established TCC unit operators claim, on average, a 99.5 % uptime based on historical performance. This demonstration will form part of the contractor management selection process and audit (section 3.2.1.6);
- Planned preventative maintenance and condition monitoring programmes;
- Flexibility in scheduling for alternative work i.e. should there be any major issues with the TCC unit, Premier will be able to suspend the well, recover the BOP and continue with alternative tophole work. This is consistent with Premier's batching and BOP maintenance philosophy, aiming to have alternative tophole work available; and
- Spares will be carried to ensure maximum uptime of the equipment. As the supply chain to the Falkland Islands is challenging, Premier will hold sufficient spares commensurate to the remote area of operations. For example, discussion with the TCC suppliers indicates that the 'sparing package' should include a complete spare mill and engine.

10.6.2.3 Resuspension of cuttings

The cuttings discharged directly at the seabed (the vast majority of which come from the tophole sections) may accumulate around the well and can reach up to two metres in height. North Sea experience is that the settlement of cuttings can sometimes obscure subsea equipment and risk the integrity of the various components e.g. self-sealing control fluid lines. In order to ensure that these components are kept clear of cuttings, very localised planned mobilisation of cuttings is anticipated using ROV-mounted dredging equipment at any such locations. Using the ROV water pump, the cuttings will be sucked or blown so that they are relocated a distance of a few metres from the oil and gas infrastructure. This operation is kept to the minimum necessary to allow good access to the subsea equipment. The impact of this activity on the initial water column and sediment is very similar to that which occurs when the cuttings first settle, and so is considered to be inherent in the impact assessment that follows.

10.6.3 Potential receptors

The ENVironmental Impact IDentification (ENVIID) workshop was used to identify those receptors upon which the impacts of drilling discharges warranted further investigation (Chapter 9.0). These include the impacts to:

- Water quality;
- Seabed sediments offshore (section 7.3.7.1);
- Phytoplankton and zooplankton in the North Falkland Basin (NFB) (section 7.4.1);
- Benthic organisms offshore (section 7.4.3.2); and
- Fish and squid in the NFB (section 7.4.4.2).

The above may be affected by the settlement of solids and suspended particles at the seabed which may bury animals, affect the sediment chemistry and grain size, water chemistry and water turbidity. These physical impacts may in turn affect plankton, benthic organisms and / or fish and squid species during vulnerable life stages.

10.6.4 Characterising and quantifying the impact of drilling discharges

When characterising and quantifying the impacts of drilling discharges, it is necessary to consider the following:

- Influencing factors:
  - Ocean hydrodynamics;
  - Background sediment; and
  - Drilling mud composition.
- The nature of the impact on each of the different receptors; and
- Quantification of the drilling discharges using discharge modelling.

10.6.4.1 Influencing factors

10.6.4.1.1 Ocean hydrodynamics

The currents in the Sea Lion Field predominantly move in northerly and north-westerly directions, with the current speed generally being less than 15 cm/s. At the sea bed, the currents tend to move in westerly directions with the current speed typically being less than 10 cm/s (see section 7.3.5.2).

10.6.4.1.2 Background sediments

The sediment survey for the NFB Licence Areas, PL032, PL033 and PL004 (Gardline, 2012, section 7.22) concluded that the mean grain size in the sediment at the Sea Lion area is 27 μm. The sediments were found to comprise, on average, 70.5 % of fines, 27.9 % of sand and 1.6 % of gravel across the survey area (section 7.3.7.1.1).

10.6.4.1.3 Drilling mud composition

10.6.4.1.3.1 Chemicals

Both the bentonite mud and the OBM will contain the chemical additives required to ensure:

- The correct weight of the mud so that wells are sufficiently ‘overbalanced’ (weighted) to prevent kicks of oil / gas from the reservoir into the wellbore (section 5.4.9); and
- Optimal performance to prevent problems when drilling e.g. the drillbit becoming stuck.

In line with the OCNS, every effort will be made to ensure that chemicals with low environmental impact are selected for use (section 10.6.1.1.2).

The bentonite sweeps used when drilling the tophole sections will comprise:

- Barite (OCNS E, PLONOR);
- Bentonite (OCNS E, PLONOR);
- Caustic soda (OCNS E, PLONOR);
- Soda ash (OCNS E, PLONOR); and

- Lime (OCNS E, PLONOR).

Caustic soda, soda ash and lime were not included as a mud component in the discharge model (section 10.6.4.3) due to their PLONOR status but are accounted for as a contributor to the total mud mass. Although barite and bentonite are also included on the PLONOR list as inert minerals and require no risk assessment under OSPAR rules, scientific studies have identified pseudo-toxic properties for zooplankton and filter feeders, primarily due to the particle size and sharpness of the minerals compared with natural suspended solids (Smit *et al*., 2006). As such, these two components are included in the modelled risk assessment. The bentonite displacement mud used in the topholes comprises the same components as the bentonite sweeps with the exception of lime.

The additives that will be required within the OBM are not yet known, but a typical OBM comprises:

- Barite (OCNS E);
- Non-aqueous fluid;
- Emulsifiers;
- Brine; and
- Gelling agents.

10.6.4.1.3.2 Metals

A comparison was made between the background metal concentrations in sediment in the Sea Lion area (Gardline, 2012) and the levels contained within an analogous Water Based Mud (WBM) (Table 10.37:). As shown, the concentrations of cadmium, copper, iron, mercury, lead and zinc would all be higher in the mud than in the background sediment.

Table 10.37: Metal concentrations of MI-High[a] drilling mud and Sea Lion sediment

Metal	Mi-High (µg/g) [a]	Sea Lion Sediment (µg/g)
Cadmium (Cd)	0.77	0.3
Chromium (Cr)	6.5	46
Copper (Cu)	88	22
Iron (Fe)	9,270	-
Mercury (Hg)	5.9	0.03
Lead (Pb)	243	7.5
Zinc (Zn)	167	71
Nickel (Ni)	-	18

a Mi-high is a type of barite used in WBM and is used as a conservative estimate of metal content within UK-market sourced drilling mud barite (Neff, 2005).

10.6.4.2 Nature of the impact on receptors

10.6.4.2.1 Water quality

The primary impacts of drilling discharges on water quality, at the seabed or from the surface, arise from the suspension of particulate matter in the water and the presence of chemicals within the discharge. Importantly, the impact on water quality is closely tied to the impacts on marine organisms.

Nonetheless, the Sea Lion Field is located in an area within the Falkland Islands continental shelf that is directly influenced by both Patagonian Shelf waters and superficial sub-Antarctic waters which spread over wide areas of the continental shelf and serve to rapidly disperse and dilute any discharges (section 7.3.3). Further, all chemical components within the discharges will be selected to ensure minimal impact (section 10.6.1.1.2).

10.6.4.2.2 Phytoplankton and Zooplankton

Surface drilling discharge suspensions may lead to increased turbidity which can reduce light penetration in the upper water column. The waters of the NFB are highly productive during the austral spring (section 7.4.1.2.1) and any significant reduction in light penetration could potentially affect primary production via a shorter or shifted phytoplankton bloom period or changes in species composition if impacts were over a wide enough area and / or for a significant period of time.

However, experiments assessing the impact of WBM concentrations on survivorship of the marine diatom (*Thalassiosira pseudonana*) following exposure to 50 mg/l for a period of 10 days did not show any significant changes in algae biomass or physiological condition (Cranford *et al*., 1998a).

Runciman (2001) carried out water-phase exposures in accordance with OSPAR methods (using the phytoplankton *Skeletonema costatum*) for assessing aqueous toxicity using WBM samples collected from seabed cuttings piles. The study concluded that it was very unlikely that significant effects on phytoplankton productivity would occur during a short term exposure if this type of material were re-suspended in the water column.

With regard to zooplankton, high concentrations of suspended particulates may cause impacts owing to physical interaction with the gills, gastrointestinal tract and feeding behaviour which are expected to be of greater concern than impacts from chemical toxicity (Smit *et al*., 2006). Nonetheless, in a review of impacts, Wills (1999) concluded that water column organisms would rarely be exposed to drilling fluids long enough and at sufficiently high concentrations to elicit any acute or sub-lethal responses.

In terms of impacts from OBM heat treated cuttings, a Norwegian study concluded that the environmental risk associated with these discharges is comparable to that from WBM discharges (Aquateam COWI, 2014).

10.6.4.2.3 Seabed sediment

The main recognised impacts from the discharge of drill cuttings and associated muds are on the sediment and benthic fauna.

Sediment quality at the Phase 1 drill sites will primarily be affected by the discharge of drill cuttings direct to the seabed from the two tophole sections of each well (section 10.6.2.1) and the impacts on the sediment are closely tied to the impacts upon benthic fauna.

The cuttings deposition will result in a localised increase in the existing average grain size (27 μm), and therefore has the potential to change sediment structure in the immediate vicinity of the wells. While these sections will also be circulated with bentonite sweeps, which contain barite, bentonite, caustic soda, soda ash and lime (section 10.6.4.1.3), toxicologically these components are virtually inert (Neff, 2005). Therefore, while the tophole drill cuttings may impact the sediment with regard to particle size modification, they are not expected to alter the sediment chemistry (section 10.6.6.3) unless the water concentration in the sediment pores exceeds the published Predicted No Effect Concentration (PNEC).

As the OBM cuttings will be ground by the TCC prior to discharge (section 10.6.2.2), the particles of thermally treated cuttings are expected to be smaller than those discharged as part of the WBM cuttings. Therefore, smothering from OBM treated cuttings is expected to be less than for WBM cuttings (Aquateam, 2014).

10.6.4.2.4 Benthic fauna

Surveys carried out on the NFB (section 7.2.2) indicated that the benthic communities in the area were typical of the sediment type and were fairly homogeneous throughout the surveyed area (section 7.4.3.2). Further, there are no known habitats in the area equivalent to those of conservation significance in the UK (section 7.4.3.2.2).

Nonetheless, impacts to benthic fauna from drilling discharges may include:

- Disturbance and smothering caused by burial;
- Changes to species assemblages owing to modified sediment structure (particle size);
- Changes to availability of oxygen within the sediment; and / or
- Physical impacts caused by suspended particles.

10.6.4.2.4.1 Disturbance and smothering

The impacts of disturbance, smothering and burial of benthic organisms by cuttings are direct and immediate and will affect only those organisms directly beneath the deposition. Studies have indicated that there is a risk of impact to benthic fauna when burial layers exceed a thickness of 6.5 mm (Trannum, 2004; Kjeilen-Eilertsen *et al*., 2004; Neff, 2005 and Smit *et al*., 2006).

10.6.4.2.4.2 Changes to sediment structure

Of greater impact to the benthos in the longer term is the potential for change in the sediment structure which could affect the suitability of the seabed for re-colonisation by species normally characteristic of the area. It is thought that such effects can persist for many years (Genesis, 2015a). It is suggested by Smit *et al*., (2006) that, in the absence of any other stressors, a 95 % increase in the existing median grain size (i.e. to >52 μm) would be sufficient to carry the risk of impacting upon 5 % of the most sensitive benthic organisms present.

Studies have shown that re-colonisation of cuttings pile sediments may commence 1-2 years after the cessation of cuttings discharges (UKOOA, 1999; Neff, 2005) and such predictions are supported by results from environmental surveys conducted in the Sea Lion area during 2012 (section 7.2.2). Studies were carried out comparing data from baseline surveys where no drilling had previously taken place, with those from post-drilling surveys around areas of historical drilling activity carried out in 2009 (section 7.2.2). These surveys indicated that there was no evidence of sustained disturbance as a result of historical drilling activities and that species diversity, community assemblage and abundance were typical of those found in background / undisturbed areas (section 7.4.3.2). Additionally, environmental surveys carried out during the FOSA drilling campaign in 1998 included pre- and post-drilling surveys around the 'Little Blue A' well and indicated no change in the composition of dominant species and similar levels of abundance and species diversity in both surveys (section 7.3.7.1.1). Therefore, exploration drilling activities did not appear to appreciably disturb the benthic community in the area.

10.6.4.2.4.3 Availability of oxygen

While impacts on benthos are most commonly assumed to occur as a result of direct burial, Trannum *et al*., (2010) conducted experiments comparing the impacts of burial by WBM cuttings versus burial by natural sediments. The study found a significant reduction in number of taxa, abundance, biomass and diversity of macrofauna with increasing thickness of drill cuttings, which was not observed for the natural sediment particles and it was thought that the WBM influenced oxygen consumption and oxygen penetration depth in the sediment (Trannum *et al*., 2010).

It was concluded that drill cuttings initiated a typical eutrophication response and that impacts to benthos were not, therefore, limited to the physical disturbances caused by direct burial but could also result from changes to the sediment environment (Trannum *et al*., 2010). It is suggested by Smit *et al*., (2006) that oxygen depletion of >20 % would be sufficient to carry the risk of impacting upon benthic organisms.

10.6.4.2.4.4 Physical impacts

Benthic filter feeding organisms, such as bivalve molluscs, are known to be affected by suspended particulate matter due to clogging in the gills (Cranford *et al*., 1998b). Indeed, laboratory studies have shown that elevated concentrations of bentonite and barite can affect the growth of filter feeding organisms (Cranford and Gordon, 1992; Cranford *et al*., 1999; Barlow and Kingston, 2001). Nonetheless, particles such as barite settle out rapidly resulting in declining concentrations of barite in the water column, and even in the benthic boundary layer where most bivalves feed, it is considered probable that barite has limited effect (Neff, 2010).

10.6.4.2.5 Fish and squid

Impacts to fish and squid from drilling discharges may include:

- Displacement of adults from feeding grounds; and
- Disturbance to eggs, larvae and juvenile stages.

10.6.4.2.5.1 Displacement from feeding grounds

As stated above, surface and seabed drilling discharges can result in high levels of suspended particulate matter within the water column prior to its settlement on the seabed. Studies suggest that concentrations of suspended particulate matter of approximately 200 mg/l may damage the gills of fish while higher concentrations may inhibit feeding activity (Smit *et al*., 2006). While adult fish are able to move away from turbid areas, such avoidance behaviour may serve to displace them from important feeding areas.

The proposed well locations are situated within the Falkland Islands Northern Slope (NS) habitat zone which has been identified as an important feeding area for a number of fish species, whose abundance varies with season (section 7.4.4.2.2.1). As the drilling operations are scheduled to occur during over a duration spanning more than one year, they may be ongoing at any time of year and could therefore coincide with recorded high abundances of numerous fish species, many of which are of commercial importance (section 7.4.4.2.4).

10.6.4.2.5.2 Disturbance to eggs, larvae and juveniles

Experiments carried out by Cranford *et al*., (1998a) assessing the impact of turbidity on survivorship of fish embryos and larvae showed a significant decrease in survivorship in late-stage haddock embryos (8-12 days old) and yolk sac larvae (3-7 days post-hatch) at the highest WBM concentrations tested (100 mg/l). In contrast, early stage embryos (1-4 days old) and feeding larvae (13-17 days post-hatch) showed no significant response to any of the WBM concentrations (Cranford *et al*., 1998a).

Whilst a number of fish and squid species spawn within the Falkland Islands waters, no commercial species are known to have spawning grounds within the area of the Sea Lion Field and many migrate outside of Falkland Islands waters to spawn (section 7.4.4.2.3). However, some non-commercial species e.g. species of fathead sculpins such as *Psychrolutes marmoratus* and small morid cods are likely to spawn in the area (section 7.4.4.2.3). Equally, it is understood that a number of skate species breed in the area due to their distributions and based on the known occurrence of egg cases, hatchlings and reproductively active females (Arkhipkin *et al*., 2008; Pompert, 2011; Arkhipkin *et al*., 2012a and P Brickle *pers. obs*.).

10.6.4.2.6 Metal contamination and bioaccumulation in marine organisms

A concern over potential metals contamination of demersal finfish, including the Patagonian toothfish, was raised during scoping consultations (Chapter 6.0).

Metals in general have been shown to biomagnify through food chains, including ‘heavy metals’, which is a loose term for certain metals and non-metals that have more harmful effects (OSPAR, 2000). However, heavy metals in barite, which is contained within the WBM and the OBM (section 10.6.4.1.3), occur as virtually insoluble salts and their bioavailability is therefore very limited (Carroll *et al*., 2000). Indeed, numerous studies have concluded that the heavy metals present in drilling muds, at the given concentrations, are not likely to be biologically available.

For example, a study undertaken by Neff *et al*. (1988a) exposed four species of benthic marine animals to marine sediments containing barite from WBMs. The results indicated that when exposed over a long period at high concentrations, the benthic organisms had a slight tendency to accumulate heavy metals in the gut and the gills in the form of unassimilated barite particles. However, the concentrations of barite used in the experimental sediments were much higher than would be found in the environment surrounding the drill cutting piles. It was therefore concluded that the likelihood of heavy metal uptake from WBM barites in the field was minimal.

Neff *et al*. (1988b) undertook another experiment to assess the biomagnification of heavy metals (barium and chromium) from barite. Flounder and lobster were provided with sandworms (*Neanthes virens*) that had been exposed to sediments containing the settle-able fraction of drilling fluid. The results indicated that neither barium nor chromium had been accumulated by the lobster or the flounder. Again, the barium and chromium that was present in the sandworm was found in the ingested sediments in the gut, rather than in the animal's tissues.

The level of heavy metals in heat treated OBM cuttings is expected to be the same as that in WBM cuttings so similar impacts, or lack thereof, are expected (Aquateam, 2014). Indeed, Stagg and McIntosh (1996) who investigated the bioaccumulation of metals from OBMs using variations in sediment contamination, found no differences in the liver or muscle of the demersal fish used (the Dab (*Limanda limanda*)) between treatments. In addition to this, the fish exposed to the drill cuttings directly did not exhibit increased concentrations of metals, again indicating that the metals were non-bioavailable.

Bowmer *et al*. (1996) also showed that there was no evidence of bioaccumulation of metals in the cardiid bivalve mollusc (*Cerastoderma edule*), the tellinid bivalve mollusc (*Macoma balthica*) or the arenicolid polychaete annelid (*Arenicola marina*). The concentrations of metals in the test organisms were not significantly different to those exposed to control sediments.

In contrast to the above studies, Farestveit et. al (reported in Fjogstad *et al*. (2000) who also investigated the bioavailability of weighting materials such as barite, did find some evidence for bioaccumulation of metals. Toxicological studies were conducted using fish-feed with a 10 % addition of high lead (5000 ppm) barite and while no acute metal poisoning occurred during the 10 week test, the barite-exposed fish did show enriched values of lead in both liver and blood. Importantly however, the study used an extremely high dose that could not be experienced in practice (i.e. twenty times the levels reported for 'high' metals barite in Table 10.37: above), and ten times that used in exploration campaign barite, which was <500 ppm. Similarly, Schaaning *et al*. (2002) also found bioaccumulation of metals in polychaetes and gastropods fed on barite-spiked sediments for 28 days, however, with the exception of lead, similar bioaccumulation levels were also observed in organisms fed on uncontaminated sediments so it was unclear as to whether adequate depuration time had been observed before analysing the gastropods.

With regard to the background in the Sea Lion area, there has been little work carried out on the baseline levels of heavy metals in fish inhabiting the Falkland Islands, l*et al*one on the North Slope or areas adjacent to the Sea Lion Field. Therefore, little baseline information is available. However, Hanchet *et al*. (2012) analysed muscle tissue samples collected from Antarctic toothfish and Patagonian toothfish, and some of their prey species, from the Ross Sea off Antarctica to determine their mercury content. The levels were highly variable within, and between, the species studied but were positively correlated with fish length in four of the five species studied (toothfish and their prey). In particular, the mercury levels in Patagonian toothfish were more than four times greater than in Antarctic toothfish. Hanchet *et al*. (2012) suggested that the differences between the two toothfish species could be explained through differences in their distribution and differences in their positions in the food web. However, the low levels of mercury in Antarctic toothfish relative to its prey species, could only be explained by a lower rate of mercury assimilation within this species and / or a higher rate of mercury elimination.

It is clear that a baseline is required for toothfish and other species in this environment. Given the low concentrations of heavy metals in MI-High drilling mud, the finite period of drilling and low levels in Sea Lion sediment in conjunction with the relatively low abundances of toothfish in this area it is very unlikely that drilling will have an impact on the rate of bioaccumulation of heavy metals in the ichthyofauna of the area.

10.6.4.3 Quantification of the discharges - discharge modelling

To enable greater understanding of the impacts associated with drilling discharges, Premier conducted the following modelling:

- 'DREAM' (Dose-related Risk and Effect Assessment Model) / 'ParTrack' (Particle Tracking)) model published by the Foundation for Scientific and Industrial Research (SINTEF) (v6.5.1 & v8.0). (Genesis, 2015a, updated by Premier in 2017d).

The oil production and WI wells will be drilled over three clustered DCs (the main, eastern and southern DC's) and two remote GPI wells (section 10.6.2). The modelling below therefore covers the maximum number of clustered wells as well as the two remote GPI wells (section 5.4.4.1 and 5.4.42).

The aim of the model was to estimate:

- Impacts to the sediment which required assessment of the:
  - Thickness of the mud and cuttings layer on the seabed; and
  - Overall environmental risk to the sediment based on the above information and:
    - Grain size change;
    - Toxicity; and
    - Pore water oxygen depletion.
- Water column impacts:
  - Environmental risk in the water column resulting from:
    - Toxicity; and
    - Particle suspension.
- Recovery of the water column and sediments over time.

10.6.4.3.1 The DREAM / ParTrack modelling approach

The DREAM / ParTrack model calculates particle dispersion in the water column and deposition on the seabed and also calculates the time required for concentrations of contaminants to return to previous levels once the discharges have ceased. In doing so, the model factors in processes such as:

- Mixing;
- Re-suspension and dilution due to currents;
- Sediment re-colonisation leading to bioturbation and biodegradation of the sediments; and
- Changes in chemical toxicity over time.

The DREAM / ParTrack model predictions have been validated through field measurements at the Trolla Field in water depths of 265 m in the Norwegian Sea. Here, a correlation was observed between the simulated and the measured deposition of the cuttings on the sea floor (Rye, 2010; Jødestøl and Furuholt, 2010). Indeed, the observed deposition thickness was lower than that predicted by the ParTrack model, which suggests that the modelling results may be considered to be conservative.

To enable brevity in this section, the following describes only the information required to ensure appreciation and understanding of the modelling results. Full details on the DREAM / ParTrack methodology are provided in Premier (2017d). Full detail with regard to the modelling parameters utilised e.g. metocean data (currents, wind, temperature and salinity and bathymetry) is provided in section 7.

10.6.4.3.2 Discharge parameters and assumptions used in DREAM / ParTrack

The masses of mud and cuttings discharged during drilling were calculated by Premier using data on the well profiles, mud usage rates and section volumes (Table 10.38:). In particular, the masses of discharged cuttings shown in Table 10.38: were calculated based on the different section volumes plus a 10 % wellbore washout. The total weight of muds used and associated cuttings are summarised in Table 10.39: .

Within the model, the oil production and WI wells at the three DC's and two remote GPI wells were spaced according to the optimised well layout design, including new locations for the GPI wells and the relocation of four WI wells to the new eastern DC (Figure 10.27). In addition to the maximum well count being modelled, it was conservatively assumed that the wells drilled at each DC location would be drilled consecutively. The exact spud locations (i.e. the place where the first tophole section is drilled) may vary slightly as design and operations progress, and if a tophole section is unsuccessful it may need to be re-drilled in an adjacent location (section 10.6.2), but overall the wells are expected to be drilled within the same overall area. It is possible that if the progress of a well is not satisfactory, it will be sealed downhole with a new trajectory drilled side-wards from within the existing hole, known as a 'sidetrack'. This is difficult to predict but two sidetracks have been allowed for (within the Main DC cluster), assuming that two already-drilled tophole sections can be used. Note that these re-drills, and associated additional cuttings, are included in the model and are within the maximum well count of 30 (Table 10.38:).

The GPI well(s) may be drilled with WBM system, but as a worst case they are included in the modelling as being identical to a WI well that is drilled with OBM in the lower sections.

The oil content in the model is represented by an aliphatic component with a toxicity of 70 mg/l in pore water, as adopted in OSPAR Agreement 2015/05. In the model, the component has been modified to give it a low vapour pressure, as would be expected after going through a thermal treatment process.

Table 10.38: Sea Lion Phase 1 production well drilling discharges [a]

Well section	Drilling fluid	Section length (m)	Total mud used (t)	Discharged materials (tonnes)				Discharge depth assumed
				Cuttings	Barite	Bentonite	Oil	
Oil Production Wells (x 20)								
42” (107 cm)	Bentonite sweeps and displacement mud	77	196	182	40	8	0	Seabed
26” (66 cm)		350	572	317	116	22.5	0	
17 ½” (44 cm)	OBM	400	41	164	27	0	1.0	Up to 20 m below sea surface following treatment to <0.5 % oil content
12 ¼” (31 cm)		3,500	177	703	114	0	4.1	
8 ½” (22 cm)		1,500	37	145	24	0	0.8	
Sidetracks (x 2) (re-entering boreholes already drilled so there is no extra well count)								
17 ½” (41 cm)	OBM	400	41	164	27	0	1.0	Up to 20 m below sea surface following treatment to <0.5 % oil content
12 ¼” (31 cm)		3,500	177	703	114	0	4.1	
8 ½ ” (22 cm)		1,500	37	145	24	0	0.8	
WI wells (x 8)								
42” (107 cm)	Bentonite sweeps and displacement mud	77	196	182	40	8	0	Seabed
26” (66 cm)		350	572	317	116	22.5	0	
17 ½” (44 cm)	OBM	1,400	144	574	93	0	3.3	Up to 20 m below sea surface following treatment to <0.5 % oil content
12 ¼” (31 cm)		3,400	172	682	111	0	4.0	

Well section	Drilling fluid	Section length (m)	Total mud used (t)	Discharged materials (tonnes)				Discharge depth assumed
				Cuttings	Barite	Bentonite	Oil	
Oil Production Wells (x 20)								
GPI wells (x 2 (1 well plus 1 contingency if required)) [b]								
42” (107 cm)	Bentonite sweeps and displacement mud	77	196	182	40	8	0	Seabed
26” (66 cm)		700	572	317	116	22.5	0	
17 ½” (44 cm)	WBM / OBM [b]	1,350	144	574	93	0	0	WBM: Discharged at seabed; or OBM: Cuttings cleaning up via TCC and dry cuttings discharged from MODU with oil content on cutting of <0.5 % dry weight. Mud reused.

a Source: Calculated by Genesis (2015a) and updated in 2017 based on expected Sea Lion Phase 1 drilling programme

b It is anticipated that the first GPI well will be drilled with all sections in WBM, which is suitable for the simple vertical well that is required. However, if a second GPI well is required, or if the sequence of wells alters, the lower section/s of one or both GPI wells may be drilled after the rig has already been configured for OBM operations. In such a case, the lower section may be drilled with OBM. To reduce complexity in the model, the GPI wells have been modelled as being identical to a WI well, which gives a conservative prediction of impact.

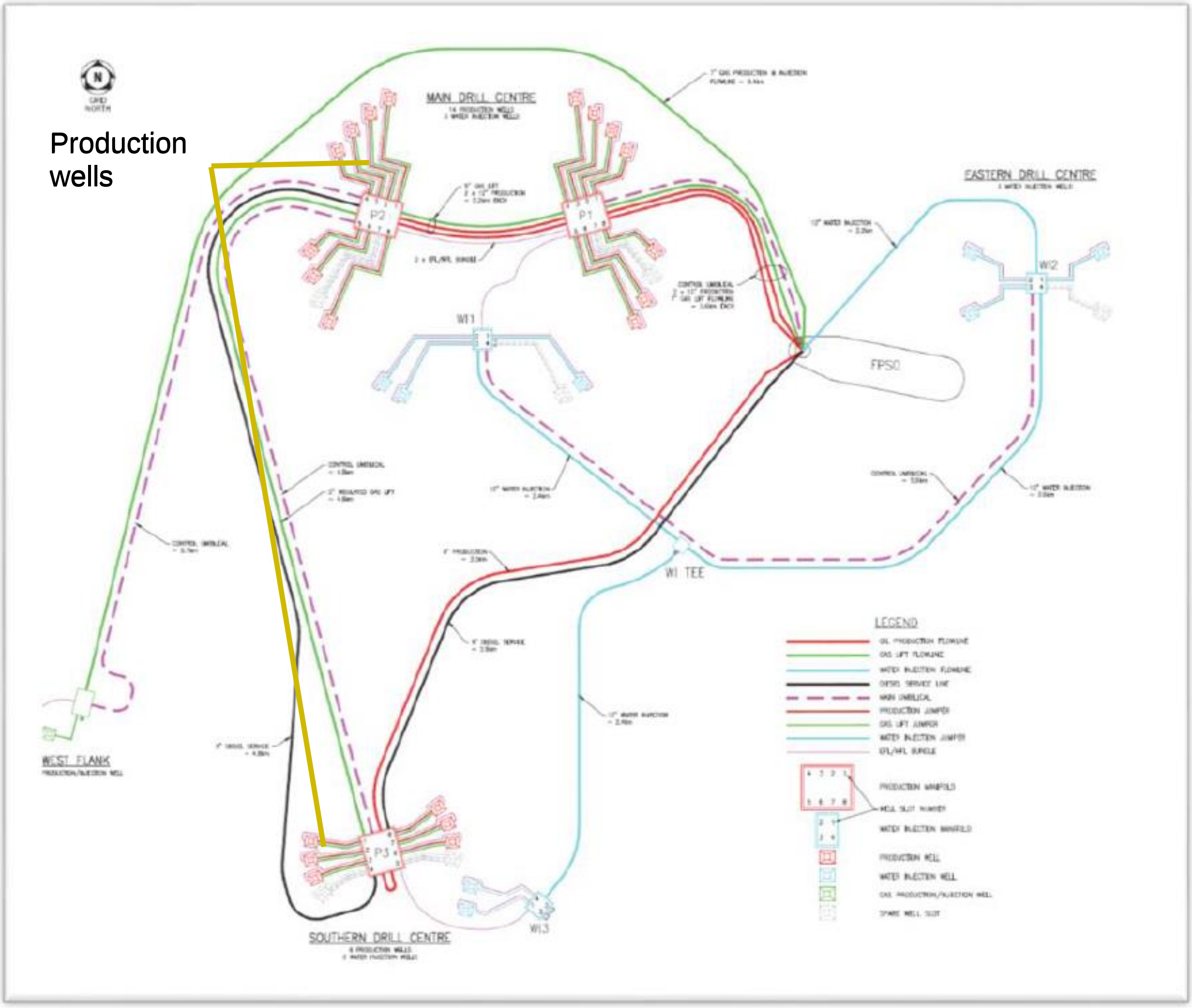


Figure 10.27: Modelled production and WI well locations at the main and secondary DCs

Table 10.39: Summary of mud and cuttings totals

Well type	Max. no. of wells	WBM used (t)	WBM cuttings (t)	WBM discharged (t)	OBM used (t)	OBM cuttings (t)	Base oil on cuttings (t)
Production	20	15,360	9,980	15,360	5,100	20,240	118
Production sidetrack (entering boreholes already drilled)	0	-	-	-	510	2,024	12
Water injection	8	6,144	3,992	6,144	2,528	10,048	58
Gas production / injection a	2	1,824	2,146	1,824	-	-	-
Total	30	23,328	16,118	23,328	8,138	32,312	188

a Note slightly higher discharges have been modelled and assessed including discharges of treated OBM cuttings should an OBM system be used for the GPI well(s)

10.6.4.3.3 Understanding the model - PEC:PNEC ratio and Environmental Impact Factor (EIF)

10.6.4.3.3.1 PEC:PNEC

The DREAM model was originally designed to assess the impacts of produced water discharge. While the model can be adapted to assess drilling discharges, the factors considered for water column and sediment impacts differ slightly and are based on comparisons of the following:

Sediment ($PEC:PNEC_1$):

- PEC_1 (Predicted Environmental Change) i.e. the level of change to the sediment with regard to the following stressors:
  - Concentration of a chemical in pore water to which marine organisms could be exposed during and after the discharge;
  - Thickness of the deposition;
  - Degree of change to grain size; and
  - Oxygen content depletion.
- $PNEC_1$ (Predicted No Effect Change) i.e. the highest level of changes caused by the above stressors at which no harmful effects are expected to occur to marine organisms, as determined from scientific literature.

Water column ($PEC:PNEC_2$):

- PEC_2 (Predicted Environmental Concentration) i.e. the concentration of a chemical, oil or suspended matter to which marine organisms in the water column would be exposed during and after the discharge as predicted by the model; and
- $PNEC_2$ (Predicted No Effect Concentration) i.e. the highest theoretical concentration of the same components at which no harmful effects are expected to occur to marine organisms in the water column.

Despite the differing definitions however, the interpretation of the PEC:PNEC ratio is the same for both the sediments ($PEC:PNEC_1$) and water column ($PEC:PNEC_2$), and both are referred to as ‘PEC:PNEC’ hereafter. While the PEC is predicted by the model, the PNEC is defined as the concentration at which the Potentially Affected Fraction (PAF) of a species is 5 %.

A PAF of 5 % corresponds to a PEC:PNEC ratio of 1 and is a generally accepted risk level representing the concentration below which marine organisms are unlikely to be affected (EC, 2003). Where the PEC:PNEC ratio is >1, adverse effects from the discharges are anticipated and this is referred to as having a ‘risk > 5%’.

10.6.4.3.3.2 Environmental Impact Factor

The model expresses the impacts to the water column and sediment in terms of the Environmental Impact Factor (EIF):

- For water column modelling, an EIF of 1 is defined as a cuboid volume of water equal to 100 m x 100 m x 10 m (0.0001 km^3), in which the calculated PEC > PNEC i.e. there is a risk to >5 % of the most sensitive species present; and

- For sediment modelling, an EIF of 1 is defined as a square equal to 100 m x 100 m (0.01 km^2), in which the calculated PEC exceeds the PNEC i.e. there is a risk to >5 % of the most sensitive species present.

The results of the model are therefore expressed as:

- The volume (km^3) in which there is a risk to more than 5 % of the most sensitive species present in the water column e.g. an EIF of 12 means that there is a risk to more than 5 % of the most sensitive species in 12 km^3 of water; and
- The area (km^2) in which there is a risk to more than 5 % of the most sensitive species present on the seabed an EIF of 12 means that there is a risk to more than 5 % of the most sensitive species in 12 km^2 of seabed.

10.6.4.3.4 Modelling results

10.6.4.3.4.1 Seabed impacts

The model estimates the thickness of the deposited layer of matter, the grain sizes of the deposition, the toxicity of oil / chemical components in the deposited material and the depletion of oxygen by any biodegradation of organic matter (in this case both toxicity and oxygen depletion are caused by the oil content of the TCC cleaned cuttings). All four parameters are used to inform the assessment of the total risk to the sediment (i.e. the EIF). To best reflect this relationship, the modelling results are shown in Table 10.40: to show the contribution of deposition thickness and changes in grain size to the overall risk.

Table 10.40: Modelling results for the environmental risk to the sediments around the DCs and GPI wells

Deposition thickness	Sediment grain size, toxicity and oxygen depletion
Figure 10.28 shows the predicted worst case deposition thickness at the end of drilling around the three DC clusters and the two remote GPI wells. There is no significant overlap in deposition between the main drilling locations. In the absence of any other stressors, it was estimated by Smit *et al*., (2006) that a burial thickness exceeding 6.5 mm could result in 5 % of the most sensitive species being impacted (section 10.6.4.2.4.1). Deposition thicknesses were predicted to exceed 6.5 mm between 100-280 m from the centre of the main DC, with smaller deposition areas at the southern and eastern drill centres and extending to only 20-65 m from the GPI wells. As anticipated, the thickest areas of deposition are immediately around each drilling location (out to approximately 60 metres from each well) with a maximum deposition thickness of around 1,300 mm at the main DC, 1,200 mm at the southern DC and 800 mm at the GPI wells (Figure 10.29) although there may be local fluctuations around these figures. This thickness is mainly due to the larger cuttings particles from the tophole sections which are discharged directly onto the seabed. The depositional thickness at the end of drilling the wells was found to exceed 6.5 mm over an area of up to 0.15 km^2. Beyond this area, the thickness decreases rapidly with distance from the wells to <1 mm at approximately 1 km from the main DC, 400 m from the southern DC and 120 m from the GPI wells (Figure 10.29). A wider area is covered by a thinner deposition layer resulting from the finer barite, bentonite and cuttings particles that are discharged following treatment of the OBM cuttings. Since these barite and bentonite particles are discharged 20 m below the surface, rather than at the seabed, they can be carried long distances by ocean currents (several kilometres) before settling.	The predicted influence of drill cuttings on grain size, toxicity and oxygen depletion at the Main DC (which has the highest number of wells drilled) are shown in Figure 10.30. The risk contributions from grain size change is less than 5 % in almost all areas, but remains a contributor to overall risk in the areas immediately around the wells. Sediment risks at >5 % due to increased grain size are expected to be localised to each well, or adjacent wells. Outside the immediate vicinity of the wells, toxicity and oxygen depletion are the main contributors to environmental risk in the seabed. Oil toxicity diminishes over time as the oil biodegrades, although this transfers to oxygen depletion in the process, which 'grows in'. This is caused by the breakdown of the oil component which consumes oxygen, and the oxygen levels are restored very slowly from oxygen dissolved in seawater. This, too, will diminish over time and will eventually disappear. Overall the aggregate oxygen depletion starts to reverse and shows a net recovery beginning about 2 months after the end of drilling.
Total environmental risk to the sediment (based on the EIF)	
Figure 10.31a shows the environmental risk to the seabed around the main DC at the end of drilling. The total environmental risk incorporates the estimates of burial thickness, grain size change, toxicity and pore-water oxygen depletion. The area of seabed around the main DC wells in which there is >5 % risk to sensitive species present is 2.666 km^2 at the end of drilling, and is predicted to extend to around 1 km at the furthest point immediately after drilling has ceased. Figure 10.31b also shows the recovery of the seabed five years after drilling has ceased, after which time substantive recovery of the pile is normally observed, and the maximum extent of the area of 5 % risk has reduced significantly. 20 years after drilling, there is substantial recovery, with the 5 % risk area reducing to 0.2096 km^2 and extending to around 200 m Figure 10.31d. At that point, the seabed is expected to have returned to a productive state, albeit modified to its original condition (Genesis, 2015a, updated by Premier, 2017d). Given that the three DCs and GPI well locations are sufficiently far from each other, there are not expected to be any cumulative impacts from the drilling at the four locations.	
Contribution to the environmental risk to sediment	
As might be expected from section 10.6.4.2, the sediment risk caused by drilling is predicted to be primarily due to oxygen depletion (Figure 10.32) resulting from the residual oil content. Burial thickness, grain size and chemical toxicity change follow in order of stress to the seabed. Recovery is expected rapidly at first and a permanently modified area of around 60 m from the wells and well within the 500m zone of the DCs and GPI wells is ultimately expected at the end of field life [a].	

[a] Note the modelling uses very conservative assumptions. The deposition thickness modelling covers the maximum number of wells drilled (30). The sediment risk (grain size, toxicity and oxygen depletion) and total environmental risk scenarios were modelled for the Main DC wells as this location has the highest number of wells and is therefore a worst case proxy.

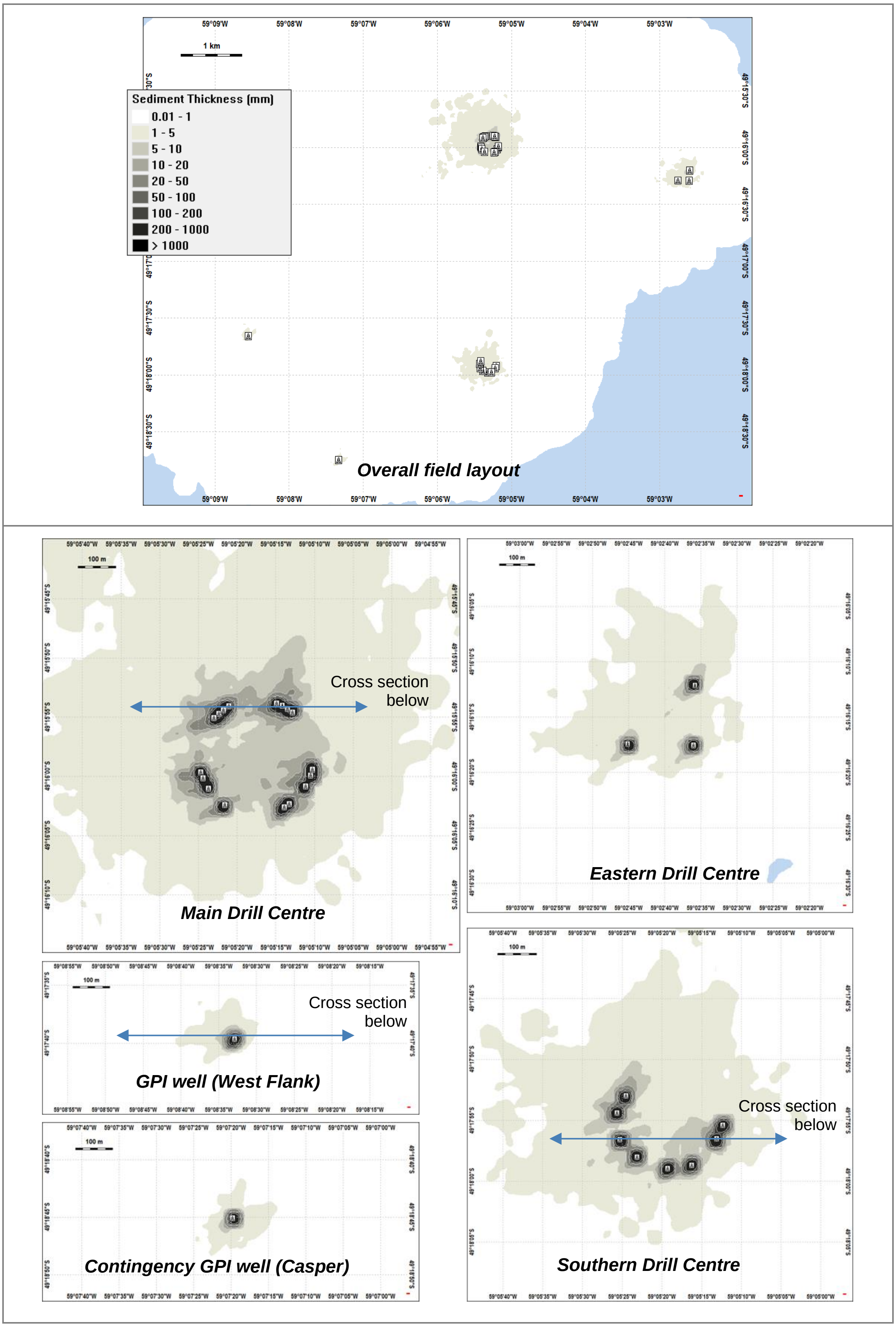
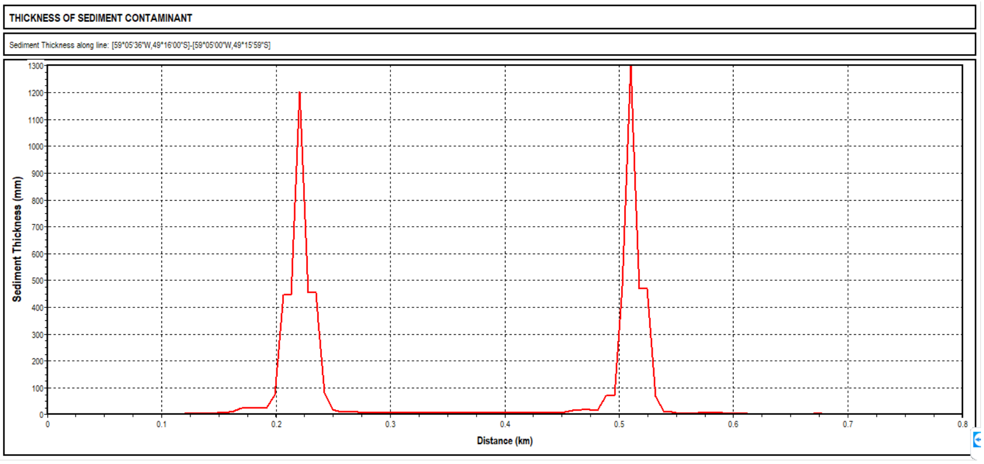
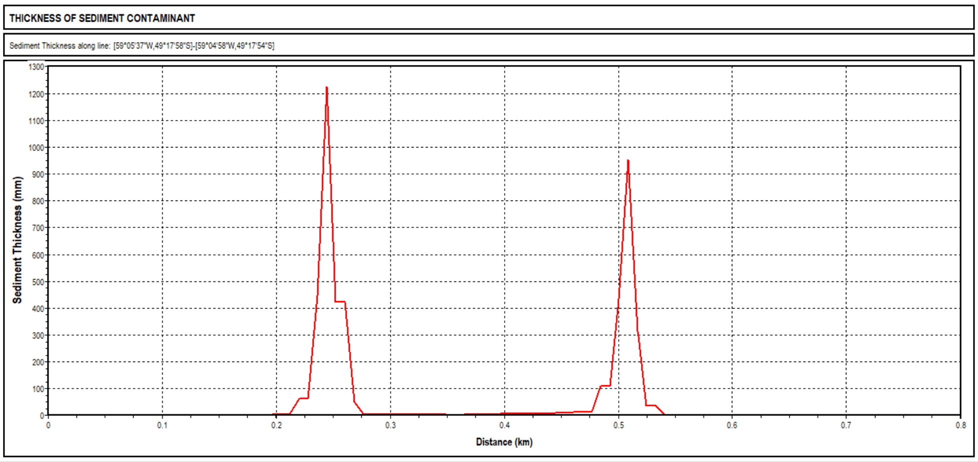


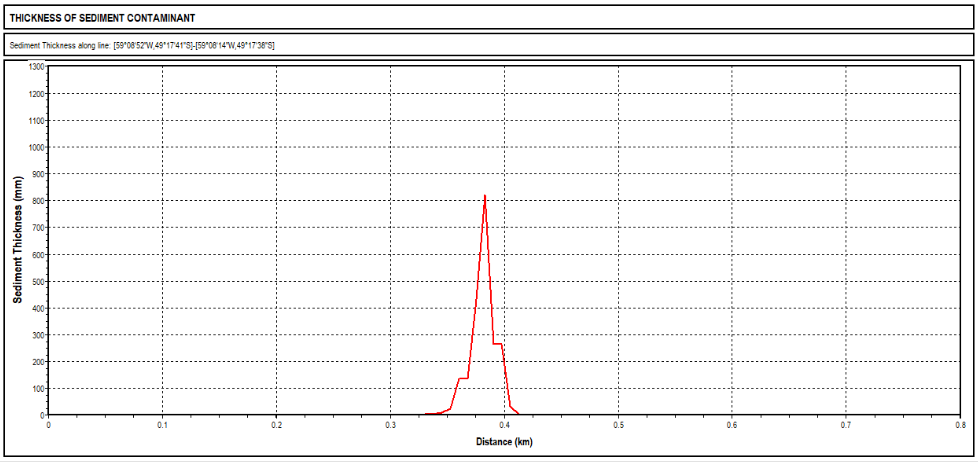
Figure 10.28: Modelled production and WI well locations at the main and secondary DCs
Deposition thickness around DCs and GPI wells at end of drilling



a) Main DC at the end of drilling

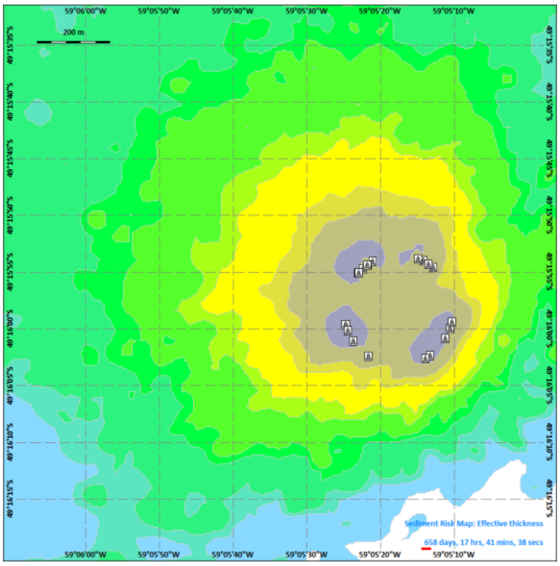


b) Southern DC at the end of drilling

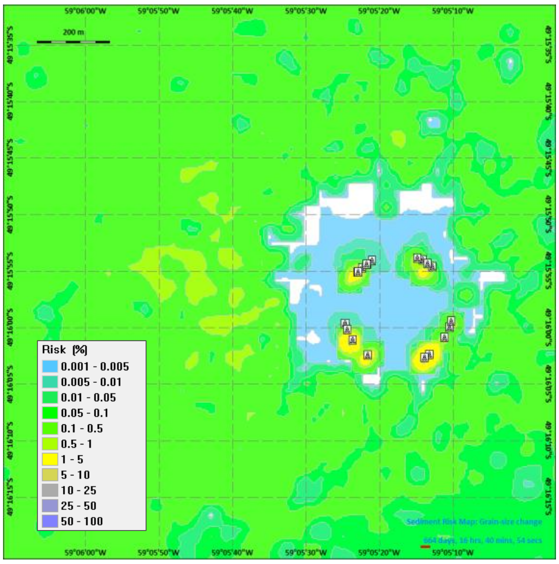


c) GPI well at the end of drilling

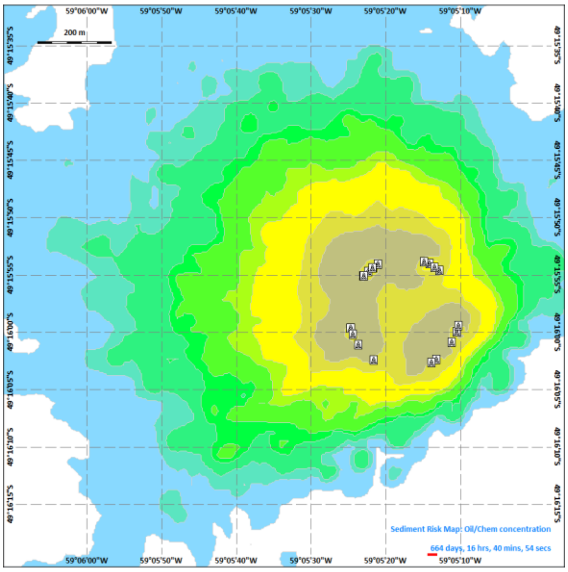
Figure 10.29: Modelled production and WI well locations at the main and secondary DCs Cross section through the cuttings piles showing the deposition thickness in profile



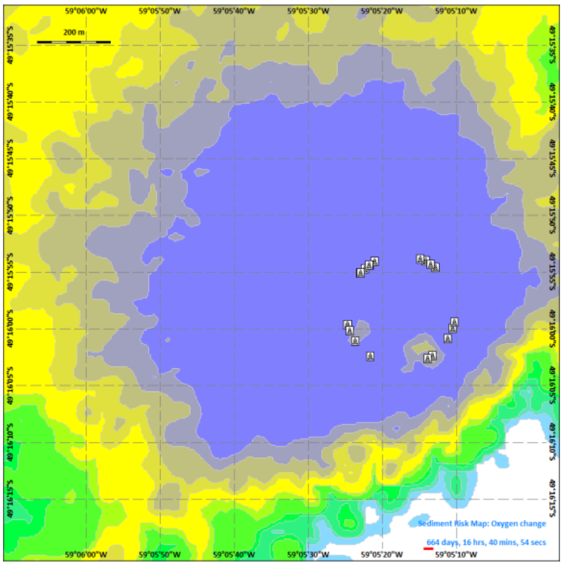
a) Risk contribution from burial thickness at main DC



b) Risk contribution from grain size change at main DC

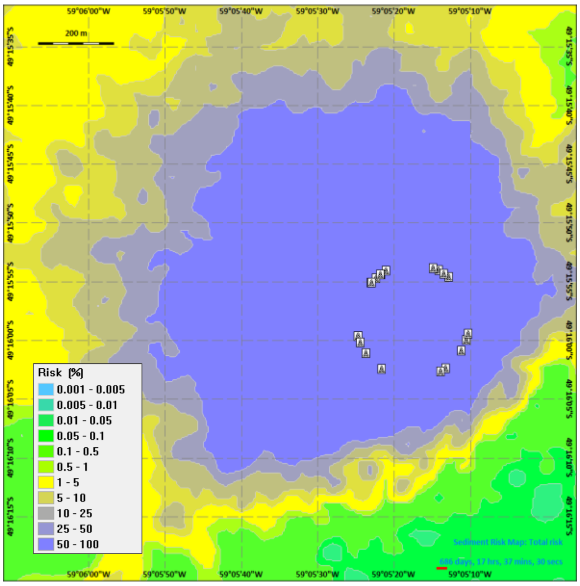


c) Risk contribution from oil toxicity at main DC

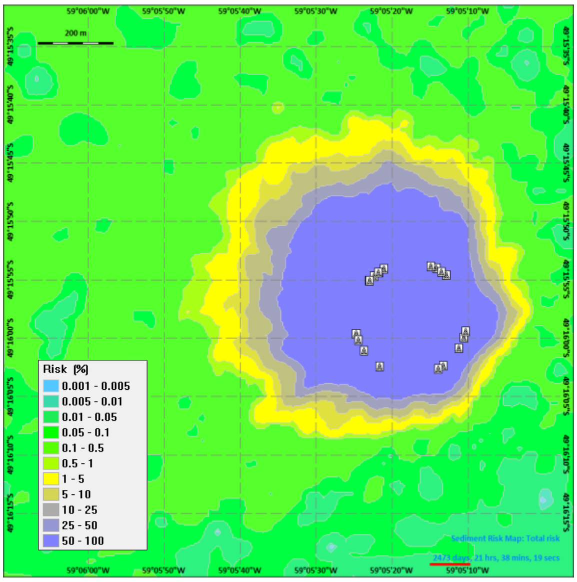


d) Risk contribution from oxygen depletion at main DC

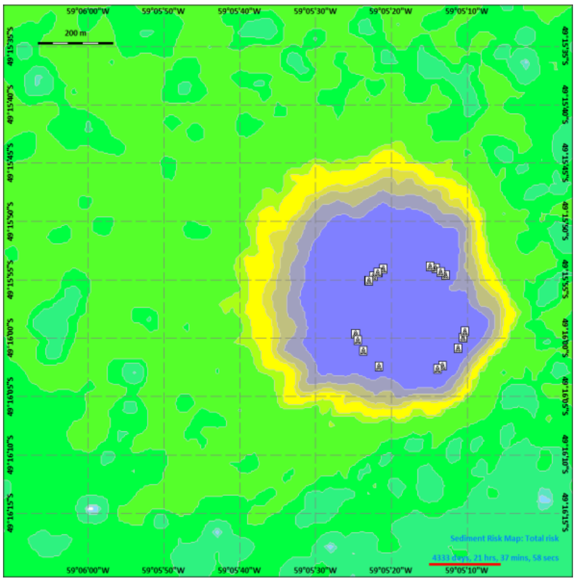
Figure 10.30: Modelled production and WI well locations at the main and secondary DCs Spatial illustration of contributions to sediment risk around the main DC at the end of drilling



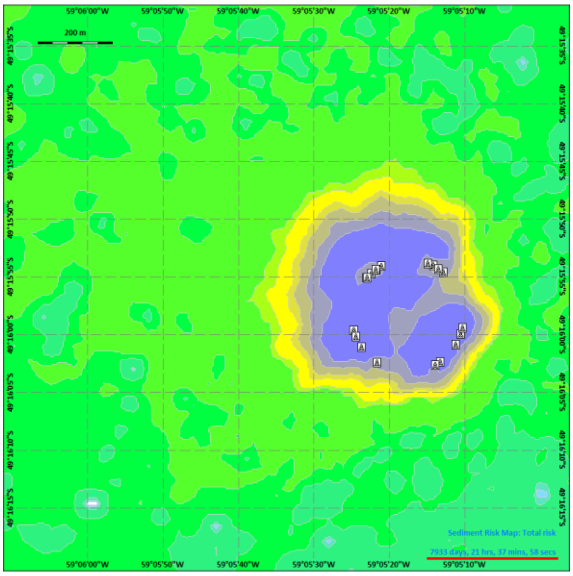
a) Main DC - end of drilling



b) Main DC - 5 years after end of drilling



c) Main DC - 10 years after end of drilling



d) Main DC - 20 years after end of drilling

Figure 10.31: Total environmental risk to the sediment at the main DC at end of drilling, 5, 10 and 20 years after drilling

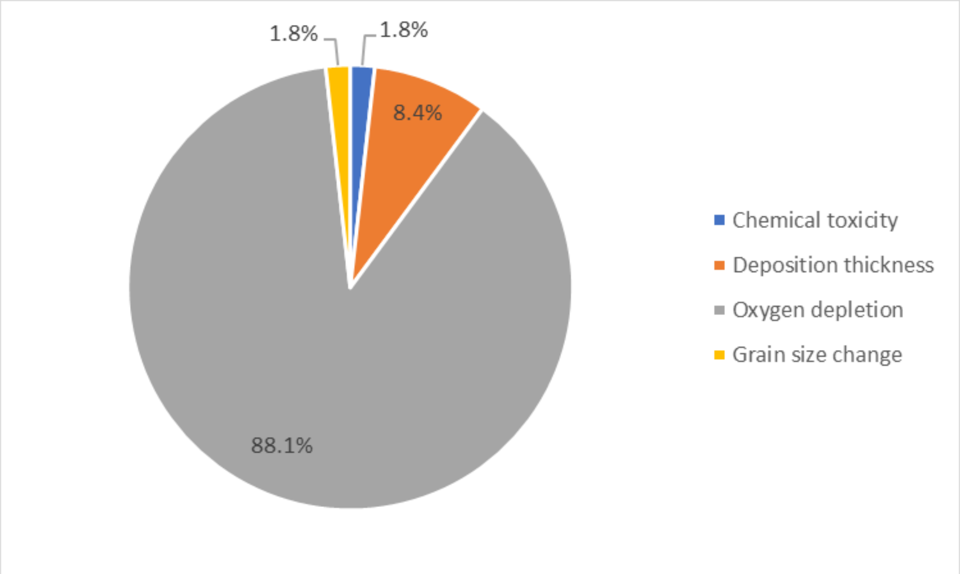


Figure 10.32: Contribution to risk to the seabed at the end of drilling the DC

10.6.4.3.4.2 Water column impacts

The modelling predicted that the plume of suspended particles and fluids generated during the drilling of each well section would disperse before drilling of the next section is commenced. These results therefore focus on two worst case example plumes:

- One generated during the largest tophole discharge of bentonite sweeps and mud at the seabed during the 26'' section of one of the GPI wells; and
- One generated during discharge of the largest batch of treated OBM cuttings from the MODU, 20 m below the sea surface, following drilling of one of the 12 ¼'' GPI well sections.

The predicted instantaneous risk to the water column from these two plumes is shown in Figure 10.33.

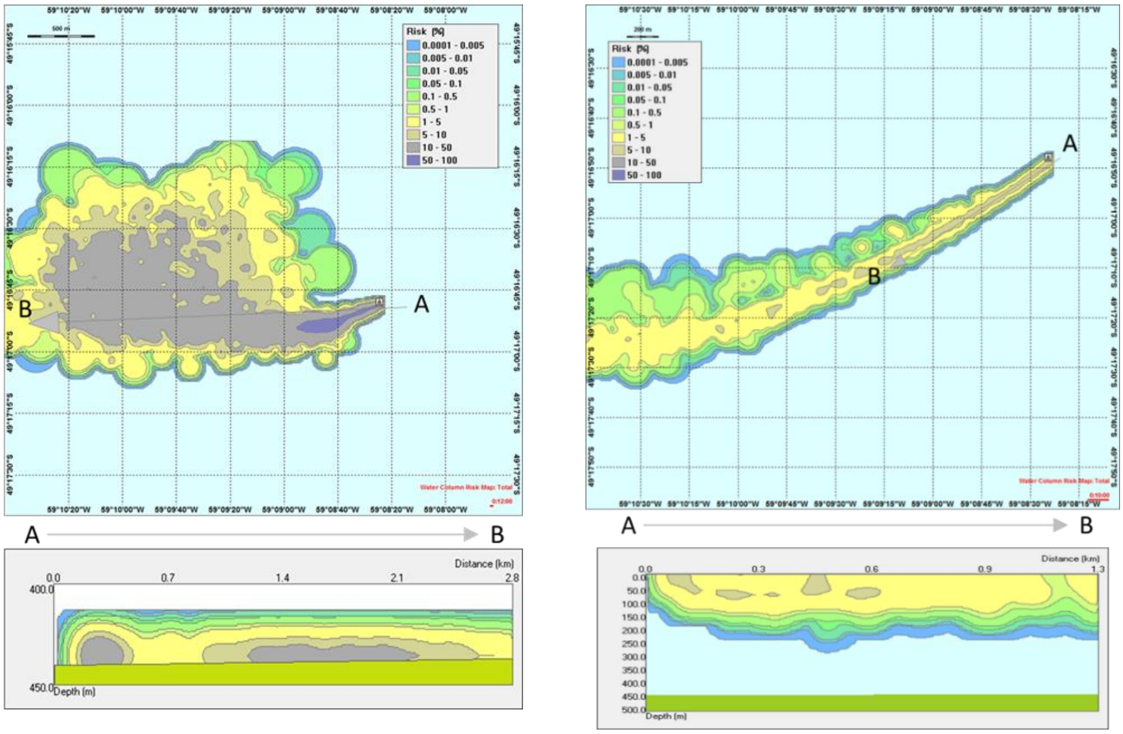
During drilling of the tophole section, the risk was >5 % up to 4 km from the discharge point and fell to <5 % at 4 km 2.5 days after drilling had ceased. The plume was largely confined to the bottom 50 m of the water column (Figure 10.33a). The total volume of water impacted at >5 % during the entire discharge was 0.2 km3 and the main contributors to water column risk were the barite and bentonite particles (Figure 10.34a).

As shown in Figure 10.33b, the plume of treated OBM cuttings from the 12 ¼'' GPI well section was dispersed quickly away from the discharge point owing to the:

- Strong sub-surface currents; and
- Lower rate of discharge than occurs with the tophole sections that have a larger borehole diameter and no mud recycling.

As a result, the risk associated with OBM cuttings discharges was very small and fell to <5 % after only five hours. During the discharge, at most, 0.02 km3 of water column was at >5 % risk and this was mainly confined to the top 50 m of the water column Figure 10.33b. As shown in Figure 10.34b, 90 % of the risk was found to result from suspended barite particles.

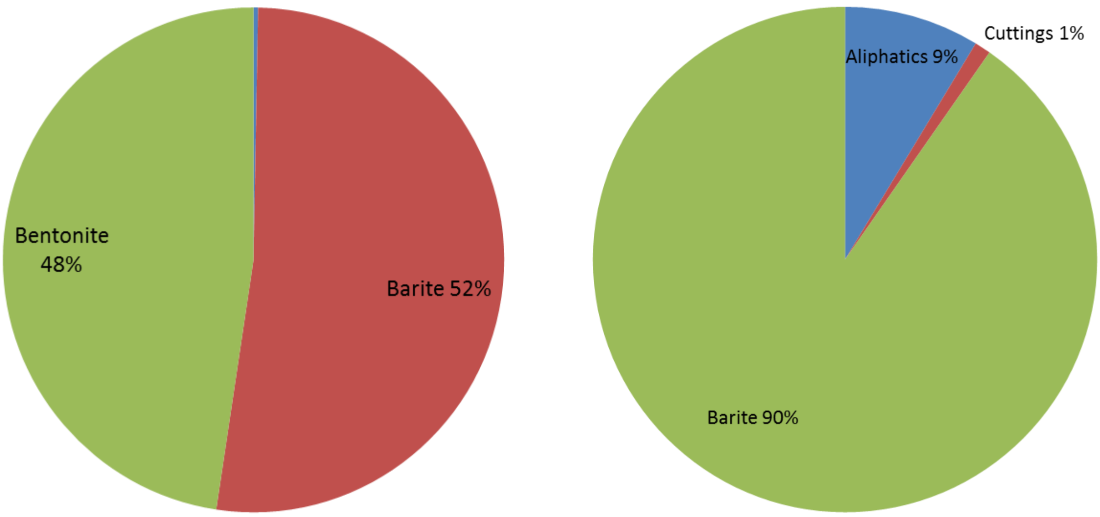
During both discharges, transport of material was found to be in a northwesterly direction with the prevailing currents.



a) Seabed discharges from the 26'' GPI well section

b) Surface (-20 m) discharges from the 12 ¼'' GPI well section

Figure 10.33: Instantaneous risk to water column from worst case discharges (Genesis, 2015a, updated by Premier 2016f)



a) Seabed discharges from the 26'' GPI well section

b) Surface discharges from the 12 ¼'' GPI well section

Figure 10.34: Contribution to water column risk from worst case discharge (Genesis, 2015a, updated by Premier, 2017d)

10.6.5 Industry-standard mitigation measures

The following base case and industry-standard mitigation measures were factored into the initial impact assessment:

- OBM drilling fluids will be re-circulated with cuttings being separated from the muds and the mud being re-used to minimise discharges of cuttings and waste mud as far as possible;
- OBM cuttings will be returned to the rig and thermally treated with the TCC to ensure the oil content complies with legislation as a minimum (section 10.6.1.1.1), with the aim of exceeding the compliance requirement prior to discharge (i.e. <0.5 % oil on cuttings by dry weight); and
- Selection of the most environmentally benign chemicals available on the Cefas list of registered products where possible (notwithstanding the need for optimal operational performance);

10.6.6 Impact Assessment

The following section draws upon all the information provided above to assess the 'Sensitivity of the Receptor' and the 'Severity of Effect' in order to determine the overall 'Impact' of planned activities.

A summary of the impact assessment outcomes is tabulated in section 10.6.12 which shows the worst case impact for each activity and receptor.

10.6.6.1 Water quality

All discharges are to the open ocean, in depths of 450 m, and the affected water column is influenced by numerous currents (section 10.6.4.3.4) and therefore, the **sensitivity of the receptor** is considered to be '**Very Low'**.

The discharge of drill cuttings is expected to result in a very localised reduction in water quality both in surface waters and in the lower part of the water column, due to an increase in turbidity and the presence of chemicals (section 10.6.4.3.4). While the worst case modelling results indicate that a seabed plume of tophole discharges (at seabed) could extend over 4 km down-current from each well location, affecting a maximum area of 0.2 km^3, turbidity in the water column is not expected to extend more than 50 m above the seabed whilst drilling the tophole sections, or below 50 m of the sea surface whilst drilling the lower well sections (section 10.6.4.3.4). On completion of drilling operations, the oceanic currents will rapidly dilute the suspended particles within the water column which is predicted to recover within 2.5 days of each tophole section and five hours of each lower well section being drilled (section 10.6.4.3.4). Based on the relatively small volume of water being affected and the rapid and full recovery once the activity ceases such that any affect is unlikely to be detectable against background levels, the severity of effect is considered to be '**Slight**'.

Therefore, the overall significance of impact to water quality is considered to be '**Very Low (1)**'.

10.6.6.2 Phytoplankton and zooplankton

Both phytoplankton and zooplankton are widely distributed throughout the Falkland Islands Continental Shelf and do not represent any rare or vulnerable species. Therefore, the **sensitivity of the receptor** is considered to be **'Very Low'**.

The impact on phytoplankton and zooplankton will be very localised and temporary. The increase in water column turbidity, and reduced light penetration, resulting from suspended fine particulates is expected to be localised and the upper water column is predicted to rapidly recover (section 10.6.4.3.4). Given the negligible nature of the impact based upon the literature (section 10.6.4.2.2), and that the environmental risk from each discharge plume is predicted to be very localised with rapid and full recovery such that any affect is unlikely to be detectable against background levels, it is anticipated that any effects will be fully-reversible with no potential for cumulative effects. Therefore, the **severity of effect** to plankton is considered to be **'Slight'.**

Therefore, the **overall significance of impact** to phytoplankton and zooplankton is considered to be '**Very Low (1)**'.

10.6.6.3 Seabed sediments

Given that the habitat is undesignated and that there is no potential to transfer contaminants to any nearby sensitive areas (section 10.6.4.2.3), the **sensitivity of the receptor** is assessed as '**Very Low**'.

The impact of grain size change will diminish rapidly with increasing distance from the wells and sediment risks > 5 % due to grain size change are expected to be confined to within 30-40 m of each well (section 10.6.4.3.4). Given that the impact is expected to be restricted to a very localised area and that there will be a barely detectable impact on habitats, the **severity of the effect** to sediment quality is considered to be '**Minor**'

Therefore, the **overall significance of impact** to seabed sediments is assessed as '**Very Low (2)**'.

10.6.6.4 Benthic fauna

According to the surveys already carried out (section 10.6.4.2.4), there are no known vulnerable species recorded within the benthos and the community structure is widespread and typical of the area. However, a data gap exists because the Sea Lion environmental baseline survey did not sample the specific drilling locations. Whilst differences in benthic habitat are considered to be very unlikely, and the **sensitivity of the receptor** is likely to be '**Very Low'**, to take a precautionary approach it is assessed here as '**Low**'.

Deposition thicknesses were predicted to exceed 6.5 mm up to 280 m from the centre of the main DC (at the maximum reach) and up to 65 m from the GPI well(s) (at the maximum reach) (section 10.6.4.3.4.1) and the impacts of disturbance and smothering will be restricted to sessile organisms within these distances (section 10.6.4.2.4.1). Increases in grain size that could result in a change to sediment structure were predicted to extend to a maximum of 1 km from each well (section 10.6.4.3.4.1). The model indicates that a risk to > 5 % of the species present around the main DC is expected to occur in an area of 2.666 km^2 at the end of drilling (section 10.6.4.3.4). While this area is small, the model also predicts that the area will be reduced in 5 years and is expected to reduce to approximately 0.2096 km^2 after 20 years (section 10.6.4.3.4). However, as described in section 10.6.4.2.4, field studies in the area have indicated that recovery periods for exploration drill cuttings piles are far quicker than estimated in the model and that the model tends to overestimate deposition thickness. Additionally, both literature and ground-truthing (albeit from WBM wellsites) indicate that recolonisation of the pile will commence within 1-2 years (section 10.6.4.2.4.2). Other studies support the modelled outputs in concluding that the fine layer of barite that may settle out from the discharge of treated OBM cuttings is unlikely to have any toxic effect (section 10.6.4.2.6).

Further, as stated in section 10.6.4.3, the modelling carried out is highly conservative as it assumes the maximum number of 30 wells being drilled from the new subsea layout, with worst case assumptions used for well length and assumes the worst case use of OBM in the lower well sections of the GPI wells. The modelling also assumes that the wells are drilled consecutively at each DC i.e. with no drilling break.

However, the planned Sea Lion drilling programme includes a rig move from the Main DC (the location with the highest number of planned wells) where after drilling the initial Main DC wells, the rig moves to drill the Eastern DC wells before returning to complete the Main DC drilling operations. The modelling assumptions used do not include this level of well sequencing detail and are therefore conservative and likely to overestimate the impacts, as follows:

- The assumed consecutive well sequencing means that the deposition from the first well is rapidly covered by deposition from the next well, etc. thereby reducing the recovery of the seabed.
- Once oil gets sedimented and buried it consumes oxygen.
- Recovery of oxygen is quite fast when the layer is very thin. However, once the seabed reaches a certain level of thickness & oil deposition, it beomes anoxic and takes a much longer time to recover.
- As oil is getting buried faster and recovering more slowly due to the consecutive well sequencing assumed, so the risk of deoxygenation increases relative to the other risks.

Note: calculated risk is very sensitive to deoxygenation which is a stronger multiplier than the other stressors of grain size change, burial thickness and toxicity.

Note: This is the main reason for targeting 0.5% oil on cuttings.

In conclusion, and on balance, the **severity of the effect** to the benthic fauna is considered to be '**Moderate**'.

Therefore, the **overall significance of impact** to benthic fauna is '**Moderate (6)**'.

10.6.6.5 Fish and shellfish

The modelling indicates that a maximum instantaneous volume of water of 0.2 km^3 would be at >5 % environmental risk during the drilling operations (section 10.6.4.3.4). The spatial extent (volume) of the habitat predicted to be affected by the total drilling discharges is therefore of little to no geographical importance (<0.001 % of available habitat) to the fish populations migrating to the area to feed. Further, while the grey-tailed and yellownose skate and the spurdog both have an IUCN status of 'Endangered' or 'Vulnerable', such elasmobranchs are highly mobile species and have the ability to move to another area of habitat if disturbed by drill cuttings discharges. Further they are generally found in shallower waters, are not abundant within the zone of influence and are dispersed spawners (section 10.6.4.2.5). Therefore, due to the very small proportion of key species that could be affected, the **sensitivity of the receptor** is considered to be **'Low'**.

Owing to the localised area and short-term and reversible nature of the effect, the **severity of the effect** to fish species is considered to be **'Minor'**.

Therefore, the **overall significance of impact** to fish and shellfish is assessed as **'Low (4)'**.

10.6.7 Project-specific mitigation measures

The impacts are anticipated to range from **'Very Low'** to **'Moderate'**. Since the majority of risk to the seabed is caused by the oil content of treated cuttings through oxygen depletion, the key project-specific mitigation measure is the efficient operation of the TCC unit to minimise oil content which is part of the base case (section 5.13) and is thus factored into the initial impact assessment. Although the process has not been trialled in this specific geology before, the strata are of types experienced elsewhere and experience worldwide is that 0.5 % oil on cuttings is rarely exceeded. On a long campaign such as this there is time to optimise, and continually improve, the process to achieve lower levels of oil on cuttings discharged.

Pre-drilling environmental surveys will also be carried out to confirm that no habitats or species of conservation significance are present within the zone of influence, and analysis of PAH content of treated OBM cuttings will be undertaken (section 10.6.10.1).

10.6.8 Residual impacts

10.6.8.1 Impacts to benthic fauna

The initial assessment takes account of all the mitigation measures which are built-in to the basis of design (i.e. use of the TCC unit), and while continuing efforts to improve the oil on cuttings concentration may reduce the impact slightly if improvements can be made over the duration of the drilling campaign, this is not guaranteed. As such, the residual impact and risk assessments remain the same such that the impact to benthic fauna remains **'Moderate (6)**'.

Note: it is anticipated that the outcomes of the pre-drilling survey will indicate that the benthos in the Sea Lion Field is the same as the surrounding areas (which have been surveyed extensively). Should this occur, the **sensitivity of the receptor** would be reduced to **'Very Low'**, thus reducing the overall impact significance to **'Low (3)'**, however the impact is left as **'Moderate (6)'** for now to take a precautionary approach.

10.6.9 Cumulative impact

In terms of cumulative impacts resulting from increased ‘concentration’ and the ‘extent and duration’ (section 8.10.1) of drill cuttings discharges, there are no other O&G activities currently scheduled to occur in the NFB during the Sea Lion Phase 1 drilling campaign. Nonetheless, exploration drilling has occurred on the NFB since 1998 and each of the exploration wells, carried out by numerous operators, discharged WBM and cuttings both at the seabed and the surface.

In the region of the main DC, there have been a number of wells drilled to appraise the initial Sea Lion discovery, as is shown in Figure 10.35. The closest well to the DC is 14/10-4, which is an abandoned well, approximately 555 m to the southeast and was spudded in March 2011.

In March 2012, Gardline Environmental conducted a post-drilling survey at five well locations within the Sea Lion Field (Gardline, 2013b). In summary, 32 stations were sampled surrounding wells that had been drilled in 2009 with WBM (14/10-1, 14/10-2, 14/10-6, 14/10-9 and 14/15-4a). The results indicated that, there was little detectable change at these locations from the surrounding areas. The survey showed that:

- The sediment was dominated by medium and coarse silt;
- Hydrocarbon and metal concentrations recorded during the survey were generally within the expected range for the region;
- Depth and sediment type gave no evidence of any previous point source contamination; and
- The fauna recorded was considered homogeneous, with no evidence of any previous disturbance to the benthic community as a result of historical drilling activity at the existing wells (Gardline, 2013b).

The lack of detectable change from background levels at these abandoned well sites indicates that there is unlikely to be any significant cumulative impact between the current proposed operation and previous exploration drilling campaigns in the region.

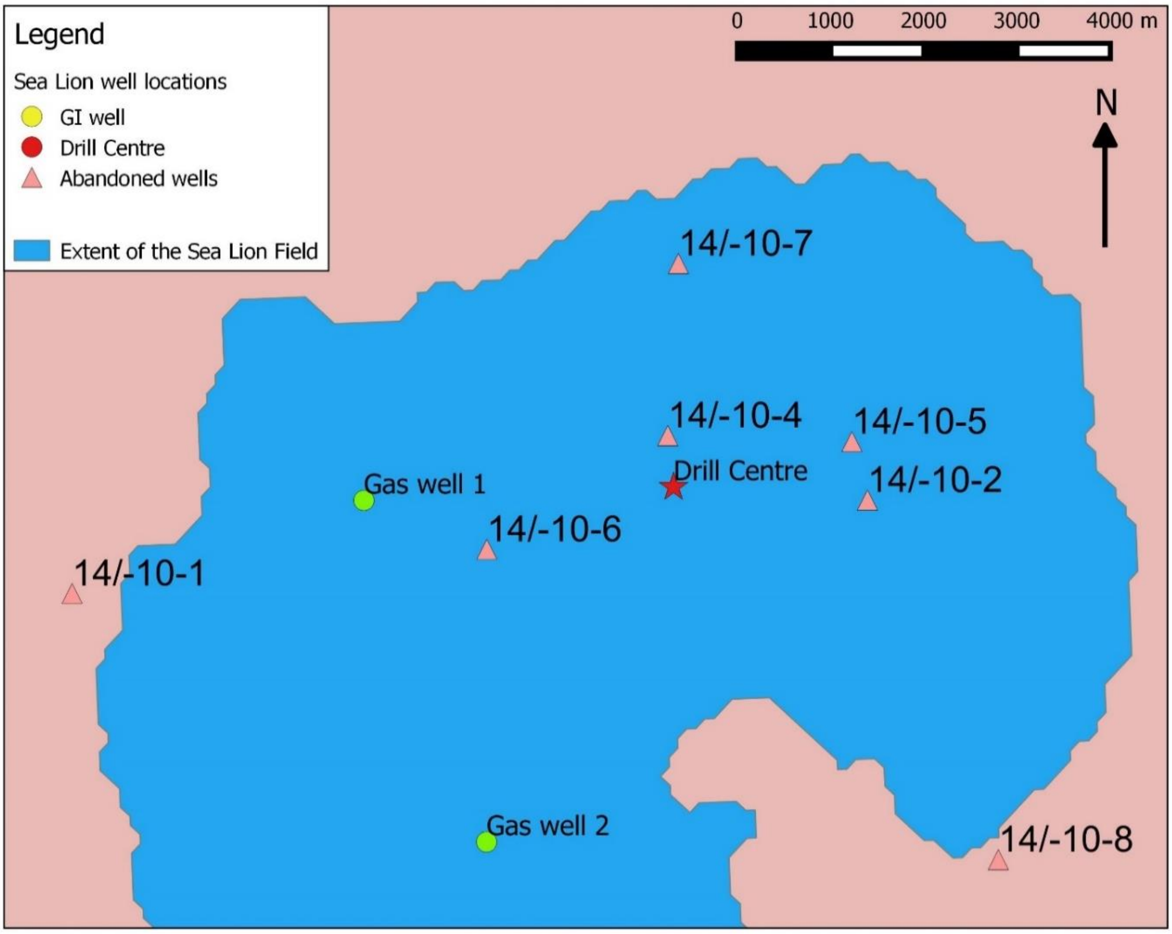


Figure 10.35: The locations of existing (abandoned) wells within 2.5 km of the Drill Centre

10.6.10 Confidence

The details of the drilling campaign are clearly defined and the quantities of drilling mud and cuttings have been estimated on a highly conservative basis. The nature of the impact of drilling discharges is relatively well known from several decades of research, model validation studies conducted by SINTEF and the ground-truthing study carried out following the 2012 Sea Lion survey described above. Modelling uncertainties have been identified (Table 10.41) and while their potential to materially alter the outcome of the modelling has been considered, it is acknowledged that improvements in the modelling design could increase the accuracy of quantification of the impact. Indeed, improvements in the modelling process may lead to predictions of lesser impacts, as was indicated by the ground-truthing study carried out in the Trolla Field (section 10.6.4.3.1). Additionally, and as stated above, the very conservative approach was taken of modelling the maximum well cuttings discharges at the DCs and remote GPI locations.

While the Gap Analyses Programme (GAP) has identified benthic ecosystems as a priority area which would benefit from further research to inform environmental assessments (section 7.2.4.1), benthic data collected in the drilling area so far has not indicated the presence of any species or habitats of conservation concern and the benthos is believed to be relatively homogeneous across the area (section 7.4.3.2). Nonetheless, the absence of a site-specific benthic survey to date is acknowledged as a data gap, although it is considered unlikely that these data gaps have the potential to significantly change the outcome of the assessment. If anything, completion of the pre-drilling may enable a less precautionary approach with regard to the assessment of the sensitivity of benthic species and habitats as a receptor.

On balance, owing to the uncertainties within the model and the acknowledge data gap, the degree of confidence in the impact assessment is considered to be 'Probable'.

Table 10.41: Modelling uncertainties

Uncertainty	Description
Discharge quantities	The discharge geometry is constrained by operational equipment and typical drilling rig design and is unlikely to significantly change. The downhole conditions are potentially quite variable in terms of volumes of mud required but this is allowed for in the inputs provided to the model, which are based on conservative assumptions.
Cuttings particle size distribution	The size distribution of the cuttings particles is based on an average of data from drilling in the Norwegian Sea. Regional variation is possible relating to the rock types being drilled and it would be beneficial to report on cuttings particle size distribution from ongoing drilling campaigns in this region to inform future modelling.
Metocean conditions	The metocean dataset covers three years. This provides a wide range of weather conditions and the modelling results consistently show a tendency for dispersion to the north west of the site. However, the currents do move in all directions at different times and deposition is locally variable due to the short nature of each discharge such that the plumes may disperse more efficiently than is indicated in the model.
Environmental sensitivities	Grain size change is an important parameter and the threshold for this parameter within the risk assessment is based on the analysis of environmental monitoring data from the Norwegian Continental Shelf covering 246 species. Burial thickness is based on data from Europe and the United States. Importantly, there may be regional differences in prevailing fauna that would mean different thresholds are appropriate in the Sea Lion area. Nevertheless, the basis of the thresholds is considered to represent the best available data and covers a wide range of benthic fauna.

10.6.10.1 Monitoring required

The following monitoring will be carried out to improve the degree of confidence in the impact assessment:

- **Pre-drilling survey**: this will typically involve video only to determine the nature of the seabed at the precise drilling site.
- **Post-drilling benthic survey**: Post-drilling benthic surveys will be carried out in line with the methodology recommended by the GAP project which includes seabed grabs, video and water column sampling;
- **Post-drilling cuttings pile analysis**: the assumptions used in the modelling have a large impact on the predicted environmental risk to the seabed. Premier will conduct sediment sampling of the seabed post-drilling in order to inform future assessments of drilling discharges in the region; and
- Analysis of PAH content of treated cuttings from the TCC unit.

Detailed monitoring requirements will be established during the Environmental Monitoring and Management Plan (EMMP) workshop. All monitoring requirements agreed by Premier and FIG will be recorded and managed via the project-specific Phase 1 Environmental Monitoring and Management Plan (EMMP) (an outline EMMP is provided in Chapter 15).

10.6.11 Offsetting

For significant residual and impact and risks (Moderate or above), offsetting via an Environmental Fund is proposed, see section 8.9 for further details.

10.6.12 Findings summary

Table 10.42: Summary of the impact assessment for discharge of drill cuttings during the Phase 1 Development

Activity	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a] Initial	Impact / Risk Significance [a] Residual	Confidence	Mitigation / Prevention / Control
Drilling operations	Discharge of: Seawater and bentonite sweeps; Tophole drill cuttings; and Thermally treated and ground OBM drill cuttings	Water quality: Suspension of particles leading to increased turbidity	Planned	1 & 2	Very Low	Slight	n/a	Very Low (1)	n/a	Probable	Industry-standard: Drilling discharges to be minimised as far as possible in line with BAT; Selection of benign chemicals where possible; OBM cuttings returned to the rig and thermally treated to minimise oil on cuttings (aiming to exceed compliance requirements); and Post-drilling monitoring of seabed recovery. Project-specific: Continual improvement so that oil on cuttings will be minimised, as far as is possible, during drilling campaign to below a 0.5 % average
		Plankton: Reduction in the ambient light, chemical content or plume and barite particles may affect zooplankton			Very Low	Slight		Very Low (1)	n/a		
		Seabed sediment: Deposition of drill cuttings modifying sediment particle size			Very Low	Minor		Very Low (2)	n/a		
		Benthic fauna: Burial of benthic fauna, modification of habitat, toxicity and oxygen depletion			Low	Moderate		Moderate (6)	Moderate (6)		
		Fish and shellfish: Suspended barite particle may affect gill structures			Low	Minor		Low (4)	n/a		

a See Chapter 8.0 for definitions of sensitivity, severity, likelihood and significance.

10.7 Operational Discharges

Table of Contents

10.7 Operational discharges

10.7.1 Introduction

Numerous discharges to sea will occur throughout the Phase 1 Development. These will include domestic waste waters, drain, bilge and ballast waters from vessels throughout the field life, drill cuttings and fluids during Stages 1 and 2 of the Development and operational and marine discharges which will occur mostly during steady state production (Stage 3). The use of chemicals during the Phase 1 Development was raised as a concern by stakeholders during scoping consultations (Chapter 6.0).

This chapter assesses the impacts and risks associated with operational and domestic discharges, including:

- Hydrotesting water;
- Wellbore clean-up fluid;
- Cooling water (CW);
- Subsea hydraulic fluids;
- Produced water (PW);
- Grey and black water (sewage);
- Food waste;
- Drainage and bilge water; and
- Hypersaline water.

Note: the impacts associated with other discharges to sea e.g. drilling discharges and ballast water are described elsewhere in this document, as described in section 9.2.

10.7.1.1 Relevant legislation

Conventions and legislation relevant to operational discharges to sea include:

- International Conventions:
  - International Convention for the Prevention of Pollution from Ships (MARPOL) 1973/78:
    - Annex I – Regulations for the Prevention of Pollution by Oil.
    - Annex IV – Prevention of Pollution by Sewage from Ships.
    - Annex V – Prevention of Pollution by Garbage from Ships.
  - Convention on the Protection of the Marine Environment of the North East Atlantic 1992 (OSPAR Convention):
    - OSPAR Recommendation 2001/1 for the Management of Produced Water from Offshore Installations as amended by OSPAR Recommendation 2006/4;
    - OSPAR Decision 2000/2 on a Harmonised Mandatory Control System (HMCS) for the Use and Reduction of the Discharge of Offshore Chemicals;

        - OSPAR Recommendation 2012/5 for a Risk-based Approach to the Management of Produced Water Discharges from Offshore Installations; and
        - OSPAR Agreement 2005/8 on a Monitoring Programme for Concentrations of Radioactive Substances in the Marine Environment (Update 2011).

- Key UK Legislation:
  - Offshore Petroleum Activities (Oil Pollution Prevention and Control) (OPPC) Regulations 2005 (and all amendments);
  - The Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008 which implement Annex IV and Annex V of MARPOL 73/78 and provide a general prohibition against the overboard disposal of all types of garbage waste from vessels and offshore installations;
  - Offshore Chemical Regulations (OCR) 2002 (and all amendments); and
  - The Environmental Authorisations (Scotland) Regulations 2018 which has replaced The Radioactive Substances Act 1993 Amendment (Scotland) Regulations .
- Relevant Falklands legislation:
  - Marine Environment (Protection) Ordinance of 1995;
  - Environment Protection (Overseas Territories) Order of 1988;
  - Environment Protection (Overseas Territories) (Amendment) Order of 1997;
  - Offshore Petroleum (Licensing) Regulations 1995 and 2000; and
  - Oil in Territorial Waters Ordinance (1960).
- Relevant Falklands operational notices:
  - Petroleum Operations Notice (PON) No. 8.

Under the above, there are numerous compliance requirements with regard to oil content, chemical selection and the discharge of PW as a whole.

10.7.1.1.1 Produced water compliance

10.7.1.1.1.1 Oil in water

The OSPAR Convention contains an underpinning requirement to use Best Available Techniques (BAT) to minimise pollution and this extends to the management of produced water. OSPAR 2006/5 introduced a presumption that Produced Water Reinjection (PWRI) would be taken as a starting position in determining what is BAT for a particular asset or discharge.

OSPAR Recommendation 2001/1 specifies that all discharges of PW must comply with a monthly average dispersed oil in water (OiW) content of 30 mg/l or less, and that no single discharge should exceed 100 mg/l. PW must be treated to minimise the OiW content using BAT and consent conditions normally require sampling and analysis two times per day when discharging, or once per month when reinjecting. Other requirements are included in guidance and consent conditions including those for metering, management of critical elements and the reporting of unusual oily sheens beyond 500 m.

FIG PON8 guidance is a target of 40 mg/l for produced water although Premier understand that FIG expect to adopt a 30 mg/l monthly average standard in line with the UK, averaged over those days when a discharge occurs and ignoring days when there is no discharge.

10.7.1.1.1.2 Produced water as a substance

In addition to reservoir hydrocarbons, chemicals and NORM (see 10.7.1.13 below), PW also contains other naturally occurring substances that are present in the hydrocarbon reservoir. In line with OSPAR requirements these are analysed and reported twice a year.

The OSPAR commission aims to achieve a reduction in the discharge of hazardous substances to sea and is targeting the cessation of hazardous discharges by 2020. The ultimate aim is to achieve concentrations in the marine environment which are near background levels for naturally occurring substances, and close to zero for man-made substances. To this end, OSPAR has embarked on a process of risk-based assessment of produced water discharges and has formalised this approach in OSPAR Recommendation 2012/5 and Agreement 2012/7. This was adopted with a view to understanding the toxicity of PW as a whole substance and achieving the 2020 goal.

All parties contracting to OSPAR are required to use a Risk-Based Approach (RBA) when assessing the environmental risk posed by their PW discharges. The RBA is a method of:

- Assessing the toxicity of 'whole PW' as a substance in its own right; and
- Prioritising mitigation actions for discharges or substances that pose the greatest risk.

In the UK, this has resulted in a voluntary implementation programme that engages all discharging assets in undertaking an RBA. Once the programme is completed, it is expected that the outputs from the RBA process will be reflected in ongoing submissions under OPPC and under the Offshore Chemicals Regulations.

10.7.1.1.2 Chemical compliance

The UK has controlled offshore chemicals since 1979 via the Offshore Chemical Notification Scheme (OCNS). This has developed into an OSPAR-wide control scheme via the Harmonised Mandatory Control System (HMCS) which is an outcome of OSPAR Decision 2000/2 and Recommendations 2010/3 and 2010/4. This contains requirements for chemicals to be pre-screened by applying standardised laboratory tests in an application or standard known as the Harmonised Offshore Chemical Notification Format (HOCNF). Those with acceptable properties are given rankings as to their potential risk in typical usage and are added to the Cefas Definitive Ranked List of Registered Products. Only chemicals from this list may be used or discharged offshore for oil and gas purposes.

Chemicals with the best performance (lowest toxicity, lowest bioaccumulation and lowest biodegradation) are given a classification of 'Gold'. Their discharge must be subject to a risk assessment unless they are categorised as Posing Little Or NO Risk (PLONOR) to the environment according to OSPAR Agreement 2013/6. PLONOR chemicals include, for example, inert minerals, nut fibres, methanol and monoethylene glycol. In the UK and Netherlands, the risks are assessed at 500 m from the discharge using a dispersion calculation known as the Chemical Hazard and Risk Model (CHARM). For those chemicals that cannot be assessed using

CHARM, such as inorganic or PLONOR chemicals, a separate OCNS classification is given from 'A' to 'E', with 'E' denoting the best environmental performance.

For any chemicals that have specific undesirable properties around biodegradation, toxicity and bioaccumulation, these are given a 'substitution warning' which means that their use must be justified and replacements sought. The goal has been a phase out of discharge of these chemicals by 1st January 2017. Chemicals with traces of certain undesirable substances such as particular metals, including those on a list for priority action (OSPAR 2004/12 revised 2013) are given a 'warning' code and their use must be specifically justified in applications.

All chemicals dosed into the Cooling Water (CW) and Produced Water (PW) will be selected to minimise the potential environmental impact in line with OSPAR Decision 2000/2. They will be subject to ongoing review and improvement where practicable.

10.7.1.1.3 Oil based muds in well completion fluids

The Offshore Chemical Regulations (OCR) were updated in 2011 to include the discharge of hydrocarbon chemicals or substitute hydrocarbon chemicals (i.e. Non-Aqueous Drill Fluids (NADF) such as Oil Based Muds (OBM)). If any OBM is to be discharged with well fluids, such as completion fluids, the discharge will be conditioned to meet certain maximum discharge volumes and concentrations. Representative samples of the discharged material shall be collected at regular intervals during the course of the discharge to determine the hydrocarbon chemical or substitute hydrocarbon chemical content of the discharge. In the event of any discharge giving rise to a visible "oil sheen" on the sea surface, the discharge operation must be notified to BEIS (formerly DECC) and all discharges are to be reported to BEIS following completion of the operation.

10.7.1.1.4 Naturally Occurring Radioactive Materials (NORM)

Under OSPAR Agreement 2013/11, it is necessary in the UK to sample discharged PW on a quarterly basis to test for quantities of radionuclides which can occur naturally in the PW.

10.7.1.1.5 The PON 8 and oil sheen reporting

The FIG PON8 is primarily intended for use when reporting oil spills. However, as per the guidance below, the pro forma must also be used to report on oil sheens which may result from PW discharges. This guidance is intended to reflect the fact that all oil spills are reportable under law but that normally operating produced water streams (if applicable) are already reported via the installation's produced water monitoring records and returns.

The PON 8 directly specifies the following:

- If the sheen does not result directly from the produced water stream it must be reported using form PON 8 regardless of its size. There is no lower limit to the size of spill / sheen reported.
- If the sheen results from the produced water stream and the discharge contains in excess of 100 mg/l oil in water then it must be reported using form PON 8 regardless of its size. There is no lower limit to the size of spill / sheen reported.

Therefore, if the sheen results from the produced water stream and the discharge contains less than 100 mg/l of oil in water, then a spill need not be reported. However, if the appearance of the sheen differs from 'the norm', or if another source or discharge is causing an unusual coloration of the water around the installation then the Department of Mineral Resources should be informed of the incident by telephone as soon as possible. This should not be treated or recorded as an oil spill. The purpose of the report will be to enable the Department to respond to enquiries from third parties (spotter planes, civilian aircraft, ship's masters etc.). The decision as to whether the sheen is 'unusual' in appearance is left to the common sense and judgement of the Offshore Installation Manager (OIM) at the time.

10.7.1.1.6 Sewage and food waste

In compliance with MARPOL Annex IV, which applies to vessels > 400 GT or certified to carry > 15 persons on board, untreated black water (sewage) may only be discharged beyond 12 nm from shore whilst the vessel is moving. Between 3-12 nm, sewage must be treated prior to disposal at sea and only if vessels are moving at a speed of greater than or equal to four knots. Depending on the vessel's sewage treatment kit, some sewage may be discharged within three nm, and again only if it is travelling at a minimum of four knots. For stationary offshore 'vessels' such as the FPSO and MODU, although they are >12 nm from shore, sewage must be treated before discharge to sea.

Food waste must be macerated to ensure a maximum solid particle size of 25 mm prior to discharge as required under MARPOL Annex V, to aid its dispersal and decomposition in the water column.

All vessels must maintain a Waste Disposal Log.

10.7.1.1.7 Oil content in drainage and bilge water

Under MARPOL Annex I, the discharge to sea of drainage or bilge water by vessels at sea is prohibited unless the oil content of the discharge, without dilution, is less than or equal to 15 parts per million (ppm). Discharges must cease in the event that a sheen becomes visible.

Under the OPPC regulations, the discharge of drainage water from offshore installations is prohibited unless the oil content of the discharge, without dilution, is less than or equal to 40 ppm.

When in transit, both the MODU and the FPSO will qualify as vessels under MARPOL and will thus adhere to the 15 ppm limit. When stationary and operational however, the MODU and FPSO will qualify as offshore installations under OPPC and would be required to adhere to the 40 ppm limit. However, Premier has committed to adhering to the lower 15 ppm limit once on station as well as when in transit for both the MODU and FPSO.

All vessels must use an Oil Record Book to record all oil discharges from drainage and bilge water.

10.7.2 Sources of operational discharges to sea

Operational discharges to sea during the Phase 1 Development include:

- Hydrotesting water and ballasting liquids at the pre-commissioning stage;
- Wellbore clean-up fluid;
- Cooling water (CW) throughout steady state production;
- Hydraulic fluids during operation of subsea valves;
- PW when it first starts to appear and the Produced Water Re-Injection (PWRI) system is being commissioned which may take three to six months;
- PW during unplanned PWRI downtime at any time throughout the field life;
- Grey water e.g. waste water from showers, cooking, cleaning, food preparation;
- Black water e.g. sewage;
- Food waste;
- Drainage and bilge water from the MODU / FPSO; and
- Hypersaline water from the creation of potable water.

10.7.2.1 Hydrotesting and ballasting discharges to sea

During pre-commissioning in Stage 1 of the Development, it will be necessary to hydrotest the Subsea Umbilicals, Risers and Flowlines (SURF). Hydrotesting of the flowlines and risers is an important step in confirming their structural integrity and to demonstrate the absence of leaks.

During the test, the SURF will be flooded with inhibited seawater or an inhibited mixture of water and monoethylene glycol and the lines will be pressurised and monitored for a period (typically less than 24 hours) to check for leaks before the water is released in a controlled discharge to sea. Pipeline hydrotesting normally involves pumping a biodegradable gel ahead of the flushing water to ensure the whole pipeline contents are displaced, leaving the pipeline with the correct preservation fluids prior to startup.

During installation in Stage 1 of the Development, structures, pipelines and umbilicals will be lowered to the seabed. To control buoyancy and vertical position, these are often filled with a carrier liquid which can be topped up using liquids in attached bladders, often inhibited seawater or an inhibited mix of water and monoethylene glycol, similar in composition to hydrotest fluids. During descent to the seabed, some of these liquids are discharged and during connection of the equipment and disconnection of the installation vessel, all of the liquids may be discharged.

10.7.2.2 Wellbore clean-up fluid

When each well is displaced from Oil Based Mud (OBM) to brine during completion, OBM contaminated water is returned to the mud pits on the MODU. The OBM is skimmed off and sheen tested before discharge to the sea, oily water separators will also be used to help this process. This typically results in about 3, 000 bbls (approximately 477 m3) per well (90,000 bbls / 14,310 m3 for the total drilling campaign) of visibly oil-free water being discharged offshore. Any residuals that cannot be discharged will be returned to the supply base for incineration.

The visibly oil-free water will be discharged in line with legislation (section 10.7.1.1.2) and the Oil and Gas UK Well Clean-up Good Practice Guidelines (section 10.7.5).

10.7.2.3 Cooling water discharges to sea

As described in section 5.8.5.1, the cooling water system will use cold seawater to absorb heat from a cooling medium system via a series of heat exchangers, with the warm seawater being discharged back to sea on a continuous loop. These cooling water (CW) discharges will be at an elevated temperature of approximately 50°C.

10.7.2.4 Hydraulic fluids during operation of subsea valves

Valves that control flow and operation of the subsea system are operated by means of hydraulic fluids pumped from the FPSO. The control system includes dual high pressure and low pressure hydraulic control lines for full redundancy. The distribution networks shall be designed to avoid common modes of failure and promote reliable operations. Self-sealing connectors are provided between the control lines within the umbilicals and the subsea manifolds so that there is negligible discharge of fluids during connection and maintenance. Each time a valve is operated, an amount of fluid is released. A small amount of fluid also passes across the valve seals during normal operations as the liquid is held in a pressurised state. Recent industry guidance on the management of such fluids will be followed (Energy Institute, 2016).

A biodegradable water / glycol-based fluid will be used. Oceanic HW443R is currently selected which is Cefas-registered OCNS category 'D' and has no substitution warning and high biodegradability. Its main components are water and monoethylene glycol which is a PLONOR chemical along with a rhodamine dye to help pinpoint any leaks should they occur. This selection may be subject to change (e.g. a different manufacturer) as the design progresses but a glycol-based fluid with a similar performance would be chosen, and no substitution chemicals will be used.

10.7.2.5 Produced water discharges to sea

Once into steady state production, PW will be treated and a level of 10 mg/l dispersed oil will be targetted for PW treatment performance. Treated PW will be mixed with treated seawater before reinjection into the reservoir at a maximum concentration of 10 mg/l dispersed OiW via one of two PWRI units. This is intended to enhance oil recovery from the reservoir (section 5.8.5.6) and alleviate the need to discharge produced water to sea during normal production operations. This effectively ensures the long-term re-use of a major discharge stream with zero planned PW discharges to sea during normal operations.

However, when PW from the oil production wells first starts to arrive on the installation, there is the potential that some PW will be discharged while the PWRI units are commissioned. The volumes of PW that may be discharged during commissioning are, as yet, unknown but are expected to be small and short-lived as the PWRI units will be brought on line as soon as possible. Additionally, throughout field life, it may be necessary to discharge PW in the event that the PWRI units malfunction or that the water cannot be cleaned to the necessary 10 mg/l dispersed OiW required for reinjection.

In the event of PW discharge during commissioning or unavailability of the PWRI option, the water will be cleaned prior to discharge to ensure that, as a minimum, it is compliant with PW legislation (section 10.7.1.1.1), namely 30 mg/l monthly average and 100 mg/l in any one sample. It is anticipated however that such discharges will carry an OiW concentration in the region of 10 – 15 mg/l. In the event that the OiW concentration is higher, the water can be diverted to the off-spec tank which has a capacity of c. 12,850 m^3.

Legally compliant PW discharges, in the event of PWRI unavailability during early and late field life, were modelled using DREAM to assess the impact of PW discharges and to align with the RBA requirements of OSPAR Recommendation 2012/5 (section 10.7.1.1.1.2). Although it is not a requirement in the UK to apply RBA until first water production, it has been applied here as a good practice to help identify any issues that would be addressed more efficiently at this stage and as a means of predicting the scale of potential impacts.

10.7.2.6 Grey and black water

Grey water (e.g. domestic waste water from showers, dishwashing etc.) and black water (sewage) will undergo treatment prior to discharge as described in section 10.7.1.1.6.

The sewage discharge points will be at minimum draught (c. 9m) below the surface of the water.

10.7.2.7 Food waste

Food waste from the galley will be macerated prior to discharge as described in section 10.7.1.1.6. The discharge points will be at minimum draught (c. 9m) below the surface of the water.

10.7.2.8 MODU / FPSO bilge and drainage water

The MODU is a registered ship and will adhere to the 15 ppm limit.

The FPSO will be registered as a ship for transit (and potentially thereafter). However, when moored in the exclusion zone, the FPSO would qualify as an offshore installation to which OPPC would apply in the UK and therefore, in principle, it would be normal for an upper limit of 40 mg/l to apply to all drainage.

However, the requirement to demonstrate BAT would also apply and it is expected that the FPSO's bilge and slops oily water systems will discharge at an upper limit of 15 ppm. The FPSO bilge water system will accept drainage from 'machinery spaces' (mainly the engine room) and will have a MARPOL-compliant bilge water treatment system that cannot discharge water in excess of 15 ppm.

Oil separated from the drainage water on the MODU will be shipped to Stanley prior to incineration and / or provision to local businesses such as Stanley Growers (market garden) for use in oil burning heaters. Sludge separated from the drainage water and bilge on the FPSO will also be sent back to Stanley for incineration.

10.7.2.9 Hypersaline discharges

Hypersaline water will be generated by desalination plants used to generate freshwater from seawater. The freshwater will be used for numerous operations as well as for consumption, as described in section 5.11.4.2. The hypersaline water will be discharged to sea.

10.7.3 Potential receptors

The ENVironmental Impact IDentification (ENVIID) workshop was used to identify those receptors upon which the impacts and / or risks associated with operational discharges to sea warranted further investigation (Chapter 5.11.4.2).

Marine environmental receptors, which may be impacted by operational discharges, are:

- Water quality;
- Plankton (section 7.4.1);
- Fish (section 7.4.4.2); and
- Seabirds (section 7.4.5.2).

The above are considered to be receptors owing to the potential for acute and chronic impacts associated with the oil, chemical and natural components of operational discharge plumes.

10.7.4 Characterising and quantifying the impact and risk of operational discharges to sea

When characterising and quantifying the potential impacts and risks of operational discharges, it is necessary to consider the following:

- The composition, behaviour and fate of discharges;
- Nature of the potential impact e.g. acute and chronic effects;
- The potential for oil sheen formation;
- Volume of planned operational discharges; and
- Estimation of volumes and risks associated with unplanned PW discharges, and the associated risks.

10.7.4.1 Composition, behaviour and fate of discharges

10.7.4.1.1 Hydrotest, wellbore clean-up fluid, cooling waters and hydraulic fluids

The composition, behaviour and fate of the hydrotest, wellbore clean-up fluid and cooling waters, and that of the hydraulic fluids is provided in Table 10.43.

Table 10.43: Discharge composition, behaviour and fate

Discharge fluid	Composition, behaviour and fate
Hydrotest water	The SURF will be flooded with inhibited seawater which will be dosed with chemicals such as oxygen scavengers, corrosion inhibitors and biocides. The exact volumes of water and chemicals to be discharged to sea are yet to be determined and will be defined during the FEED process. However, it is anticipated that water discharged at the seabed will be rapidly dispersed and diluted. All chemicals dosed into the hydrotesting and ballasting water and will be selected to minimise the potential environmental impact in line with OSPAR Decision 2000/2. They will be subject to ongoing review and improvement where practicable.
Wellbore clean-up fluid	Wellbore clean-up fluid discharged to sea may contain traces of OBM (up to 200 mg/l). All OBM chemicals will be selected in line with the OCNS (section 10.7.1.1.2). Discharges will be in discrete volumes at the end of each well allowing time in between discharges for the water to disperse. The water will be discharged at depth (most likely through the cuttings discharge line), which will aid mixing and dispersion.
Cooling water	CW will be dosed with a biocide to prevent marine growth in the heat exchange system and therefore, discharges will contain biocides. Given the temperature and salinity of the CW discharges, it is expected that the CW plume will be buoyant and will remain in the top 200 m of the water column. All chemicals dosed into the CW and will be selected to minimise the potential environmental impact in line with OSPAR Decision 2000/2. They will be subject to ongoing review and improvement where practicable.
Hydraulic fluids	Hydraulic fluids are a single substance used to enable subsea valve actuation. A biodegradable water / glycol-based fluid will be used. Oceanic HW443R is currently selected which is Cefas-registered OCNS category 'D' and has no substitution warning and high biodegradability. Its main components are water and monoethylene glycol which is a PLONOR chemical along with a rhodamine dye to help pinpoint any leaks should they occur. This selection may be subject to change (e.g. a different manufacturer) as the design progresses but a glycol-based fluid with a similar performance would be chosen, and no substitution chemicals will be used. With regard to its behaviour and fate, such small quantities are discharged that it is expected to be rapidly diluted by seabed currents.

10.7.4.1.2 Produced water

10.7.4.1.2.1 Composition of produced water

Specifically, PW may contain:

- Production chemicals to assist with:
  - Flow assurance;
  - Oil separation; and
  - Water injection.
- Naturally Occurring Radioactive Material (NORM);
- Reservoir hydrocarbon which is separate from the aqueous phase (free oil) and is therefore mostly removed from the water in the separation process;
- Dispersed oil which refers to small droplets of oil which are suspended in the aqueous phase; and
- Dissolved oil which comprises of naturally produced low molecular weight organic compounds such as organic acids, polycyclic aromatic hydrocarbons, phenols and volatiles which contribute to its overall toxicity (Yang and Tulloch 2002, Veil *et al*. 2004).

Most of the free and dispersed oil is removed from the PW in the treatment process leaving a small residue expected to be less than 10 mg/l. Although the removal of dispersed oil droplets in the treatment process does include soluble oils that are contained within the droplets, dissolved oil is not specifically removed by the separation process or by mechanical treatment processes and therefore remains within the PW.

Chemical content

Chemicals contribute to the overall toxicity of PW and the difference in the acute toxicity of chemicals can be up to four orders of magnitude (Holdway, 2002). Technological means of ensuring flow assurance and OiW separation are built-in to the Phase 1 basis of design to minimise reliance on flow assurance and separation chemicals (section5.8.2.1). However, some chemical use will be necessary.

The exact chemicals intended for use have not yet been selected from manufacturers and therefore Table 10.44 lists analogous chemicals representative of those that will be used. In accordance with the legislation (section 10.7.1.1) all chemicals will be on the approved lists and the vast majority of the anticipated production chemicals will have:

- An HQ band of ‘Gold’ (i.e. low aquatic toxicity, readily biodegradable and non-bioaccumulative);
- No product warnings; and
- No Substitution warnings.

NORM

Several naturally occurring radioactive materials typically occur in PW. The most abundant are usually radium-226 (226Ra) and radium-228 (228Ra). Concentrations of 226Ra and 228Ra in PW tend to increase with salinity, although this relationship can vary (Neff, 2002).

The detailed NORM content of Phase 1 PW is not known. Gamma rays are emitted by all radioactive decay processes and are therefore an indicator of general activity of the rocks and fluids. Gamma ray logging of the strata shows that there is no increase in gamma ray detection through the reservoir compared with surrounding rocks, and in fact the oil- and water-bearing sands exhibit significantly lower activity than the surrounding claystone.

Reservoir hydrocarbon content (free and dispersed oil)

As described above, the Phase 1 philosophy is for zero discharge of PW by using PWRI, however, while the PWRI is being commissioned and in the event of PWRI downtime or declines in injectivity, it may be necessary to discharge the PW to sea. In compliance with OSPAR and the UK OPPC regulations, all PW will be treated, and samples will be taken twice per day to ensure that the OiW concentration in discharged PW does not exceed a monthly average of 30 mg/l and no single sample will exceed 100 mg/l.

However, given that the Oil in Water (OiW) concentration needs to be as low as 10 mg/l in order to reinject the PW, it is anticipated that the concentration would still be in the region of 10 - 15 mg/l should the PWRI units become unavailable. Further, Premier will always endeavor to improve upon the legal OiW limits in line with its annual environmental objectives and targets (Chapter 15).

Table 10.44: List of analogous chemicals likely to be used during steady state production

Chemical analogue	Function	HQ band / OCNS rating	Product warning	Applied dosage (mg/l)	Partitioning co-efficient	PNEC [a] (mg/l)	Concentration after partitioning (mg/l)	
							Early field life	Late field life
Flow assurance and separation chemicals								
RBW82317	Deoiler	Gold	No	20	-0.1	13.336	24.4	20.4
Cleartron MRD 208SW	Solids flocculant	Gold	No	20	-0.1	13.340	24.4	20.4
Emulsotron CC3298-NL	Demulsifier	Gold	No	19	5.22	0.51	0.0001	0.0011
RX-5526	Oil antifoam	Gold	No	15	-3.3	0.112	127	16.7
EC6157A	Scale inhibitor	Gold	No	25	-0.1	10	30.5	25.5
Injected chemicals								
Flexoil® WM-1840-F2	Wax inhibitor	Gold	No	500	3.86	0.249	55	6.1
EPT-2093	Oxygen scavenger	Gold	No	11	-0.1	2.860	1.2	0.1
Calcium Nitrate	Calcium nitrate	Gold	No	150	-0.1	0.070	16.5	1.8
EC6202A	Organic biocide	Silver	No	500	-0.33	0.002	55	6.1
Foamtreat 943	Water antifoam	Gold	No	10	0.9	0.218	1.1	0.1
EC6157A	Scale inhibitor	Gold	No	25	-0.1	10	2.8	0.3
Cleartron MRD 208SW	Solids flocculant	Gold	No	20	-0.1	13.340	2.2	0.2

a Predicted No Effect Concentration

OiW will be measured by an approved technique, normally a specific method of infrared absorption correlated against laboratory samples that have been tested using gas-chromatography flame ionisation detection (DECC, 2014a).

Naturally produced organic compounds

Naturally occurring organic substances in PW include both volatile and non-volatile compounds which are dissolved in the water and therefore cannot be removed by the OiW separation regime (C-NOPB, 2002). These dissolved oils include polycyclic-aromatic hydrocarbons (PAH), monocyclic-aromatic hydrocarbons (e.g. BTEX: benzene, toluene, ethyl-benzene and xylene), metals and high molecular weight phenols e.g. alkyl-phenols.

The specific composition of Sea Lion PW is not yet known. Therefore, a review of PW from North Sea reservoirs was carried out to identify a North Sea analogue. Based on this review, the composition of natural components in Sea Lion PW is estimated in Table 10.45 (Genesis, 2015b). Predicted no-effect (PNEC) concentrations are also shown indicating the concentration below which no harmful effects will occur, as judged by an OSPAR expert panel and documented in OSPAR Agreement 2014/05.

It should be noted however that the composition of Sea Lion PW may differ significantly from North Sea PW, not least because the salinity of the Sea Lion PW is low compared to average North Sea PW. Sea Lion oil was formed from freshwater bodies (i.e. is of lacustrine origin) and a certain level of mercury in the oil is assumed (Table 10.45). While a low salinity North Sea analogue was used, there is a high degree of uncertainty with the estimates.

From the CEDRE testing (CEDRE, 2017), a low level of PAH was measured in the crude oil and also in water in contact with the crude. It is therefore likely that the PAH levels estimated for the modelling assessment are very conservative. It is noted that the PAH components comprise the majority of the risk to the water column, and therefore the level of risk estimated is also probably conservative. Once into steady state production, it will be possible to identify the exact composition of the Sea Lion PW.

Table 10.45: Estimation of the Sea Lion PW composition based on an analogous low salinity PW from the North Sea [a]

Component	Type				Concentration in the PW (mg/l)	PNEC[b]	Component	Type				Concentration (mg/l)	PNEC[b]
	PAH	MAH	Metal	Alkyl phenols				PAH	MAH	Metal	Alkyl phenols		
Acenaphthene	✓				0.0202	0.38	Benzene		✓			27.3	8
Acenaphthylene	✓				0.0072	0.13	Ethyl Benzene		✓			2.7	10
Anthracene	✓				0.0103	0.1	Toluene		✓			15.9	7.4
Benz(a)anthracene	✓				0.0028	0.0012	Xylene		✓			10.2	8
Benzo(a)pyrene	✓				0.0014	0.00017	Copper (Cu)			✓		0.0011	2.6
Benzo(b)fluoranthene	✓				0.0035	0.00017	Arsenic (As)			✓		0.00073	0.6
Benzo(g,h,i)perylene	✓				0.0021	0.00017	Cadmium (Cd)			✓		0.00014	0.218
Benzo(k)fluoranthene	✓				0.0008	0.00017	Chromium (Cr)			✓		0.00065	0.69
Chrysene	✓				0.0097	0.007	Lead (Pb)			✓		0.00045	1.3
Dibenz(a,h)anthracene	✓				0.0024	0.00014	Mercury (Hg)			✓		0.00012	0.0472
Dibenzothiophene	✓				0.6164	0.1	Nickel (Ni)			✓		0.00298	8.6
Fluoranthene	✓				0.0046	0.0063	Zinc (Zn)			✓		0.00847	3.25
Fluorene	✓				0.1039	0.25	C1-C3 Alkyl Phenols				✓	10.339	7.7
Indeno(1,2,3-cd)pyrene	✓				0.0007	0.00017	C4-C5 Alkyl Phenols				✓	0.2996	0.64
Naphthalene	✓				7.2759	2	C6-C9 Alkyl Phenols				✓	0.0823	0.01
Phenanthrene	✓				1.5357	1.3	Dispersed Oil	Reservoir Hydrocarbons				30 (monthly average)	70
Pyrene	✓				0.0119	0.023							

a Note that these estimates are subject to change following the onset of steady state production and the opportunity to test the PW

b Predicted No Effect Concentration

10.7.4.1.2.2 Behaviour and fate of produced water discharges

The environmental impact of PW will depend upon its behaviour and fate following discharge, both of which depend on a number of physical, chemical and biological processes:

- Physical:
  - The duration of the discharge;
  - The volume of water and density of the discharge in comparison to seawater;
  - Depth of the discharge e.g. topside or subsea;
  - Sea state;
  - Wind strength; and
  - Current direction and strength.
- Chemical:
  - The inherent toxicity of the discharge;
  - The OiW concentration;
  - The volatility of low molecular weight hydrocarbons and biodegradation of organic compounds (OSPAR, 2009a); and
  - The concentrations of the components in the water column following natural dilution.
- Biological:
  - The length of time biota are exposed to a given concentration; and
  - The sensitivity of the organisms to the particular component.

Depending upon the above, and as described by Holdway (2002) and the International Association of Oil and Gas (O&G) Producers (OGP, 2005), the potential fate of PW plumes are varied. Produced water can:

- Sink to the seabed or remain on (or rise to) the surface, depending upon the effects of temperature and salinity on the buoyancy of the discharge plume;
- Volatilise (evaporate) to the atmosphere (low molecular weight organic compounds);
- Be biodegraded by micro-organisms (low molecular weight organic compounds);
- Precipitate (become solid) on discharge (low molecular weight organic compounds);
- Adsorb (attach) onto suspended solids and settle out onto the bottom sediments (higher molecular weight organic particles);
- Be dispersed by water currents; and / or
- Be ingested and metabolised by pelagic and / or benthic marine organisms.

Individually or collectively, these processes tend to reduce concentrations of PW components in the receiving environment and thereby decrease their potential toxicity and bioavailability to marine organisms (OGP, 2005).

10.7.4.1.3 Grey water, black water and food waste

The maceration of the food, discharge concentrations, location and depth of grey and black water should all ensure that waste discharges are dispersed and diluted rapidly by the natural water movement around the vessels, thus minimising the impact of nutrient enrichment. Additionally, the natural activity of bacteria and other marine organisms will rapidly break down organic waste.

10.7.4.1.4 MODU / FPSO bilge and drainage discharges

Water from the MODU / FPSO drainage separation and bilge processes may contain emulsified oil and grease, diesel, hydraulic oil, lube oil, and marine fuels. Following separation, the water will be discharged provided it has an OiW concentration <15 ppm.

10.7.4.1.5 Hypersaline water

The volume of hypersaline discharge from each vessel will depend upon the crew on board and any additional operational requirements for potable water. The potential impacts of hypersaline discharges in open ocean conditions are not well understood and the majority of studies report on the impacts to sub-tropical or temperate shallow, nearshore and low-energy marine environments. The desalination plants included in a critical review of published studies on the impacts of hypersaline water by Roberts *et al*. (2010) discharged volumes ranging from 2,000 - 288,000 m3 per day with salinity concentrations ranging from 37.3 practical salinity units (psu) to 75 psu in the nearshore, shallow water environment.

In the majority of cases, the intensity of the plume appeared to diminish rapidly and was usually no greater than 2 psu (or 2 mg/l) above the background salinity of 34 psu (34 mg/l) within 20 m of the outlet, and less than 0.5 psu (0.5 mg/l) when measured hundreds of metres from the outlet.

10.7.4.2 Nature of the potential impact

10.7.4.2.1 Hydrotest, wellbore clean-up fluid, cooling water and hydraulic fluid

All the chemicals which make up the composition of the hydrotest, wellbore clean-up fluid and cooling waters as well as the OBM and hydraulic oils are listed within the Cefas Definitive Ranked List of Registered Products (section 10.7.1.1.2). As such, all the chemicals used will have gone through rigorous testing with regard to their biodegradability, toxicity and persistence. The potential impacts to water quality and marine organisms are associated with these factors. In particular, the hydrotest and cooling water will contain biocides that are necessarily intended to have lethal effects. While there is the possibility for acute effects, it is likely that the discharges will be rapidly diluted by seabed and surface currents such that no chronic impacts are anticipated.

With regard to hydraulic oils specifically, the potential impacts to marine organisms are associated with the components in the oil. Historically, hydraulic fluids often had Substitution warnings (section 10.7.1.1.2), often due to the low biodegradability of the lubricant components. However, as hydraulic fluids without Substitution warnings are now available and are intended for use, and as such small quantities are discharged, any environmental impact is expected to be minimal.

10.7.4.2.2 Produced water

10.7.4.2.2.1 Acute impacts of PW discharge on marine organisms

Numerous studies have been carried out to assess the impacts of acute toxicity of 'whole PW' as a substance and were reviewed by Holdway (2002). The acute effects of the PW discharges studied included:

- Alteration of benthic communities dominated by short-lived opportunistic species up to 100 m from offshore installations (Neff *et al*., 1992);
- A decrease in abundance of biofouling organisms on solid platform structures; and
- Increased mortality of filter feeders within 23 m of a PW outfall (Black *et al*., 1994a, b).

However, within the studies reviewed, a large range in results was observed. It was concluded by the respective authors that the range in impacts observed was due to the varying concentrations and types of chemicals in the PW batches tested and distribution models predicted that acute toxicity effects would be negligible outside the immediate mixing zone (Holdway, 2002). Therefore, with careful selection of chemicals known to have minimal environmental effect (section 10.7.1.1.2), the acute toxicity of PW is considered to be modest (Holdway, 2002).

Centre for Environment, Fisheries and Aquaculture Science (Cefas) have summarised the potential impacts of produced water in Strategic Environmental Assessment work for the UK Government (e.g. DTI, 2001) stating that produced water being discharged into the North Sea would not have a direct toxic effect beyond the immediate vicinity of the platform. This is corroborated by other sources e.g. Lee and Neff (2011) and supported by sensitive biotests.

10.7.4.2.2.2 Chronic impacts of PW discharge on marine organisms

There are less data available regarding the chronic effects of PW. Nonetheless, some of the potential effects seen in the field and the laboratory during chronic toxicity tests include:

- Impacts on the surface microlayer surrounding producing installations;
- Altered benthic community species composition;
- Altered behaviour and physiology;
- Reduced growth; and
- Decreased rates of reproduction (fecundity).

Identifying chronic effects of produced water is complex however, and impacts may be both direct and / or indirect. Further, the studies from chronic toxicity tests in laboratories, mesocosm tests (i.e. an outdoor experimental system that examines the natural environment under controlled conditions) and field studies all produce differing results.

With regard to those impacts noted in coastal regions, chronic effects on respiration and the scope for growth in filter-feeding organisms (e.g. clams) were observed at concentrations as low as 0.08 ppm following exposure to PW from oil terminals. However, this exposure was static and laboratory based and should be put in context of the extremely dynamic movement of the plume offshore, rapid dilution and (in the case of Sea Lion) absence of any plume near the seabed where filter feeders would be present.

Field studies on Mysid shrimps and minnows, where the exposure was renewed daily, found no effects of 'whole PW' at dilutions ranging from 1.6 % to 11.7 % of the solution (Holdway, 2002). Chronic mesocosm tests (i.e. an outdoor experimental system that examines the natural environment under controlled conditions) reported in Neff *et al*., (2011) noted no direct effect on phytoplankton production or larval fish survival, whereas early life stages of copepods suffered high mortalities. The copepod mortality ultimately resulted in an increase in phytoplankton and reduced growth rates of fish larvae. In other mesocosm studies summarised by Stephenson *et al*. (1994), larval mollusks and polychaete worms also were adversely affected. Therefore, these mesocosm studies show that low concentrations of produced water may have subtle effects on marine planktonic communities. However, it should be noted that mesocosm studies represent conservative, worst case exposure scenarios because the normal degradation processes, which are significant, are not properly represented. Neff (2002) reports on chronic toxicity tests on 400 PW samples from the Gulf of Mexico and reported chronic no-effect concentrations of 2.7 % or more i.e. a dilution of about 40 or less, which would occur within around 100 m of the PW discharge point at Sea Lion.

In another coastal study, giant kelp (*Macrocystis pyrifera*) recruitment was found to be affected only in regions <50 m from the outfall (Reed *et al*., 1994). In contrast, laboratory-reared red abalone (*Haliotis rufescens*) larvae exposed to PW at different distances from the source exhibited significant effects on mortality, settlement, metamorphosis, viability, and swimming behaviour up to 500 m from the source (Raimondi and Schmitt, 1992).

Although the specific species and produced waters in these studies may be different to the Sea Lion Development which is in a location which is 450 m in depth such that benthic species and marine flora are unlikely to the impacted at all, the main taxonomic groups are representative and these results show that planktonic larvae can be adversely affected by PW plumes in highly dynamic environments.

The Predicted No-Effect Concentrations (PNEC) used in the DREAM analysis described in section 10.7.4.5 are chronic values taken from a large dataset and are included in the latest OSPAR agreed list (Agreement 2014/05). The DREAM modelling results presented below predict the area that might be at chronic toxic risk.

10.7.4.2.3 Grey water, black water and food waste

With regard to seawater quality, the discharge of grey water, black water and galley food waste may lead to minor localised impacts on water quality due to nutrient enrichment. This in turn can result in increased numbers of plankton, and therefore a localised increase in Biological Oxygen Demand (BOD) around the discharge point.

As with any vessel at-sea, the MODU, the FPSO and all project vessels are likely to attract a mixed flock of seabirds, including albatross and petrel species which are listed under the Agreement on the Conservation of Albatrosses and Petrels (ACAP) (section 3.1.6.1), many of which rely on scavenging for much of their food.

10.7.4.2.4 Drainage and bilge water

The potential impacts of drainage and bilge water discharges are associated with any chemicals, grease, diesel or oil in the wash-down water collected by the drains or bilge tanks. While there is the possibility for acute effects through sheens, all discharges associated with drainage and bilge are likely to be highly diluted with rainwater and seawater on deck. Further, it is likely any discharges will be rapidly diluted by seabed currents such that no chronic impacts are anticipated.

10.7.4.2.5 Hypersaline water

Ecological monitoring studies have found variable effects ranging from no significant impacts to benthic communities, through to widespread alterations to community structure. However, all these are from studies on discharges to poorly flushed environments (Roberts *et al*., 2010) and thus do little to inform an impact assessment on saline discharges to the open ocean.

10.7.4.3 Potential for oil sheens

10.7.4.3.1 Sources of oil sheens

Oil sheens (and slicks) are most commonly associated with large and small spills of oil and diesel, the impacts and risks of which are assessed in section 12.1. However, legally compliant operational discharges such as PW, bilge and drainage waters are also recognised as a low-level contributor to chronic oil pollution (NRC, 1985 and 2003).

Impact to seabirds from legally compliant discharges arises predominantly from the potential for thin surface oil sheens. While OiW concentrations of discharges are tightly controlled by legislation (section 10.7.1.1.1.1), oil sheens can, in practice, be associated with PW (Fraser *et al*., 2006) and may occur at OiW concentrations as low as 25 mg/l when discharged on calm days (Wills, 2000). In the North Sea, it is necessary to report sheens which extend beyond the 500 m safety zone. These can occur even when all discharges have been in compliance with regard to OiW concentration and discharge volumes, although their occurrence is rare and normally coincides with extremely calm conditions.

However, OSPAR is concerned with the oiling of seabirds and in an OSPAR-commissioned report, Camphuysen (2005) states that there is good evidence that bilge oil is the main source of oil pollution, with a clear correlation between oiled guillemots and shipping lanes. Therefore, there is the potential that compliant bilge and drainage discharges could lead to sheens although, as described above, this would require very calm weather. Such weather occurs rarely at the Sea Lion location with waves heights at 0-1 on the Beaufort Scale occurring less than 3 % of the time according to metocean reports for the location.

Nonetheless, the sensitivity of seabirds to oil pollution via oiling and / or ingestion is taken very seriously and therefore, to take a precautionary approach, it is necessary to consider the potential contribution of all discharges to chronic oil pollution and the acute and / or chronic impacts upon seabirds.

10.7.4.3.2 Formation of oil sheens

The relationship between the discharge of oil in PW, bilge and drainage water and the occurrence of oil sheens is not well understood. The formation of sheens may be related to the characteristics of the receiving waters, the rate and depth of discharge, the characteristics of the produced water such as temperature, quantity of solids, type of hydrocarbon, discharge volume, oil droplet size and / or the presence of certain types of metals such as iron (ERIN Consulting Ltd. & OCL Services Ltd. 2003). Further, while sheens are mostly comprised of the free oil, Veil *et al*. (2004) suggest that the dispersed and dissolved oils (section 10.7.4.1.2.2), which are not easily removed from the PW, also contribute to sheen formation.

Regardless of why or how sheens form, a surface oil film of <3 μm is referred to as a 'sheen' and an oil film >3 μm is referred to as a 'slick' (ERIN Consulting Ltd. & OCL Services Ltd. 2003). According to O'Hara and Morandin (2010) a light sheen is approximately 0.1 μm thick and has a hydrocarbon volume of approximately 0.1 ml/m2 of surface.

Testing of the Sea Lion crude was undertaken to determine the impact of produced water streams on feathers (CEDRE, 2017). Local feathers from nine species of Falkland birds were tested in dispersed oil at a concentration of 100 mg/l, and oil droplets of ~100 microns were produced into the water column. This is the maximum concentration that would be present at the mouth of the discharge caisson, and the Project is targeting 10-15 mg/l of oil on a continuous basis, as well as 93% reinjection when there would be no discharge at all. Feathers exposed to the dispersed Sea Lion oil at 100 mg/l in the water column showed oil particles adhered to all species of feathers tested, though no structural damage to feathers was observed. However, it was noted that the barbules (the intricate 'feathery' parts in between the feather's structure) were messy following contact with the oil / water solution (CEDRE, 2017). Depending on their distance from the PW caisson, birds exposed to PW would probably be exposed to concentrations two or three orders of magnitude lower than that used in the test. Bulk crude at 55°C was also released into completely calm 18°C seawater. This test indicated that the Sea Lion crude can form a very thin sheen on completely calm water when a large mass is spilled. When samples of this sheen were observed in outdoor conditions they would correspond to the lower limit of Band 1 in the Bonn Agreement Oil Appearance Code i.e. near 0.04 microns thickness. When samples of the sheen were tested, the amount of oil present was below the limit of detection. This indicates that only in a large spill scenario would Sea Lion crude develop a very thin sheen, and sheens are unlikely to be observed as a result of produced water discharges (CEDRE, 2017). Although the test represents a 'best estimate' the how the oil will manifest i.e. in microscopic particles, the actual nature of the oil in produced water will be confirmed once the system is brought on line.

10.7.4.3.3 Sheens and seabird contamination

Seabirds tend to be attracted to offshore structures owing to localised enrichment from sewage and food discharges and the presence of artificial light (Tasker *et al*. 1986, Baird 1990, Wiese *et al*. 2001). Therefore, such birds may be at risk of low-level oil contamination and / or ingestion in the event of a sheen, which may lead to impacts upon:

- Feather microstructure and thus thermoregulation and buoyancy (O'Hara and Morandin, 2010, Fraser *et al*., 2006, and Levy, 1980); and / or

- Reproductive success (Camphuysen *et al*., 2005, Rocke, 1999 and Butler *et al*., 1988).

While it is known that feather fouling with as little as 10 ml of heavy oil can significantly reduce thermoregulation in seabirds and may be lethal (Hartung, 1967; McEwan and Koelink, 1973; Levy, 1980; Lambert *et al*., 1982; Jenssen and Ekker, 1989; Burger and Fry, 1993), such a degree of contamination is unlikely to ever occur from a sheen alone. However, laboratory based experiments determined that exposure to oil sheens at a thickness of 0.1 µm could result in measurable oil transfer to feathers. While the impact of such contamination has not been investigated in practice, the study was able to demonstrate that such contamination does affect the essential microstructure of the feathers (O'Hara and Morandin, 2010).

Additionally, Butler *et al*., (1988) found that contamination of feathers with as little as 0.1 ml of oil significantly reduced hatching success in Leach's storm-petrels due to abandonment of the egg by the contaminated bird and / or its mate. While the breeding success of the individuals in the experiment returned to normal the following year, this indicates the potential for small amounts of feather contamination to impact upon seabirds Butler *et al*. (1988).

The level of contamination however will depend upon the level of contact the bird has with the sheen and this is likely to depend upon the foraging modes of different species (King and Sanger, 1979; Camphuysen, 1989; Williams *et al*., 1994). For example, species that feed by diving below the surface or feeding at the ocean's surface (e.g. the IUCN 'Near Threatened' black-browed albatross or the 'Endangered' northern royal albatross, section 7.4.5.3.3) are at greater risk of plumage fouling than those that pluck prey from the surface while in-flight.

While there are limited data on the level of contact, and the thickness of the sheen, required to affect the microstructure of feathers, or to contaminate the bird sufficiently to impact upon reproduction, it is believed that small quantities of oil contamination could have severe consequences (Butler, 1998; O'Hara and Morandin, 2010).

In conclusion, while the data indicate that small levels of contamination may impact upon mortality and reproductive success in seabirds, it is not clear whether or not one-off exposure to sheens translate into impacts on the fitness of individual birds or populations.

10.7.4.4 Volume of planned discharges

10.7.4.4.1 Hydrotest, wellbore clean-up fluid, cooling water and hydraulic fluid discharge volumes

Where possible, the estimated volumes of the discharges are provided inTable 10.46.

10.7.4.4.2 Volumes of planned PW discharges during commissioning

The basis of design for the Sea Lion Field is that zero discharge of PW will occur once into steady state production. At any given time, one of the two PWRI units will be used to re-inject water into the reservoir, which provides a 'spare' should one unit require maintenance or repair. Therefore, under normal and planned operations the FPSO facilities will be capable of treating all PW for reinjection.

Table 10.46: Estimated volumes of discharge

Discharge	Estimated volumes
Hydrotest discharges	The volumes and dosages associated with hydrotesting will be defined during the FEED / Detailed Design phase of design (section 3.2.2), at which time a more detailed assessment will be provided. At this time, it will be possible to conduct Osborne-Adams subsea discharge models to determine the impact upon the benthos.
Wellbore clean-up fluid	It is anticipated that approximately 3,000 bbls (477 m3) of visibly clean water will be discharged per well. Over the development drilling campaign this will result in a total of 90,000 bbls (14,310 m3) being discharged in total.
Cooling water	It is anticipated that approximately 72,000 m3/day of CW will be discharged to sea after being used in the cooling system. While the specific biocide for use has not yet been selected, and the dosages are currently unknown, the application strategy will be optimised to ensure any impact is as low as reasonably practical given the unavoidable need for a biocide in the cooling system.
Hydraulic fluids	Small volumes of hydraulic fluid will be discharged during each valve actuation.

It is anticipated however that there may be discharge of PW when it first starts to appear and the PWRI units are being commissioned. At the time of writing it was not possible to estimate when PW may start to arrive, nor how much may be discharged during the commissioning phase. However, water will start to cut from the production wells at different times and the PWRI commissioning process will commence upon first arrival of water from any one of the production wells. Therefore, all efforts will be made to minimise discharges that follow between the first ‘water cut’ and full implementation of the PWRI system. Therefore, it is anticipated that PW discharges during the commissioning stage will be low volume and short-lived.

All PW will be treated and sampled prior to discharge to ensure that it is compliant with the OSPAR and UK OPPC OiW concentration limits and an OiW concentration of 10-15 mg/l will be targeted at all times. In the event that the OiW concentration exceeds the legal limits, it will be diverted to an off-specification (‘off-spec’) tank (c. 12,850 m^3) and will not be discharged (section 10.7.2.5).

10.7.4.4.3 Volumes of grey and black water

It is estimated that the conventional systems on the vessels will generate 0.2 m^3 / person / day of grey water, and 0.07 m

/ person / day of black water (Huhta *et al*., 2007). Using these data it is possible to estimate the waste water volumes that will be produced by vessels associated with the three Stages of the project (Table 10.47).

It should be noted here that for vessels > 400 GT or certified to carry >15 persons on board, black water cannot be discharged within 3 nm of the coast (section 10.7.1.1.6).

Table 10.47: Estimated grey and black water volumes generated by vessels during the Phase 1 Development

Development stage	Water m^3 / day / person		Volume of grey water (m^3)	Volume of black water (m^3)
	Grey water	Black water		
Stage 1 (42 months)				
Total	0.2	0.07	48,480	16,968
Average per month			1,154	404
Stage 2 (39 months)				
Total	0.2	0.07	57,126[a]	19,994 [a]
Average per month			1,970	689
Stage 3 (17.5 years)				
Total	0.2	0.07	238,839[a]	83,594 [a]
Average per month			1,137	398
Cumulative over whole project				
Total for 23.5 years			344,445	120,556
Average per month over 23.5 years			1,221	428

a As Direct Offtake option has been selected, the number of vessels will be reduced. As such the number of vessels represented above is greater than the number of vessels now expected and illustrates the worst case .

10.7.4.4.4 Volumes of MODU / FPSO bilge and drainage water

The amount of water passing through the drains pumps will depend on the volume of precipitation received. It is therefore not possible to estimate the quantity of water (and thus oil) that may be discharged. In the event that drainage or bilge water exceeds 15 mg/l however, discharges will cease.

10.7.4.4.5 Volumes of hypersaline discharge

The volume of desalination discharge water will depend upon the demand for potable water on any given vessel (e.g. the number of people on board) and the volume of water required for operations. Typically, to generate sufficient volumes of potable water, the volume of desalination discharge water is approximately 0.3 m^3 / person / day which results in an average of 957 m^3 per month over the course of the Development (Table 10.48).

Table 10.48: Estimated hypersaline discharge volumes during the Phase 1 Development

Development stage	Water m^3 / day / person [a]	Water m^3 / day for operations	Volume of saline water (m^3)	
			For consumption	For operations
Stage 1 (42 months)				
Total	0.3	n/a	72,001	0
Average per month			1,714	0
Stage 2 (29 months)				
Total	0.3	276 [b]	52,744 [c]	243,432 [c]
Average per month			1,819	8,394
Stage 3 (17.5 years)				
Total	0.3	276b	124,055 [c]	1,762,950 [c]
Average per month			591	8,395
Cumulative over whole project				
Total for 23.5 years			248,800	2,006,382
Average per month over 23.5 years (282 months)			882	7,115
Total average per month over 23 years			7,997	

a Volumes of hypersaline discharge water from generating potable water for consumption are estimated at 0.3 m^3 / person / day.

b Figure provided by Premier as an estimate of the daily hypersaline discharge expected to result from the creation of 60 tonnes / day of potable water, to cover all FPSO freshwater requirements (including water for personnel).

c As Direct Offtake option has been selected, the number of vessels will be reduced. As such the number of vessels represented above is greater than the number of vessels now expected and illustrates the worst case .

10.7.4.5 Estimation and modelling of unplanned PW discharges

It is anticipated that even in the event of successful PWRI, PW discharges may occur up to 7 % of the time (25 days per year). PW discharges may occur when the PWRI facilities are shutdown; during such times, it may be necessary to divert PW to the off-spec tank for reprocessing, or discharge it to sea. Succesful PWRI is not guaranteed, and in the event of significant issues with injectivity the project may need to use sea water only for reservoir management, meaning that all produced water would be disposed of overboard. In the event of abnormal conditions requiring that the PW be discharged, the effluent will be treated and sampled prior to discharge in order to ensure the OiW content is within the legal limits (section 10.7.1.1.1.1). As stated above, PW with OiW concentrations that are outwith 10-15 mg/l will be diverted to the off-spec tank (section 10.7.2.5).

To predict the risk to the water column from PW discharges during PWRI downtime, Genesis were commissioned to carry out the following modelling:

- DREAM (Dose-related Risk and Effect Assessment Model) and EIF (Environmental Impact Factor) (DREAM/EIF) modelling to assess the risks associated with PW discharges to sea (Premier, 2017d).

The aims of the model were:

- To simulate anticipated realistic worst case PW discharges during early and late field life using the estimated flow rates and PW composition;
- To compare predicted concentrations of substances within the PW discharges with known 'no-effect concentrations' published by OSPAR for discharges to the marine environment; and
- To assess the overall risk to the marine environment from the discharges of oil, low molecular weight organic compounds and chemicals.

10.7.4.5.1 Potential volumes of unplanned PW discharges

The quantity of PW generated by the Phase 1 Development will increase over time as the oil reservoir becomes depleted. Therefore, in the event that the PWRI units are down, the potential daily volume of PW discharge would be higher in late field life than it would be in early field life.

The anticipated volumes of oil production and PW are shown inTable 10.49. These values reflect both high oil volumes, which tend to increase concentrations of chemicals in PW, and high water volumes, which can result in the minimum rate of dispersion upon discharge.

Table 10.49: Flow rates and volumes of PW and oil production

Produced fluid	Early field life	Late field life
Oil Production	11,924 m^3/d	1,590 m^3/d
PW	1,590 m^3/d	17,479 m^3/d
Total produced fluids	13,514 m^3/d	19,068 m^3/d
7 % downtime	25.5 d/yr	25.5 d/yr
PW discharge in 25 days	39,748 m^3	445,714 m^3

10.7.4.5.2 The DREAM / EIF modelling approach

The DREAM / EIF modelling approach is an accepted method for assessing PW and chemical discharges in the North Sea and, according to DECC (now BEIS) (2014a), is one of the tools accepted for demonstrating levels of risk within the relatively recent Risk Based Approach (RBA) framework (section 10.7.1.1.1).

DREAM consists of both a 'dispersion model', based on wind and 3D current data, and a 'component-specific fate model' whereby the physiochemical, toxicological and biodegradation properties of the compounds within a discharge are modelled. From these combined models, overall toxicity risks to the environment are calculated. To enable brevity in this section, the following describes only the information required to ensure appreciation and understanding of the modelling results. Full detail with regard to the modelling parameters utilised e.g. metocean data (currents, wind, temperature and salinity and bathymetry) and the DREAM/ EIF methodology are provided in the full modelling report (Premier, 2017d).

10.7.4.5.2.1 Discharge parameters used in DREAM

Table 10.50 shows the discharge parameters that were used in DREAM to assess the risk associated with Phase 1 PW discharges.

Table 10.50: PW discharge parameters used in DREAM

<table>
<tr><th colspan="2">Parameter</th><th>Value</th><th>Comments</th></tr>
<tr><td rowspan="2">Discharge location</td><td>Latitude</td><td>49° 16' 21.9912" S</td><td rowspan="2">Coordinates of the FPSO [a].</td></tr>
<tr><td>Longitude</td><td>59° 5' 53.0042" W</td></tr>
<tr><td colspan="2">Discharge depth (m)</td><td>0.1 m [b]</td><td>A discharge just below the surface has been assumed to represent the downward momentum of the plume.</td></tr>
<tr><td colspan="2">Discharge temp (°C)</td><td>75°C [b]</td><td>-</td></tr>
<tr><td colspan="2">Discharge orientation</td><td>Vertically downwards</td><td>-</td></tr>
<tr><td rowspan="2">Discharge rate</td><td>Early field life</td><td>1,590 m^3/d</td><td rowspan="2">From production profiles</td></tr>
<tr><td>Late field life</td><td>17,479 m^3/d</td></tr>
<tr><td colspan="2">Discharge salinity (mg/l)</td><td>6.4</td><td>From Basis of Design document (Premier, 2015a)</td></tr>
<tr><td colspan="2">Discharge duration modelled</td><td>7 % downtime in a year = 25.5 days</td><td>Model duration is 42 days to allow up to two weeks for the plume to reach a steady state followed by 28 days discharge in accordance with the BEIS (formerly DECC) RBA Guidance (2014a).
Model assumes that PW discharges will occur continually rather than intermittently through the year.</td></tr>
</table>

[a] the co-ordinates used for produced water modelling are slightly different to the current position of the FPSO because, as the field design progressed, the FPSO location was moved slightly. This is not considered to have a material impact on the modelling conducted.

[b] During FEED the discharge depth was revised to minimum draft (c. 9m) below water level and the temperature of the produced water increased to 90 °C, As both changes will promote dispersion the DREAM modelling has therefore not been revised as it represents worst case.

10.7.4.5.2.2 Understanding the model, the PEC:PNEC ratio and the Environmental Impact Factor (EIF)

The risk assessment is based on a comparison of the:

- PEC (Predicted Environmental Concentration) i.e. the concentrations of different components in the water column resulting from PW discharge as predicted by the model (Table 10.51); and
- PNEC (Predicted No Effect Concentration) i.e. the highest theoretical concentration of the same components at which no harmful effects are expected to occur to marine organisms (Table 10.51).

In other words, the model assesses whether or not the concentrations resulting from Phase 1 PW discharges will exceed the concentrations which marine organisms can ‘tolerate’ to determine whether or not the impacts will be likely to cause significant harm (Table 10.51).

An EIF of 1 is defined as a cuboid volume of water equal to 100 m x 100 m x 10 m (0.0001 km^3) in which the calculated PEC exceeds the PNEC. In practice, an EIF of 1 signifies that within this volume (0.0001 km^3), there is a risk to more than 5 % of the most sensitive species present (i.e. the Potentially Affected Fraction (PAF)). Therefore, an EIF of, for example, 100, indicates that there is a risk to >5 % of the PAF in 0.01 km^3.

The model therefore uses the volume of seawater affected by PW discharge plumes as a measure for quantifying environmental risk and the results are expressed as the volume of water (km^3) in which >5 % of the PAF may be significantly impacted. Note that there is no threshold for the EIF above or below which discharges may be permitted and the EIF is primarily a comparative tool.

Table 10.51: Explanation of the PEC, PNEC and the EIF and how these are calculated and used by DREAM

Factor	Definition	Calculated by:
Predicted Environmental Concentration (PEC)	The concentration of PW components in the water column resulting from the Phase 1 PW	DREAM calculates the fate of each component by modelling the influence of: • Currents (tidal, residual, meteorological forcing); • Turbulent mixing (horizontal and vertical); • Density (difference through salinity and temperature); • Evaporation at the sea surface; and • Reduction of concentration due to biodegradation.
Predicted No Effect Concentration (PNEC)	The highest theoretical concentration of the same components at which no harmful effects are expected to occur to marine organisms	The PNEC value is derived from the: • EC50 (i.e. the half maximal effect concentration) which is the concentration at which 50 % of test organisms experience growth inhibition when compared to a control; • (LC50) (i.e. the median lethal concentration) which is the concentration at which 50 % of the sample population of a specific test-animal in a specified period die from exposure; and • NOEC (i.e. the No Effect Concentration) which is the highest concentration at which there is no observed effect to test animals when compared to a control. • The EC50, LC50 and NOEC are divided by an assessment factor in order to arrive at the expected chronic PNEC. An additional assessment factor is used to reflect any uncertainties in the representativeness of the laboratory results. An assessment factor of 100 was applied in this study in line with the RBA guidance issued by DECC (now BEIS) in 2014 (DECC, 2014a).
PEC:PNEC > 1	PEC:PNEC > 1 means there is a risk to > 5% of the most sensitive species present.	The DREAM model calculates an individual PEC:PNEC ratio for each of the components in the PW and applies a species sensitivity distribution to each. This allows the model to combine and compare the contribution of different PW components to the overall risk to species present, known as the Potentially Affected Fraction (PAF). The level of 5 % risk to the PAF (corresponding to a PEC/PNEC ratio of 1) is a generally-accepted risk level representing the concentration below which no adverse effects on organisms are expected (EC, 2003).
Environmental Impact Factor (EIF)	A volume of water equal to 100 m x 100 m x 10 m (i.e. 0.0001 km^3) in which the PEC:PNEC > 1. An EIF of 1 means that there is a risk to more than 5% of the PAF in 0.0001 km^3.	DREAM predicts the PEC across the model domain and each cuboid of water within that domain in which the EIF = 1. The model then effectively adds together each cuboid to give the overall EIF for that particular release. Three EIFs for early field life and late field life were predicted: • The maximum EIF i.e. the largest EIF value derived throughout the model run duration. The instantaneous EIF is sensitive to small changes in environmental inputs, such as wind and currents, throughout the modelling period; • The time-averaged monthly EIF which is more stable, presenting an average EIF of the modelling period once stable conditions have been established; and

Factor	Definition	Calculated by:
		• The 'annualised' EIF which takes account of the intermittent nature of any PW discharges given that 25 days (7 %) worth of discharge will not be continuous (as is considered acceptable in the RBA). The value of EIF denotes the volume (expressed in km^3) over which risk to the PAF exceeds 5 %.

10.7.4.5.2.3 DREAM Results

Figure 10.36 shows the 'combined maximum instantaneous EIF' values over the entire model duration of 42 days during both early and late field life.

The 'combined instantaneous' element means time is not taken into account in this plot. In other words, where the model indicated there was a risk to >5 % of the PAF in one place on day one of the discharge and a risk of >5 % to the PAF in a different place on day 25 of the discharge, all of these maximum EIF values are plotted in Figure 10.36. Therefore, this figure indicates the maximum risks as if they were all happening at the same time. However, in reality these areas would not all be affected to the same extent at the same time.

The cross-sections below these risk plots show that the discharged water does not descend significantly into the water column due to the temperature and salinity of the plume. The PW plume is confined to the top 80 m of the water column in early field life, and 120 m in late field life (Figure 10.36).

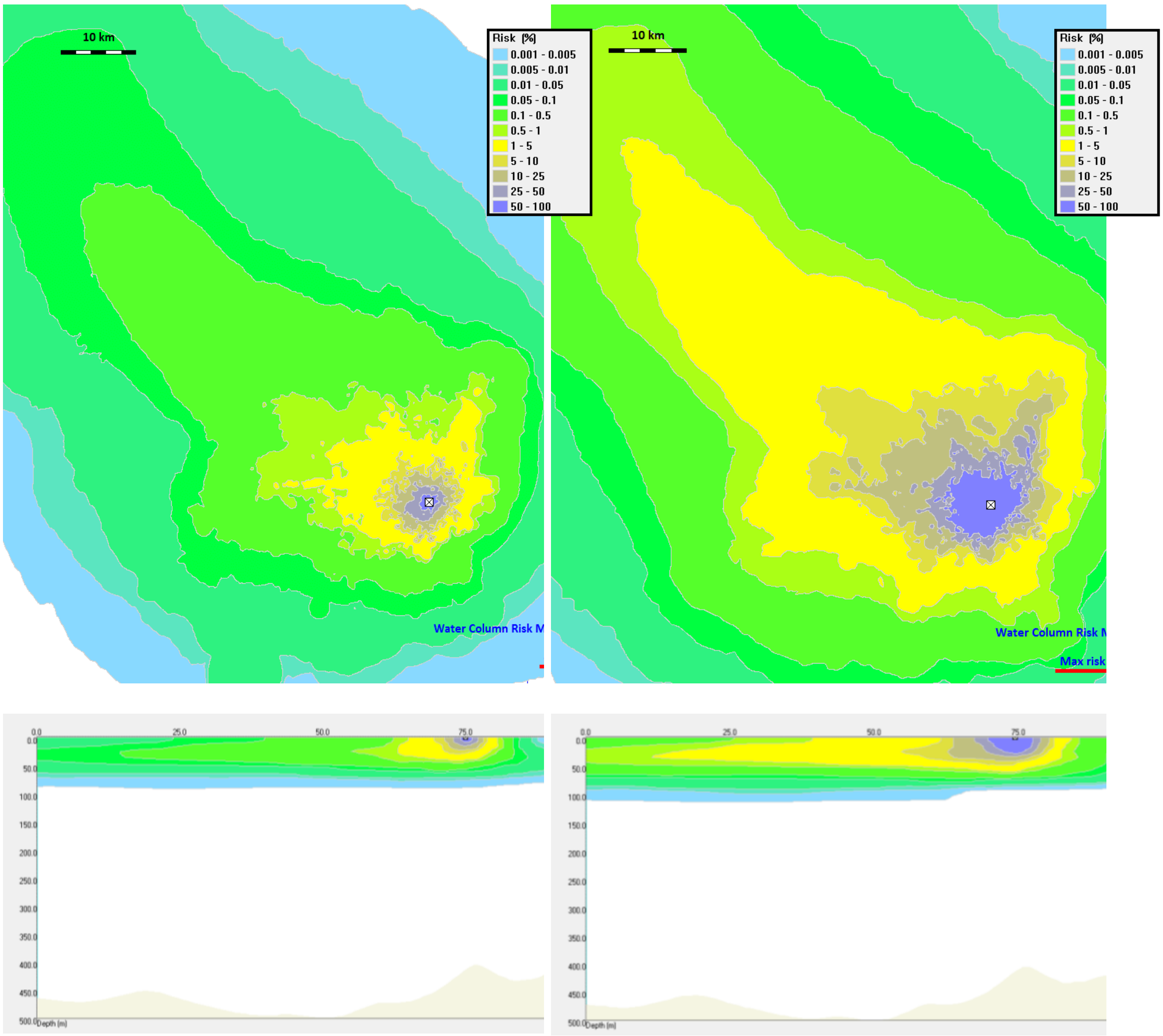
Figure 10.37 plots the distribution of the maximum instantaneous EIF on a single day during both early and late field life, thus incorporating the reality that the PW plume will disperse over time. Day 37 was chosen as the day giving the highest EIF during the month of July 2011, which in turn was chosen as the least dispersive month in the metocean record. These plots demonstrate that on any given day, the volume of water in which there was a risk to >5 % of the PAF is less than the cumulative volume indicated in Figure 10.36. Here it can also be seen in the cross-sections that in early and late field life, the effect of the plume on a single day does not descend below 60 m into the water column (Figure 10.37) although this varies from day to day.

In order to take account of the changing metocean conditions and to provide a more stable and realistic result for comparison in line with SINTEF and DECC (now BEIS) guidelines, the average EIF for the duration of the model run was calculated using the daily EIFs shown in Figure 10.38. The time-averaged EIFs for both early and late field life, are provided in Table 10.52.

Similarly, during PWRI downtime, it is unlikely that PW discharges will occur continuously for 25 days as is assumed by the model. It is more likely that any discharges will be intermittent throughout the year. Therefore, it is useful, as advised in the DECC (now BEIS) RBA Guidance (2014a), to determine the 'annualised' EIF which averages the 25 day discharge over the year (Table 10.52).

As is shown in all representations of the data, the EIF is far higher in late field life than in early field life owing to the volume of PW which may be discharged.

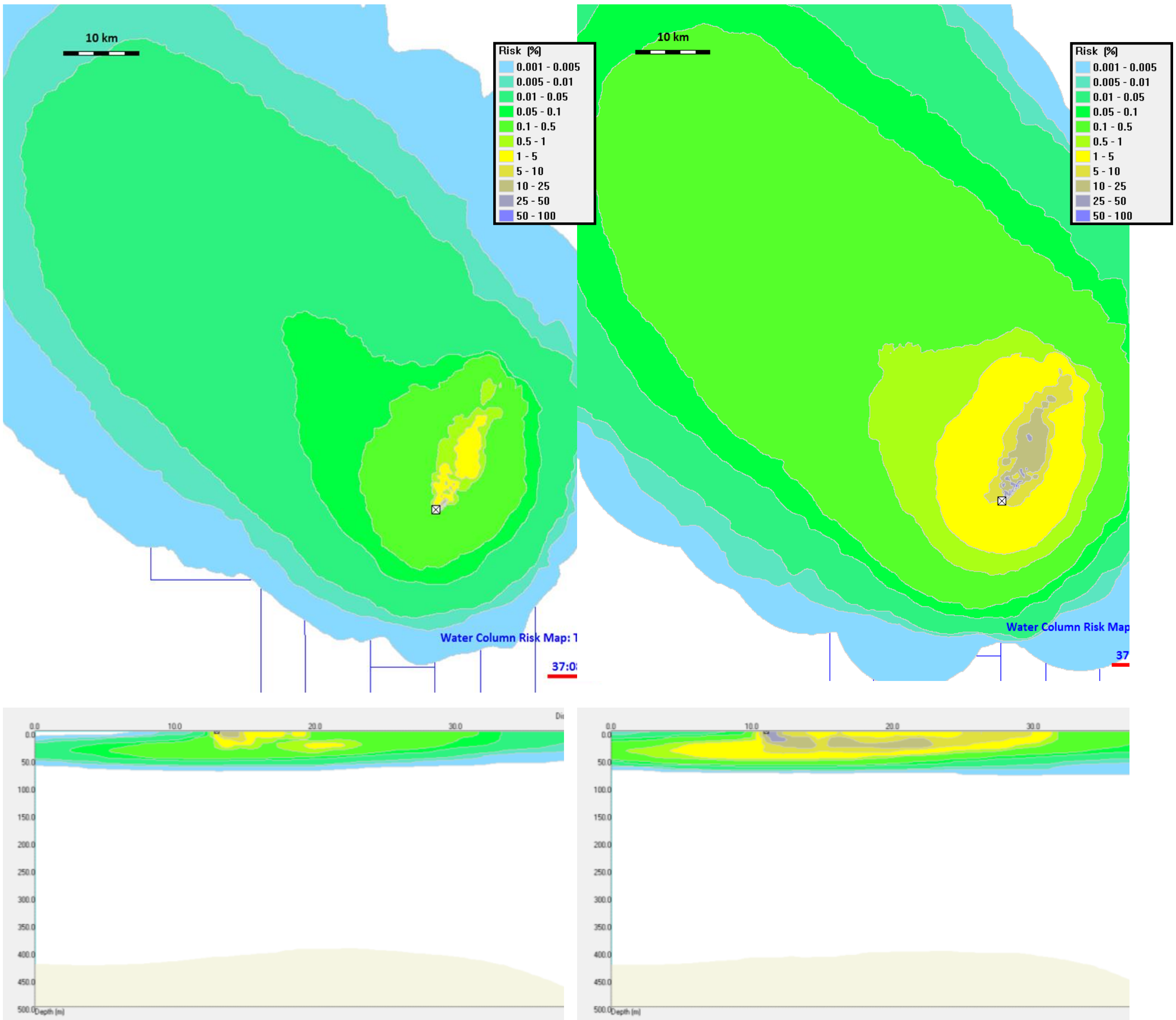
Finally, Figure 10.39 shows a breakdown of the main components which contribute to the overall EIFs in both early and late field life. As may be expected, the biocide was the main contributor to the risk given its necessarily low PNEC. The other main contributors to the EIF were the naturally produced PAHs and alkyl-phenols. Dispersed oil, conservatively modelled here as 30 mg/l, poses no significant toxic risk. In later life, the added chemicals become less important and the natural components dominate the predicted effect.



a) Early field life

b) Late field life

Figure 10.36: Maximum EIF at any point over the model duration showing the composite risk during early and late field life



a) Early field life b) Late field life

Figure 10.37: Instantaneous EIF on day 37 of the model run duration (time of maximum EIF)

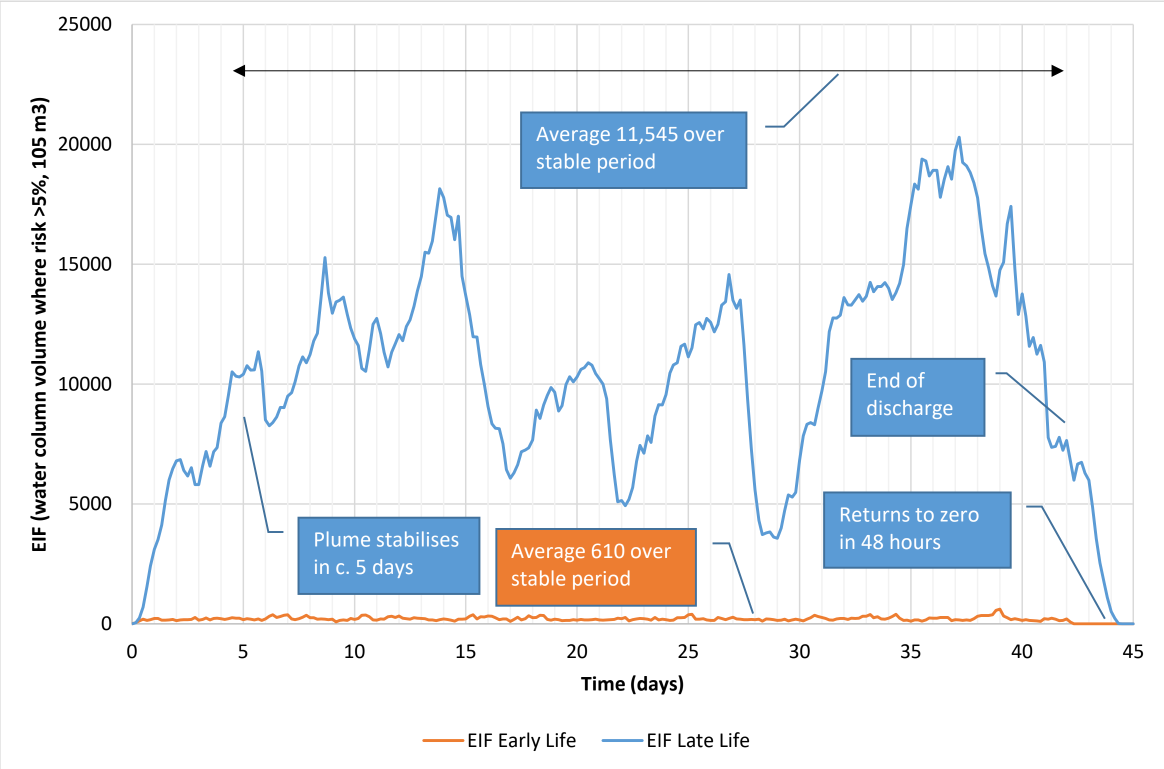
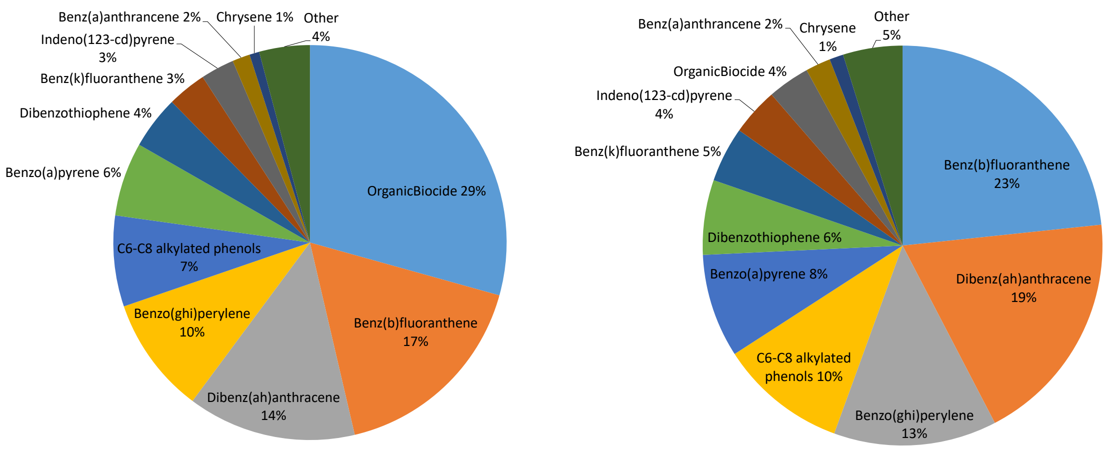


Figure 10.38: Daily EIFs over model duration. Note: the first two weeks' output of the model runs were disregarded in the calculations to allow the plume to stabilise in the water column as is advised in the DECC (now BEIS) RBA Guidance (2014a)

Table 10.52: Time averaged and annualised EIFs for early and late field life

Model result	Early field life		Late field life	
	EIF	Representing	EIF	Representing
Time averaged EIF	610	0.061 km^3 of water in which there is a risk to more than 5 % of the most sensitive species	11,545	1.1545 km^3 of water in which there is a risk to more than 5 % of the most sensitive species
Annualised EIF [a]	43	0.0043 km^3 of water in which there is a risk to more than 5 % of the most sensitive species	808	0.0808 km^3 of water in which there is a risk to more than 5 % of the most sensitive species

a The annualised EIFs shows the EIF of the 25 days (i.e. the 7 % of the time that the PWRI units are down) averaged over the year



a) Early field life b) Late field life

Figure 10.39: Contribution of the main components to the EIF value

10.7.4.5.2.4 Comparison with North Sea EIFs

While it can be useful to compare the EIFs for PW from different installations, there is little published data on PW modelling studies yet as this is a relatively recent requirement under the OSPAR RBA process (section 10.7.1.1.1.2).

Nonetheless, some installations on the Norwegian Continental Shelf (NCS) underwent RBA modelling in 2008, the results of which were published in Smit *et al*., 2011. Of all the installations reviewed, the maximum annualised EIF observed was 1,200 (equating to a volume of 0.12 km^3 in which the risk was >5 % to the PAF), which is slightly higher than the late field life EIF for the Sea Lion Field of 808 (Table 10.52 above). However, direct comparisons are somewhat meaningless at this stage because:

- The estimated Sea Lion PW composition may be very different from the real composition, which is as yet unknown;
- The analogue North Sea data used were chosen owing to the low salinity of the PW while the NCS RBA data are not from low saline PWs;
- It is not possible from Smit *et al*. (2011) to check the basis of the calculations used for the NCS installations; and
- The EIF may have been calculated differently due to revised PNEC values.

10.7.5 Industry-standard mitigation

In addition to the legal requirements of MARPOL etc. the industry standards include:

- Selection of the most environmentally benign chemicals available on the Cefas list of registered products where possible (notwithstanding the need for optimal operational performance);
- The use of BAT to minimise PW discharge volumes and / or OiW e.g. PWRI and the Project target of 10-15 mg/l;

- That the RBA be taken, and DREAM modelling repeated once the exact composition is known, to assess the impact of PW as a whole substance (section 10.7.1.1.1.2);
- That the Energy Institute (2016) Guidance on the management of subsea hydraulic fluids is followed;
- That a Maintenance Management System (MMS) be used to ensure that all equipment is sufficiently maintained;
- Compliance with the ISO14001 certified HSES-MS working procedures and OiW objectives and targets; and
- Compliance with the Oil and Gas UK Good Practice Well Clean-up Guidelines.

10.7.6 Impact and risk assessment

The following section draws upon all the information provided above to assess the 'Sensitivity of the Receptor' and the 'Severity of Effect' in order to determine the overall 'Impact' of planned activities. Assessment of unplanned events includes an assessment of the 'Likelihood of Occurrence' to determine the 'Risk'.

A summary of the impact and risk assessment outcomes is tabulated in section 10.7.11, which shows the worst case impact / risk for each activity and receptor.

10.7.6.1 Impact assessment of operational discharges

10.7.6.1.1 Hydrotesting, wellbore clean-up fluid, cooling water and hydraulic fluid

While individual marine organisms may be impacted at the point of subsea or surface discharges, any impact is anticipated to be short-lived and localised such that there will be no impact at the population level and no species or habitats that are of conservation importance will be affected. With regard to biocide discharges in particular, the only marine organisms likely to be impacted are those which cannot actively remove themselves from the mixing zone e.g. plankton. Further, the discharges will be to the open ocean and any effects will be localised with no potential to transmit contaminants to nearby sensitive receptors. Therefore, the **sensitivity of the receptors** (water quality and marine organisms) is considered to be **'Very Low'**.

While the specific volumes of the hydrotest, wellbore clean-up fluid, cooling water discharges and hydraulic fluids, and the chemicals dosed within them, are not yet known, the chemicals will be compliant with the OCNS (section 10.7.1.1.2) and will be selected to minimise environmental impact (section 10.7.5). It is therefore anticipated that any impacts will not be detectable above background variability and will be rapidly and fully reversible once the activity ceases and / or outwith the mixing zone of surface discharges. Therefore, the **severity of effect** is considered to **'Slight'**.

Therefore, the overall **significance of the impact** from the planned discharge of hydrotest water, wellbore clean-up fluid, cooling water and hydraulic fluids is considered to be **'Very Low (1)'**.

10.7.6.1.2 Produced water discharges during commissioning

While individual marine organisms may be impacted at the point of PW discharges, any impact is anticipated to be short-lived and localised such that there will be no impact at the population level and no species or habitats that are of conservation importance will be affected. Further, the discharges will be to the open ocean and any effects will be localised. Therefore, the **sensitivity of the receptors** (water quality and marine fauna) is considered to be **'Very Low'**.

The DREAM modelling described in section 10.7.4.5 was carried out to model the impact of unplanned discharges during PWRI downtime during early and late field life. However, the early life outcomes can be used to assess the severity of effect of discharges of PW during the commissioning phase.

While the exact composition of the Sea Lion PW is unknown at this time (section 10.7.4.1.2.1), all of the components within PW have the potential to cause both acute and chronic impacts to marine organisms (section 10.7.4.2.2). However, studies examining these impacts were carried out in coastal environments rather than oceanic environments in which the impacts are likely to be lower. Nonetheless, the studies concluded that, while the toxicity of PW was modest and mostly restricted to the mixing zone, the level of toxicity depended upon the chemical components within (section 10.7.4.2.2). Indeed, the DREAM model showed that the greatest contributor to the Sea Lion PW EIF was the biocide, which is necessarily fatal to marine organisms (section 10.7.4.5.2.3, Figure 10.39 above).

The most appropriate modelling result to 'transfer' to the commissioning PW discharge is the Time-Averaged early-life EIF (Table 10.52). The EIF of 610 indicates that there is a risk to more than 5 % of the most sensitive species present over a volume of 0.061 km^3. However, there are two key differences that should be noted. Firstly, commissioning discharges are likely to last for longer than 25 days overall while, secondly, the volumes of discharge during commissioning are likely to be lower as the production wells will only just have started to cut water and the volumes of water will be sporadic. On balance, it is assumed that the result can be used to assess the commissioning discharges.

Given that this area is relatively small, and that the nature of the impact is mostly restricted to the immediate mixing zones (section 10.7.4.2.2) the discharge is expected to have a localised effect for the duration of the discharge with fully reversible effects once activity ceases. Moreover, the DREAM model assumes a discharged OiW concentration of 30 mg/l while in reality, the concentration is anticipated to be in the region of 10 - 15 mg/l (section 10.7.2.5). On balance, and given that the discharge may occur for longer than 25 days while the PWRI system is commissioned, albeit with lower volumes, the **severity of the effect** is considered to be **'Moderate'**.

Therefore, the overall **significance of the impact** is considered to be **'Low (3)'**.

10.7.6.1.3 Grey water, black water and food waste

The offshore habitat in the vicinity of the Sea Lion Field is undesignated and ubiquitous in nature and, given that the discharges will be into open ocean conditions, the extent of eutrophication from the discharge of grey and black water (section 10.7.4.2.3) is expected to be very small. For grey water, black water and food waste, the **sensitivity of water quality, and plankton, as receptors** is therefore considered to be **'Very Low'**.

While the discharge to sea of grey water, black water and food waste may cause slight eutrophication of the surrounding waters, wave action will rapidly disperse and dilute effluent and the action of micro-organisms will breakdown additional nutrients (section 10.7.4.2.3). Taking account of compliance with MARPOL Annex IV, the impacts of the discharges are expected to be rapidly reversible and barely detectable above background variability. Therefore, the **severity of effect** has therefore been assessed as **'Slight'**.

The overall **significance of direct impacts** of the discharge of grey water, black water and food waste is therefore **'Very Low (1)'**.

10.7.6.1.4 Discharge to sea of drainage and bilge water

With regard to water quality, discharges will be to the open ocean where wave action will rapidly dilute any oil remaining in the discharged water. Therefore, the **sensitivity of water quality as a receptor** to this level of oil contamination is considered to be **'Very Low'**.

Equally, at this concentration, any effect on the water quality will be localised, short-term and reversible and the **severity of effect** of drainage and bilge water discharges is therefore considered to be **'Slight'**.

The overall **significance of the impact** of the discharge of deck drainage and bilge water is therefore assessed as **'Very Low (1)'**.

10.7.6.1.5 Discharge of hypersaline water

The Sea Lion Field is located in the open ocean, in waters over 450 m in depth, with currents sufficient to rapidly dilute and disperse hypersaline discharges. Therefore, few flora or fauna are likely to be exposed to high saline conditions and no populations that are considered to be of geographical importance. Therefore, the **sensitivity of the receptors** is considered to be **'Very Low'**.

Given that the majority of studies on the impacts of saline discharges are to poorly flushed and subtropical environments (section 10.7.4.2.5) there are few data to draw upon when assessing the severity of effect. However, even in these regions, the impacts ranged from changes in community structure to 'no impacts'. Further these studies were based on hypersaline discharges as high as 288,000 m^3 per day (section 10.7.4.1.5) where the Phase 1 discharges are expected, on average, to be 7,997 m^3 per month (section 10.7.4.4.5). On balance, and given that the Phase 1 discharges will be to the open ocean, any impacts are expected to be 'rapidly and fully reversible with highly localised effects' such that the **severity of effect** is considered to be **'Slight'**.

The overall **significance of direct impacts** of the discharge of hypersaline water is **'Very Low (1)'**.

10.7.6.2 Risk assessment of unplanned events

10.7.6.2.1 PW discharge during PWRI downtime

The **sensitivity of receptors** is as described above for commissioning discharges of PW and is therefore considered to be **'Very Low'**.

As described above, the DREAM model indicated that, on average, in early field life, there is a risk to > 5% of the most sensitive species in only 0.061 km^3 around the FPSO. In late field life this volume increases to 1.1545 km^3 (Table 10.52). However, all of these results assume that 25 days' worth of PW will be discharged continuously when, in reality, any discharges resulting from PWRI downtime would most likely be spread over the year. Taking account of the PWRI uptime of 93 %, the annualised EIFs are reduced such that in early field life, there is a risk to >5 % of the most sensitive species in only 0.0043 km^3 around the FPSO and 0.0808 km^3 in late field life (Table 10.52). Given that this area, which better represents the reality, is relatively small, and that the nature of the impact is mostly restricted to the immediate mixing zones (section 10.7.4.5.2.3) the impact is expected to have a localised effect for short periods with fully reversible effects once activity ceases. Moreover, the DREAM model assumes a discharged OiW concentration of 30 mg/l while in reality, the concentration is anticipated to be in the region of 10 - 15 mg/l. Therefore, the **severity of the effect** is considered to be **'Minor'**.

Therefore, the overall **significance of the impact** is considered to be **'Very Low (2)'**.

Given that the PW will only be discharged in the event that both PWRI units malfunction, and an off spec tank will be used to store and re-clean any water that does not meet the discharge specification, the **likelihood of occurrence** of PW being discharged is **'Unlikely'**.

Therefore, the overall **significance of the risk** is considered to be **'Very Low (2)'**.

10.7.6.2.2 Oil sheens from PW or bilge/drainage water

Seabirds are attracted to offshore installations owing to light and the discharges of macerated food and sewage (section 10.7.4.3.3). Of those that may be feeding in the area, it is likely that some of these species will be classed as 'Vulnerable' or 'Endangered' by the IUCN (which equates to 'High' sensitivity). Further, many of the scavenging / diving species of seabird that associate with vessels in Falkland Islands waters are also listed as ACAP (Agreement on the Conservation of Albatrosses and Petrels) species which are considered to be under wider threat (largely from fisheries related mortality). Therefore, overall, the **sensitivity of the seabird receptors** is considered to be **'Very High'**.

In the event that the PW needs to be discharged all water will be treated and sampled to ensure that the OiW concentrations are low enough to secure a worst case monthly average concentration of <30 mg/l and no PW will be discharged in the event that a sample exceeds 100 mg/l. As described in section 10.7.2.5, it is anticipated that the OiW concentration will range between 10-15 mg/l. Regular monitoring will identify any drift in quality (section 10.7.5) and the off-spec tank will be used for non-compliant PW (section 10.7.2.5). The tank will be used for long enough to enable stable conditions to be achieved

Testing of the Sea Lion crude showed that a large spill of crude can form a sheen in very calm waters but the discharge of PW is unlikely to form a sheen owing to the low concentrations likely to discharged at the PW caisson and the minimal sheen forming behaviour observed during the PW tests (section 10.7.4.3.2). The tests also showed that oil particles did adhere to feathers at a concentration of 100 mg/l, although no structural damage was observed (section 10.7.4.3.3). There may be the potential for sheens from the lower volume bilge and drainage discharges.

In practise, the impacts of contamination from sheens on long-term fitness are, as yet, unknown and the impacts may either be reversible or lethal depending on the amount of fouling (section 10.7.4.3.3). Further, the metocean conditions in the region are such that any sheen resulting from PW discharge, bilge and drainage is likely to be temporary (section 10.7.4.3.2). Nonetheless, given that a sheen of even 0.1 μm has the potential to reduce fitness, and to take a precautionary approach, the **severity of effect** is considered to be **'Moderate'**.

The overall **significance of the impact** of seabirds being oiled by a sheen is therefore considered to be **'Upper Moderate (15)'**.

With regard to the likelihood of occurrence, given that both PWRI units would need to malfunction before PW is discharged, that sheens are not expected at all for the produced water discharge given the oil properties and that drainage and bilge will only be discharged if the OiW concentration is <15 ppm the **likelihood of a persistent sheen forming and seabirds becoming oiled** is considered to be **'Very Unlikely'**.

Therefore, the overall **significance of the risk** of a sheen oiling seabirds is considered to be **'Low (4)'**.

10.7.7 Project-specific mitigation measures

All mitigation measures are built-in to the basis of design and the HSES-MS and are therefore taken into account in the initial impact assessment. OiW concentrations and PWRI uptime will be included within the Premier environmental objectives and targets (O&T) (Chapter 15) which are designed to ensure compliance with the HSES Policy and continual improvement. At all times, Premier will endeavor to improve upon the legally compliant OiW limits with anticipated concentrations as low as 10 - 15 mg/l.

Given that all the impacts and risks associated with operational discharges are considered to be **'Low'** or below, there is no need for project-specific mitigation measures over and above those which are built-into the basis of design and the use of environmental O&T.

10.7.8 Residual impacts and risks

Not applicable.

10.7.9 Cumulative impact

10.7.9.1 Hydrotest, wellbore clean-up fluid, cooling water and hydraulic fluid

Hydrotesting and hydraulic fluid discharges will occur in the same area where drill cuttings may have disturbed the seabed. However, it is not anticipated that this will change the predicted impacts in any significant way.

Further, owing to the degree of dispersion and the fact that no other O&G installations are operating in the Sea Lion area, no cumulative impacts are anticipated from the use of compliant operational chemicals.

10.7.9.2 Produced water, drainage and bilge discharges

Details on the potential for cumulative and chronic impacts of oil discharges from all sources are provided in Chapter 13.

10.7.9.3 Grey and black water and food discharges

All vessels discharge grey and black water and food waste at sea in line with MARPOL regulations such that there is the potential for Phase 1 discharges to lead to cumulative impacts from increased 'concentration' and increased 'extent and proportion' (section 8.10.1).

The volumes discharged are related to the number of persons on board at any given time. During the Phase 1 Development, the combined disposal of grey and black water and food waste from the MODU, FPSO and vessels will add to that produced by existing users of the marine environment therefore potentially increasing the concentration, extent and / or the duration of discharges overall.

The number of fishing vessels operating within Falkland Islands waters varies considerably throughout the year. The highest peak in number of vessels is associated with the Illex fishing season (section 7.7.3.1.1.1), when the number of vessels at sea can rise to over 130. A second smaller peak is associated with the second fishing season, which comprises loligo and finfish trawlers, with a maximum of about 40 vessels (Figure 10.40). Over the course of the year, the weekly mean number of vessels fishing within Falklands waters between 2012 and 2014 was 45 (data from FIG, 2015o).

While the number of crew on each fishing vessel varies, with an assumption of 40 crew per vessel, the total number of crew at-sea on fishing vessels peaks for a short-term at about 5,200. The addition of 120 crew on the rig, 80-120 on the FPSO and 35 on the support vessels represents a small increase (approximately 5 %) in the total number of people at-sea in the busiest period in these waters. Additional discharges to sea therefore amount to <5 % of those generated by fishing vessels per month. With the volumes estimated, these waste streams are not regarded as an environmental threat.

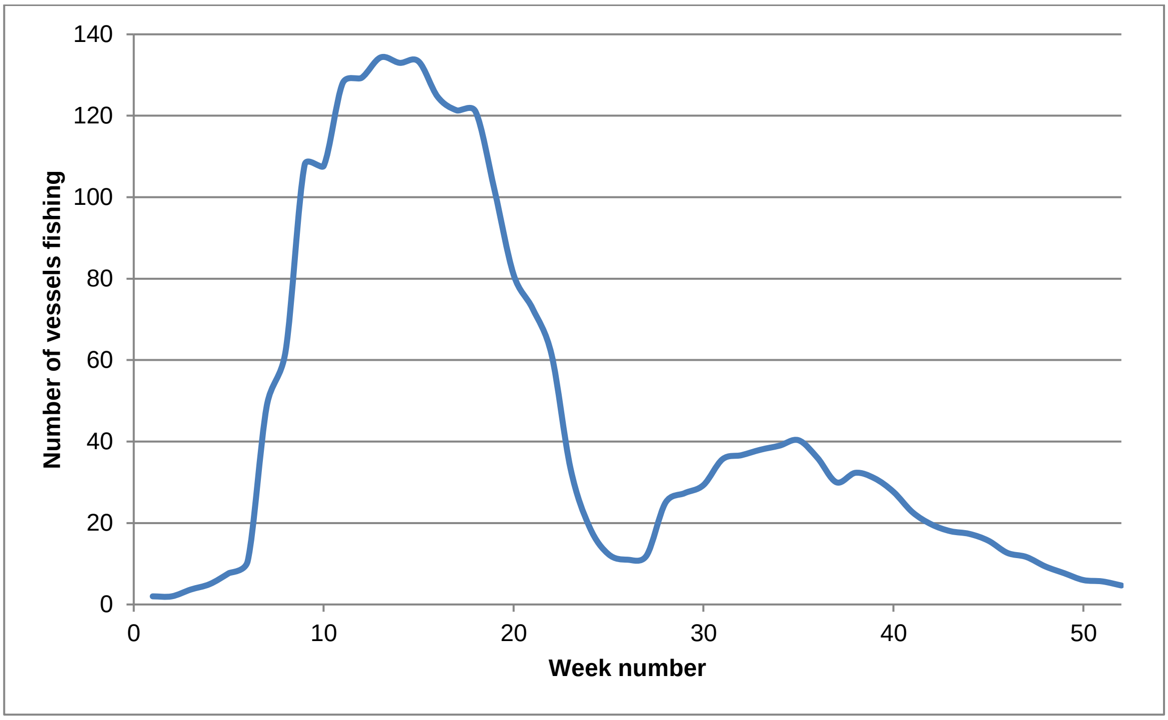


Figure 10.40: The mean number of fishing vessels operating within Falkland Islands waters on a weekly basis, between 2012 and 2014

10.7.9.4 Hypersaline discharges

Although some fishing vessels carry desalination plants, many do not such that discharges of hypersaline water from the MODU and the FPSO are not expected to add to significant existing discharges. Also, owing to the degree of dispersion and the fact that no other oil and gas installations are operating in the Sea Lion area, no cumulative impacts are anticipated from hypersaline discharges in the area.

10.7.10 Confidence

Given that the volume of hydrotest water, and the dosages of biocide in CW are as yet unknown, the confidence in both impact assessments is considered to be **'Probable'**. Similarly, while the clean-up fluids will be 'visibly clean' (section 10.7.2.1) as the concentration of OBM in the clean-up fluids is unknown, the confidence in the assessment is considered to be **'Probable'**.

PWRI has proven effective in certain reservoirs in the North Sea, the efficacy of the PWRI units with Sea Lion crude/reservoir conditions has yet to be assessed in practice. Therefore, the confidence in the impact assessment of PW discharges is considered to be **'Probable'**.

Confidence in the assessment of impacts from other discharges to sea (greywater, black water, food waste, drainage and bilge water, hypersaline discharge and clean-up fluids) and in the risk assessment is **'Certain'**.

The risks associated with PW discharges in the event of PWRI downtime were quantified with the DREAM model. However, a number of uncertainties in the model need to be considered with regard to the assumptions made (Table 10.53) and the data available in the literature was based on data which largely pertain to coastal rather than the 'open ocean'. Therefore, the confidence in the risk assessments is **'Uncertain'**.

Initial testing has indicated that Sea Lion PW is unlikely to form a sheen, and has shown that feather contact with PW does result in oil particles becoming attached to feathers, though no structural damage was observed. At this time, confidence in the assessment of oil sheen risks is **'Probable'**.

Table 10.53: Modelling uncertainties

Uncertainty	Description
Flow rates	The Phase 1 production profiles were used for the modelling of the PW and the oil flow rate was used to calculate the partitioning coefficients (the Logpow) of the chemicals. While the dosages were provided by Premier, the actual chemicals and dosages may differ when it comes to production. The volumes should be representative and the modelling has applied the best available information.
PW composition and parameters	Data on the natural composition of the Sea Lion formation water, in terms of the parameters normally used for assessing water column risk, are unavailable. The composition of a low salinity North Sea analogue was used in the model. However, as the reservoirs and geology are very different to the North Sea the composition from the lacustrine Sea Lion reservoir could vary significantly. A review of potential PW risks is recommended at a point when Sea Lion PW composition is better understood and when PW first appears in production.
Metocean data	Three years of detailed metocean data has been analysed to identify average current speeds in the Sea Lion area. Conditions used in the modelling were chosen to be the most quiescent month of the available dataset, in order to create the calmest water and thus the least dispersion. The conclusions are conservative in this respect.

10.7.10.1 Monitoring required

Oil in produced water concentrations will be monitored as standard with samples taken twice daily during any periods where it is necessary to discharge PW. Also, despite the indication that Sea Lion crude will not form a sheen, vigilance will be maintained with regard to the formation of sheens and any sheens will be reported to FIG. Further monitoring measures, such as satellite surveillance, could also identify any sheens from other sources e.g. bilge, drainage discharges or wellbore clean-up fluid to ensure that actions, if required, are correctly focused, in the event that sheens unexpectedly become an issue.

SMMOs will be posted on vessels and identification of oiled or dead birds offshore will be included in their scope. Fingerprinting of the Sea Lion crude will also allow testing of oiled birds to help determine the source of oiling.

All chemical use and discharge will be tracked and reported to FIG.

All vessels will use an Oil Record Book to record all oil discharges from drainage and bilge water and a Waste Disposal Log.

All discharges of wellbore clean-up fluid will be conducted in line with Oil and Gas UK Guidelines (section 10.7.5). A minimum of five representative samples spaced across each well operation will be sent onshore for analysis and duplicate samples retained on the rig.

Detailed monitoring requirements have been established during the Environmental Monitoring and Management Plan (EMMP) workshop. All monitoring requirements agreed by Premier and FIG will be recorded and managed via the project-specific Phase 1 EMMP (an outline EMMP is provided in Chapter 15).

10.7.11 Offsetting

As no residual impacts or risks identified in this section are considered significant, i.e. Moderate or above, offsetting is not considered (see section 8.9).

10.7.12 Findings summary

Table 10.54: Summary of the impact assessment for operational, domestic and marine discharges

Activity / Event	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Chemical discharges	Discharge of hydrotesting, wellbore clean-up fluid and cooling waters and hydraulic fluids	Impacts on water quality and potential for acute and chronic impacts on marine organisms,	Planned	1	Very Low	Slight	n/a	Very Low (1)	n/a	Probable	Industry-standard: Selection of benign chemicals where possible; OiW target of 10-15 mg/l; RBA of PW; EI (2016) Guidance; Maintenance Management System; HSES-MS; Off spec tank; and O&G UK Well Clean-up Guidelines Project-specific: None proposed.
Production from the FPSO	Discharge of PW during PWRI commissioning		Planned	2	Very Low	Moderate	n/a	Low (3)	n/a	Probable	
MODU, FPSO and vessel activity	Discharge of grey water, black water and food waste	Impact to water quality, plankton and seabirds	Planned	1, 2 & 3	Very Low	Slight	n/a	Very Low (1)	n/a	Certain	
	Discharge of drainage / bilge water	Impact on water quality	Planned	1, 2 & 3	Very Low	Slight	n/a	Very Low (1)	n/a	Certain	
	Discharge of hypersaline water	Impact to flora and fauna	Planned	1, 2 & 3	Very Low	Slight	n/a	Very Low (1)	n/a	Certain	
PWRI unavailability	Discharge of PW	Impact to flora and fauna	Unplanned	3	Very Low	Minor	Unlikely	Very Low (2)	n/a	Uncertain	

Activity / Event	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Off-spec discharge of PW / bilge / drainage	Formation of a sheen	Impacts to seabirds	Unplanned	2 & 3	Very High	Moderate	Very Unlikely	Low (4)	n/a	Probable	

a See Chapter 8 for definitions of sensitivity, severity, likelihood and significance.

10.8 Thermal discharges

Table of Contents

10.8.1 Introduction

Owing to its waxy nature, Sea Lion crude solidifies at low temperatures and it is therefore necessary to ensure that the oil remains fluid by maintaining the correct temperature. The crude has to remain hot enough to flow, but cool enough to prevent damage to flowlines and process equipment. Flow assurance is managed with flow assurance chemicals, such as wax inhibitors, and engineering solutions, such as heating and cooling systems (Section 5.8.4.1). The latter can result in the discharge of waste heat to the environment.

As described by Langford (1990), cooling systems that use seawater, and the associated discharges, can lead to environmental impacts via:

- The abstraction of large volumes of seawater;
- Entrainment of organisms on seawater intake filters;
- Entrainment and passage of organisms through the cooling system;
- The addition of biocides to the cooling water to control biofouling in the system; and
- The discharge and dispersal of heated seawater.

Many of the above were screened out during the ENVironmental Impact IDentification Workshop (ENVIID) owing to the low significance of the impacts, and the impact of biocides in cooling water is assessed in section 10.7.

Although produced water reinjection is built into the design, it may need to be disposed of overboard during PWRI system downtime or if PWRI does not deliver the anticipated reservoir pressure management. Additionally, there will be a period of commissioning where Produced Water (PW) may be discharged for between 3-6 months at the beginning of the field life. In such cases, the PW will also be at an elevated temperature and will produce a thermal plume.

Cooling water systems are used to control the temperature of engines and turbines in order to run optimally towards efficient, safe and reliable operations. The Floating Production, Storage and Offloading vessel (FPSO) in particular has turbines, compressors and pumps that require continuous cooling when operating, which is achieved by constantly pumping seawater through heat exchangers that carry heat away from the machinery. All continuous cooling water from machinery is co-mingled and discharged via the crude oil cooling water outlet and is included in the assessment. Some machinery, such as fire pumps, are used occasionally and have a dedicated discharge but such discharges are small and very intermittent and have been scoped out of this assessment.

This chapter specifically assesses the potential impacts associated with the introduction of thermal energy to the marine environment.

Note: the impacts associated with other liquid discharges are described elsewhere in this document, as described in Section 9.2.

10.8.1.1 Legislation regarding thermal discharges

No legislation is in place to govern the impacts of thermal discharge. However, the International Finance Corporation (IFC) Environment, Health and Safety Guidelines on Wastewater and Ambient Water Quality recommend that the:

> *'Temperature of waste water prior to its discharge does not result in an increase greater than 3°C of ambient temperature at the edge of a scientifically established mixing zone which takes ambient water quality, receiving water use and assimilative capacity into account.' (IFC, 2007b)*

The IFC Guidelines are mainly intended for freshwater and coastal protection. However, the intent of the guideline remains useful for offshore discharges (Genesis, 2015b). The 3°C temperature increase reflects a threshold above which impacts on aquatic biota may occur. The 'mixing zone' describes an area within which a 3°C temperature increase can be tolerated, provided it does not significantly impact the larger ecological unit or the overall success of species that traverse the area (IFC, 2007b). The mixing zone is therefore site-specific and detailed guidelines are published by the US Environmental Protection Agency on how to designate such a zone (e.g. USEPA, 1991).

10.8.2 Sources of thermal impact

The potential sources of thermal impacts during the Phase 1 Development include:

- Insulated (and thus passively heated) subsea infrastructure including insulated Subsea Production Systems (SPS) and Subsea Umbilicals, Risers and Flowlines (SURF) on the seabed.
- Heated surface discharges:
  - Continuous and planned cooling water discharges;
  - Discharge of Produced Water (PW) during commissioning of the Produced Water Re-Injection (PWRI) units (three to six months);
  - Bilge and slop water discharges; and
  - Unplanned PW discharges (under abnormal conditions only).

10.8.2.1 Heated subsea infrastructure

The produced fluids will already be at an elevated temperature. This heat is retained as much as possible using insulation to passively maintain flow assurance in the SPS and SURF. Nonetheless, some heat loss at the seabed will occur.

In the event that the production process undergoes a planned or unplanned shutdown, there is a risk that the oil in SPS and SURF could cool and cause blockages. To prevent this, active flow assurance techniques are used to keep the oil at an appropriate temperature, again which may result in the loss of heat at the seabed or in the water column via the risers.

10.8.2.2 Surface discharges of heated water

The topside cooling system will use cold seawater to absorb heat from a closed loop cooling medium circuit. The cooling medium absorbs heat from the process via a series of heat exchangers and is then re-cooled with the seawater; the warm seawater is then discharged back to sea. These cooling water (CW) discharges will be at an elevated temperature, with a maximum of around 50°C and all discharges will be planned.

A separate marine cooling system located in the engine room will use cold seawater to cool several marine systems including a closed loop cooling medium circuit for marine equipment, steam condensers for the closed loop steam system, and the fresh water generator package. All seawater will be discharged back to sea from several overboard discharge locations located in the engine room at a temperature in the region of 28°C. The discharged seawater capacity will increase during crude offloading periods to meet the additional cooling requirement from the steam turbines of the cargo offloading pumps.

Any discharges of PW will be at a temperature of approximately 90°C. However, as is described in detail in Section 10.7, the target is that PW will be reinjected into the reservoir such that no discharges will occur during steady state production. However, there may be the need to discharge the PW for three to six months while the PWRI units are commissioned. Beyond this, any discharge of PW would be due to equipment downtime or reservoir injectivity issues. In the event that both of the PWRI units fail simultaneously, it may be necessary to discharge the PW, at 90°C, for a short duration. In the event that PWRI provides adequate reservoir pressure management, as a worst case, it is estimated that PW discharges due to PWRI downtime may occur for up 7 % of each year (or 25 days). If PW proves inaffective for reservoir pressure management, due to problems with injectivity, then all produced water may require overboard disposal.

10.8.3 Potential receptors

The ENVIID workshop was used to identify those receptors upon which the impacts and / or risks of thermal discharges warranted further investigation (Chapter 9.0). These include the impacts and risks to:

- Pelagic marine flora and fauna:
- Plankton (Section 7.4.1); and
- Fish (Section 7.4.4.2).
- Benthic marine flora and fauna (section 7.4.3.2).

The above may be affected as the native marine flora and fauna normally inhabit sea temperatures ranging between 5 and 11 °C (Genesis, 2015b), although the seas in this area are fed by strong currents from both the Circumpolar Antarctic Current (via the Falklands Current) and the Brazil Current where larger extremes exist.

10.8.4 Characterising and quantifying the impacts of thermal discharges

When characterising and quantifying the potential impacts of thermal discharges it is necessary to consider:

- The behaviour and fate of thermal plumes resulting from:
  - Insulated subsea infrastructure; and

- CW and PW discharges.
- The nature of thermal impacts; and
- Quantification of the impacts and risks of thermal discharges:
  - Heated seawater resulting from subsea equipment; and
  - Modelling of the surface discharge plumes.

10.8.4.1 The behaviour and fate of thermal plumes

10.8.4.1.1 Heated subsea infrastructure and seawater

While heated SPS and SURF may elevate the temperature of surrounding water which will rise and dissipate, some heat may be transferred to the sediments directly beneath infrastructure. Local pockets of warmer water may develop adjacent to the pipelines.

10.8.4.1.2 Surface discharges of heated water

While the ambient seawater temperature may vary with season, the temperature of CW and PW will be significantly higher than the ambient temperature year-round. Nonetheless, the heat in discharges will dissipate in the marine environment as the plume mixes.

The rate at which heat is dissipated will depend on the extent and rate of mixing between the discharge plume and the receiving body of water. Continuous thermal discharges to semi-enclosed bodies of water, such as estuaries, can result in a net increase in the temperature of the water column or in stratified layers of different temperatures. However, in open ocean conditions, the plume is likely to mix more homogenously and thermal dissipation is expected to be rapid, particularly in turbulent metocean conditions.

In the event that the discharge plume is very buoyant such that it remains at the surface, some heat energy may also be lost to the atmosphere.

10.8.4.2 Nature of the impact

Both direct and indirect impacts can result from thermal discharges both at the surface and subsea.

The direct effects of thermal discharges on the marine environment are those that may affect the success of species present. These effects include:

- Alteration of the temperature regime of the water column or sediment (Langford, 1990; UKSAC, 2015), including changes to:
  - The mean temperature;
  - The maximum temperature; and
  - Temperature fluctuations and the rate of change.
  - Lethal and sub-lethal responses of marine organisms to changes in temperature regime;
  - Stimulation in productivity in a range of organisms; and
  - Reduction in the dissolved oxygen saturation.

The indirect effects of thermal discharges on the marine environment include those which may affect the larger ecological unit and include:

- Changes in the distribution and composition of communities of marine organisms.

The majority of studies into the effects of thermal energy on marine flora and fauna explore the impacts in coastal and intertidal regions receiving discharges from power generation plants. In such regions, it is recognised that discharges over a number of years can serve to increase the ambient temperature of the receiving environment (Scheil *et al*., 2004; UKSAC, 2015). However, the results presented varied. Some studies showed significant changes to community structure and species abundance in key taxa, albeit with no influx of warmer-water species (Scheil *et al*., 2004). Other studies concluded that heated effluent did not change assemblage structure or the spatial distribution of the study taxa over and above background variability (Lardicci *et al*., 1989).

With regard to the potential for impacts in the open ocean however, few data are available although it is unlikely that thermal discharges would alter the temperature of the water column in any sustained way. British Antarctic Survey (BAS) were commissioned by Premier to estimate marine growth (see section 10.3), and noted in their report that the discharge of large volumes of warm water may change local microalgal production, which has the potential to contribute to algal blooms (BAS, 2014).

With regard to the impact of heated subsea equipment, again there is a paucity of data. While it is possible that subsea sources of heat may stimulate growth in the immediate area, it is unlikely that the equipment and surrounding environment could reach lethal or sub-lethal temperatures or change the temperature of the surrounding environmental in any significant way.

10.8.4.3 Quantification of the impacts and risks

10.8.4.3.1 Heated subsea infrastructure

The aim of the insulated infrastructure is to prevent heat loss. However, whilst some heat loss from the insulated subsea infrastructure will occur, the external temperature is not expected to be much higher than the ambient temperature due to the high levels of insulation.

10.8.4.3.2 Volumes of planned PW discharges during commissioning

See section 10.7.4.4.2 above.

10.8.4.3.3 DREAM Modelling of surface CW and PW discharge plumes

The DREAM model incorporates a temperature simulation model that is capable of predicting changes in temperature in the receiving environment based on the temperature of discharged substances, the ambient conditions and thermal advection in dispersion (Genesis, 2015b). While CW discharges are planned and PW discharges once into steady state production (Stage 3) would be unplanned, the discharges of both were modelled together to capture any accumulated effect.

The following describes only the information required to ensure appreciation and understanding of the modelling results. Full details with regard to the DREAM/EIF methodology and metocean data used are given in Premier (2017d).

10.8.4.3.3.1 Discharge parameters

The discharge parameters of the CW and PW are shown in Table 10.55.

Table 10.55: Discharge parameter inputs to DREAM

Parameter		Cooling water	Produced water	Description
Discharge location	Latitude[a]	49° 16' 21.9912"S	49° 16' 21.9912"S	CW discharge is assumed to be 50 m from the PW discharge as this is the width of the FPSO.
	Longitude[a]	59° 5' 50.5"W	59° 5' 53.0042"W	
Discharge depth (m)		4 m	4 m	This is a worst case assumption as the outlets are being designed to be at minimum draught approx. 9 m below sea level, which will increase the rate of dispersion.
Discharge orientation		Vertically downwards	Vertically downwards	-
Discharge temp (°C)		50	90	-
Discharge rate	Early field life	72,000 m^3/d	1,590 m^3/d	CW discharges will be planned and, outwith the first three to six months, PW discharges will be unplanned, occurring for an estimated 7 % of the time
	Late field life		17,479 m^3/d	
Discharge salinity (PSU)		34 (seawater)	6.4	-

[a] This modelling was performed for updated discharge parameters (i.e. Produced water temperature and discharge depth) at the original FPSO location c. 2km to the north to the revised location. This distance change is not considered to have a material impact on the modelling conducted.

10.8.4.3.3.2 Understanding the model

The model results are interpreted in accordance with the IFC Guidelines which require that ambient temperature of the receiving environment is not increased by > 3°C at the edge of the 'scientifically established mixing zone' (section 10.8.1.1).

With regard to establishing the size of the mixing zone, it is necessary to consider the context of the receiving environment (USEPA, 1991). In the context of offshore thermal discharges in the OSPAR area, the edge of a 500 m radius zone around the installation is often considered an area of mixing outside which risks should be reduced to an acceptable level, and this is one way of applying the 3°C temperature increase threshold.

In other situations, it is the point at which rapid, dynamic mixing processes give way to slower, passive mixing e.g. at the edge of a 'surface boil' when considering an outfall. Other measures quoted are the water depth applied as a distance, or simply a 100 m distance as a screening tool. In the absence of precedents in the North Falkland Basin (NFB), the distance of 100 m can be applied as a conservative test, such that if the threshold were not met in this distance, it would warrant more detailed consideration. Therefore, an increase of 3°C within 100 m of the discharge point has been applied as a zone to reflect the IFC standard. The results of the model are expressed as the temperature difference between the water within the mixing zone and the yearly average ambient temperature which in the NFB is assumed to be 8°C.

10.8.4.3.3.3 Model results

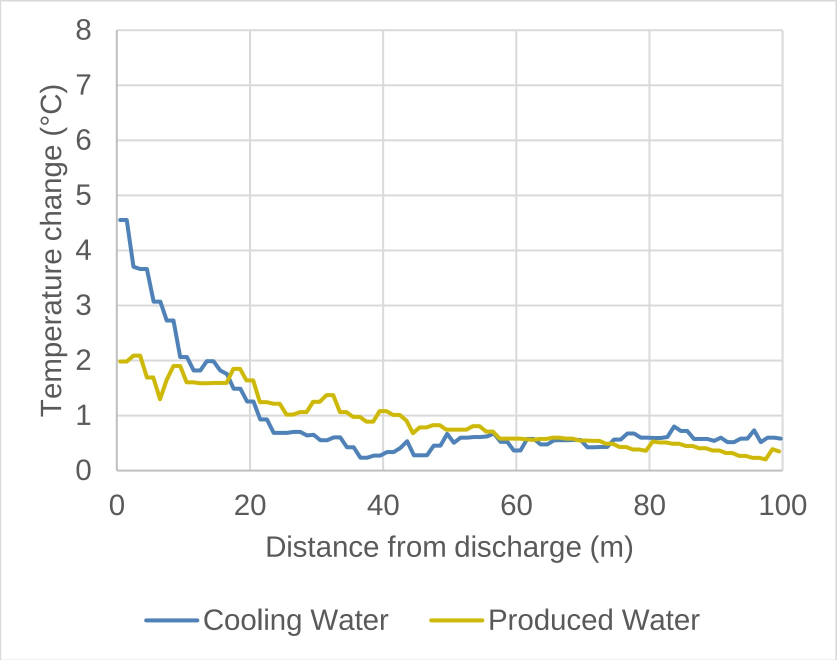
The maximum temperature differences between the mixing zone and ambient seawater at increasing distance from the discharge point are plotted in Figure 10.41 for early and late field life. Figure 10.42 shows the instantaneous temperature difference at a single moment in time between the mixing zone and ambient water during early and late field life. Cross sections through the water column of both the CW and PW plumes are shown below the plots in Figure 10.42. To present the worst case modelling results, these plots indicate the temperature differences during quiescent metocean conditions which would result in the poorest dispersion of the discharge.

Results of the model indicated that:

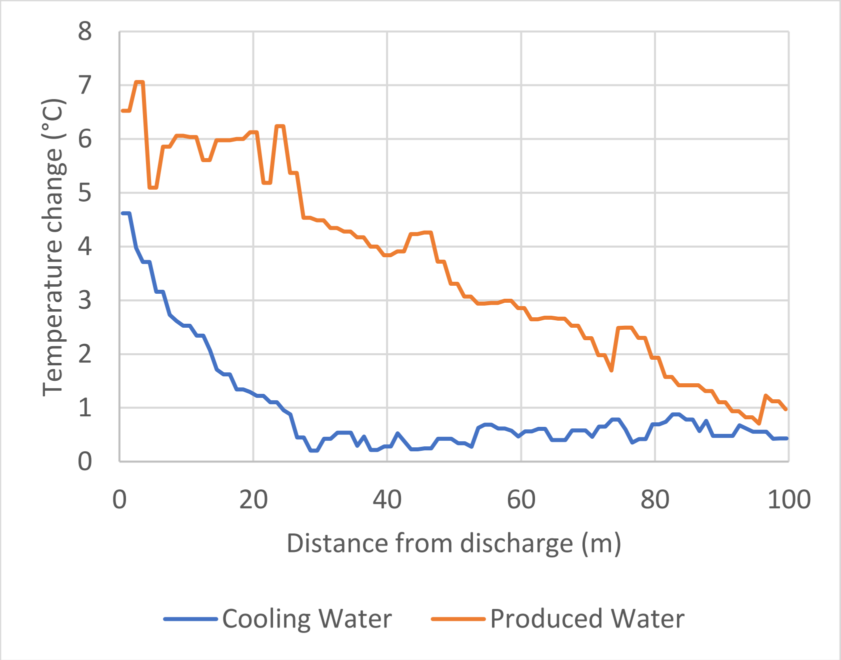
- The CW plume cools down rapidly after release and drops to < 3°C above ambient within 10 m during both early and late field life (Figure 10.41);
- The PW plume cools down rapidly after release and drops to < 3°C above ambient within 10 m during early field life and within 50-60 m in late field life (Figure 10.41) owing to the differences between the daily PW flowrates at these times (Table 10.56 above) and the subsequent increase in volume.

Note that while the daily flowrate of PW in late field life is less than that of CW, the combination of the increased PW volume at 90°C alters the outcome (Table 10.56 above).

Increases in temperature caused by both CW and PW do not extend below the top 30 m of the water column (Figure 10.42).

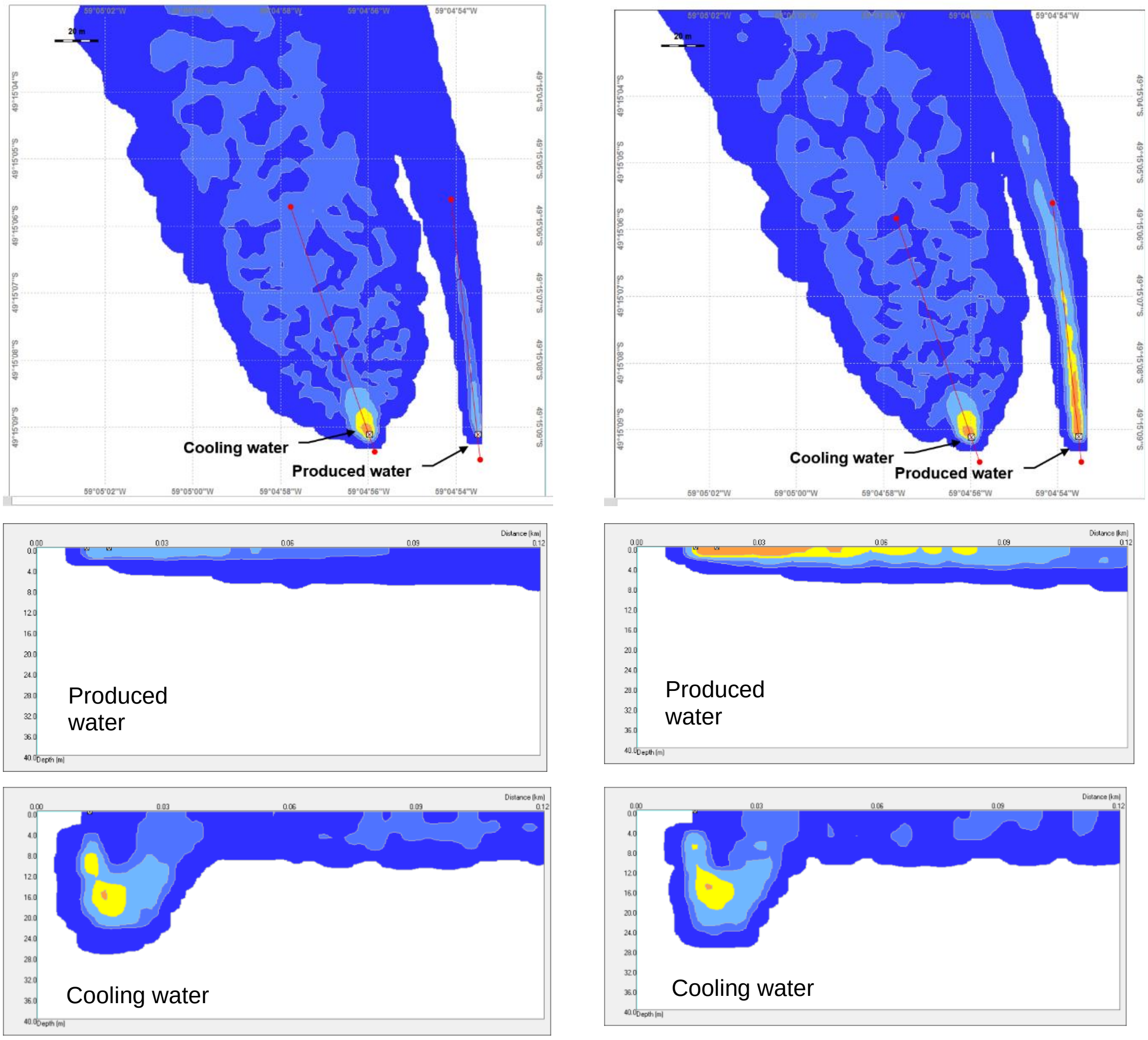


a) Early field life



b) Late field life

Figure 10.41: Graphs of maximum temperature difference from ambient seawater for both PW and CW discharges in early and late field life



a) Early field life

b) Late field life

Figure 10.42: Plots of temperature differences (°C) from ambient seawater for both PW and CW discharges in early and late field life

10.8.5 Industry-standard mitigation measures

No industry-standard mitigation measures exist for the management of thermal discharges, although it is common for discharges to be assessed against IFC standards.

10.8.6 Impact and risk assessment

10.8.6.1 Impact assessment of thermal discharges

The following section draws upon all the information provided above to assess the 'Sensitivity of the Receptor' and the 'Severity of Effect' in order to determine the overall 'Impact' of planned activities. Assessment of unplanned events includes an assessment of the 'Likelihood of Occurrence' to determine the 'Risk'.

A summary of the impact and risk assessment outcomes is tabulated in section 10.8.12, which shows the worst case impact / risk for each activity and receptor.

10.8.6.1.1 Heated subsea infrastructure on the benthos

In the event that the subsea equipment releases sufficient heat to warm the sediment and / or the surrounding seawater, it is possible that this may impact directly upon the benthic fauna in the immediate area. Given that any populations which may be affected are not of geographical importance however, and the habitat is undesignated, the **sensitivity of the receptor** is considered to be **'Very Low'**.

Equally, any effect from the heat generated by the subsea equipment is likely to be highly localised such that it is very unlikely that any impacts will be detectable above background levels. Therefore, the **severity of effect** is considered to be **'Slight'**.

Therefore, the **significance of the impact** of the temperature of subsea infrastructure is considered to be **'Very Low (1)'**.

10.8.6.1.2 Cooling water discharges on pelagic receptors

As described in section 10.8.4.2, the majority of studies into the impacts of thermal discharge plumes relate to coastal and intertidal regions. Discharges of CW will be to the open ocean and temperature increases of > 3°C are restricted to within 10 m of discharge source. Therefore, these increases will not impact any species of geographical importance at a population level such that the **sensitivity of the pelagic receptors** is considered to be **'Very Low'**.

The turbulent metocean conditions in the Sea Lion area are such that it is unlikely that impacts will be detectable above background variability. Given that the temperature differences are < 3°C well within the 'edge' of the 100 m mixing zone (section 10.8.4.3.3), the **severity of effect** is considered to be **'Slight'**.

Therefore, the overall **significance of the impact** from the planned discharge of CW is considered to be **'Very Low (1)'**.

10.8.6.1.3 Produced water discharges during commissioning

Discharges of PW during commissioning are expected to last for between three and six months only. This will create minimal change in water temperature differences for a short period of time. Discharges of PW will be to the open ocean and temperature increases of > 3°C are restricted to within 10 m of discharge source. Therefore, these increases will not impact any species of geographical importance at a population level such that the **sensitivity of receptors** is considered to be **'Very Low'**.

The turbulent metocean conditions in the Sea Lion area are such that it is unlikely that impacts will be detectable above background variability. Given that the temperature differences are < 3°C well within the 'edge' of the 100 m mixing zone (section 10.8.4.3.3), the **severity of effect** is considered to be **'Slight'**.

Therefore, the **significance of the impact** for the short-term planned discharge of PW is considered to be **'Very Low (1)'**.

10.8.6.2 Risk assessment of thermal discharges

10.8.6.2.1 Produced water discharges

The modelling results described in section 10.8.4.3.3, indicate that unplanned discharges of PW will create minimal change with water temperature differences falling below the IFC threshold of 3°C within 10 m of the discharge during early field life and 50-60 m in late field life. Therefore, the **significance of the impact** for the unplanned discharge of PW is the same as that for the planned discharge of CW and is considered to be **'Very Low (1)'**.

Given that the base case is to re-inject PW using two PWRI units, the **likelihood of occurrence** of PW being discharged is considered to be **'Possible'**.

Therefore, the overall **significance of the risk** is considered to be **'Very Low (3)'**.

10.8.7 Project-specific mitigation measures

Given that the impacts and risks of thermal discharges are 'Very Low', no project-specific mitigation measures are required.

10.8.8 Residual impacts and risks

Not applicable.

10.8.9 Cumulative impact

No cumulative effects are anticipated.

10.8.10 Confidence

Confidence in the impact assessment for heated subsea equipment is **'Probable'** owing to the lack of data on the level of heat loss that may occur and the potential impacts.

With regard to CW and PW, while the literature only describes the impacts of thermal discharges on coastal and intertidal regions, the DREAM modelling was used to quantify the distance at which the discharge plume will have returned to ambient levels. There is an additional uncertainty around the influence of a continuous heated discharge stream (CW) and algal blooms. Therefore, confidence in the impact assessment for CW discharges is **'Probable'**, and the impact and risk assessments for PW discharges are considered to be **'Certain'**.

10.8.10.1 Monitoring required

No specific monitoring over and above any legal or Premier's corporate standards have currently been identified. Detailed monitoring requirements have been established during the Environmental Monitoring and Management Plan (EMMP) workshop. All monitoring requirements agreed by Premier and FIG will be recorded and managed via the project-specific Phase 1 EMMP (an outline EMMP is provided in Chapter 15).

10.8.11 Offsetting

As no residual impacts or risks identified in this section are considered significant, i.e. Moderate or above, offsetting is not considered (see Section 8.9).

10.8.12 Findings summary

Table 10.56: Summary of the impact assessment for thermal discharge

Activity / Event	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Insulated subsea infrastructure (passive)	Radiation of heat	Potential to heat surrounding sediment and water with effects on benthic flora	Planned	2 & 3	Very Low	Slight	n/a	Very Low (1)	n/a	Probable	Industry-standard: None Project-specific: None proposed
Topside cooling process	Discharge of cooling water (50°C)	Potential for direct and indirect impacts on flora and fauna from heated discharge	Planned	2 & 3	Very Low	Slight	n/a	Very Low (1)	n/a	Probable	
Production from the FPSO	Discharge of PW (90°C) during PWRI commissioning		Planned	2	Very Low	Slight	n/a	Very Low (1)	n/a	Probable	
PWRI malfunction or injectivity failure	Discharge of PW (90°C)		Unplanned	2 & 3	Very Low	Slight	Possible	Very Low (3)	n/a	Certain	

[a] See Chapter 8.0 for definitions of sensitivity, severity, likelihood and significance

10.9 Atmospheric emissions (climatic factors)

Table of Contents

10.9.1 Introduction

Numerous activities associated with the Phase 1 Development will generate atmospheric emissions and this was raised as a concern by stakeholders during scoping consultations (Chapter 6.0).

Atmospheric emissions and changes in air quality can result in:

- Global and transboundary environmental impacts e.g. global warming, ocean acidification and acid deposition (e.g. acid rain);
- Social impacts e.g.:
  - Impacts on local air quality and human receptors; and
  - Impacts on the human population with regard to nuisance factors such as odour.

This chapter assesses the environmental impacts (climatic factors) of atmospheric emissions.

As described in Premier's Carbon Strategy, Premier acknowledges the weight of scientific research indicating the challenges faced in human-induced climate change. Therefore, reduction in emissions is a focus within the project design and a number of emission reduction technologies have been built-in to the basis of design (section 5.13) to optimise energy efficiency. The majority of emissions will arise from the combustion of fossil fuels during the transportation of goods and personnel by sea, air and road and from power generation on the FPSO.

Note: With respect to vessel emissions, the EIS assesses all project vessels including, for oil export, the emissions from the CTT and attendant vessels in Direct Offtake operations. . The following chapter assesses the impact of the atmospheric emissions resulting fromoffshore and inshore / onshore operations to ensure the worst case scenario has been assessed.

Note: the potential impact of emissions on air quality and human health are assessed in section 11.12 and the impact of emissions from a nuisance perspective, e.g. odour, is assessed in section 11.10. Other impacts related to vessel and helicopter use are described elsewhere in this document, as described in section 9.2.

10.9.1.1 Relevant legislation

Conventions, legislation and strategies relevant to atmospheric emissions in the Falkland Islands are:

- International protocols and conventions:
  - Kyoto Protocol to the United Nations Framework Convention on Climate Change.
  - Paris Climate Agreement, United Nations Framework Convention on Climate Change (starting 2020).
  - International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78 Annex VI on the Prevention of Air Pollution from Ships.
  - Montreal Protocol 1987.
- UK Legislation that may be relevant:
  - Climate Change Act 2008.

  - Offshore Combustion Installations (Prevention and Control of Pollution) Regulations 2001 (Amendment) Regulations 2007.
  - The Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2008.
  - Ozone Depleting Substances (ODS) Regulations 2015.
  - Fluorinated GHGs Regulations 2015.
- FIG Energy Strategy (FIG, 2015w):

Under the above, there are numerous compliance requirements with regard to emissions.

10.9.1.1.1 Greenhouse gas emissions compliance

There are seven direct greenhouse gases (GHGs) that directly trap heat into the atmosphere, the primary GHG being carbon dioxide. These are governed by the Kyoto Protocol which came into force in 2005 and is a legally binding international treaty. Under the Kyoto Protocol, national emissions limits are set for each contracting party (i.e. each country which is party to the Protocol). These limits restrict the total volume of carbon dioxide and other greenhouse gas emissions which can be emitted by the contracting party over a five year period. There are also four indirect GHGs which can affect the climate depending on atmospheric chemistry and are reported on, but for which targets are not set.

Under the first Kyoto commitment (2008-2012), countries that were party to the protocol agreed to reduce GHG emissions by an average of 5.2 % by 2012 when compared to 1990 levels. Under the second Kyoto commitment (the 'Doha Amendment') which runs from 2013 to 2020, the remaining participants agreed to cut emissions by an average of 18 % by 2020, again compared to 1990 levels.

As a United Kingdom Overseas Territory (UKOT), the Falkland Islands are not subject to the European Union Emissions Trading Scheme (EU ETS) which was designed to facilitate the reduction in emissions. However, the Islands are bound by the Kyoto Protocol and are required to comply with it, although in practice, the UK performs the obligations related to the protocol on their behalf. Therefore, Falkland Islands' emissions are reported by the UK and are taken into account when assessing compliance with the UK's Kyoto target. The Islands are therefore expected to introduce policies in line with the objectives of the UK Climate Change Programme in driving energy efficiencies.

The FIG Energy Strategy (2015v) has an objective to:

> *'ensure that the emissions from hydrocarbons activity which does not take place on shore are as low as is practicable'.*

It should be noted that the future of the Kyoto Protocol as a tool for reducing, and reporting on, GHG emissions beyond 2020 is uncertain. Currently, negotiations continue as to whether or not the Kyoto protocol remains fit for purpose or whether another international treaty should be developed for use beyond 2020 (Demaze, 2013).

10.9.1.1.1.1 Climate Change Act 2008

Under the Climate Change Act 2008 national (UK) emissions of all Kyoto GHG must be cut by at least 80 % of 1990 levels by 2050. The Act provides a framework for reaching this target in stages over the years leading up to 2050 by setting carbon budgets which cap the GHG emissions allowed in each five year period. An independent Committee on Climate Change has been created under the Act to provide advice to the UK Government on these targets and related policies. The first four carbon budgets have now been set by legislation. They cover 2008-2012, 2013-2017, 2018-2022 and 2023-2027. The fifth carbon budget (2028-2032) has been proposed and is currently going through the UK Parliament.

10.9.1.1.2 Fluorinated Gas compliance

Fluorinated gases (F-Gases) are man-made gases which were designed to replace Ozone-Depleting Substances (ODS) for use within refrigerants, solvents, foam blowing agents, fire-fighting fluids and HVAC (heating, ventilation and air-conditioning). F-Gases do not deplete the ozone layer, are energy efficient and are safe due to their low levels of toxicity / flammability. However, despite not harming the ozone layer, F-Gases are very powerful GHGs and as such, the emission of F-Gases is prohibited and all unplanned releases must be reported.

Further, under the Climate Change Act, the Committee on Climate Change has proposed that F-Gases be replaced by low-carbon alternatives in refrigeration, air conditioning and other uses by 2030.

10.9.1.1.3 Ozone Depleting Substances (ODS) compliance

Under the Montreal Protocol (which is aligned with MARPOL 73/78 Annex VI), the use of ODSs is being phased out. The phase-out of most ODS's is now complete. Notwithstanding critical use exemptions, the use of virgin and reclaimed / recycled Halon and chlorofluorocarbons (CFCs) in new equipment and during maintenance is now prohibited.

Similarly, the use of new hydrochlorofluorocarbons (HCFCs) is prohibited and the use of reclaimed / recycled HCFCs must be phased out by 1st January 2020 (or by 2015 under the UK ODS regulations).

10.9.1.1.4 MARPOL Annex VI on energy efficiency in shipping

In 1973, IMO adopted the International Convention for the Prevention of Pollution from Ships, now known universally as MARPOL. The convention has been repeatedly amended and updated by the Marine Environmental Protection Committee (MEPC). Annex VI was introduced in 1997 and is concerned with both the prevention of air pollution and with energy efficiency by shipping.

10.9.1.1.4.1 Air pollution (ODS, NOx, SOx and VOCs)

The aim of Annex VI is the progressive reduction in global emissions of oxides of sulphur (SOx), oxides of nitrogen (NOx), Volatile Organic Compounds (VOCs) and Particulate Matter (PM) by shipping and the introduction of emission control areas (ECAs) to further reduce emissions of the above in designated sea areas.

Further detail on the requirements of Annex VI are provided in:

- Section 11.12, which assesses impacts on air quality and human receptors in Berkeley Sound; and

- Section 11.10, which assess the impact of emissions from the perspective of odour.

10.9.1.1.4.2 GHG and energy efficiency in shipping

CO_2 emissions from international shipping cannot be attributed to any particular national economy due to its global nature and complex operation such that shipping is not included within the Kyoto Protocol. Therefore, in 2011, the IMO MEPC adopted mandatory technical and operational energy efficiency measures which are expected to significantly reduce the amount of CO_2 emissions from international shipping. Chapter 4 of MARPOL Annex VI (and associated amendments to Chapter 1 and 2) came into force in 2013. Chapter 4 applies to all ships of > 400 gross tonnage and requires the following:

- Mandatory:
  - Energy Efficiency Design Index (EEDI), for new ships; and
  - Ship Energy Efficiency Management Plan (SEEMP), for all ships.
- Voluntary:
  - Use of the Energy Efficiency Operational Indicator (EEOI).

The EEDI aims to promote the use of more energy efficient equipment and engines but as it applies to new ships only, including oil tankers, bulk carriers, general cargo and container ships, it is unlikely this will apply to any vessels used for the Sea Lion project.

The Ship Energy Efficiency Management Plan (SEEMP) is a management tool and establishes a mechanism for ship operators to improve the energy efficiency of a ship during its operation lifecycle, in a cost-effective manner. It works according to planning, implementation, monitoring and review of a number of energy efficiency measures within a continuous improvement management cycle (IMO, 2016b).

The EEOI is a performance monitoring tool used to:

- Measure fuel efficiency in different operational modes (e.g. vessel speed, trim and draft); and
- To gauge the effect of changes in operation such as improved voyage planning, more frequent propeller cleaning and / or the introduction of technical measures such as waste heat recovery systems or a new propeller (IMO, 2016b).

By enabling identification of the most fuel efficient modes of operation, the EEOI may be used to inform key performance indicators within the SEEMP (IMO, 2016b). Premier will ensure the CTT owner uses the EEOI when developing KPIs related to their operation.

10.9.2 Sources of atmospheric emissions which affect the environment

The main sources of emissions from the Phase 1 Development which may impact upon the environment include:

- Gaseous emissions from planned activities:
  - Combustion activities:
- Use of vessels during all operations;

- Transportation of personnel and equipment via vessels, road vehicles and helicopters and fixed-wing flights;
- Fuel combustion for power generation on the Mobile Offshore Drilling Unit (MODU) and the Floating Production, Storage and Offload Unit (FPSO) during construction, production and offloading;
- Well clean-up of four wells and potentially an additional 18 wells (worst case) via the MODU;
- Maintenance of the High Pressure (HP) flaring pilot light;
- Combustion of gas during flaring of produced gas during planned shutdowns;
- Fuel combustion by vessels during all operations;
- Operation of the onshore supply base and the Temporary Dock Facility (TDF);
- Incineration of combustible waste at the onshore supply base (if required); and
- Use of diesel generators at the onshore supply base. and
- Emissions during diesel bunkering to LTVs in Berkeley Sound; and
- Emissions during cargo offloading / transfer from the FPSO to the CTT.
- Gaseous emissions during unplanned or emergency events:
- Emergency blowdown (the rapid depressurisation of high pressure vessels and pipelines and flaring of the gas for safety purposes);
- Venting of hydrocarbon gas blankets used to buffer the FPSO cargo tanks in the event that the Vapour Recovery Package fails; and
- Accidental release of F-Gases.

Details on the use of vessels, helicopters and fixed wing flights during Stages 1 to 3 of the Development are provided in section 5.11 of the Development Description.

Note: in compliance with the Montreal Protocol (section 10.9.1.1.3) no ODS will be used during the Phase 1 Development. Therefore, these are not listed as a source of emissions. To ensure compliance with the Montreal Protocol, all vessels will be audited prior to selection in line with Premier's Contractor Management Strategy (section 3.2.17). This is also ensured by compliance with MARPOL certification requirements during routine vessel registration.

10.9.3 Potential environmental receptors

The ENVironmental Impact IDentification (ENVIID) workshop was used to identify those receptors upon which the impacts and / or risks of emissions warranted further investigation (Chapter 9.0). These include the impacts and risks to:

- The global atmosphere and the incremental and transboundary effects on:
  - Global warming (via the emission of GHG gases);
  - Oceanic water quality (via ocean acidification); and
  - Soil quality, water quality and / or flora and fauna (via acid deposition).

Note that the impact of emissions on local air quality and odour on the local human population as a receptor are described in sections 11.10 and 11.12 respectively.

10.9.4 Characterising and quantifying the impacts and risks

When characterising and quantifying the global and transboundary environmental impact of emissions, it is necessary to consider the following:

- The characteristics, sources, composition and behaviour of gaseous emissions;
- The nature of the impacts;
- The emissions context e.g.:
  - Historic Falkland Islands' emissions;
  - Historic UK emissions; and
  - Projected future UK emissions.
- Quantification of emissions from Phase 1 activities providing:
  - Detail on the emissions factors used;
  - Estimation of planned emissions; and
  - Estimation of unplanned emissions:
    - Emergency blowdown
    - Venting emissions offshore in event of VRP failure; and
    - F-gas release.
- Comparison of Phase 1 emissions with existing context:
  - Comparison with historic GHG emissions;
  - Comparison with projected future GHG emissions; and
  - Comparison of NOx and SOx emissions.

10.9.4.1 Characteristics, sources, composition and behaviour of emissions

Gases are emitted through the combustion of fossil fuels (which results in the emission of CO_2, NOx, SOx and CO) and the venting of gases (i.e. CH_4 and NMVOCs) (Table 10.57). All of these gases can impact upon global warming while CO_2 contributes to ocean acidification and NOx and SOx can lead to acid deposition.

Under the Kyoto Protocol, gaseous emissions can be grouped into direct GHGs and indirect GHGs. Each of these GHGs has the potential to contribute to global warming to differing extents and in order to estimate the impact of emissions, it is necessary to understand the Global Warming Potential (GWP) of each gas. The direct and indirect GHGs are described below followed by an explanation of the GWP.

10.9.4.1.1 Direct (Kyoto) GHGs

Direct GHGs include those that directly result in radiative warming of the atmosphere. These include gases that result from combustion (e.g. CO_2, N_2O), venting (e.g. CH_4) and the F-Gases which are used in closed systems e.g. HVAC. Together these make up the Kyoto 'basket' of gases. The Kyoto gases that are relevant to the oil and gas (O&G) industry are listed in Table 10.57.

10.9.4.1.2 Indirect GHGs

In addition to the direct GHGs, there are four gases that result from combustion and venting of fossil fuels which have an indirect GHG effect by increasing ozone (O_3) concentrations in the tropospheric layer (the lower 5-10 miles of the atmosphere) (section 7.3.1.1). These gases are listed in Table 10.57.

Specifically, O_3 in the tropospheric layer is produced when nitrogen oxides (NOX), carbon monoxide (CO), sulphur dioxide (SO_2) and non-methane volatile organic compounds (NMVOC) react with sunlight such that these gases are known as ‘ozone precursors’ (Table 10.57).

Ozone is a GHG in its own right with a 100-year GWP of 1,000 (i.e. 1 tonne of O_3 is 1,000 times as powerful as CO_2 in its contribution to global warming) such that its creation can exacerbate global warming. Generally, however, tropospheric ozone is a short-lived GHG which decays in the atmosphere much more quickly than CO_2. In addition to impacts upon global warming, the indirect GHGs are those which react in the atmosphere to produce acid rain (Table 10.57).

Tropospheric ozone formation, however, requires a dynamic photochemical reaction including oxides of nitrogen that are sustained over daily cycles and occurs in or downwind of large conurbations that have sustained levels of NOx. It is unlikely to occur in remote, well mixed locations such as at Sea Lion where background levels of NOx are extremely low. The relatively high precipitation in this region that will remove soluble gases such as NOx and the lack of significant natural or other anthropogenic sources are all indicators that significant ozone formation is unlikely.

10.9.4.1.3 Global Warming Potential

The GWP of a gas is most commonly used to indicate how much heat would be absorbed by a gas over a 100 year period and is determined by understanding:

- How well the gas absorbs heat energy (preventing the heat from escaping to space); and
- How long the gas stays in the atmosphere.

To estimate the impact of each gas, all gases are compared to CO_2, which has a GWP of one (1). Therefore, the higher the GWP, the great the influence a given gas has on global warming. When the GWP is applied to the estimated emissions for different gases, the result is expressed as the ‘Carbon Dioxide Equivalent’ (CO_2e); i.e. the equivalent amount of CO_2 that would have to be produced to result in the same degree of global warming.

The Intergovernmental Panel on Climate Change (IPCC) conducts periodic assessments on human induced climate change and, based on the most recent scientific understanding, publishes the most up-to-date GWPs for each GHG. These vary slightly over time and may vary over the life of the Project. Currently, all contracting parties to Kyoto should use the GWPs provided in the IPPC Fourth Assessment Report (AR4) 2007 (IPCC, 2007) (Table 10.57). However, to enable comparison with existing data such as historic Falkland Islands and UK emissions, the GWP factors previously used under the Second Assessment Report (SAR) are also shown in Table 10.57.

The most recent assessment is the IPCC Fifth Assessment Report (AR5) 2013 (IPCC, 2013). However, with regard to future reporting, there is no guidance on whether or not the AR5 GWPs should be used and the future of the Kyoto Protocol beyond 2020 is uncertain. Phase 1 emission reporting requirements will adhere to applicable guidance on GWPs issued nearer the time.

Table 10.57: Summary of the direct (Kyoto) and indirect greenhouse gases, the GWP, source and impact as a pollutant

Greenhouse Gas	GWP [a]		Source and behaviour	Impacts upon
	SAR [b]	AR4 [c]		
Kyoto (Direct) GHGs [c]				
Carbon dioxide (CO_2)	1	1	CO_2 is emitted through fuel combustion. It serves as the baseline for other GWP values. CO_2 remains in the atmosphere for a very long time and changes in atmospheric CO_2 concentrations persist for thousands of years.	Global warming Ocean acidification
Nitrous oxide (N_2O)	310	298	N_2O is typically emitted through fuel combustion. N_2O emitted today remains in the atmosphere for up to 170 years.	Global warming Acid rain Air quality [d]
Methane (CH_4) [e]	21	25	While some CH_4 is emitted via the combustion of fuels, CH_4 is typically emitted through natural gas venting. While CH_4 absorbs more heat energy than CO_2, it is mostly removed from the atmosphere after about 12 years by chemical reaction.	Global warming
F-Gases:			F-Gases are not emitted during the course of normal operations.	Global warming
HFCs [f]	140-11,700	12-14,800		
PFCs [f]	6,500-9,200	7,390-12,200		
SF_6 [f]	23,900	22,800		
Indirect GHGs				
Nitrogen oxides (NOX)	-	- g	NOx are produced during the combustion process when nitrogen and oxygen are present at elevated temperatures. Nitrogen oxides (NOx) consist of nitric oxide (NO), nitrogen dioxide (NO2) and nitrous oxide (N_2O). Their lifespans in the atmosphere range from one to seven days for NO and NO2, to 170 years for N_2O. Additionally, NOx are both ozone precursors and are formative in the development of hydroxyl (OH) groups which destroy CH_4.	Global warming via ozone production Global cooling via destruction of CH_4 Acid rain Air quality [d]

Greenhouse Gas	GWP [a]		Source and behaviour	Impacts upon
	SAR [b]	AR4 [c]		
Sulphur dioxide (SO_2)	-	-	SO_2 is produced from the burning of fossil fuels that contain sulphur e.g. coal and oil. SO_2 dissolves easily in water to form sulphuric acid and is also an Ozone precursor.	Global warming via ozone production Global cooling from aerosol formation Acid rain Air quality [d]
Carbon monoxide (CO)	-	1.9	CO is produced by the incomplete burning of fossil fuels, including natural gas. CO is unique among pollutants in the lower atmosphere in that it lasts for approximately one month which is long enough for it to be transported long distances but not long enough to be distributed uniformly. CO is also an ozone precursor and reduce OH thus reducing CH_4 destruction	Global warming via ozone production Air quality [d]
Non-methane volatile organic compounds (NMVOC)	-	2.5 h	NMVOCs are organic compounds that easily become vapours or gases. They include non-methane hydrocarbons (NMHC) and oxygenated NMHC (e.g. alcohols, aldehydes and organic acids). Along with carbon, they contain elements such as hydrogen, oxygen, fluorine, chlorine, bromine, sulphur or nitrogen. Many VOCs can react with other air pollutants to produce ground level ozone.	Global warming via ozone production

a 100-year GWP

b In order to enable 'like-for-like' comparison between the estimated Phase 1 Development emissions and the 2012 Falkland Islands and UK emissions, the GWPs from the IPCC Second Assessment Report (SAR) (IPCC, 1995) are used below. Note that these give no GWP for the indirect GHGs.

c In order to compare the Phase 1 emissions with the projected future UK emissions, the GWPs published in the Fourth Assessment Report (AR4) (IPCC, 2007) are used, as is required from 2015 according to the UN Report on the Conference of the Parties (UN, 2012). Note that once into production in 2020, the current guidance on GWPs will be applied for all Phase 1 emissions reporting.

d Air quality impacts on the human population from, NOx, SOx and CO emissions are assessed in section 11.12, which provides further detail on the behaviors of these gases as they relate to human health.

e The GWP for methane includes indirect effects of tropospheric ozone production and stratospheric water vapour production.

f HFC = Hydrofluorocarbons, PFC = Perfluorocarbons and SF_6 = Sulphur hexafluoride.

g The short lifetime and complex nature of the impact of NOx on global warming through ozone enhancement against and CH_4 reduction, make calculations of GWP for NOx emissions very uncertain (IPCC, 2007). The net radiative forcing of NOx emissions depends strongly on the location of emission and seasonal and daily timing. Due to the lack of agreement among the available studies even on the sign (i.e. positive or negative) of the GWP for NOx, a central estimate for the 100-year GWP for NOx is not presented.

h GWP averaged over 10 NMVOCs listed in the IPCC AR4 (IPCC, 2007).

10.9.4.2 Nature of the impact

The potential impacts to the varying receptors result from the following processes:

- Global warming from the emission of combustion and other GHGs;
- Ocean acidification from the emission of CO_2; and

- The formation of acid rain.

10.9.4.2.1 GHGs and global warming

While the greenhouse effect is a natural and essential dynamic, which is required to enable life on earth (section 7.3.1), the increasing quantity of anthropogenic GHGs in the atmosphere accelerates the process with the result of long-term global warming. According to the IPCC (2014) recent anthropogenic emissions of greenhouse gases are the highest in history and changes in climate have caused impacts on natural and human systems on all continents and across the oceans.

The global consequences of atmospheric emissions are generally believed to include:

- Rising sea levels owing to the melting of Arctic, Antarctic and worldwide glacial ice:
  - Changing coastlines.
- Changing climate zones:
  - Ecological impacts to ecosystems and biodiversity; and
  - Economic impacts on infrastructure, agriculture and tourism.

It is anticipated that many aspects of climate change and its associated impacts will continue for centuries, even if anthropogenic emissions of GHG were to cease now (IPCC, 2014). The above impacts are acknowledged in Premier's Carbon Strategy which aims to minimise Premier's contribution to global GHG emissions.

According to the FIG Energy Strategy (FIG, 2015w), an ongoing project is being carried out by Upson *et al*., (2016) under the TEFRA (Terrestrial Ecosystems of the Falklands – a climate change Risk Assessment) project to consider the impacts of climate change on the terrestrial environment of the Falklands. The following potential impacts are identified:

- Changes in plant pests, diseases and invasive plants;
- Increased drying and erosion of soils;
- Inability of native plants unable to shift ranges or track changes in situ in order to survive predicted warming; and
- Habitat disturbance by extreme events from, for example, increased risk of fires and decreases in soil carbon content.

10.9.4.2.2 Ocean acidification

CO_2 is highly soluble in water and consequently the oceans absorb CO_2 from the atmosphere by direct air-sea exchange making the oceans a global 'carbon sink' (i.e. a natural body which reduces carbon in the atmosphere). The exchange process equilibrates surface water CO_2 to atmospheric levels within a timescale of approximately one year (Doney *et al*., 2009). While the absorption of CO_2 from the atmosphere into the oceanic carbon sink could be beneficial with regard to global warming, there is an associated cost.

When CO_2 dissolves in seawater it forms carbonic acid (H2CO3). Over long timescales this reaches an equilibrium, and the chemical dynamics of carbonic acid in seawater serve to buffer pH in a relatively narrow range. However, recent increases in atmospheric CO_2 concentrations are resulting in a change to this equilibrium and a decrease in the pH, thus moving oceans toward a more acidic state. Increasing atmospheric CO_2 concentrations are expected to decrease surface ocean pH by 0.3 – 0.5 units by 2100 (Caldeira and Wickett, 2003; Orr *et al*., 2005).

In addition to CO_2, the emission of NOx and SOx from emissions in the form of wet and dry acid deposition can also contribute to global ocean acidification (Doney *et al*., 2007). Atmospheric inputs of the dissociation products of nitric acid (HNO3) and sulphuric acid (H2SO4) alter surface seawater alkalinity, pH, and inorganic carbon storage. Acid deposition of this kind does create an interesting dynamic however as the decrease in surface alkalinity drives a net air–sea efflux of CO_2, which actually reduces the surface levels of dissolved inorganic carbon so that the effects can offset each other, and the overall decline in surface pH is small (Doney *et al*., 2007).

The main effect of ocean acidification is the lowering of calcium carbonate saturation states, which impacts upon shell-forming marine organisms from plankton to benthic molluscs, echinoderms, and corals (Doney *et al*., 2009). Quantification of the impact of acidification on the ability of individual species to calcify remains elusive. However, reduced skeletal growth under increased CO_2 levels has already been shown for corals, molluscs and many other marine organisms (Metalpa *et al*., 2011).

10.9.4.2.3 NOx, SOx and acid deposition

Acid deposition is a broad term that describes several ways through which acid falls out from the atmosphere. These emissions can be dry or wet (acid rain). The principal cause of acid rain is the emission of NOx and SOx from the combustion of fossil fuels (Table 10.57) which react with water molecules to form sulphuric and nitric acid in the atmosphere (Singh and Agrawal, 2006, OECD, 2013). While dry deposition generally occurs close to the point of emission, depending upon the quantity of emissions, wet deposition may occur thousands of kilometres away from the original source of emission.

The acidification of rain-water is identified as a serious environmental problem of a transboundary nature (WBG, 1998a, Singh and Agrawal, 2006, Beylot and Villeneuve, 2013). According to Singh and Agrawal (2006), the OECD (2013) and Doney *et al*., (2007) the potential impacts of acid deposition and nitrogen oxides include:

- Land-based impacts:
  - Impacts on forest ecosystems which can vary greatly according to soil type, plant species, atmospheric conditions, insect populations, and other factors that are not well understood (WBG, 1998b):
    - Increases in the soil acidity causing a decrease in soil fertility and negative impacts on growth and productivity of forest trees and crop plants; and
    - Direct damage to foliage.
  - Acidification of water bodies causing large scale negative impact on aquatic organisms including fish;

- Effects on the human population via impacts on human health and the eroding of infrastructure; and
- Eutrophication and subsequent changes in water quality and species richness resulting from NOx emissions (OECD, 2013).

- Oceanic impacts:
  - Lowering of oceanic and coastal pH (section 10.9.4.2.2 above).

The UK Environmental Agency's guidance states that the impact of emissions to air on vegetation and ecosystems should be assessed for certain designated sites within a 10 km and 2 km radius of the source. While the UK designations do not apply in the Falkland Islands, locally significant sites in the vicinity of the potential incinerator include Kidney Island Group National Nature Reserve (NNR) and Important Bird Area (IBA), and Cape Pembroke NNR (as part of Stanley Common) and Important Plant Area (IPA).

10.9.4.3 GHG emissions context

In order to inform the assessment of the 'severity of effect' of the Phase 1 emissions, it is necessary to quantify the Falkland Islands and UK emissions to enable comparison.

10.9.4.3.1 Historic Falkland Islands GHG emissions

Atmospheric emissions statistics for the Falkland Islands (as provided by the FIG Policy Unit, 2019) indicate that the emissions in 2017 were equal to 0.388 million tonnes CO_2e (Table 10.58). Table 10.59 shows the Falkland Islands' emissions by IPCC sector. It is important to note that, as yet, the Falkland Islands' data between 1990 and 2017 do not include:

- Emissions from international aviation and shipping;
- Emissions arising from previous Oil and Gas (O&G) exploration campaigns; and
- Emissions of the indirect GHGs (NOX, SO_2, CO and VOC).

These omissions must be taken into account when making direct comparisons as is carried out in section 10.9.4.6 below and all comparisons between the Phase 1 Development and Falkland Islands emissions must be caveated.

Table 10.58: Summary of historical Falkland Islands' emissions of direct Kyoto GHGs[a]

Emission Year	Kyoto (direct) GHG ($MtCO_2e$) [b]						Total [c] ($MtCO_2e$)
	CO_2	CH_4	N_2O	F-Gases			
				HFCs	PFCs	SF_6	
1990	0.173	0.162	0.111	0	0	0	0.445
1995	0.146	0.155	0.107	0	0	0	0.408
2000	0.161	0.146	0.101	0	0	0	0.408
2005	0.176	0.130	0.089	0.001	0	0	0.395
2010	0.179	0.106	0.077	0.001	0	0	0.364
2015	0.275	0.105	0.079	0.001	0	-	0.460
2016	0.169	0.104	0.077	0.001	0	-	0.351
2017	0.201	0.107	0.079	0.001	0	-	0.388

a Source: Falkland Islands emissions data provided by FIG Policy Unit (FIG, 2019).

b Note that these estimations are based upon GWPs from the IPPC Second Assessment Report (Table 10.57 above).

c Total represents the total Falkland Islands emissions not the sum of the columns.

Table 10.59: Summary of historical Falkland Islands' emissions of Kyoto GHGs by IPCC sector[a]

Year	Kyoto (direct) ($MtCO_2e$) [b]					Total [e] ($MtCO_2e$)
	Energy [c]	Transport	Agriculture	LULUCF [d]	Waste	
1990	0.008	0.158	0.269	-	0.001	0.445
1995	0.008	0.126	0.259	0.002	0.001	0.408
2000	0.010	0.134	0.243	0.006	0.001	0.408
2005	0.011	0.146	0.215	0.008	0.001	0.395
2010	0.008	0.144	0.177	0.019	0.001	0.364
2015	0.009	0.234	0.175	0.023	0.001	0.460
2016	0.009	0.126	0.174	0.023	0.001	0.351
2017	0.008	0.160	0.179	0.024	0.001	0.388

a Source: Falkland Islands' emissions data provided by EPD (FIG, 2014c) grouped according to the IPCC categories listed within the UK GHG Inventory, 1990 to 2012 (DECC, 2014c).

b Note that these estimations are based upon GWPs from the IPPC Second Assessment Report (Table 10.57 above).

c These data exclude previous O&G operations.

d LULUCF: 'Land and use, land-use change and forestry'.

e Total represents the total of Falklands not the sum of the columns

10.9.4.3.2 Historic UK GHG emissions

To inform the assessment on the impact of Phase 1 emissions on the UK's ability to meet its Kyoto commitments, it was considered appropriate to use the total UK emissions (which will include the Falklands emissions) as a point of comparison. The 2017 total UK emissions data were used as these were verified and reported to Kyoto. However, in order to provide a more direct comparison between Premier and its peers, data are also provided for emissions from the UK Continental Shelf (UKCS) for 2014.

According to the UK GHG Inventory 1990 to 2017 (DBEIS, 2019) the 2017 UK emissions amounted to 460.2 $MtCO_2e$ (Table 10.60). Emissions from the energy sector accounted for 24.5 % (112.6 $MtCO_2e$) of direct GHG emissions (Table 10.61). Within the energy sector, 4.35 % (4.9 $MtCO_2e$) of emissions were from the O&G industry. Note that these data do not include the indirect GHGs which do not require reporting under the Kyoto protocol, however, indirect GHG emissions (to 2012) are shown in Figure 10.43.

Table 10.60: Summary of historical total UK emissions of direct Kyoto GHGs[a]

Emission Year	Kyoto (direct) GHG ($MtCO_2e$) [b, c]						Total [d] ($MtCO_2e$)
	CO_2	CH_4	N_2O	F-Gases			
				HFCs	PFCs	SF_6	
1990	596.3	132.5	48.2	14.4	1.7	1.3	794.4
1995	560.1	125.9	38.6	19.1	0.6	1.3	745.6

2000	558.3	108.4	28.5	9.8	0.6	1.8	707.5
2005	557.9	86.9	24.4	13.0	0.4	1.1	683.7
2010	498.3	63.9	21.3	16.4	0.3	0.7	600.9
2015	408.3	52.7	20.3	15.9	0.3	0.5	498.0
2016	385.8	51.1	20.2	15.1	0.4	0.5	473.1
2017	373.2	51.5	20.5	14.1	0.4	0.5	460.2

a UK GHG Inventory 1990 to 2017 from the UK Greenhouse Gase Emissions, Final Figures – Statistical Release (DBEIS, 2019)

b Note that these data do not include the indirect GHG, namely NOx, SO_2, CO or VOC

c Note that these estimations are based upon GWPs from the IPPC Second Assessment Report (Table 10.57 above).

d Total represents the total UK not the sum of the columns

Table 10.61: Summary of historical total UK emissions of direct Kyoto GHGs by IPCC sector[a]

Year	UK emissions ($MtCO_2e$) [b]					Total [c] ($MtCO_2e$)
	Energy	Industrial Processes	Agriculture	LULUCF	Waste	
1990	277.9	59.9	53.9	270	66.6	794.4
1995	238.0	50.8	52.9	-1.7	69.1	745.6
2000	221.6	27.1	50.3	-3.8	62.9	707.5
2005	231.5	20.6	47.8	-7.1	49.0	683.7
2010	207.4	12.6	44.6	-9.1	29.7	600.9
2015	145.3	12.7	45.1	-9.7	20.6	498.0
2016	121.7	10.6	45.1	-9.8	20.0	473.1
2017	112.6	10.8	45.6	-9.9	20.3	460.2

a GHG Inventories for England, Scotland, Wales and Northern Ireland: 1990-2017,from the UK National Atmospheric Emissions Inventory (UKNAEI, 2019)

b Note that these estimations are based upon GWPs from the IPPC Second Assessment Report (Table 10.57 above).

c Total represents the total UK not the sum of the columns

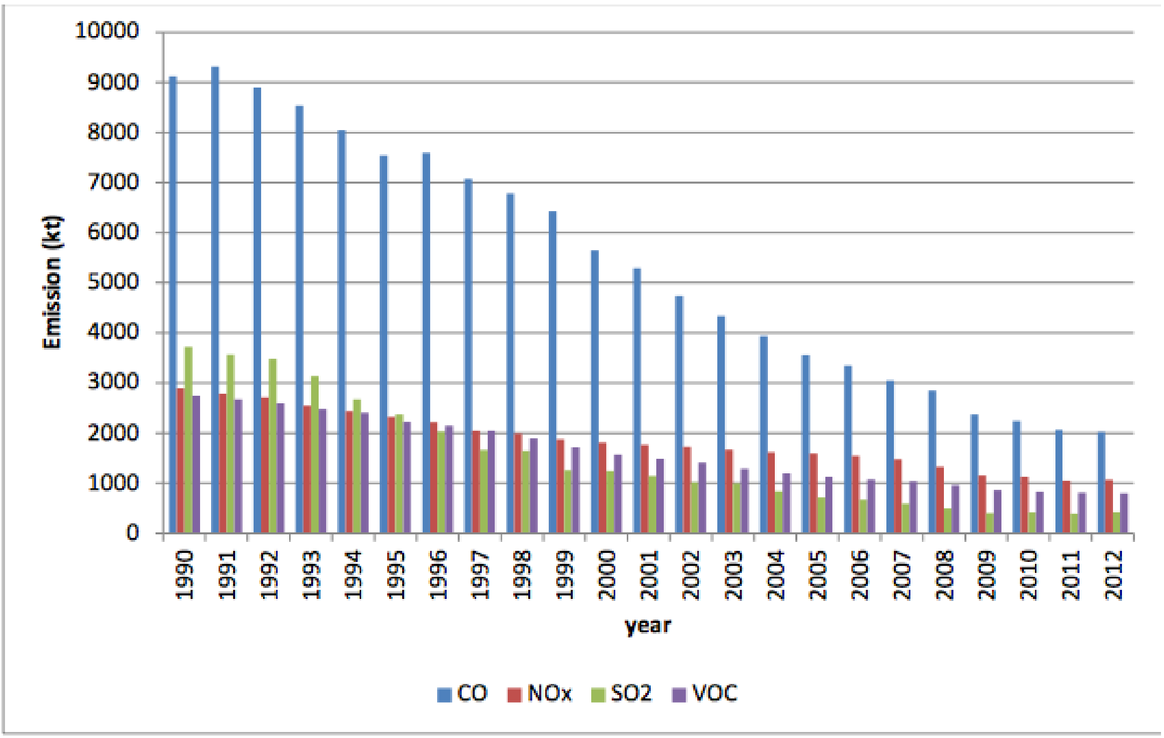


Figure 10.43: Total UK Emissions of indirect GHGs for 1990 to 2012

10.9.4.3.2.1 Recent UKCS emissions

To enable a more direct comparison with the UK O&G industry, emissions data from the most recent Oil and Gas UK Annual Environmental Report (O&G UK, 2018) which reports on environmental performance on the UK Continental Shelf (UKCS) are provided in Table 10.62. In this context, UKCS means offshore oil and gas exploration and production operations, and excludes vessels associated with installation, supply, maintenance and surveys, shuttle tankers or export tankers, aviation, onshore activities and any other offshore industries.

When making comparisons, it should be noted that no data on the UKCS N_2O emissions are provided in the report and that N_2O has a high GWP. Further, the data provided by the O&G UK report were not presented as the CO_2 equivalent. Therefore, this has been provided in Table 10.62 using the AR4 GWPs (Table 10.57 above).

Table 10.62: 2017 UKCS emissions figures[a]

Emissions	Direct GHG ($MtCO_2$)						Indirect GHG's ($MtCO_2$)			
	CO_2	CH_4	N_2O	F-Gases			NOx	SO_2	CO	NMVOC
				HFCs	PFCs	SF_6				
Emissions	14.2	0.0433	no data	no data	no data	no data	0.046	0.0022	0.0207	0.0381
CO_2e [b]	14.2	1.0775	no data	no data	no data	no data	0	0	0.03933	0.09525
CO_2e total	13.79778									

a Taken from the Oil and Gas UK Annual Environmental Report 2018

b Note that AR4 GWPs (Table 10.57 above) are used to estimate the Phase 1 emissions (direct GHG only) for comparison to the 2018 UKCS emissions (direct GHG only).

10.9.4.3.3 Projected future total UK GHG emissions

Emissions in the Falkland Islands are covered by the UK and must be reported in the UK GHG inventory. Falkland Islands' emissions will make a contribution to the UK emissions as reported against the Kyoto Protocol and the Climate Act and, therefore, the impact of the Phase 1 emissions on the UK emissions targets must be considered.

Table 10.63 shows the UK Carbon Budgets set under the UK Climate Change Act (section 10.9.1.1.1.1) alongside the projected future emissions (DBEIS, 2019). As shown in Table 10.63, the actual UK emissions were below the 1st carbon budget target and the projected emissions for the next two reporting periods (2 and 3) indicate that the emissions will remain below the targets. However, taking into account the uncertainty around projected data, the projected UK emissions during the fourth carbon budget period (2023 to 2027) are expected to exceed the target. The UK Government is currently considering ways to reduce emissions over the fourth carbon budget period and after the fifth carbon budget has been finalised (2016), plans will be published (DECC, 2015).

Table 10.63: Actual and projected UK CO_2e emissions and targets[a]

Carbon budget period [b]		Allocated UK CO_2e budget ($MtCO_2e$)	Number of years	Average allocated UK $MtCO_2e$ per year [a]	Total projected UK Carbon emissions ($MtCO_2e$) [c, d]	Average projected UK $MtCO_2e$ per year (over 5 years) [c, d]	Difference between UK target and projected UK emissions ($MtCO_2e$)
1	2008 to 2012	3,018	5	603.6	2,982 (actual)	596.4 (actual) e	- 36 (actual)
2	2013 to 2017	2,782	5	556.4	2,650	488 (actual)	-384 (actual)
3	2018 to 2022	2,544	5	508.8	2,453	490.6	-91
4	2023 to 2027	1,950	5	381	2,096	419.2	146
5	2028 - 2032	1,725 e	5	345 e	1,972	394.4	247

a Adapted from the DECC (BEIS) Updated Energy and Emissions Projections 2016 (BEIS, March 2019).

b Carbon budget periods are as agreed under the Climate Change Act and are not necessarily aligned to the Kyoto reporting periods.

c No data is given in the BEIS projection report (BEIS, 2019) on which GWP values were used to estimate the future emissions.

d Note that the total projected UK emissions are lower in the 2017 Energy and Emissions Projections report than they were in the 2015 report.

e It is acknowledged that this figure is slightly higher than the average of the 2008-2017 data provided in Table 10.60 above. However all data are taken directly from BEIS (formerly DECC) reports as referenced.

f Note that the 5th carbon budget has been proposed by the Committee on Climate Change and is undergoing the process of being legislated for in the UK Parliament.

10.9.4.4 Quantification of Phase 1 emissions

All emissions reduction technologies built-in to the basis of design have been factored into the estimation of emissions from planned activities. These include:

- The use of produced gas from the Sea Lion Development wells as the main fuel supply;
- No planned flaring during steady state production;
- Use of a Flare Recovery Package to prevent flaring under normal operating conditions (i.e. other than pilot flare and blowdowns);
- Use of Vapour Recovery Package to prevent venting of the cargo tank HC gas blanket under normal operating conditions;
- Use of Dry Low Emission ready turbines; and
- Use of Marine Gas Oil instead of Intermediate Fuel Oil (i.e. a lighter fuel) when operating inshore.

10.9.4.4.1 Emissions factors

As described above (Table 10.57 above), direct and indirect GHGs include those that result from the combustion of fuels (e.g. CO_2, N_2O), those that result from the direct venting of gas (e.g. CH_4) and those that are used in closed systems (e.g. F-Gases).

The amount of GHG emission resulting from the above activities is calculated as follows:

'Activity (source of emissions)' x 'the Emissions Factor for the GHG' = GHG emission

The emissions factors used in this assessment are provided in Table 10.64.

Table 10.64: Emissions factors for routine activities

Activity (source of emissions)	CO_2	CH_4	N_2O	NOx	SO_2	CO	VOC
Fuel Gas (Turbines) a	2.86	0.000920	0.000220	0.006100	0.000013	0.003000	0.000036
Diesel consumption (Turbines) a	3.2	0.000033	0.000220	0.013500	0.004000	0.000920	0.000295
Diesel consumption (Engines) a	3.2	0.000180	0.000220	0.059400	0.004000	0.015700	0.002000

Activity (source of emissions)	CO_2	CH_4	N_2O	NOx	SO_2	CO	VOC
Helifuel consumption b	3.2	0.000087	0.000220	0.012500	0.008000	0.005200	0.000800
Shipping transport (diesel engines) b, c	3.2	0.000270	0.00022	0.059000	0.004000 c	0.008000	0.002400
Charter flight aviation fuel d, e	3.15	0.000030	0.000100	0.018363	0.001180	0.005655	0.000318
Diesel consumption d (Onshore coach)	3.135	0.000112	0.000050	0.007962	0.000009	0.054746	0.001376
Well clean-up flaring (oil) a	3.2	0.025000	0.000081	0.003700	0.000013	0.018000	0.025000
Well clean-up flaring (gas) a	2.8	0.045000	0.000081	0.001200	0.000013	0.006700	0.005000
Base oil f	3.2	0.000180	0.000220	0.059400	0.004000	0.015700	0.002000
Production flaring a	2.8	0.045000	0.000081	0.001200	0.000013	0.006700	0.005000
Cold venting b	-	0.700000	-	-	-	-	0.300000
Incineration (municipal waste incineration) d	0.337770	0.002010	0.000000	0.001007	0.000026	0.000136	0.000009

a Data from OGUK EEMS Atmospherics Calculations Guidance (2008).

b OGP methods for estimating atmospheric emissions from E&P operations, publication 197 (OGP, 1994).

c Note that OGP guidance does not differentiate between Intermediate Fuel Oil (IFO) and Marine Gas Oil (MGO) and assumes shipping transport uses diesel engines. However, differentiation is made with regard to the sulphur content of fuels which is estimated at 0.2% w/w in this case. The convention is to multiply the sulphur content by two (2) such that 0.002 x 2 = 0.004 for the emissions factor.

d DEFRA National Atmospheric Emission Inventory (NAEI, 2014).

e Guidelines to Defra / DECC's (now BEIS) GHG Conversion Factors for Company Reporting, 2012 (DECC, 2012).

f Base oil will be used to promote efficient combustion and minimise risks of drop-out from the flare. Base oil is very similar in composition to diesel having evolved from diesel in the early days of oil-based mud. Therefore, the diesel combustion factors have been used for estimating the emissions resulting from the burning of base oil.

10.9.4.4.2 Estimation of planned emissions

No direct venting of process gas will occur during routine and planned operations and the emission of F-Gases is prohibited (section 10.9.1.1.2). Therefore, the only routine emissions that will occur are those that result from combustion and VOCs emitted during offloading from the FPSO to the CTT. A small amount of gas is inevitably released from seals on process gas equipment, known as fugitive emissions, which are quantified in annual reporting.

Combustion emissions can be estimated by multiplying the total fuel consumption by the published emissions factors (see above) for each fuel type. The total fuel consumption was estimated using the fuel consumption rates in Table 10.65 and the duration of use of each source as is defined in sections 5.11.2 and 5.11.3.1 in the Development Description. The emissions factors used in this assessment for the different fuel types are provided in Table 10.64 above.

The estimated quantities of GHGs emissions for each Stage of the Development are provided in Table 10.66. The total Sea Lion Phase 1 emissions over the full 23 year period of Development (construction, installation and operations) are summarised in Table 10.67.

Table 10.65: Consumption rates for each planned source of combustion emissions

Emissions source	Fuel consumption	
	In transit	In field
Vessel use		
Tugs / Anchor Handlers during tow and manoeuvring of MODU, laying of FPSO mooring and towing FPSO to the Falkland Islands [a]	14 t/d [b]	
MODU when drilling	-	19 t/d
Large Transport Vessel (LTV)	17 t/d	6 t/d
Installation Vessel	10 t/d	10 t/d
Installation vessel - Large Offshore Construction Vessel (OCV)	61 t/d	26 t/d
Fast Transit Carrier	25 t/d	4 t/d
Coaster Vessels	15 t/d	-
MRSV (Supply vessel)	6 t/d [c]	
MRSV (ERRV)	4 t/d [c]	
Conventional Trading Tanker (CTT)	n/a [d]	
OSV when assisting CTT	5 t/d	
Well test flaring from MODU		
Flaring of oil during clean-up of four wells via the MODU	-	76 - 1,262 t/well test
Flaring of gas during clean-up of four wells via the MODU	-	105 - 751 t/well test
Use of base oil to ensure efficient burning during well clean-up and to minimise flare drop-out	-	42 - 633 t/well test
Worst case: Flaring of oil during well clean-up of all remaining 18 wells via the MODU	-	1,262 t/well test
Worst case: Flaring of gas during well clean-up of all remaining (18) wells via the MODU	-	105 t/well test
Worst case: Use of base oil to ensure efficient burning during well clean-up of all remaining (18) wells via the MODU to minimise flare drop-out	-	633 t/well test
Personnel transportation		
Helicopter flights	n/a	0.5 t/hr [e]
Charter flight from LGW UK to MPN	n/a	5.3 t/hr [f]
Onshore transport	n/a	0.015 t/hr [g]

Search and rescue		
Search and Rescue Helicopter test flights	n/a	0.5 t/hr
Onshore		
Supply base vehicles [h]	n/a	0.015 t/hr/vehicle
Diesel generators	-	0 t/d [m]
Combustible waste incineration	-	572 t/year [l]
Production		
Flare pilot light	n/a	28 t/d [i]
Flaring during commissioning / planned shutdowns	n/a	862 t/d [j]
FPSO Fuel Gas use - steady state production	n/a	278 t/d [k]
FPSO Diesel use, essential consumers, steady state production	n/a	12 t/d

a The FPSO will be towed by up to three tugs.

b Fuel consumption taken from typical AHT M/V Pacific Wyvern Datasheet

c Fuel consumption based on estimates of use during the 2015 drilling campaign (from End of Well Reports (Premier, 2015e, 2016a-d).

d Fuel consumption of the CTT during the completion of loading and transport to market has not been included as this will be covered and reported by the ship's compliance with MARPOL Annex VI which will be audited during the nomination process (section 5.10.1.6).

e Helicopter fuel consumption taken from Institute of Petroleum (2000), assuming worst case of 625 litres/hour.

f Charter flight duration and fuel consumption is based on the current Airbridge Aircraft Airbus A330-200 operating between Brize Norton and MPN (Airberlin, 2014).

g Falkland Islands Tours and Travel *pers. comm*.

h The energy requirements of the shore base are expected to be in keeping with light industrial activities and are fully assessed in section 11.5. Power requirements will primarily be for domestic use, such as lighting and heating, and will be supplied from Stanley Power station, which currently receives 35-40 % of its power from renewable sources (section 11.5). Therefore, it is not expected that the addition of emissions for the onshore supply base would appreciably alter the impact assessment conclusions reached in this EIS. An estimated fuel consumption for each vessel is assumed.

i Conversion of mmscf gas to tonnes gas: 1 mmscf natural gas = 28,317 m^3 = 1,264 mols of gas. Assume molecular weight of 22 (as typical) equals 27.8 tonnes. Assumed that worst case 0.5 mmscf/d produced gas will be required for the pilot flare, with long-term foreseeable flaring from blowdown and plant interventions of a further 0.5 mmscf/d.

j Flaring during commissioning is estimated to be at a rate of 31 mmscf/d.

k Assuming use of 10 mmscf/d of fuel gas averaged over field life.

l Tonnes per year of waste incinerated at the supply base.

m The supply base generators will only be used in the event of interruptions to the Stanley power supply at critical times such that it is not possible to estimate running hours. However, if deployed, the use of fuel for the supply base generators would be offset against the reduced fuel use at the power station such that no additional emissions would result.

Table 10.66: Summary of atmospheric emissions per Phase 1 Development Stage (using SAR GWPs)

Phase 1a Development Stage	Total fuel burned	Tonnes Emitted									
		Kyoto GHG's (Direct)						Indirect GHG's			
		CO_2	CH_4	N_2O	F-Gas [a]			NO_x	SO_2	CO	NMVOC
					HFCs	PFCs	SF6				
Stage 1 (42 months)											
All vessels	82,961	265,475	20	18	0	0	0	4,905	332	861	189
Well clean-up (4 wells)	7,182	22,431	159	1	131	8	109	107	0	0	0
Well clean-up (Worst case: 6 extra wells)	10,868	34,268	218	1	216	13	174	172	0	0	0
All personnel transportation	14,032	44,278	1	2	0	0	0	248	27	80	5
Supply base	3,558	5,648	4	0	0	0	0	90	6	28	3
Emissions sub-total		372,101	402	22	0	0	0	5,522	365	969	197
CO2e		372,101	8,432	6,929	0	0	0	0	0	0	0
CO2e		**387,461**						**0**			
CO2e Sub-total		**387,461**									
Stage 2 (29 months)											
All vessels	39,618	126,776	11	9	0	0	0	2,337	158	317	95
Well clean-up (Worst case: 12 extra wells)	23,999	76,295	437	3	509	31	400	400	0	0	0

Phase 1a Development Stage	Total fuel burned	Tonnes Emitted									
		Kyoto GHG's (Direct)						Indirect GHG's			
		CO_2	CH_4	N_2O	F-Gas [a]			NO_x	SO_2	CO	NMVOC
					HFCs	PFCs	SF6				
All personnel transportation	25,496	80,375	1	3	0	0	0	460	40	145	9
Production [b]	280,380	802,183	257	62	0	0	0	1,717	7	839	10
Supply base	1,453	554	3	0	2	0	2	2	0	2	0
Emissions sub-total		1,086,183	708	76	510	31	402	4,916	205	1,303	114
CO2e		1,086,183	14,872	23,597							
CO2e		**1,124,653**						**0**			
CO2e Sub-total		**1,124,653**									
Stage 3 (per year)											
All vessels	13,584	43,469	4	3	0	0	0	801	54	109	33
All personnel transportation	10,255	32,316	0	1	0	0	0	186	14	58	3
Production [c]	120,139	352,276	103	27	0	0	0	820	43	344	7
Supply base	599	279	1	0	0	0	0	1	0	2	0
Emissions sub-total		428,340	108	31	0	0	0	1,809	111	513	43
CO2e		428,340	2,272	9,573	0	0	0	0	0	0	0
CO2e		**440,185**						**0**			
CO2e Sub-total		**440,185**									
Stage 3 (total over 17.5 years)											

Phase 1a Development Stage	Total fuel burned	Tonnes Emitted									
		Kyoto GHG's (Direct)						Indirect GHG's			
		CO_2	CH_4	N_2O	F-Gas [a]			NO_x	SO_2	CO	NMVOC
					HFCs	PFCs	SF6				
All vessels	237,720	760,704	64	52	0	0	0	14,025	951	1,902	571
All personnel transportation	179,464	565,531	6	19	0	0	0	3,260	250	1,023	60
Production [c]	2,102,424	6,164,827	1,803	469	0	0	0	14,355	748	6,026	124
Supply base	10,489	4,883	20	0	0	0	0	14	0	28	1
Emissions sub-total		7,495,945	1,893	540	0	0	0	31,655	1,949	8,979	0
CO2e		7,495,945	39,756	167,532	0	0	0	0	0	0	0
CO2e		**7,703,232**						**0**			
CO2e Sub-total		**7,703,232**									

a The emission of F-Gases is prohibited and will not occur as part of routine operations (section 10.9.1.1). They are included within these tables to ensure presentation of a complete and consistent estimation of the emission of the direct Kyoto GHGs throughout.

b Including 30 days flaring during commissioning.

c Assumes 30 days flaring per year including blowdowns during shutdowns where the process system is depressurised and the gas sent to flare.

Table 10.67: Summary of atmospheric emissions for the whole Phase 1 Development (23.5 years) (using SAR GWPs)

Emissions	Tonnes									
	Kyoto GHG's (Direct)						Indirect GHG's			
	CO_2	CH_4	N_2O	F-Gas			NO_x	SO_2	CO	NMVOC
				HFCs	PFCs	SF_6				
Total Phase 1a Development (23.5 years)										
Emissions total	8,954,229	3,003	639	510	31	402	42,093	2,520	11,251	1,066
CO_2e	8,954,229	63,059	198,058	0	0	0	0	0	0	0
CO_2e	**9,215,346**						**0**			
CO_2e total	**9,215,346**									
Average emissions over 23.5 years										
Average emissions per year	381,031	128	27	22	1	17	1,791	107	479	45
Average emissions per year (CO_2e)	381,031	2,683	8,428	0	0	0	0	0	0	0
CO_2e per annum	**392,142**						**0**			
CO_2e total per annum	**392,142**									

10.9.4.4.3 Estimation of unplanned emissions

10.9.4.4.3.1 Emergency blowdown

As described in section 5.8.5.3, the Phase 1 Development is based on a 'zero flaring' philosophy during normal and routine activities. However, it is possible that emergency blowdowns could be required on occasion for safety reasons. Given the nature of such events, it is not possible to estimate accurately how often this would be required but through experience it is possible to estimate overall flaring volumes during operations. During an emergency blowdown it is assumed that the event would take approximately 15 minutes and the gas release rate would be approximately 204 kg/s (amounting to 184 tonnes) of exhaust gas. The CO_2e emissions resulting from a blowdown are estimated in Table 10.68 below using emissions factors listed in Table 10.64 above.

Foreseeable flaring resulting from planned shutdowns, deliberate maintenance and normal levels of unplanned flaring events are factored into Table 10.66 above.

10.9.4.4.3.2 Venting emissions offshore

As described in section 5.8.4.6, hydrocarbon (HC) gas blanketing will be used on the FPSO to buffer the cargo tanks with a VRP system in place to prevent the release of the gas blanket as the cargo tanks fill. Therefore, the only source of venting would if the VRP system were to malfunction, leading to direct venting.

In the event the VRP is unavailable, inert gas will be generated for use (section 5.8.4.6). However, there is the potential for some of the HC gas blanket to be vented prior to a change-out to inert gas. This emission would comprise primarily methane (CH_4) and VOCs which could contribute to global warming. As a worst case estimate, it is possible that a maximum inventory of 77.68 tonnes of HC gas could be released prior to a complete change-out to inert-gas.

The CO_2e emissions resulting from a worst case venting of HC gas are estimated in Table 10.68 using emissions factors listed in Table 10.64 above. Note that venting estimates are not included in the overall estimates of the Development emissions, or annual average, as it is not possible to credibly estimate how often this may be required.

Table 10.68: Estimated emissions during emergency and unplanned events

Activity	Total (tonnes)	Tonnes									
		Kyoto GHG's (Direct)						Indirect GHG's			
		CO_2	CH_4	N_2O	F-Gas			NOx	SO_2	CO	VOC
					HFCs	PFCs	SF_6				
Emergency blowdown											
Gas burned	184	515	8	0	0	0	0	0	0	1	1
CO_2e		515.2	173.88	4.62	0	0	0	0	0	0	0
CO_2e		694									
VRP malfunction											
Gas vented	78	-	54	-	-	-	-	-	-	-	23
CO_2e		0	1,142	-	-	-	-	-	-	-	0
CO_2e		**1,142**									

10.9.4.4.3.3 F-Gas release

As described in section 10.9.1.1.2 above, the release of F-Gases to the atmosphere is prohibited such that zero emission of F-Gases is the base case (Table 10.66 above).

In the event that an accidental release were to occur, this would be reported to FIG in terms of the CO_2e of the release. Given that this would be an unplanned event, it is not possible to estimate the potential quantities that could be released. However, Premier will aim to use F-Gases in the lower GWP range.

10.9.4.5 NOx and SOx emissions

10.9.4.5.1 Offshore

As described in section 10.9.4.6.3, the total NOx and SOx emissions are very low when compared to the UK 2012 emissions. At the Sea Lion location the prevailing wind direction, high humidity, frequent showers of rain and the distance to land masses mean that it is extremely unlikely that measurable levels of acidity will occur over land from the FPSO emissions. Indeed, modelling studies undertaken for the project show sea level concentrations of NOx from offshore combustions emissions reducing to near zero over 10 kilometres (Premier, 2017d). Therefore, the potential for direct and localised impacts of emissions from the FPSO were screened out (Premier, 2017d) and emissions of NOx and SOx from the FPSO are included within the assessment of ocean acidification.

10.9.4.5.2 Onshore

As the exact model and location of the potential incinerator and the diesel generators is not yet known, an assessment for an incinerator in the UK with a 17.5 m stack, using diesel fuel and with a similar throughput to the incinerator proposed at the supply base has been referenced (see Sol Environmental, 2016). This assessment concludes that maximum off-site concentrations of all pollutants at around 100 m from the incinerator are within the relevant air quality standards for habitats and human receptors (Sol Environmental, 2016).

10.9.4.5.3 Inshore

Residual emissions of NOx and SOx is limited to the combustion of marine diesel on the LTVs for power generation and life/support systems and the infrequent visits of the subsea installation vessels

Given the significant reduction in emission sources, and the dominant wind direction blowing emissions out to sea and thus away from any immediate ecological receptors on the shores of Berkeley Sound, the residual inshore emissions of NOx and SOx from the LTVs and related vessel activities have been screened out from further assessment.

10.9.4.6 Comparison of Phase 1 emissions with existing context

10.9.4.6.1 Comparison with historical Falkland Islands and UK GHG emissions

The published Falkland Islands emissions, and the verified total UK emissions data extend to 2017 (the end of the second Kyoto commitment), as is shown in section 10.9.4.3. Therefore, when comparing the estimated Phase 1 emissions to historical emissions, the IPPC SAR GWPs (Table 10.57 above) were used to enable ‘like-for-like’ comparison (Table 10.69). A comparison between the Phase 1 emissions and the 2018 offshore oil and gas sector (UKCS) is also provided. Given that the UKCS data are from 2018, both the UKCS and Phase 1 CO_2 equivalents were estimated using the AR4 GWPs (Table 10.57 above).

As described in section 10.9.4.3.1 it is understood that the Falkland Islands dataset is currently incomplete and is thus an underestimate as the Falkland Islands dataset does not include e.g. aviation, shipping and previous offshore oil and gas activity. Therefore, based on the CO_2e emissions, calculated from CO_2, CH_4 and N_2O alone, the average annual emissions of direct GHGs during the Phase 1 Development amount to 101 % of the 2017 Falkland Islands emissions (Table 10.69). In the UK context, the average annual emissions from the Phase 1 Development is equal to 0.09 % of the 2012 UK CO_2e emissions (Table 10.69). When compared to the 2014 UKCS emissions alone, i.e. those of the UK offshore oil and gas industry, the Phase 1 emissions amount to 2.6 % (Table 10.69). However, it should be noted that, unlike the UKCS data, the Phase 1 emissions estimated in this EIS include all the emissions associated with offshore, inshore (LTV vessels), onshore and at-shore operations, including all associated shipping (except the purchaser’s CTT) and aviation. As the UKCS data do not include emissions from all equivalent offshore operations, such as associated vessels, the Phase 1 emissions as a percentage of the UKCS emissions appear higher than they would on a like-for-like basis.

Table 10.69: Phase 1 average annual emissions in the context of Falkland Islands' and UK emissions data[a]

Direct GHG	Emissions of direct GHG ($MtCO_2e$)			Average Phase 1 emissions per annum using SAR GWPs ($MtCO_2e$)	Average Phase 1 emissions per annum using AR4 GWPs ($MtCO_2e$)	Average Phase 1 CO_2e emissions per annum as a % of:		
	Falkland Islands (2017)	UK Total (2017)	UKCS (2018)			Falkland Islands 2017 emissions [b]	UK 2017 emissions	UKCS 2018 emissions
CO_2	0.201	373.2	14.2	0.381	0.381	189.55	0.10	2.68
CH_4	0.107	51.5	1.078	0.0027	0.0032	2.52	0.01	0.25
N_2O	0.079	20.5	-	0.0084	0.0081	10.63	0.04	-
HFCs	0.001	14.1	-	0	0	-	0.00	-
PFCs	0	0.4	-	0	0	-	0.00	-
SF_6	0	0.5	-	0	0	-	0.00	-
Total	0.388	460.23	15.29	0.3921	0.3923	101.06	0.09	2.56

a Note that these compare the Kyoto GHGs only and exclude NOx, SOx, CO and VOC

b Data do not include aviation, shipping or offshore oil and gas emissions

c Estimated using the SAR GWPs (Table 10.57 above).

d Estimated using the AR4 GWPs (Table 10.57 above).

10.9.4.6.2 Comparison with projected total UK GHG emissions

When comparing the Phase 1 emissions with projected future UK emissions to provide a context within which to assess the 'severity of effect', the GWPs from the AR4 report (IPPC, 2007) were used, as advised in the UN Report on the Conference of the Parties (UN, 2012).

Comparing the direct Kyoto emissions alone, the estimated annual Phase 1 emissions will amount to 0.077 % of the UK emissions during the third carbon budget period (2018 - 2022), 0.103 % during the fourth period (2023 - 2027), and 0.114 % of the fifth carbon budg*et al*lowance (Table 10.70). However, it should be noted that the Phase 1 annual emissions presented in Table 10.70 are averaged over the whole Development for simplicity. In reality, the emissions will be higher during Stages 1 and 2 than they will be in steady state production (Stage 3) such that the annual average presented here is actually higher than it will be in Stage 3. During the Carbon Budget Periods four and five, the Development will be into Stage 3 so the annual emissions will be lower, and therefore the percentages shown below are very conservative to present a worst case.

Table 10.70: Comparison between the Phase 1 direct GHG emissions and the projected future UK direct GHG emissions

Carbon budget period [b]		Number of years	Allocated UK CO_2e budget ($MTCO_2e$)	Average allocated $MTCO_2e$ per year	Average projected UK $MTCO_2e$ per year	Estimated Phase 1 Development emission $MTCO_2$ per year	Phase 1 emissions as a percentage of annual $MTCO_2$ allowance
1	2008 to 2012	5	3,018.00	603.6	596.4 (actual) [d]	-	
2	2013 to 2017	5	2,782.00	556.4	530	-	
3	2018 to 2022	5	2,544.00	508.8	490.6	0.3923	0.077%
4	2023 to 2027	5	1,905.00	381	419.2	0.3923	0.103%
5	2028 to 2032	5	1,725.00	345	394.4	0.3923	0.114%

a Source: DECC (now BEIS) Updated energy and emissions projections 2016 (BEIS, March 2017).

b Carbon budget periods are as agreed under the Climate Change Act and are not necessarily aligned to the Kyoto reporting periods.

c Note that AR4 GWPs (Table 10.57 above) are used to estimate the Phase 1 emissions (direct GHG only) for comparison to the projected future UK emissions (direct GHG only).

c Proposed allowance which is currently going through UK parliament.

10.9.4.6.3 Comparison of NOx and SOx emissions

As can be seen in section 10.9.4.3.2.1, the raw data for the emissions of NOx and SOx by the Falkland Islands and the UK are not provided. Therefore, while estimates of NOx and SOx emissions from the Phase 1 Development are estimated (Table 10.67 above), it is not possible to accurately compare these emissions within a verified context. Nonetheless, using the data in Figure 10.43 above, which indicates a decline in indirect GHG emissions, it is estimated that the average annual Phase 1 NOx emission (Table 10.67 above) will amount to approximately 0.18 % of the 2017 UK total (read from Figure 10.43 to be c. 1,000,000 tonnes). That of SOx is estimated to 0.02 % of the 2017 UK total (read from Figure 10.43 to be c. 500,000 tonnes).

The concentration and dispersion of the NOx and SOx emissions is estimated above in section 10.9.4.5.

10.9.5 Industry-standard mitigation measures

10.9.5.1 Combustion emissions

The industry-standard mitigations as applied by Premier include:

- Use of Best Available Techniques (BAT) in the Development Basis of Design (as described in section 10.9.5);

- Regular monitoring and inspection of all combustion equipment and use of a Management Maintenance System with Planned Maintenance Routines to ensure all combustion equipment runs as efficiently as possible;
- Testing of fuel gas to enable analysis of composition thus improving emissions estimates;
- Metering of fuel gas used and recording of diesel use;
- Monitoring, recording and reporting all emissions;
- Auditing of third parties as part of the selection and pre-mobilisation processes; and
- Ongoing ALARP reviews throughout the field life which will take account all emissions monitoring outcomes.

Premier also carries out all of its activities in line with its ISO14001 certified HSES Framework. Within this, and as part of its Carbon Strategy, Premier is committed to reducing its GHG emissions to a level that is 'As Low As Reasonably Practicable' (ALARP) and will set SMART (Specific, Measurable, Achievable, Realistic and Time-based) environmental objectives and targets each year.

The Project Safety Review (PSR) process also includes emissions reviews as well as assessments of climate-change related risks (including, where relevant, extreme weather events and ice-flow patterns).

10.9.5.2 F-Gas emissions

Owing to the very high GWPs of F-Gases (Table 10.57 above), all F-Gas containing equipment is subject to preventative maintenance (e.g. level checks and leak checks in accordance with legislation) to prevent losses of even small quantities of F-Gases by fugitive emission or by leaks. The frequency of maintenance and leak checks is determined by the quantity of the F-Gas contained within the equipment and the GWP of a full release e.g. if the GWP of the F-Gas was such that a release of the full inventory would exceed five tonnes of CO_2e, the piece of equipment would require annual leak testing.

10.9.6 Impact and risk assessment

The following section draws upon all the information provided above to assess the 'Sensitivity of the Receptor' and the 'Severity of Effect' in order to determine the overall 'Impact' of planned activities. Assessment of unplanned events includes an assessment of the 'Likelihood of Occurrence' to determine the 'Risk'.

A summary of the impact and risk assessment outcomes for this Development is tabulated in section 10.9.12, which shows the worst case impact / risk for each activity and receptor and details are provided below.

10.9.6.1 Impact assessment

10.9.6.1.1 Global warming and GHG emissions

As described in section 8.5.2.1.1, the **sensitivity of the global (transboundary) atmosphere** as a receptor is considered to be **'Very High'**.

The average annual CO_2e emissions of Kyoto GHGs during the Phase 1 Development is anticipated to be 101 % of the declared 2017 Falkland Islands emissions, and 0.09 % of 2017 UK emissions and 2.56 % of the 2018 UK offshore oil and gas (UKCS) emissions (Table 10.69 above). Therefore, relative to the 2017 Falkland Islands emissions, the proposed annual Development emissions are very high. However, it is acknowledged that the Falkland Islands data is incomplete (section 10.9.4.3.1) such that, after including aviation, shipping and previous offshore emissions on a like-for-like basis, the Development will comprise a much smaller percentage-increase to Falkland Islands emissions than is currently estimated.

When comparing the estimated annual Phase 1 emissions to the projected future UK emissions (2018 - 2032) (which will include Falkland Islands emissions), the conservative percentage contributions range from 0.077 - 0.114 % (section 10.9.4.6.2). The increased contribution over the years reflects the fact the future UK emissions are expected to decrease in order to meet the reducing UK emissions targets (and indeed have reduced between the 2015 and 2017 projections) (section 10.9.4.6.2).

Nonetheless, in the context of the future UK total emissions (including the Falkland Islands), the Phase 1 annual emissions contribution is very small. While the UK Government is currently aware that its projected future emissions are expected to exceed the carbon budget beyond 2023 (section 10.9.4.3.3), the Phase 1 Development is a new operation and incorporates current BAT to ensure efficiency and reduce emissions per unit gain. Therefore, it is not expected that the Phase 1 emissions will compromise the current or future UK Kyoto or Climate Act targets and, therefore, the **severity of the effect** is considered to be **'Minor'**.

Therefore, the **overall significance of impact** from the emission of GHGs is considered to be **'Moderate (10)'**.

10.9.6.1.2 Water quality and ocean acidification

The sensitivity of water quality as a receptor is usually considered in terms of whether the receiving body of water is 'closed with no flushing' or is 'open ocean', reflecting its ability, or otherwise, to flush pollutants received from a single point source. In this context, the sensitivity of oceanic water quality as a receptor could be considered to be 'Very Low'. However, the impact of ocean acidification is directly related to the emission of CO_2 which persists for centuries in the atmosphere, is absorbed by the surface of the ocean (and so is not a single point source of release), and has a long-lived effect (section 10.9.4.2.2). Therefore, on balance, the **sensitivity of the global (transboundary) ocean** as a receptor to atmospheric emissions is considered to be **'High'**.

The amount of CO_2, NOx and SOx generated as a result of the proposed operations is very low in relation to overall UK emissions and would, in its own right, have a negligible effect on the oceans' pH. For example, the average annual Phase 1 CO_2 emission amounts to only 0.09 % of the 2017 UK CO_2 emissions (Table 10.69). Given this, and the fact that the Phase 1 Development is inherently designed to minimise emissions, the **severity of the effect** on water quality is considered to be **'Minor'**.

Therefore, the **overall significance of impact** from the emission of CO_2 with regard to ocean acidification is considered to be **'Moderate (8)'**.

10.9.6.1.3 Direct acid deposition inshore

Emissions in Berkeley Sound are directed to sea in the majority of weather conditions and the ecological receptors of concern on the flanks of Berkeley Sound are dominated by acid grasslands which are adapted to low pH in soils and water. However, there are a number of plant species which have IUCN 'Endangered' or 'Vulnerable' status in the region of Berkeley Sound e.g. Antarctic cudweed (section 7.5.1.5). Whilst these are thought to be present mostly on the west coast of the Sound, it is unclear whether this distribution is an artifact of survey effort. Further, if required, the incinerator will be sited within the proposed supply base in Stanley, and there are two sites which are both NNRs and IBA/IPAs within a 10 km radius of the proposed incinerator location. Given that these are designated sites and are located to the east of the proposed incinerator (section 11.12), such that they are likely to be in the zone where predominant winds will blow the flue gases most of the time, the **sensitivity of a generic receptor** is considered to be **'High'**.

Further, with regard to emissions from the supply base, the designated habitats are between 5 -7 km from the stack itself such that the emissions from the stack are likely to be highly dispersed by the time they reach these habitats. A comparative example shows that within 100 m of the stack, concentrations of pollutants are within the relevant air quality standards for habitats (section 11.12). Therefore, the **severity of effect** of inshore and onshore emissions is considered to be **'Slight'**.

Therefore, the **overall significance of impact** of acid rain is considered to be **'Low (4)'**.

10.9.6.2 Risk assessment

10.9.6.2.1 Emergency blowdowns and VRP failure

As described in section 8.5.2.1.1, the sensitivity of the global (transboundary) atmosphere as a receptor is considered to be 'Very High'.

The incremental increase resulting from combustion of gas during blowdowns and / or the venting of the HC gas blanket in the event of VRP failure is anticipated to be small such that the severity of effect of added emissions is considered to be 'Slight'.

The significance of the impact is therefore considered to be 'Low (5)'.

The VRP will be considered to be an environmentally critical piece of equipment within the Maintenance Management System and the likelihood of occurrence of blowdowns and VRP failure is **'Possible'**.

Therefore, the **overall significance of the risk** is considered to be **'Low (6)'**.

10.9.6.2.2 Release of F-Gases

As described in section 8.5.2.1.1, the **sensitivity of the global (transboundary) atmosphere** as a receptor is considered to be **'Very High'**.

In the event that F-Gas containing equipment fails, there is the potential for an F-Gas to leak. Any such emissions would be one-off, finite and very limited in volume. Therefore, the **severity of effect** of atmospheric emissions to the global atmosphere is considered to be **'Slight'**.

The **significance of the impact** is therefore considered to be **'Low (5)'**.

While the F-Gas containing equipment will be subject to standard maintenance, the likelihood of the equipment malfunctioning is considered to be **'Possible'**.

Therefore, the **overall significance of the risk** associated with the VRP malfunctioning is considered to be **'Low (6)'**.

10.9.7 Project-specific mitigation measures

All mitigation measures intended to reduce GHG emissions to ALARP are built-in to the Phase 1 basis of design (section 5.13) and are factored into the quantification of emissions (section 10.9.4.4). These, along with the HSES-MS, are factored into the initial impact and risk assessment. Therefore, the impacts and risks, as determined from the initial assessment, are considered to be ALARP.

Additional mitigations considered 'reasonably practicable' at this stage, and based upon the initial impact assessment, are:

- Ensuring tanker owners use the EEOI when developing KPIs related to the CTT; and
- Investigation of pilot-free flare design using automatic ignition systems.

10.9.8 Residual impacts and risks

The initial assessment takes account of all the mitigation measures which are built-in to the basis of design and while SMART goals and ALARP reviews may serve to reduce emissions in future, at this time, they cannot change the initial assessment. Therefore, the residual impact and risk assessments remain the same such that the impacts to global warming and ocean acidification remain **'Moderate'**.

10.9.9 Cumulative impact

While no O&G activities are currently expected to occur in the NFB alongside the Phase 1 Development, both Premier and Noble Energy Falklands Ltd. (NEFL) conducted exploration drilling campaigns in 2015. Further, the NFB supports numerous shipping activities all of which will emit GHGs from combustion which all may lead to cumulative impacts from increased 'concentration' and increased 'extent and proportion' (section 8.10.1). It is therefore necessary to consider the Phase 1 emissions in the broader context.

Given that the key impacts of concern with regard to emissions are global warming and ocean acidification, both of which are long-term and transboundary in nature, it is not relevant to break these emissions down into yearly units when assessing the cumulative input. One measure of overall emissions over comparable timescales can be made by adding the total emissions of all known O&G activities that will have occurred in the NFB between 2015 and 2040, in addition to those of the Falkland Islands (Table 10.71), noting that these do not include aviation or shipping on a like-for-like basis.

Table 10.71: Estimated total atmospheric emissions resulting from O&G operations in the NFB from during field-life life [a]

Emissions source	Tonnes						
	CO_2	CH_4	N_2O	NOx	SO_2	CO	VOC
NEFL and Premier exploration drilling campaigns CO_2e	155,605	3,187	15,694	95,741	0	1,416	766
Phase 1 Total CO_2e (23.5 years)	8,954,229	63,059	198,058	0	0	0	0
O&G CO_2e total (2015 - 2040)	9,215,346						
Falkland Island emissions (2015 - 2040)[b]	875,710	2,303,383	840,925	0	0	0	0
CO_2e total	13,235,364						

a Using IPPC SAR GWPs (IPCC, 1995).

b Extrapolation of the Falkland Islands 2017 emissions based upon the IPPC SAR (1995) GWPs and excluding aviation and shipping emissions.

10.9.10 Confidence

The duration of the Phase 1 Development is known and the associated transport for equipment, supplies and crew have been estimated on a conservative basis to provide worst case estimates. Where possible, up-to-date emissions factors and GWPs have been used to calculate the emissions arising from the project activities and to compare ‘like-for-like’ emissions data.

The relationship between emissions and global warming, ocean acidification and regional air quality are well researched and documented. Therefore, level of confidence in the predictions of these impacts is considered to be **‘Certain’**.

10.9.10.1 Monitoring required

At all times, Premier will monitor its emissions to enable reporting, which is set out by regulation and Premier’s corporate reporting standards. The Premier monitoring strategy for emissions will be set out in the Environmental Monitoring and Management Plan (EMMP).

All monitoring requirements agreed by Premier and FIG will be recorded and managed via the project-specific Phase 1 EMMP (an outline EMMP is provided in Chapter 15).

10.9.11 Offsetting

For significant residual and impact and risks (Moderate or above), offsetting via an Environmental Fund is proposed, see section 8.9 for further details.

10.9.12 Findings summary

Table 10.72: Summary of the assessment of the impact of atmospheric emissions on the environment

Activity	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Fuel combustion throughout Development	Emission of direct and indirect GHG	Contribution to global warming	Planned	1, 2 & 3	Very High	Minor	n/a	Moderate (10)	Moderate (10)	Certain	Industry-standard: Use of BAT in project design; Monitoring and measuring of emissions; Selection and pre-mobilisation auditing; Optimisation of operations; Management Maintenance System; SMART objectives and targets; and Ongoing ALARP reviews. Project-specific: Use of EEOI in developing tanker KPIs; and Investigation of pilot-free flare design using automatic ignition systems.
	Emission of CO_2, NOx and SO_2	Contribution to ocean acidification			High	Minor	n/a	Moderate (8)	Moderate (8)	Certain	
Fuel combustion by by diesel generators and the potential waste incinerator at the supply base	Emissions of NOx and SO_2	Direct impact upon soil quality, flora and fauna around Berkeley Sound and Stanley			High	Slight	n/a	Low (4)	n/a	Uncertain	
			Planned	1, 2 & 3	High	Slight	n/a	Low (4)	n/a	Uncertain	
Malfunction of HVAC and fire-fighting equipment	Release of F-Gases		Unplanned	1, 2 & 3	Very High	Slight	Possible	Low (6)	n/a	Certain	

a See Chapter 8 for definitions of sensitivity, severity, likelihood and significance.

10.10 Waste generation and management

Table of Contents

10.10.1 Introduction

Every activity during the Phase 1 Development will generate waste which must be managed in a safe and environmentally responsible way in accordance with the Waste Hierarchy, an established principle in waste management worldwide, and Premier's corporate environmental standards. The Waste Hierarchy (Figure 10.44) emphasises minimisation and beneficial endpoints, with disposal to landfill considered the option of last resort that is only suitable when managed in accordance with international good practice.

The disposal of waste to sea is prohibited under the London Convention (1972) and MARPOL Convention (1973/78). There are a few exceptions allowing the discharge of non-hazardous liquids (section 10.7) but the majority of waste must be transferred to shore. Once ashore, modern disposal and recycling techniques can be employed to minimise the impact of waste on the environment. However, such techniques and accompanying resources are currently limited in the Falkland Islands, and waste management was identified as a concern for stakeholders during the 2014 and 2016 public scoping consultations (Chapter 6). The hope for improved waste management facilities in the future, both for Oil and Gas (O&G) operations and more widely, was also communicated. Premier is taking a collaborative approach with FIG in helping to determine the most environmentally sound in-country solutions, for the Phase 1 waste in as short a timescale as practicable.

The Phase 1 Development will result in many waste streams and this chapter assesses the impacts and risks associated with the management of solid and hazardous liquid waste streams only (Table 10.73). Waste management associated with decommissioning (Development Stage 4) will be covered in a dedicated EIA, which will be prepared in support of the decommissioning programme (section 5.12).

Note: the impacts of discharges to sea including drill cuttings, produced water, bilge water, drainage water, grey water, galley discharges, sewage and ballast water, and the impact of incinerator emissions, are described elsewhere in this document, as described in section 9.2 and shown in Table 10.73.

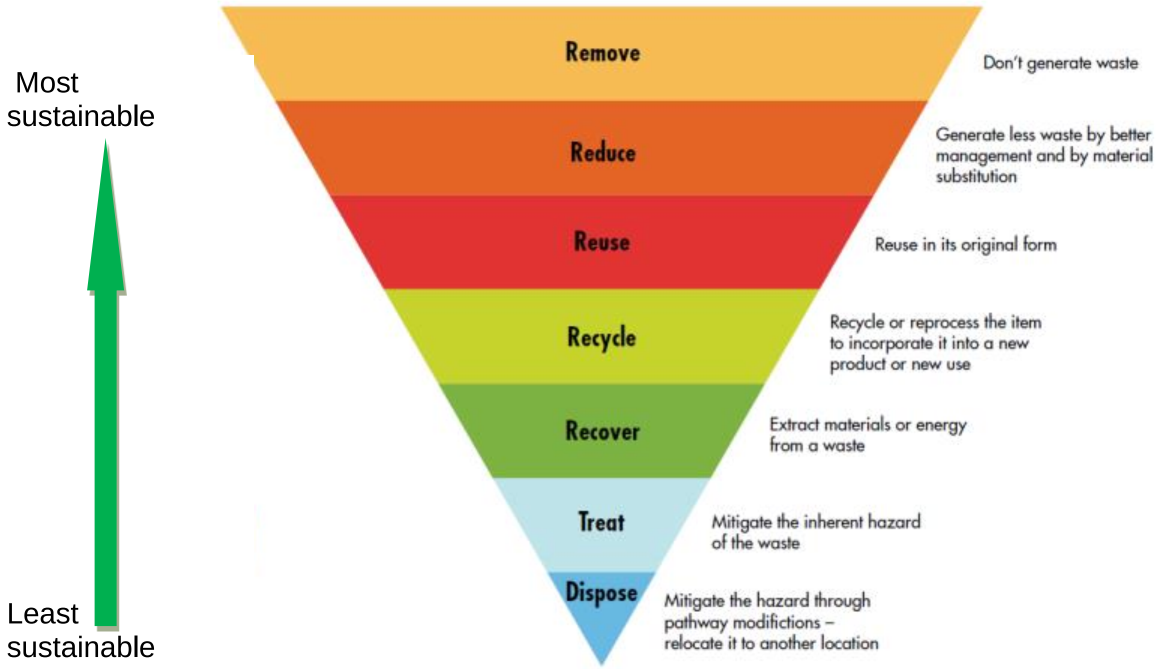


Figure 10.44: Waste Hierarchy

Table 10.73: Summary of waste streams generated by the Phase 1 Development, showing where they are assessed within this EIS

Waste stream	Generated during Stage:			Discharge to sea	Where addressed in EIS
	1	2	3		
Offshore and onshore waste streams including: Containers and empty Intermediate Bulk Containers (IBCs); Metal, gas cylinders; Waste oil, including contaminated oil, oily rags; Rubber; Glass; Food waste (generated or arriving onshore); Wood, paper, cardboard; Flammable liquids; Bulk hoses, chemical sacks; Medical waste; Plastics; Low-hazard chemicals e.g. barite; Oil-based mud; Hardened cement; Non-hazardous filters, hazardous filters; Electrical waste including hazardous electrical waste;	✓	✓	✓	✘	This chapter

Waste stream	Generated during Stage:			Discharge to sea	Where addressed in EIS
	1	2	3		
Aerosols, chemicals, Paints / solvents Batteries, light bulbs; Tank washings, oily water, oily well-cleanup fluids; and Potential oil spill-related waste.					
Water-based mud and associated drill cuttings	✓	✓		✓	Section 10.6
Appropriately treated drill cuttings generated during drilling with OBM	✓	✓		✓	
Hydrotest water and well completion water (visibly clean)	✓	✓	✘	✓	Section 10.7
Hydraulic fluids	✘	✓	✓	✓	
Produced water (containing oil, heavy metals, iron etc.)	✘	✓	✓	✓	
Cooling water	✘	✓	✓	✓	
Domestic waste water e.g. grey water and black water (sewage)	✓	✓	✓	✓	
Food waste	✓	✓	✓	✓	
Deck drainage water e.g. precipitation run-off	✓	✓	✓	✓	
Bilge water	✓	✓	✓	✓	
Hypersaline water from the desalination plants, which creates potable water	✓	✓	✓	✓	
Ballast water	✓	✓	✓	✓	Section 10.12

10.10.1.1 Relevant legislation

Currently there is no waste-specific legislation enacted in the Falkland Islands. However, in compliance with the FIG Guidance Note 02/13 and the FIG EIA Guidance notes (FIG, 2015l), Premier has developed an overarching Waste Management Strategy (WMS), and will develop a more detailed Waste Management Plan (WMP) in detailed design, to ensure that all waste is processed, stored, transported and disposed of responsibly.

Key legislation and agreements which inform the management of waste and the development of the WMS and WMP include:

- International agreements:
  - International Convention for the Prevention of Pollution from Ships (MARPOL) 1973/78, which provides regulation on the different types of pollution and specifies whether discharge to sea is permitted:
    - Annex I – Regulations for the Prevention of Pollution by Oil.

- The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, the protocols of which apply to the onward processing of waste from the Falkland Islands to the UK.
- OECD Council Decision C (92)39/FINAL on the Control of Transfrontier Movements of Wastes Destined for Recovery Operations.
- The London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972, and the London Protocol 1996 amended 2006.
- The OSPAR Convention 1992, which incorporated the Oslo Convention 1972 for the prevention of marine pollution by dumping from ships and aircraft and the Paris Convention for the prevention of marine pollution from land-based sources.
- Regulation (EC) No 1013/2006 on shipments of waste (Waste Shipment Regulation).

Key legislation and guidance which informs the design and management of an onshore incinerator includes:

- Environmental Permitting (England and Wales) (Amendment) Regulations 2013 (SI 2013 No, 390);
- European Directive on Ambient Air and Cleaner Air for Europe EC 2008/50/EC;
- Air Quality Strategy (AQS) for England, Scotland, Wales and Northern Ireland (2007);
- Air Quality Standards Regulations (2010);
- Department for Environment, Food and Rural Affairs (DEFRA) (2016): Part IV The Environment Act 1995 Local Air Quality Management Review and Assessment Technical Guidance;
- Environment Agency (2016) Air emissions risk assessment for your environmental permit.

UK legislation that is relevant as a well-developed legislature, and also as it relates to any waste exports that may be returned to the UK, includes:

- Key UK Legislation:
  - Offshore Petroleum Activities (Oil Pollution Prevention and Control) (OPPC) Regulations 2005 (and all amendments).
  - The Merchant Shipping (Dangerous Goods and Marine Pollutants) Regulations 1997;
  - Environmental Protection Act (EPA) 1990.
  - Transfrontier Shipment (TFS) of Waste Regulations 2007.
  - The Waste (Scotland) Regulations 2012, which transpose EC Framework Directive 2008/98/EC on Waste into UK legislation.
  - Controlled Waste Regulations 1992 (as amended) (Scotland only).
  - Special Waste Amendment (Scotland) Regulations 2004.
- Relevant Falklands legislation and plans:
  - Marine Environment (Protection) Ordinance of 1995.
  - Deposits in the Sea (Exemptions) Order of 1995.
  - Environment Protection (Overseas Territories) Order of 1988.
  - Environment Protection (Overseas Territories) (Amendment) Order of 1997.

- Falkland Islands National Oil Spill Contingency Plan.

10.10.1.1.1 Waste management Duty of Care

'Duty of Care' is an established international principle whereby waste producers have a Duty of Care to store, transport and dispose of controlled waste without harming the environment. In UK law, for example, this is described in section 34 of the EPA (1990), although it is not currently enacted in Falkland Islands specific legislation.

Applying the Duty of Care means it is necessary to:

- Segregate, store and transport waste appropriately and securely, making sure that no pollution or harm to human health is caused;
- Check that waste is transported and handled by people or businesses that are authorised to do so;
- Ensure completion of the appropriate paperwork to accompany the waste;
- Ensure that waste is disposed of responsibly; and
- Ensure that waste service providers are authorised.

10.10.1.1.2 Transfrontier shipments of waste

The Basel Convention provides the framework for a global system that controls the movements of hazardous wastes between countries to ensure they are managed in an environmentally sound manner. In the UK, the Transfrontier Shipment of Waste Regulations (2007) include both hazardous and non-hazardous wastes. The 'UK Plan for Shipments of Waste' (DEFRA, 2012) sets out the UK Government policy on the shipment of waste to and from the UK, and other countries, and takes into account the UK's obligations under international, EU and national law.

Generally, shipments of waste to and from other countries for disposal (as opposed to re-use, recycling or recovery) are prohibited. However, imports to the UK from UK Overseas Territories (UKOT) are potentially allowed, by exemption, if there are no suitable methods of disposal available in the UKOT. This is subject to the processes laid out in Title II of the EU Regulation (1013/2006) and discussion with the appropriate Environmental Protection Agency.

10.10.2 Sources and categories of waste

All industrial waste falls under the category of 'controlled waste' and can be categorised as:

- **Non-Hazardous Waste** which includes the following, provided they have not been cross-contaminated with hazardous wastes:
  - Paper, plastics, cans, food waste, scrap metal, rubber and wood.
- **Hazardous Waste** which includes any material that shares the properties of a hazardous material, for example:
  - Oily waste including waste oil, used oil filters and oily rags;
  - Waste Oil Based Mud (OBM);
  - Waste chemicals i.e. those that are surplus to requirement but cannot be re-used;
  - Waste Electrical and Electronic Equipment (WEEE);

  - Empty oil / chemical containers;
  - Asbestos, batteries, paints, radioactive materials; and
  - Medical wastes.

Wastes anticipated during the Phase 1 Development, and described in this chapter, include:

- Hazardous liquid wastes:
  - Waste oil that has been separated from bilge, drainage and well completion water.
- Hazardous and non-hazardous solid wastes:
  - Office wastes e.g. paper, light bulbs, batteries, cups, ink cartridges;
  - Packaging materials e.g. wooden pallets, cardboard, dunnage, plastics, packaging bands;
  - Oil contaminated materials;
  - Scrap metals;
  - Fabrication wastes e.g. paint tins;
  - Chemical drums and containers; and
  - Ash generated from waste incineration.
- Oil spill waste (only generated in the event of a spill).

Note: other waste streams e.g. drilling mud and cuttings and operational discharges to sea and ballast water are covered in separate chapters as described in Table 10.73 above.

10.10.2.1 Hazardous liquid wastes

Bilge and drainage water will be passed through an oil separator before being discharged to sea in accordance with the requirements of MARPOL (section 10.10.1.1). The oil separated from the drainage and bilge water will typically be returned to the processing facilities on the FPSO. Occasionally the recovered oil may be sufficiently 'off spec' that it will not be suitable for processing offshore and in these instances it will be collected and stored in drums / transit tanks and will be shipped back to the onshore supply base.

Similarly, during wellbore clean-up between drilling and completion phases when each well is displaced from Oil Based Mud (OBM) to brine, the OBM contaminated water returning to the Mobile Offshore Drilling Unit (MODU) is put through a separation process. The 'visibly clean' water can then be discharged offshore (section 10.10.1.1) and any residual oil (free-oil) from the separation process will be sent to the supply base or treated in the cuttings processing equipment if feasible.

Waste oils from the above that are returned to the shore base will be incinerated using a portable incinerator (section 5.11.1.2.2).

10.10.2.2 Solid wastes

All waste that is not eligible for discharge to sea will be segregated offshore, shipped back to the Temporary Dock Facility (TDF) and taken to the laydown yard in the supply base which will be designed to include a waste reception facility (section 5.11.1.2). If necessary, the wastes will be further identified, categorised and segregated. Following this process, the waste will either be stored prior to its shipment to the UK for re-use, recovery or disposal, or it will be thermally treated in-country using a portable incinerator located in the base (section 5.11.1.2.2).

10.10.2.2.1 Incinerator ash

Ash will be produced as an orphan waste from the incineration process. The base case is that project waste will be incinerated at a new Falkland Island municipal waste site, which will include a new landfill facility that will will take the ash. In the event that the new facility is not completed in time the project will provide an incinerator and waste ash will be temporarily securely stored at the supply base and periodically sent back to the UK along with other waste returns.

If, in future, a secure, consented location and process for disposal is agreed with FIG, ash may be disposed of locally. This will be the subject of future discussions.

10.10.2.3 Oil spill waste

In the event of a spill, clean-up operations inevitably generate multiple contaminated waste streams, sometimes in great quantities. Indeed, studies undertaken by ITOPF (2011) have shown that the volume of oil clean-up materials and other debris is typically ten times the volume of oil that is spilled. Management of the waste up to the time of its final disposal, and the complete restoration of all sites, can cause major problems for response coordinators.

A range of different scenarios have been modelled to gain an understanding of the likely behaviour and impact of oils spilled at sea that might be driven ashore by currents and wind (sections 12.1 and 12.3). These modelled scenarios also estimate the potential quantities of waste materials that may arise. Analysis of the crude oil has shown that it possesses a high pour point with a high wax content (section 5.3). Given this viscous consistency, upon contact with cold sea water, the oil solidifies and forms mobile rafts which have the potential to migrate along the coast as a result of wind changes, thus contaminating more shoreline, or it may be driven back out to sea. It may also lead to the formation of tarballs. This tendency means that any oil that washes ashore may be more easily separated from the substrate and collected using only rudimentary techniques and equipment (CEDRE, 2017).

The goal of oil spill response is to restore all sites to their previous condition as soon as possible and, to meet this goal, approaches to waste management following any spill will be consistent with:

- The Falkland Islands National Oil Spill Contingency Plan (NOSCP);
- Premier's strategic waste management objectives; and
- The Phase 1 Development OSCP which will define the agreements between Premier and specialised service providers where necessary.

Typical methods used for the retrieval of oil spill wastes in remote and difficult-to-access areas are:

- Keep oil spill waste to a minimum;
- Avoid contaminating the surrounding environment;

- Prevent overflow, congestion and hold ups; and
- Sort waste as soon as possible.

However, the particular challenges that are faced by a clean–up operation along the Falkland Islands coastline arise as a result of the relative inaccessibility of the foreshore and the nature of the rocky shoreline. Further, where spilled materials come ashore and remain, it is likely that that the residues will be mixed with pebbles and cobbles and organic matter such as kelp.

It is intended that, in the event of a spill:

- All oily materials retrieved from the foreshore will be placed initially on lined temporary storage areas. These areas will:
  - Be in line with the requirements of the Falkland Islands NOSCP arrangements and located in an area agreed with FIG;
  - Be surfaced with an impermeable membrane and covered to ensure that no loss to the ground can occur and also to prevent rainwater ingress;
  - Provide interim storage for all recovered oil spill response materials and equipment including shoreline booms;
  - Ensure that the waste will be in a form that can be easily managed for onward transportation to other intermediate, or final, storage areas; and
  - Be easily accessible from the beach to allow rapid and daily evacuation of collected waste ensuring that:
    - Impacts to sensitive coastal areas are minimised; and
    - Manpower and resources can be focused on the initial clean-up effort.
- All wastes will be logged so that the quantities and types of materials that require further intermediate storage, or final disposal, can be readily assessed;
- Various techniques will be used (including washing of contaminated kit) to ensure removal of the free-oil from the waste and it is envisaged that the remaining oily water fraction would be contained in drums and IBCs; and
- Final waste storage sites will also be identified as part of the contingency planning.

More details on the oil spill waste clean-up and management are detailed in Premier's Waste Management Strategy (WMS).

10.10.3 Potential receptors

The ENVironmental Impact IDentification (ENVIID) workshop was used to identify those receptors upon which the impacts and / or risks of waste warranted further investigation (Chapter 9). These include the impacts and risks to:

- Water quality (groundwater);
- Plankton (section 7.4.1);
- Seabirds (section 7.4.5);
- Marine mammals (section 7.4.6);

- Landfill resources (tangible property) (section 7.7.4.5.6);
- Landscape and seascape (section 7.7.4.6);
- Designated sites (section 7.5.2); and
- Human population (section 7.7.2).

The above may be impacted owing to the transport and storage of waste, waste incineration, the disposal of unrecoverable waste to landfill and by waste mismanagement, should it occur.

10.10.4 Characterising and quantifying the impacts and risks associated with waste

When characterising and quantifying the impacts and risks associated with each waste stream, it is necessary to consider the:

- Waste management facilities in the Falkland Islands;
- Phase 1 Development waste management options;
- Quantification of Phase 1 waste:
  - Solid waste estimates; and
  - Type and volumes of operational waste;
- The nature of the impact of waste:
  - Shipping waste to the UK; and
  - Landfill in the UK.
- Risks associated with waste:
  - Loss of containment; and
  - Improper segregation of waste.

10.10.4.1 Waste management facilities in the Falklands

As summarised in the sections below, waste management facilities in the Falkland Islands are currently very limited. Further details on waste management options in the Falklands are documented in Smethurst (2013) and the FIG Waste Management Action Plan 2015-2017 (FIG, 2014f). A municipal waste facility that meets the relevant regulatory standards is being developed on island which will allow Premier to meet its Duty of Care commitments for the Phase 1 Development waste streams.

10.10.4.1.1 Recycling and re-use

Recycling facilities are currently not available in the Falkland Islands.

10.10.4.1.2 Waste recovery (waste-to-energy)

Currently, some waste fuels are converted into heat for the hydroponics system at the Stanley Growers' site near the proposed onshore supply base and TDF in Stanley. During the last Premier exploration campaign, the facility received waste oils from the drilling programme for energy recovery. This route, however, has a finite capacity and the use of waste oils from the Phase 1 Development would be subject to specific discussion and agreement.

10.10.4.1.3 Waste treatment

The current incinerator on the Islands (at the Falkland Islands Meat Company (FIMCO)) was used during the 2015 Premier exploration programme for non-hazardous combustible waste (e.g. paper and wood) and the ash was landfilled at Eliza Cove. A new waste facility that meets the relevant regulatory standards is being developed on island which will allow Premier to meet its Duty of Care commitments for the Phase 1 Development waste streams.

10.10.4.1.4 Landfill facilities

The municipal landfill sites in the Falklands, Eliza Cove and Mary Hill Quarry, are not suitable for landfilling of Premier's solid wastes. A new landfill facility that meets the relevant regulatory standards is being developed on island which will allow Premier to meet its Duty of Care commitments for the Phase 1 Development waste streams.

10.10.4.2 Phase 1 waste management objectives and options

As a responsible operator, and in line with its ISO 14001 certified HSES-MS (section 3.2), Premier will implement the necessary measures to ensure that waste management is carried out without endangering human health and safety, and without harming the environment.

In line with the industry-standard, Premier will follow the Waste Hierarchy (section 10.10.1) to minimise waste produced throughout the Development.

10.10.4.2.1 Option assessment

The fundamental principles of waste disposal are based on returning waste materials to the environment in a form which will have the minimal environmental impact. However, in practical terms, while there are many innovative ways to handle and process waste, there are few ultimate disposal solutions as many give rise to residues and orphan wastes that require subsequent management.

However, it should be noted that waste management in a remote location without sufficient facilities to cope with the waste streams is challenging. When assessing the options, it is important to consider the varying 'trade-offs' that exist. For example, shipment of the waste to another location will incur emissions to air and while some waste streams, such as wood or paper, may be reusable or recyclable, it is not necessarily best environmental practise to ship these a great distance for the purposes of doing so. Equally, while incineration would also result in emissions, these are offset by the reduction in emissions from waste shipment while also reducing the volume of waste that requires landfill.

A review of available options (Filkin & Co., 2017) was undertaken and the conclusions are presented in Table 10.74 below. Of the many waste management options which have been commercially proven around the world, only those that meet Premier's management objectives and are available, are considered further.

During the review (Table 10.74), waste management techniques and options were screened out when:

- They were not commercially available or proven;

- The technique was energy intensive;
- They required a high-order of operator competence; and / or
- There was an uncertain cost-benefit relationship.

As shown in Table 10.74, while every effort will be made to remove, reduce and re-use waste, the key options that emerged from the review were:

- Thermal treatment to mitigate the hazard of the waste:
  - treatment of OBM cuttings in line with legislation so they can be discharged to sea; and
  - incineration of all combustible wastes to minimise waste shipments to the UK and waste to landfill.
- Shipment of waste for re-use, recycling, recovery, treatment or disposal to landfill in the UK;

Shipment of waste for management in the UK has been undertaken in previous O&G operations where appropriate treatment and / or disposal infrastructure does not exist locally and all shipments will be made in compliance with the Basel Convention and the Transfrontier Shipment of Waste Regulations (section 10.10.1.1.2). Nonetheless, it should be noted that, the export of non-recyclable waste for disposal is not a preferred option for Premier owing to the impact of emissions, cost and reliance on the return trips of coaster vessels etc. However, as this is currently the only assured means of waste disposal for the life of field, it is proposed as the base case for disposal of all Phase 1 wastes that cannot be incinerated on Island.

Nonetheless, Premier will continue to explore other options for waste management in the medium / long-term. This will include exploring exporting waste to another, geographically closer, OECD (Economic, Co-operation and Development) country.

Table 10.74: Waste management options assessment indicating the methods that were considered both viable and in line with Premiers objectives

Waste Hierarchy solution	Definition	Location	Premier options	Viable option?
Remove	Don't generate waste	Falkland Islands and UK	The first way to minimise waste generated is to not create it in the first place. This will be done through consideration of waste in contracting and minimising packaging.	✓
Reduce	Generate Less waste by better management and material substitution			✓
Re-use	Re-use the material in its original form	Falkland Islands	In order to minimize the volumes of waste drilling muds, muds that been returned to the MODU and cleaned of cuttings will be reused on subsequent wells. Should opportunities be identified to locally re-use waste materials in future, Premier will support any suitable in-country initiatives.	✓
Recycle	Recycle or reprocess the item to incorporate it into a new product or new use	Falkland Islands	Premier recognise that whilst there are plans to ship recyclable waste materials in the Falklands, presently there is little processing infrastructure and / or demand for the types of waste materials identified during the waste forecasting (section 10.10.4.3). Therefore, the number of credible options for recycling in the Falklands is currently very limited. where an opportunity is identified to locally recycle waste material in future, Premier will support any suitable in-country initiatives.	✘
		UK	Recycling facilities are available in the UK for materials that are shipped out. It should be noted however, that for large developed economies such as the UK, a large proportion of the wastes collected for recycling are exported for processing abroad (e.g. around 50 % of metals go to the EU and China (ESA, 2012)) which then incurs further emissions.	✓
Recovery	Extract material or energy from a waste	Falkland Islands	Waste-to-energy refers to the process of generating other forms of energy (e.g. electricity and / or heat) from the primary treatment of waste. These processes include: • Recovery of heat from the combustion of incinerable wastes; • Combustion of oils as a fuel source e.g. the free-oil that is separated from oily waters offshore; and • Use of organic wastes for composting which is a process of controlled decay enabling aerobic bacteria and other micro-organisms to decompose organic matter. If an incinerator is required Premier will investigate the potential for waste heat recovery during final selection of the incinerator model. However, on Island waste heat recovery, such as that used at Stanley	✘
		UK		✓

Waste Hierarchy solution	Definition	Location	Premier options	Viable option?
			Growers will be investigated; with the use of this route being subject to specific discussion and agreement. Nonetheless, should any other opportunities for waste recovery emerge in the future, Premier will support initiatives where they are considered feasible and safe and where sufficient competence can be demonstrated.	
Treat	Mitigate the inherent hazard of the waste	Falkland Islands	Thermal treatment of cuttings: A key decision is to thermally treat drill cuttings generated with OBM so that the cuttings can be discharged to sea in line with OSPAR Decision 2000/3. This greatly reduces the amount of material that would otherwise be brought onshore for treatment and disposal. Further, and as stated above, the process also enables the re-use of the base-oil in the next batch of OBM and tests have shown that the base-oil remains of sufficiently good quality through the process.	✓
	Incineration	Falkland Islands	Incineration of waste: Existing incineration facilities do not have the capacity to manage the volume of Phase 1 Development waste (section 10.10.4.1.3), but FIG are planning to provide new incineration facilities that will be able to meet the project requirements. If this is not possible, the project proposes the use of a portable incinerator at the onshore supply base as a means of: • Reducing the volume of waste that requires disposal, thus mitigating against landfill impacts; and • Reducing the number of shipments of waste back the UK. The exact model of incinerator to be used has not yet been decided and will be subject to Premier's tender process. However, the model will comply to all UK standards (section 10.10.1.1) enabling incineration of all combustible materials, including plastics and rubbers. Premier recognise that incineration is not a complete management solution as it gives rise to ash and flue gases, as well as a range of maintenance wastes which would also need to be managed in an environmentally sound manner. However: • The resultant ash may be returned to the UK for disposal; and • The emissions are somewhat offset by the fact that incineration of the waste reduces the overall volume of waste and thus reduces the number of waste shipments to the UK.	✓
		UK		✓

Waste Hierarchy solution	Definition	Location	Premier options	Viable option?
Dispose	Landfill	Falkland Islands	As disposal to an in-country landfill is not currently an option (section 10.10.4.1.4), all material that cannot be incinerated and require landfill will be returned to the UK. There are two types of landfill that may be required for the unrecoverable Phase 1 Development waste streams: Hazardous landfill for the deposit of hazardous wastes onto, or into, the land in such a way that pollution or harm to the environment is prevented; and Stable, non-reactive landfill for the deposit of inert waste that is incapable of reacting with other wastes when placed in a designated area within a landfill.	✘
		UK		✓

10.10.4.3 Quantification of Phase 1 waste

10.10.4.3.1 Type and volumes of planned waste expected

Premier commissioned a waste study and forecast (Filkin & Co., 2017) to estimate the waste streams and volumes that may result from the Phase 1 Development. Data sources for this study included:

- 2012 UK waste production data, obtained from DEFRA (2015a);
- UKCS O&G production waste figures, obtained from the most recently available UK EEMS Report (2013), to determine the average quantity of waste produced by all North Sea installations; and
- Data from analogous activities both onshore and offshore.

The forecast provides an overview of the solid and hazardous liquid waste arisings in terms of:

- What waste types are forecast to be produced;
- What volumes of these wastes can be expected; and
- When, during the project life-cycle, can these waste types be expected to arise.

The forecast is based on key input data including the:

- Required numbers and types of project personnel (on rotation, permanent onshore personnel etc.);
- MODU operations;
- Floating Production, Storage and Offloading (FPSO) operations;
- Vessel numbers;
- Standard industry reference sources;
- Data from previous O&G operations in the Falkland Islands; and
- Data from analogous operations undertaken in the O&G sector elsewhere.

The totals below include general waste from the Conventional Trading Tanker (CTT),. As the CTT is responsible for its own waste, it is anticipated that the estimates very slightly over estimate the waste arising (e.g. around 1 % of annual arisings).

In addition to projecting the waste arising throughout the entire field life, the forecast was used to group wastes together that share the same or similar waste management characteristics. It should be noted that a large proportion of these totals will be discharged to sea (73 %), including cuttings, sewage and food waste, and therefore, will not require onshore treatment or disposal. These are covered in the drill cuttings and operational discharges chapters (sections 10.6 and 0 respectively).

Figure 10.45 below shows when the remaining 27 % of waste that requires onshore treatment arises throughout the life of the Development, and from which activity. The detailed waste forecast is summarised in Table 10.75 and Table 10.76.

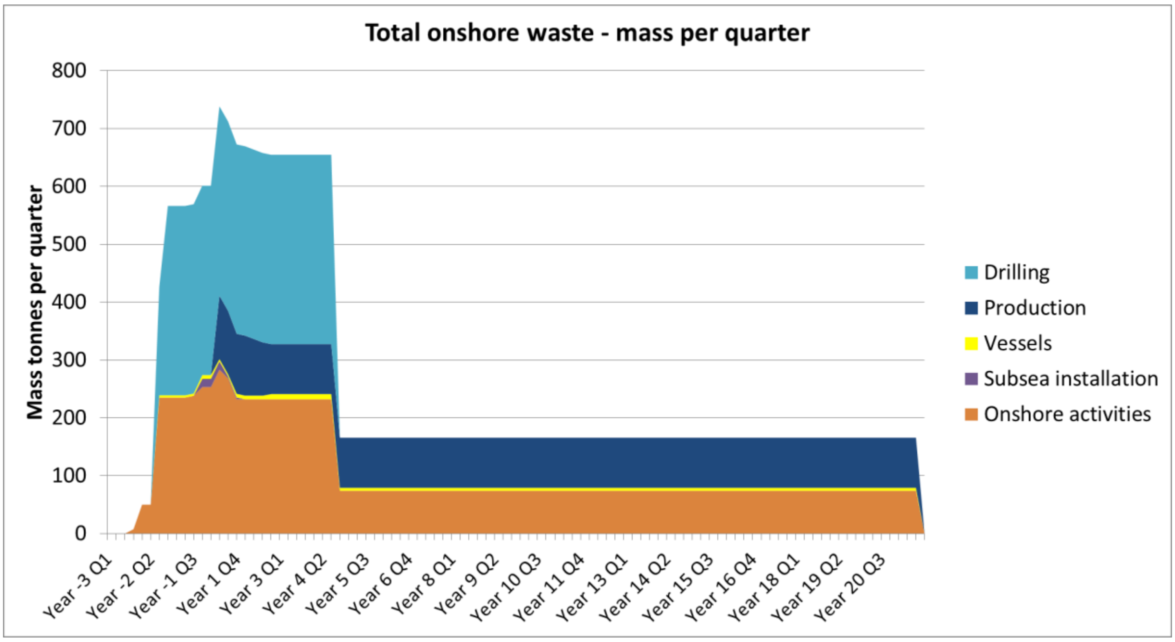


Figure 10.45: Phase 1 Development wastes per year split by activity generating the waste

Table 10.75: Forecast of hazardous and non-hazardous waste quantities that require onshore treatment, broken down by activity at different stages of the project [a]

Activity	Field life total (tonnes)	% of total	Stage 1 Q1-Year -3 to Q3-Year 1	Stage 2 Q4-Year 1 to Q3-Year 4	Stage 3 Q4-Year 4 to Q4-Year 20
Drilling	6,733	26.9%	2,806	3,928	0
Production	7,184	28.7%	219	1,089	5,877
Subsea installation	49	0.2%	46	3	0
Vessels	914	3.6%	76	184	653
Onshore activities	10,173	40.6%	2,344	2,785	5,043
Total	25,053	100%	5,491	7,989	11,573
% by stage			22 %	32 %	46 %

a These figures do not include the ash from the incinerator that will also be shipped back to the UK. This waste stream is included in Table 10.76 and will add 944 tonnes to the total.

Table 10.76: Disposal options for Sea Lion waste streams

Waste stream	Final destination (UK or Falklands)	Disposal method	Estimated quantity over field life (tonnes)	Percentage contribution over field life
Aerosols and gas cylinders	UK	Recycle / hazardous landfill	100	0.4 %
Aluminium and metal	UK	Recycle / re-use	1,475	5.9 %
Batteries	UK	Recycle	14	0.1 %
Bulk hoses	Falkland Islands	Incinerate [a]	267	1.1 %

Waste stream	Final destination (UK or Falklands)	Disposal method	Estimated quantity over field life (tonnes)	Percentage contribution over field life
Cardboard, paper and packaging	Falkland Islands	Incinerate [a]	610	2.4 %
Chemical sacks	Falkland Islands	Incinerate [a]	269	1.1 %
Chemicals	UK	Treatment / hazardous landfill	44	0.2 %
Containers and empty IBCs	UK	Re-use	236	0.9 %
Filters (hazardous)	UK / Falkland Islands	Hazardous landfill / incinerate [a]	114	0.5 %
Filters (non-hazardous)	Falkland Islands	Incinerate [a]	94	0.4 %
Food c / packaging	Falkland Islands	Incinerate [a]	2,431	9.7 %
Flammable solids and solvents	Falkland Islands	Incinerate [a]	3,540	14.1 %
General garbage, non-hazardous	Falkland Islands	Incinerate [a]	3,223	12.9 %
Glass	Falkland Islands	Re-use	70	0.3 %
Hazardous electrical waste	Falkland Islands	Recover / hazardous landfill	3	0.0 %
Hazardous waste, aerosols, pipe dope	Falkland Islands	Incinerate [a]	171	0.7 %
Light bulbs	UK	Recycle	3	0.0 %
Medical	Falkland Islands	Incinerate [a]	6	0.0 %
Non-hazardous electrical	Falkland Islands	Recover / recycle/ hazardous landfill	39	0.2 %
Oily rags, oily sludge, oily wastes, oily water and WBM washings	Falkland Islands	Incinerate [a]	4831	19.3 %
Other	Falkland Islands	Landfill	557	2.2 %
Plastics	Falkland Islands	Incinerate [a]	889	3.6 %
Printer cartridges	UK	Recycle	11	0.0 %
Slings	Falkland Islands	Incinerate [a]	541	2.2 %
Wood	Falkland Islands	Incinerate [a]	1,549	6.2 %
Oily water	Falkland Islands	Treat to sewer	4,197	16.8 %
Ash (from incineration process)	Falkland Islands	Landfill	944	-
Total waste			25,053	-

Waste stream	Final destination (UK or Falklands)	Disposal method	Estimated quantity over field life (tonnes)	Percentage contribution over field life
Total re-used (UK)			1,785	7%
Total recycled (UK)			1,532	6%
Total incinerated or waste-to-energy (Falkland Islands)			13,443	54%
Total to landfill (UK)			4,096	16%
Total oily water treatment (Falkland Islands)			4,197	17%
Secondary waste - incinerator ash to landfill (UK)			944	-

a Ash from the incineration process will be disposed of at the new FI landfill.

b It is generally expected that ash residues from static hearth incinerators of the type proposed here can vary between 3-10 % of the mass of the input waste (Filkin & Co., 2017). As a worst case, this assessment assumes 10 % of the mass of waste incinerated is left as ash which must be contained and shipped back to the UK.

c The majority of food waste will be discharged offshore in compliance with MARPOL (section 10.1010.13.5.1.2) but any food waste returning to the supply base, for example if offshore macerators are not working, would be incinerated unless future opportunities arise in collaboration with FIG for composting of such resources.

10.10.4.4 Nature of the impact of waste

10.10.4.4.1 Impact of shipping waste to the UK

Waste being returned to the UK will be transported via the returning coaster vessels, the emissions of which have been assessed in section 10.9. Although it is not anticipated that the all the coasters will be under hire to Premier on the return trip, the emissions from all coaster return trips have been assumed to ensure a worst case assessment.

When shipping waste to the UK, Premier will adhere to the relevant Conventions, Agreements and the Transfrontier Shipment (TFS) of waste controls (section 10.10.1.1).

10.10.4.4.2 Impact of regulated landfill use

The potential environmental impacts of waste disposed to landfill include:

- Direct impacts:
  - Use of a finite and unsustainable resource.
- Indirect cumulative impacts:
  - Creation of irritants such as dust, pests, noise and odour;
  - Contamination of groundwater, aquifers and soil; and
  - Production of methane as organic materials (e.g. food scraps and paper etc.) decompose.

With regard to the use of a finite resource, landfill sites in the UK are estimated to occupy an area of approximately 2,000 km2, however the UK Local Government Agency estimates that the country is due to run out of space for its landfill waste in the coming years unless new sites can be found (EA, 2012). The same forecast has, however, been made in previous years and has always been extended as new sites are found and developed, and timescales for developing new sites are often long, given planning processes, ongoing changes in regulation and competition.

The vast majority of O&G wastes in the UK are landed and disposed of in Scotland, as were wastes from the Premier exploration drilling campaign in 2015. Waste management is an area devolved to the Scottish Government and data show that landfill capacity can be managed in the medium term. For example, Scotland produces around 4 million tonnes of landfill waste per year, and has an annual consented landfill capacity of 13 million tonnes, with several sites consented for use for another 20 years (SEPA, 2016a and 2016b).

With regard to the indirect impacts, Premier has no control or influence over the impacts of landfill any more than any other consumer. However, it will aim to minimise the amount of waste that goes to landfill and will ensure that only regulated landfills are used.

10.10.4.4.2.1 Phase 1 waste in the context of the UK as a recipient

The FIG plan to establish a new municipal waste facility that will take the majority of waste from the project. Waste in categories that can not be managed on the Islands will be shipped to an international location. This section discusses the entire waste footprint of the project in the context of the UK's waste system.

The UK generated 200 million tonnes of total waste in 2012, 24 % of which was generated by Commercial and Industrial (C&I) activities (DEFRA, 2015a). Almost half of the total waste that entered final treatment in the UK in 2012 was recovered and 26.1 % was sent to landfill (DEFRA, 2015a).

A summary of the estimated Phase 1 waste is provided in Table 10.77, alongside the 2012 UK waste data. The Phase 1 Development is anticipated to generate a total of 25,997 tonnes of waste (including incinerator ash) over the course of the Field Life, 54 % of which will be produced during Stages 1 and 2 and 46 % of which will be generated during Stage 3 (Table 10.75). Notably, the total quantity of waste generated throughout the 23 year project amounts to only 0.01 % of the amount of waste generated in the UK in a single year (2012). Similarly, the Sea Lion waste which may be sent to landfill over the full 23 year project equates to 0.01 % of UK waste which went to landfill in 2012. Assuming that the UK 2012 waste tonnage was to remain consistent over the next 23 years, the total Phase 1 waste would amount to 0.0005 % of the total UK waste tonnage generated in 23 years. When compared to the UK C&I waste alone (Table 10.77) the total Phase 1 waste generated over 23 years amounts to 0.05 % of the amount of C&I waste generated in the UK in a single year (2012).

Detail on the fate of the North Sea O&G (O&G) industry wastes is provided in Table 10.78 (UKEEMS, 2013). These data show that 21 % of all UK O&G wastes go to landfill as opposed to only 16 % of Phase 1 waste. It should be noted in this comparison that the O&G waste industry figures reflect a mature and well established industry so waste options that are feasible and well-used in the UK may not be directly applicable to the same waste streams generated in the Falklands.

Table 10.77: Summary of wastes produced during the Phase 1 Development Stages 1 to 3 in comparison to total UK waste, total UK C&I waste and total UK waste to landfill

Waste source		Total Quantity (tonnes)	Average quantity per year (tonnes/year)	Percentage contribution
Stage 1	Drilling (42 months)	5,491	1,569	22 %
Stage 2	Drilling, installation, first oil and initial production (29 months)	7,989	3,329	32 %
Stage 3	Steady production (17.5 years)	11,573	661	46 %
Totals		25,053	-	-
Total UK waste 2012			200,000,000 [a]	
Total UK commercial and industrial (C&I) waste 2012			48,000,000	
Total UK waste that went to landfill in 2012			52,000,000	

a DEFRA (2015a)

Table 10.78: Comparison of the fate of O&G industry wastes

Fate of waste	North Sea O&G industry waste in 2013 [a]		Quantity (t) of Phase 1 Development waste (excl. incinerator ash)		
	Quantity (t)	As a percentage of the North Sea 2013 total	Total waste over 23-year field life	Average waste per year	As a percentage of Sea Lion total waste for one averaged year
Recovery and Reuse	4,945	3 %	1,785	78	7.2 %
Recycling	36,440	25 %	1,532	67	6.2 %
Waste to energy [b]	4,812	3 %	0	0	0 %
Incinerate	489	0.30 %	13,443	584	54.6 %
Landfill	31,427	21 %	4,096	178	16.3 %
Other route c	69,045	47 %	4,197	182	16.7 %
Total	147,158	-	25,053	1,089	-

a As taken from UK EEMS Report (2013).

b Waste-to-energy refers to the process of generating energy in the form of electricity and / or heat from the primary treatment of waste.

c Other disposal routes include but are not limited to: land treatment, specially engineered landfill, biological treatment, injection. Other recovery routes include but are not limited to: use as a fuel, used oil refining, land treatment resulting in benefit to agriculture or ecological improvement (EC Regulation No 1013 / 2006 on the Shipment of Waste, Annex 1a).

10.10.4.5 Nature of the risks associated with waste management

Both hazardous and non-hazardous waste products have the potential to impact upon the environment if they are not handled, stored, treated and recovered or disposed of appropriately. Mismanaged wastes have the potential to impact upon soil, water and groundwater quality, marine and terrestrial wildlife, resource use and human health. Premier employs strict controls on waste management in its operations and requires any lost objects to be reported, recovered if at all possible, and corrective actions to be put in place to prevent reoccurrence.

Mismanagement of waste includes:

- Improper storage leading to loss of containment of waste; and
- Improper segregation of waste during generation offshore, transportation and storage onshore leading to cross-contamination.

10.10.4.5.1 Loss of containment

Loss of containment leading to potential impacts would be an unplanned event and as such, it is not possible to quantify the amount of waste that may be released. The industry-standard mitigation measures (section 10.10.5) will be utilised, however, to minimise the likelihood of an incident.

The potential environmental impacts of a loss of containment are:

- Loss of solid waste to sea or land which could:
  - Create unsightly litter and may impact upon landscapes / seascapes and therefore, indirectly, upon the local community and visitors to the Islands with regard to wellbeing and 'quality of experience'; and
  - Be ingested by terrestrial / marine fauna or cause entanglement thus affecting the animal's fitness.
- Loss of hazardous liquid wastes to sea.

The loss of hazardous wastes to sea is covered in the spill sections 12.1, 12.2 and 12.3. With regard to the loss of solid wastes to sea, plastic litter and other objects are recognised as a major source of marine pollution (Waluda and Staniland, 2013) and such wastes are very slow to degrade.

10.10.4.5.1.1 Impacts of waste loss and litter on landscape and human population

The Falkland Islands are highly scenic and wind-blown 'litter' would be damaging visually and ecologically. While it is not possible to estimate the quantities of waste that may be blown away in the event of waste mismanagement, or to predict the destination of lost material, the Falkland Islands are suffused with beauty spots and many around Stanley, where the onshore supply base is likely to be located, could be affected. Many of these areas are highly sensitive owing to their importance for local wildlife, and in some cases, for tourism e.g. Cape Pembroke which is an NNR and IPA.

Littering of these areas with lost waste is more likely to occur in the event of losses from the onshore waste laydown yard than from waste lost at sea, and may impact upon the 'quality of experience' of both the local population and visitors to the area.

10.10.4.5.1.2 Impacts to wildlife

Buoyant debris remains suspended on the sea-surface while negatively buoyant debris sinks and may remain on the seabed for years. As many man-made materials are not biodegradable, litter and lost debris has the potential to cause damage to wildlife time and again (Laist, 1987). Therefore, animals may be exposed to the wastes over a wide area and over a long time (Laist, 1987). The threats of such debris are often mechanical and, in particular, the ingestion of, and entanglement or capture in, man-made debris is a potentially significant cause of injury and death in Crustacea, fish, seabirds and marine mammals (Derraik, 2002; Fowler, 1987; Laist, 1987; Huin and Croxall, 1996; Gregory, 2009; Waluda and Staniland, 2013). Entanglement can lead to drowning, injury, impaired ability to catch food or avoid predators (Laist, 1987) while ingestion of debris may block digestion, cause internal damage or lessen the impulse to feed (Laist, 1987).

Marine mammals (such as sea lions) are particularly vulnerable to becoming entangled in loops of rope, packing bands (Page *et al*., 2004; Waluda and Staniland, 2013) and plastic sheeting or netting, which generally becomes stuck in the fur around the neck and slowly strangles the animal. It is generally less likely that birds will become entangled but instead may ingest small floating objects which can cause chronic impact by reducing fitness (long-term survival) and potentially breeding success. Indeed, an assessment of the impact to the local population of turkey vultures (Cathartes aura) in Stanley was conducted by Augé (2016b). The turkey vultures feed around Eliza Cove and were investigated to determine the amount of anthropogenic debris in their diets. This was done by assessing the percentage of anthropogenic debris in the regurgitated pellets. It was found that on average, 16.1 % of the mass of each pellet was anthropogenic (mostly plastics) indicating that the birds are regularly ingesting waste materials.

Where a species or population is already threatened, such impacts upon fitness may have a significant effect. For example, the population of wandering albatross breeding on South Georgia, and foraging in part around the Falklands, has shown a long-term decline (Poncet *et al*., 2006), such that any additional pressure could exacerbate their decline.

It is understood that in recent years, the impacts of debris from the fishing industry around South Georgia, and within other CCAMLR (Commission for the Conservation of Antarctic Marine Living Resources) waters, has lessened owing to additional fishing license conditions and strict enforcement regimes (Waluda and Staniland, 2013). However, a significant number of animals are still impacted suggesting that debris also originates from outside the controlled areas. As improvements such as this can be evidenced, it is essential that any new industry in the region manages its waste responsibly.

10.10.4.5.2 Improper segregation

In the event that wastes are not properly segregated on the MODU / FPSO at the point of waste generation and / or that waste is mixed during transportation or onshore storage, there is the risk of non-hazardous wastes becoming contaminated with hazardous wastes. Should cross-contamination occur, non-hazardous waste may need to be treated as hazardous wastes and the potential for waste recovery may be lost. The main impact of this is the loss of opportunity for waste recovery and an increase in the use of landfill.

10.10.5 Industry standard mitigation

Industry-standard mitigations available include:

- Development of a voluntary ‘Environmental representative / steward’ (E-Rep) role among the offshore and supply base personnel;
- Waste awareness training and inclusion of a clear message in all personnel inductions;

- Segregated colour bins;
- Signage;
- Contained waste receptacles;
- Use of netting over open skips;
- Dedicated waste laydown areas; and
- Reporting of loss of waste incidents to FIG.

An example of an educational poster is shown in Figure 10.46 which encourages the containment of waste and, in particular, the cutting of packaging bands so that they do not entangle seals and sea lions in the event that they are lost to sea.

There are also a number of standard management practices which will be followed. These are:

- Compliance with the Premier HSES-MS with regard to contractor management, auditing, performance monitoring and the setting of waste objectives and targets;
- Development of the Waste Management Strategy and Waste Management Plan;
- Minimisation of waste through contracting strategy;
- International Finance Corporation (2007) Environmental, Health, and Safety General Guidelines; and
- UK HSE guidance HSG71 for storage of wastes.

Figure 10.46: Example of an educational poster for placement around the MODU and FPSO

10.10.5.1 Waste Management Strategy

- The Premier Waste Management Strategy (WMS) for the Phase 1 Development seeks to:
- Identify, quantify and characterise all waste streams, and their volumes over the 3 Stages of the development;
- Promote waste minimisation and segregation;
- Identify appropriate disposal options for the various waste streams and the timings required in the context of operating in the Falkland Islands; and
- Detail options and outline feasibility for the layout and specifications of potential facilities at Premier's laydown yard.

In order to achieve this, the WMS encompasses a 23-year forecast of waste quantities based on analysis of analogous projects (section 10.10.4.3.1). Waste treatment techniques in line with the Waste Hierarchy were identified (section 10.10.4.2.1) with consideration given to key legislative sources such as the Waste Framework Directive. Specifically, The WMS will be used to facilitate collaborative discussion with FIG on the most suitable waste solutions for the Phase 1 Development, and the Falklands. The WMS will also be used to inform the project specific Waste Management Plan, see section 10.10.5.2 below.

10.10.5.2 Waste Management Plan

In compliance with the FIG Guidance Note (02/13), the WMS will inform the more detailed Waste Management Plan (WMP) has been developed during FEED and will be finalised during Detailed Design. It will provide guidance on efficient working practices for the safe handling, storage, transportation and disposal of waste generated during the Phase 1 Development.

Specifically, the WMP details:

- Key roles and responsibilities of Premier personnel and contractors with regard to waste management;
- The regulatory and EMS guidelines upon which the WMP is based;
- The Waste Hierarchy used to minimise the amount of waste disposal and maximise recovery (Figure 10.44);
- Definition of waste types; and
- Guidance on all aspects of waste management.

10.10.6 Impact and risk assessment

The following section draws upon all the information provided above to assess the 'Sensitivity of the Receptor' and the 'Severity of Effect' in order to determine the overall 'Impact' of planned activities. Assessment of unplanned events includes an assessment of the 'Likelihood of Occurrence' to determine the 'Risk'.

A summary of the impact and risk assessment outcomes is tabulated in section 10.10.11 which shows the worst case impact / risk for each activity and receptor.

10.10.6.1 Impact assessment of waste generation and management

10.10.6.1.1 Shipment of waste to the UK

Arrangements for the temporary storage of waste awaiting transhipment in the Falklands will be agreed with and approved by FIG. Premier will collaborate with FIG and other stakeholders to plan all shipments, thus maximising their efficiency. While the use of the FIG municipal incinerator should reduce the number of waste shipments to the UK, thus reducing the emissions, it has been assumed that all coaster vessels will remain on hire to Premier to return the waste to the UK to assume a worst case. The impact of all emissions resulting from the Phase 1 Development is assessed in section 110.9.9.

10.10.6.1.2 Use of regulated landfill in the UK

Landfill occupies the lowest rank in the Waste Hierarchy and it is understood that this method of waste management is ultimately unsustainable. However, as waste that cannot be incinerated in-country will be returned to the UK, and most likely Scotland which has consented landfill space available for 20 years (section 10.10.4.4.2), the **sensitivity of UK landfill sites as a receptor** (tangible property) is considered to be **'High'**.

It is currently uncertain how long shipping waste back to the UK will be necessary and / or permissible. However, as is shown in section 10.10.4.4.1, only 20 % of Phase 1 waste is expected to go to landfill (based on the review of analogous projects and including the ash from the incinerator), which is similar to 21 % of the waste from the UKCS as a whole. In addition to the efforts made to reduce and recover waste, this percentage volume has been lessened due the incinerator which aims to minimise the volume of materials being returned to the UK. Overall, the total estimated quantity of waste from the Phase 1 Development that will be sent to landfill amounts to only 0.01 % of the UK waste sent to landfill in 2012 alone (section 10.10.4.4.2), and 0.05 % of the UK C&I waste produced in 2012. As such, this landfill use falls within the category of 'Minimal use of a finite resource throughout lifecycle of project or moderate use for finite stages of the project' and, on balance, the **severity of effect** on landfill resources for the duration of the Development is considered to be **'Minor'**.

Therefore, the overall **significance of the transboundary impact** of large amounts of waste over the Project lifetime on tangible property in the UK is assessed as **'Moderate (8)'**.

10.10.6.2 Risk assessment of unplanned and accidental events

10.10.6.2.1 Loss of containment

Given that waste mismanagement and loss of containment would be an unplanned event, it is not possible to estimate which of the potential receptors may be affected by any given event. Therefore, for the purposes of the assessment below, the most sensitive receptor is described to ensure a worst case assessment has been made.

10.10.6.2.1.1 Impacts to landscape

Assessment of the impacts on landscapes / seascapes, and the indirect impact upon the 'quality of experience' of the human population, is very subjective and almost impossible to quantify. The sensitivity of the receptor will ultimately depend upon the volume of waste accidently lost to the environment, the waste type and the path and final destination of the waste. However, with regard to landscape and seascape, impacts of losses are only likely to result from waste mismanagement at the supply base such that the range of probable destinations would be limited (section 10.10.4.5.1.1).

Nonetheless, waste could reach areas which are ‘partially developed with non-industrial infrastructure which are used for recreational purposes and tourism’ and therefore litter could ‘conflict with the current use of the area’. The **sensitivity of the landscape / seascape as a receptor** is therefore considered to be **‘High’**. Similarly, with regard to the human population as a receptor, the littering of valued and / or sensitive areas may be considered ‘unacceptable to a majority of stakeholders’. Therefore, to assume the worst case, the **sensitivity of the receptors** is considered to be **‘High’**.

Given the transient nature of litter, the impact of lost materials in any given place may not be permanent as the material may move from place to place under the influence of wind, tide, scavenging fauna and / or may be picked up by a passer-by. Despite the temporary location of the litter however, unless it is collected and appropriately disposed of, the litter itself may be permanent unless it is biodegradable and may impact upon the view from close range. Therefore, the **severity of effect** in any given place and time is considered to be **‘Minor’**.

The worst case overall **significance of the impact** of waste mismanagement to landscape / seascape could be considered to be **‘Moderate (8)’**.

Once accidentally released into the environment, it is not realistic to suggest that the lost materials can be immediately recovered and it is therefore key to prevent its release. Implementation of the WMP and the use of closed skips will minimise the likelihood of losses. Additionally, the implementation of the measures described in section 10.10.5 to achieve early and sufficient containment of waste will hopefully ensure that all personnel are informed and trained on the importance of effective waste containment. The **likelihood of loss of containment** is considered **‘Unlikely’**.

Therefore, the overall **significance of the risk** to landscape / seascape associated with loss of containment is therefore considered to be **‘Low (6)’**.

10.10.6.2.1.2 Impacts to wildlife

As with the impacts to landscape and seascape, it is not possible to predict the fate of litter and which animals it may impact upon, or how many times. However, given that impacts may occur to a protected species and / or those within a globally important population, which may also be long-lived species with a slow reproduction rate, or during a vulnerable life stage (e.g. during breeding), it has been estimated that the **sensitivity of the receptor** could be **‘Very High’**.

While the effect of litter on wildlife can be fatal (section 10.10.4.5.1.2), the impacts are likely to affect individual animals rather than groups of animals such that, in most cases, the impact would be unlikely to be detectable above background variability, or to impact upon population fitness. Therefore, the severity of effect to most receptors is likely to be **‘Slight’** and the overall impact significance **‘Low (6)’**. However, in the event that a long-lived, slow breeding species was impacted by ingestion or entanglement, such as albatross sp., there is the possibility that this could impact upon the population fitness. To take a precautionary approach therefore, the **severity of effect** is considered to be **'Minor'**.

Therefore, the worst case **significance of the impact** of waste mismanagement is assessed to be **'Moderate (10)'**.

As described above regarding the way waste may be lost, the **likelihood of loss of containment** occurring is considered to be **'Unlikely'**.

The overall **significance of the risk** to wildlife associated with loss of containment is therefore considered to be **'Low (6)'**.

10.10.6.2.2 Improper waste segregation

Assuming that normally recoverable waste was cross-contaminated with hazardous waste through poor segregation, and thus had to be disposed of (rather than recovered), this may have an effect on resource use, such as landfill, in the UK. Therefore, to take a precautionary approach and assume the use of this finite resource, the **sensitivity of the receptor** is considered to be **'Very High'**.

It is not possible to estimate the extent of any impact as cross contamination may affect one piece of scrap metal, which could be cleaned, or an entire skip full of plastic packaging or wood. However, given that improper segregation would be an unplanned event and that waste management will be regularly audited in line with the HSES-MS, it can be assumed that the quantities of cross-contaminated waste will be relatively small. Therefore, it is likely that disposal to landfill as a result of cross-contamination will have 'no or negligible use of finite resource throughout lifecycle of project' and therefore the **severity of effect** is likely to be **'Slight'**.

Therefore, the worst case **significance of the impact** of improper segregation could be considered to be **'Low (5)'**.

Implementation of the WMP will ensure that sufficiently labelled waste skips and bins will be in place on the MODU / FPSO. Nonetheless, taking a precautionary approach given that such an incident could occur through negligence by an individual, the likelihood of the event occurring is **'Possible'**.

The **overall significance of the risk** associated with improper segregation is therefore considered to be **'Low (6)'**.

10.10.7 Project specific mitigation measures

While some environmental impacts are **'Low'** or **'Very Low'** such that no further mitigation measures are considered necessary, the following impacts and risks were all considered to be **'Moderate'**, and therefore require further mitigation efforts where possible:

The transboundary impact upon tangible property (landfill resource) in the UK.

10.10.7.1 Mitigation impacts to landfill

Although landfill space may be available over the life of the field (section 10.10.4.4.2), landfill is inherently unsustainable and occupies the lowest level in the waste hierarchy.

It is therefore necessary to determine ways to further reduce the volume of waste that may be destined for landfill. While the use of an incinerator has been proposed and is included within the initial impact assessment, it will always be necessary for responsible operators to identify other reasonably practicable means for reducing the waste to landfill, and indeed the overall impacts of waste.

Industry-standard practises and the HSES-MS requirements, which aim to ensure continual improvement, are such that no additional mitigation measures are considered reasonably practical in reducing waste quantities at this time.

Note: even in the event that new landfill facilities became available in the Islands, this would not necessarily lessen the sensitivity of landfill as a receptor as disposal to landfill, wherever it is located, will always be fundamentally unsustainable.

10.10.7.2 Mitigating impacts from loss of containment

Industry-standard practises and the HSES-MS requirements, which aim to ensure continual improvement, are such that no additional mitigation measures are considered reasonably practical in reducing risks from the loss of containment of waste at this time.

10.10.8 Residual impacts and risks

10.10.8.1 Residual impact of landfill use

There will always be some wastes that cannot be incinerated, such as some recyclable wastes and speciality wastes which have to go to landfill, and whether these are transported to the UK, or taken to a new in-country facility in the future, landfill will always be fundamentally unsustainable in the long-term such that the sensitivity of the receptor (landfill) must remain **'High'**. The only way to reduce the impact of landfill use is to succeed in finding opportunities for waste management which sit higher up in the Waste Hierarchy, thus reducing the reliance on landfill and the severity of effect.

It is not currently possible to determine whether the FIG municipal waste facility will further reduce the need for disposal to landfill. Therefore, the residual impact remains **'Moderate (8)'**.

10.10.8.2 Residual risk of loss of containment

Not applicable.

10.10.9 Cumulative impact

10.10.9.1 Landfill use

While application of the Waste Hierarchy will maximise the reduction, re-use, recycling and recovery of waste (including waste-to-energy), the use of landfill sites in the UK, for a proportion of the waste will still be required which may have a cumulative effect in terms of concentration, extent and duration of waste (section 8.10.1). While the contribution to landfill from the Phase 1 Development in isolation is relatively low in the UK context, and is lower than the average waste to landfill from UKCS operations, the impact significance is considered **'Moderate'**, primarily owing to the sensitivity of the receptor, i.e. the unsustainability of the resource.

While Premier will endeavour to reduce this impact by minimising waste to landfill, it has very limited control over the cumulative and indirect impacts caused by landfill e.g. methane gas production from decomposition. However, all landfill sites in the UK are governed by numerous pieces of legislation to ensure that they are managed in accordance with best practice.

10.10.9.2 Incinerator use

As stated above, the FIG have approved plans for a new municipal waste facility and the project will only provide stand alone incineration in the event that the FIG site is not available. However, with regard to air quality, the siting of the supply base incinerator is not considered to add cumulatively to any impacts already present from the FIMCO incinerator due to their relatively distant locations.

10.10.10 Confidence

The magnitude, extent, reversibility, duration and frequency of the impact of waste generation and management are well understood from previous projects.

One uncertainty in the assessment of the onshore disposal and recovery of waste is that the waste quantities are estimated based on development wells and production in the North Sea. It is also recognised that whilst the exact incinerator product to be used is not yet defined, representative proven models of the type proposed have been used for assessment purposes.. To take a precautionary approach confidence in the assessment of all the impacts is considered to be **'Probable'**.

Confidence in the risk assessments for waste mismanagement is **'Certain'**.

10.10.10.1 Monitoring required

Monitoring of waste and compliance with the WMP will occur via:

- Pre-hire audit, and ongoing audits of the MODU and other project vessels to ensure tanks and pits provide flexibility for managing fluids to minimise pit cleaning or other liquids and to ensure waste segregation is being managed;
- Ensuring the contracting strategy with key suppliers incentivises waste minimisation and features in KPIs e.g. via ISO14001 compliance;
- Weekly inspection of storage facilities in line with the WMP inspection checklists and use of the Premier Corrective Action list where non-conformances cannot be immediately remedied;
- Monitoring of performance and by the E-Rep on the FPSO and supporting ongoing waste initiatives;
- Internal Premier waste reporting e.g. monthly provision of the Waste Disposal Logs, reporting of non-conformances or spills and corporate waste reporting and monitoring via KPIs;
- Waste reports will be made available to the appropriate regulatory bodies as required;

- The requirement to audit / assess waste contractors (section 3.2.16) and track actions in corporate systems; and
- Transfrontier shipment of waste notification controls.

Detailed monitoring requirements has been established during the Environmental Monitoring and Management Plan (EMMP) workshop. All monitoring requirements agreed by Premier and FIG will be recorded and managed via the project-specific Phase 1 EMMP (an outline EMMP is provided in Chapter 15).

10.10.11 Offsetting

For significant residual and impact and risks (Moderate or above), offsetting via an Environmental Fund is proposed, see section 8.9 for further details.

10.10.12 Findings summary

Table 10.79: Summary of the impact assessment for waste generated during the Phase 1 Development

Activity / Event	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Offshore, inshore, onshore and at-shore operations and activities	Waste generation for disposal in the UK (worst case)	Use of a finite resource, risks to groundwater, aquifers and soil, production of methane	Planned	1	High	Minor	n/a	Moderate (8)	Moderate (8)	Probable	Industry standard: Compliance with the Premier HSES-MS with regard to contractor management, auditing, performance monitoring and the setting of waste objectives and targets Project specific: Use FIG facility
	Loss of containment	Impact to landscape / seascape, and quality of experience of valued sites	Unplanned	1, 2 & 3	High	Minor	Unlikely	Low (6)	n/a	Certain	Industry standard: As above; and E-Reps scheme, waste awareness training; segregated bins, signage, netting, dedicated waste laydown areas.
Offshore, inshore, onshore and at-	Loss of containment	Impacts to wildlife, ingestion of waste by marine fauna or entanglement	Unplanned	1, 2 & 3	Very High	Minor	Unlikely	Low (6)	n/a	Certain	

Activity / Event	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
shore activities	Improper waste segregation	Loss of opportunity for waste recovery and increased use of landfill	Unplanned	1, 2 & 3	Very high	Slight	Possible	Low (6)	n/a	Certain	Project specific: None proposed.

[a] See Chapter 8 for definitions of sensitivity, severity, likelihood and significance.

10.11 Collisions between vessels and marine mammals

Table of Contents

10.11.1 Introduction

Numerous vessels will be used throughout the three Stages of the Phase 1 Development and while the use of vessels is a planned event, it is necessary to consider the risk of collision with cetaceans (whales and dolphins). Internationally, it is believed that collisions between cetaceans and vessels are more frequent than previously suspected (WDCS, 2006). Such an increase in the risk of collisions is linked to a general increase in the density of shipping traffic, the number of large fast-moving vessels (Silber *et al*., 2009) and the continuing recovery of large cetacean populations following the cessation of whaling.

This chapter specifically assesses the risk of collision between the Phase 1 Development vessels and cetaceans.

Note: The following chapter assesses the risk of collisions with marine mammals during the offshore operations and with few vessels visiting inshore water which is restricted to the arrival / departure of up to four LTVs and infrequent visits (c.11) to the LTVs by the Subsea Construction Vessels.

Note: the other impacts associated with vessel use are described elsewhere in this document, as described in section 9.2.

10.11.1.1 Legislation and guidelines regarding collision with marine mammals

Currently, there is no dedicated legislation in the UK or the Falkland Islands to protect cetaceans from ship-strike specifically. However, marine mammals are protected from deliberate harm by the:

- UK Offshore Marine Conservation (Natural Habitats & Conservation) Regulations 2001; and
- Falkland Islands Marine Mammal Protection Ordinance 1992.

10.11.2 Sources of shipping traffic

During the Phase 1 Development, shipping traffic will increase as a result of:

- Arrival and positioning of the Mobile Offshore Drilling Unit (MODU);
- Delivery and installation of the subsea mooring, drilling, production and oil export facilities;
- Arrival and positioning of the Floating Production, Storage and Offloading vessel (FPSO);
- Hook-up and commissioning of the FPSO;
- Emergency support for the MODU and FPSO;
- Supply of cargo to the Falkland Islands;
- Supply of cargo to the MODU and FPSO; and
- Conventional Trading Tankes (CTT) receiving crude oil from the FPSO (Direct Offtake).

A summary of vessel use during stages 1, 2 and 3 is given in Table 10.80. A full inventory of the vessels used during Stages 1 to 3 of the Development are provided in section 5.11.2.

The behaviour of these vessels will depend upon their specific roles e.g. cargo delivery vs. emergency support vs. oil export and the frequency of vessel movements will vary depending on the Stage of development.

Table 10.80: Summary of the vessels to be used during each stage of the Phase 1 Development [a]

Stage 1	Stage 2	Stage 3

• MODU transit to field
• Anchor handling tugs (AHT)
• Installation vessels
• Large Transport Vessels (LTV)
• Very Large Transport Vessel (VLTV)
• Fast transit carrier
• Large Offshore Construction Vessel (OCV)
• Multi-Role Support Vessels (MRSV) for;
  – Supply Vessels
  – Emergency Response and Rescue Vessel (ERRV)
• Coaster Supply Vessels
• FPSO transit to Sea Lion Field (towed by 3 tugs) [b]
• Positioning and presence of FPSO on location with 500 m exclusion zone
	• MODU transit in-field
	• Anchor handling tugs (AHT)
	• Supply Vessels
	• ERRV
	• Coaster Supply Vessels
	• FPSO on location with 500 m exclusion zone
	• Oil export vessels:
	  – Purchaser's Conventional Trading Tanker (CTT);
	  – Offshore Support Vessel (OSV);
	  – Multi-Role Support Vessel (MRSV).
		• Supply Vessels
		• ERRV
		• Coaster Supply Vessels
		• FPSO on location with 500 m exclusion zone
		• Oil export vessels:
		  – Purchaser's CTT;
		  – OSV;
		  – MRSV.

a Note: these vessels may be subject to change. This list is assumed to be a worst case to enable a precautionary assessment.

b The FPSO will be towed by three tugs.

10.11.3 Potential receptors

The ENVironmental Impact IDentification (ENVIID) workshop was used to identify the specific receptors upon which the risk of collision warranted further investigation (Chapter 9). The receptors that may be subject to the risk of collision during the Phase 1 Development include a wide range of large cetacean species that are known to occur within Falkland Islands waters (section 7.4.6).

Small cetaceans (dolphins) are fast moving and agile enough to avoid vessels travelling at moderate speed and are likely to be at greater risk from small fast moving craft rather than those associated with the Development. Indeed, some species, such as Peale's dolphin (Lagenorhynchus australis), are attracted to large vessels to bow-ride. For these reasons, small cetaceans are not considered further in this assessment, which explores only the risk of collisions between Phase 1 vessels and large cetaceans (whales).

10.11.4 Characterising and quantifying the risk of collision

When characterising and quantifying the risk of collisions between large cetaceans and vessels during the Phase 1 Development, it is necessary to consider:

- The history of marine mammal collisions in the Falkland Islands;
- The potential impacts of vessel and cetacean collisions;
- Cetacean behaviour, population and distribution;
- Vessel size, speed, behaviour and distribution; and
- Overlap between Phase 1 vessel traffic and cetacean distribution.

10.11.4.1 History of marine mammal collisions in the Falkland Islands

The current Falkland Islands Species Action Plan for Cetaceans identifies a number of potential threats to cetaceans but does not regard ship-strike to be a problem in the Falklands (FIG, 2008c). Indeed, there are no known records of collisions between vessels and cetaceans in the Falkland Islands.

Although there are numerous records of beached cetaceans (of 26 species) (Augé *et al*., 2018), the likely cause of death is not recorded and it is not known how many of these animals were examined for signs of ship-strike. Equally, it is unlikely that all cetaceans that die at-sea in Falkland waters strand on Falklands beaches and given the prevalence of ship-strike elsewhere in the world, it seems likely that there will have been some incidents in the past that have gone undetected or have not been reported.

10.11.4.2 Potential impacts of vessel and cetacean collisions

Globally, collision between marine mammals and vessels has become an increasingly important issue (WDCS, 2006) with the potential to impact upon individuals and / or populations.

In the event that a collision was to occur, the individual animal may suffer:

- Lethal injury (Figure 10.47a);
- Injury leading indirectly to death e.g. owing to an inability to feed, loss of impulse to feed;
- Injury with unknown longer term impact (Figure 10.47b); or
- Injury leading to reduced fitness e.g. breeding success.

Depending upon the health of the population, all of the above may ultimately impact upon the population of a species, and for a rare species, loss of an individual may be a significant contributor to population decline.

For example, the impact of collisions with vessels is thought to be threatening the survival of the northern right whale (Eubalaena glacialis), which is an IUCN (International Union for the Conservation of Nature) ‘Critically Endangered’ species (NMFS, 2005). Further, interactions between fin whales and ships in the Mediterranean Sea are also causing concern (Vaes and Druon, 2013) and Berman-Kowalewski *et al*. (2010) report interactions between blue whales and shipping off the coast of California.

a) Baleen whale following collision with vessel
(Source: http://marine-conservation)

b) Baleen whale following ship collision
(Source: oceanwidescience.org)

Figure 10.47: Images of lethal and sub-lethal injuries to baleen whales following vessel collisions

10.11.4.3 Cetacean behaviour, abundance and distribution

The behaviour, abundance and distribution of individual species all affect both the impact of collisions, and the likelihood of occurrence. For example, where a population size is in decline, an individual strike will be of greater significance than for a population with high abundance. With regard to behaviour and distribution, a range of factors are thought to influence the likelihood of a collision (Table 10.81).

Therefore, when assessing the impact and risk of cetacean collisions it is important to consider:

- The size and trends of the relevant whale populations and whether or not they are in decline, thus influencing the impact of a single collision at the population level; and
- The known behaviour of different species which can make individuals of a particular species more likely to be involved in a collision.

Large cetaceans, albeit at lower densities, can be encountered anywhere within Falkland Islands waters (White *et al*., 2002). However, the number of large cetaceans encountered within Falkland Islands waters varies on a seasonal basis, with highest density encountered in the coastal waters during the summer and autumn for sei whales and winter for southern right whales.

Although the evidence is anecdotal, the number of large cetaceans in Falkland Islands waters and elsewhere in the southwest Atlantic appears to be increasing (Frans and Augé, 2016). While all marine mammals in Falkland Islands waters are protected and have been identified as priority conservation species (FIG, 2008a), two species that are encountered in the coastal waters of the Falklands are most likely to be susceptible to collision. These are:

- Southern right whales, due to their behaviour and abundance; and
- Sei whales owing to their abundance.

Table 10.81: Summarising the effect of cetacean behaviour and distribution on the likelihood of collision

Factor	Description
Age and condition	A high proportion of the recorded incidents relate to young animals or females with calves.
Swimming speed	Each species will display characteristic behaviour in terms of swimming speed and time spent on the surface.
Congregation	At certain times, animals may congregate in areas to feed or breed. The risk of colliding with an animal where high densities occur is increased.
Distribution	Where animals show a tendency to distribute themselves in areas which are also used by shipping traffic, the risk of colliding may increase.
Feeding / mating behaviour	Animals engaged in feeding or mating behaviour are less likely to respond to an approaching vessel. Also, many large whales feed on planktonic organisms in the surface layers of the water. Therefore, feeding animals may spend longer on or near the surface than those that are travelling. Most planktonic organisms perform a daily vertical migration, being closer to the surface at night. Therefore, cetaceans may be more vulnerable at night when feeding near the surface and undetectable by watch keepers on vessels.
Vessel habituation	Animals that are constantly subjected to vessel noise may become habituated and not respond to an approaching vessel.

10.11.4.3.1 Southern right whale

The size of the southern right whale population that breeds off the Argentine coast is well studied and is growing at about 7% per annum (IWC, 2015). Until the winter of 2017, in the Falklands, southern right whales were only occasionally seen in inshore waters and even in Stanley Harbour (A. Black pers. obs.). Although right whales were known to be present within Falkland Islands waters throughout the year, acoustic and visual surveys indicated that their numbers were highest in the spring and summer months; however, during the winter of 2017 an unprecedented influx of southern right whales was witnessed (section 7.4.6.3.1.2). At the time of writing, it is unclear whether 2017 was an unusual year or whether this is the start of long-term trend.

With regard to their behaviour and distribution, right whales appear to be particularly vulnerable to collision strike because they:

- Tend toward a coastal distribution;
- Spend prolonged periods near the surface;
- Are slow moving; and
- Tend not to react to approaching vessels.

10.11.4.3.2 Sei whales

Although the occurrence of this species has been erratic in the past (showing considerable inter-annual variation), the sei whale is by far the most numerous species of large whale in coastal waters near Stanley during the summer and autumn months (White *et al*., 2002; FIG, 2008c; Weir, 2017). Others report that they are found throughout the inshore waters of the entire archipelago (Thomsen and Munro, 2014). While the first results of photo-identification are emerging there is not sufficient survey data to determine an accurate population estimate, there is anecdotal evidence that the number within Falklands' waters, and more generally within the southwest Atlantic, are increasing (Iñíguez *et al*., 2010).

Sei whales are currently listed as 'Endangered' on the IUCN Red List and are also afforded conservation status and management under CITES (Convention on the International Trade in Endangered Species) and CMS (Convention on Migratory Species).

The International Whaling Commission (IWC) indicate that mortality of >2 % of any population would be unacceptable and 1 % of the population estimate would be cause for concern (IWC, 1996). The size of the population in Falkland Islands waters is unknown however and therefore local incidental mortality limits cannot be set.

With regard to their behaviour, while, there are records from around the world of collisions between sei whales and vessels (IWC database, 2014) they are considered to be at lower risk than most other large whale species (Vanderlaan and Taggart, 2007). This is primarily because they:

- Appear to respond to approaching vessels;
- Are relatively fast swimmers; and
- Tend to swim just below the surface leaving a clear trail of 'fluke prints' in their wake (Sea Watch Foundation, 2012).

It should be noted that elsewhere in the world sei whales are considered to be an offshore species; however, in the Falklands this species is associated with relatively shallow inshore waters.

The initial results of observations recording the dive behaviour of sei whales are available in Weir (2017), which indicates that this species is highly mobile. Estimated average speeds of 5.5 to 6.2 km/hr, breathing rates of 32.16 blows/hr and dive times up to 13.5 minutes were recorded (Weir, 2017). Combined with relatively inconspicuous behaviour on the surface, these parameters make sei whales relatively difficult to detect visually, which supports observations made by other observers regarding the difficulty of seeing these animals at-sea (A. Black pers. obs.).

10.11.4.4 Vessel behaviour

10.11.4.4.1 Effect of vessel size and speed on collision impact and likelihood

In varying combinations, both the size and speed of vessels can affect both the impact of a collision and the likelihood of avoiding whales once sighted.

With regard to the impact, analysis by Vanderlaan and Taggart (2007) found a direct relationship between vessel speed and the outcome of a collision with increasing speed shown to increase the probability of lethal injury (Figure 10.48). With regard to likelihood, vessel speed and size both have implications for the detection of marine mammals and the ability, or otherwise, to take effective avoidance action if a cetacean was seen ahead of a vessel (Clyde and Leaper, 1999). As shown in Figure 10.49, it can be seen that:

- Large vessels such as tankers and container ships are unable to respond quickly enough to significantly reduce the likelihood of a collision; and

- Decreased speed reduces the likelihood (and severity) of a collision in vessels of all sizes.

These data corroborate the findings of Laist *et al*. (2001) who reviewed the available data regarding collisions between vessels and cetaceans and made several interesting observations:

- Although all types and sizes of vessels may hit whales, most lethal and serious injuries to whales are caused by relatively large vessels (>80 m in length);
- Most severe and lethal injuries caused by ship-strikes appear to be caused by vessels traveling at >14 knots;
- Ship collisions probably have a negligible effect on the status and trend of most whale populations, but may have a significant effect on very small populations or discrete groups; and
- The available accounts of real events suggest that most whales hit by ships are not seen beforehand or are seen only at the last moment (Laist *et al*., 2001).

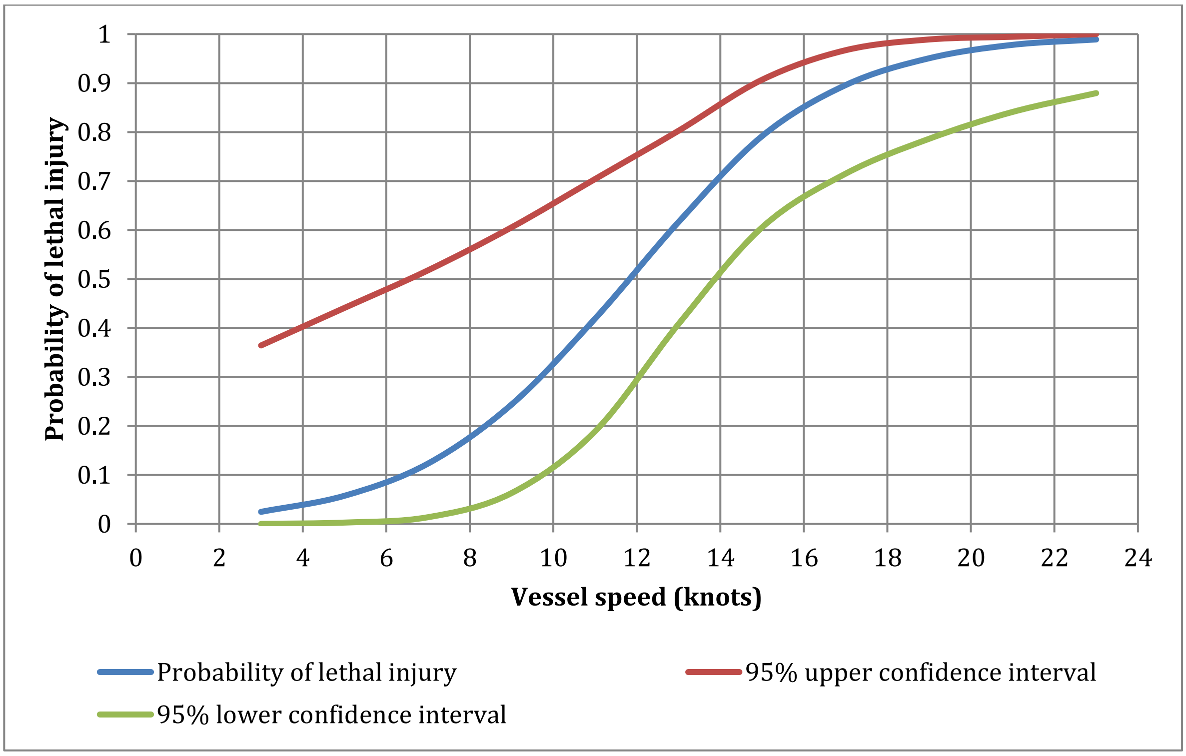


Figure 10.48: Probability of a lethal injury resulting from a vessel strike to a large whale as a function of vessel speed (from Vanderlaan and Taggart, 2006)

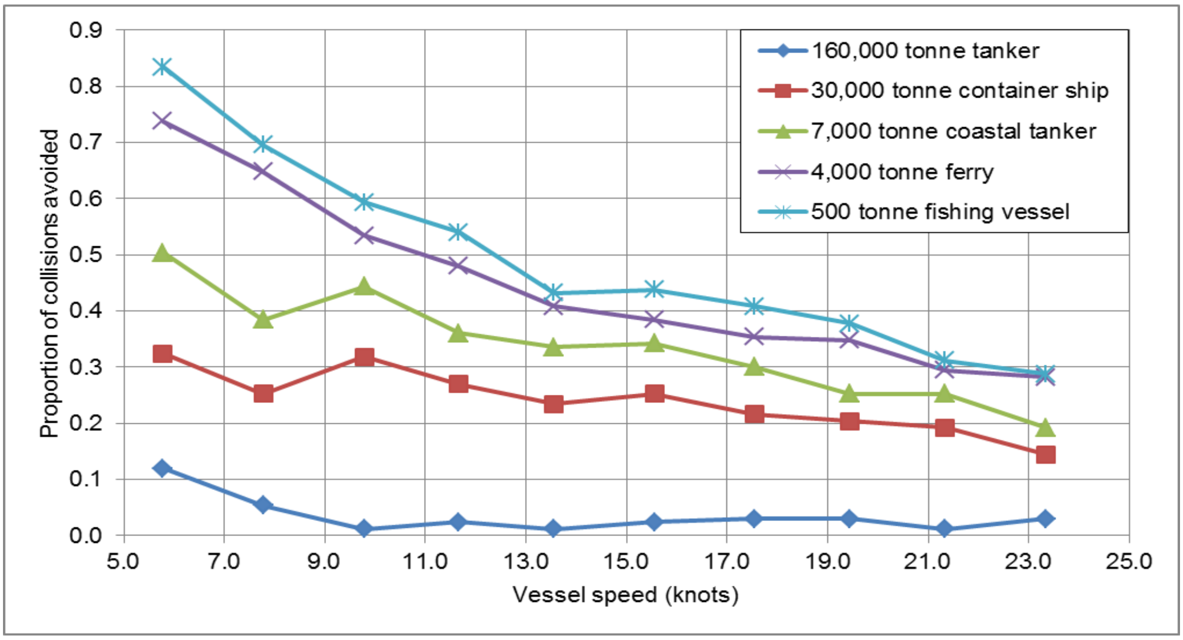


Figure 10.49: Proportion of collisions that were successfully avoided as a proportion of the total that would have occurred if no avoidance action was taken (from Clyde and Leaper, 1999)

10.11.4.4.2 Effect of vessel distribution on collision likelihood

The location, route and behaviour of vessels influence the likelihood of a collision with regard to congregations and distribution of marine mammals. Wherever high densities of cetaceans and shipping coexist there is the potential for collisions (see Williams and O'Hara, 2009; Vaes and Druon, 2013). Where information regarding both vessel movements and cetacean populations is available, it is clear that geographic bottlenecks occur. While there is limited data regarding cetacean distributions around the Falkland Islands, there is some very detailed information regarding shipping movements, although this has only been recorded since June 2014.

As shown in Figure 10.50, several routes are regularly used by vessels and mostly converge in Port William, Stanley and Berkeley Sound (in the northeast corner of the Islands) such that geographic bottlenecks of vessel traffic occur in these coastal waters. The band of heavy vessel activity near the 200 m isobath to the south and east of the Falklands is due to the activity of the loligo trawl fleet (section 7.7.3.2.1.1).

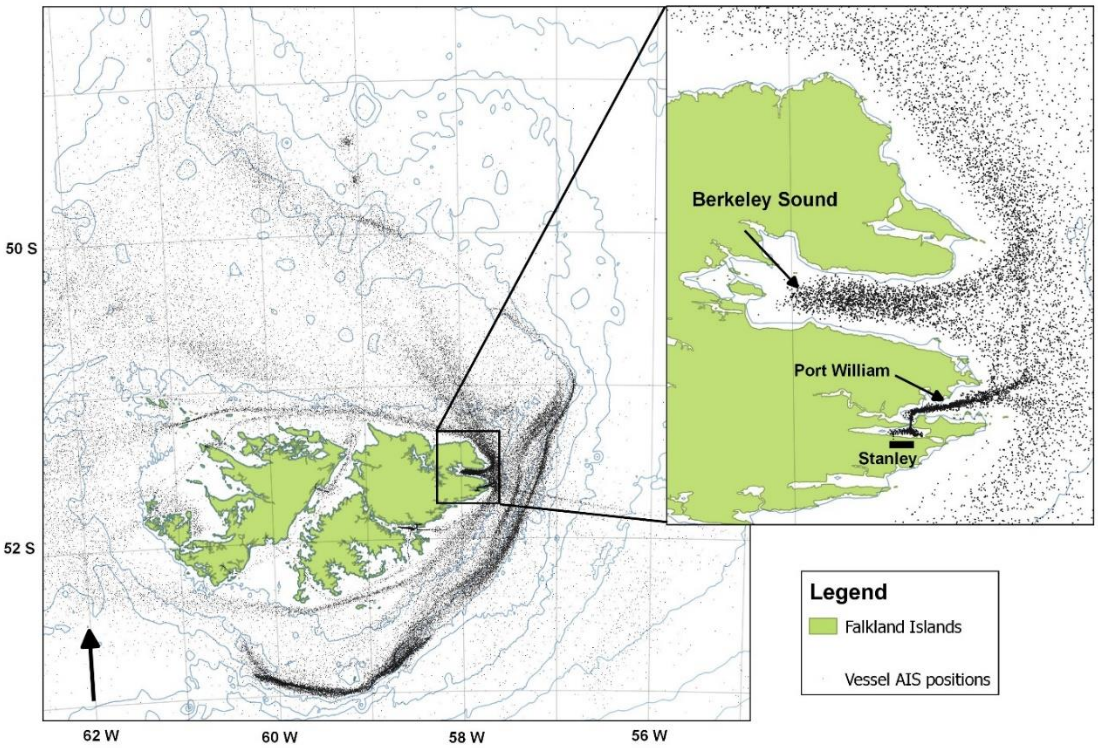


Figure 10.50: Distribution of vessel activity between June 2014 and June 2015, each dot represents the position of a moving vessel

10.11.4.5 Overlap in Phase 1 vessel traffic and cetacean distribution

With regard to the above information, it is necessary to consider the specification and behaviour, route and location of vessels associated with the Phase 1 Development.

The exact number, type and likely routes of vessels used in the Phase 1 Development are yet to be finalised. However, specifications of typical vessels likely to be used, and their behaviour is provided in Table 10.82. The highest number of vessels will be used during Stage 1 (Table 10.82) and based upon this, it could be suggested that the risk of collision to marine mammals will be greatest in Stage 1. However, these vessels (e.g. installation vessels) will be in place for a relatively short duration and Stage 3 (steady state production and the associated vessels) will last for 17.5 years.

With regard to the overlap in vessel activity and cetacean distribution, the distribution of right and sei whales in particular is not well understood (section 10.11.4.3). However, the fact that both are sighted within the NFB, Berkeley Sound and near Stanley Harbour year-round suggests that these species have spatial and temporal patterns of distribution, which overlap with shipping activity.

Table 10.82: Summary of vessel use during the Phase 1 component of the Sea Lion Development

Stage	Total number of vessels at sea at any one time in the NFB	Range of vessel lengths (m)	Mean vessel length (m)	Mean vessel speed (kn)	Main vessels locations
Vessels associated with the offshore component of the Development (drilling, installation and production)					
Stage 1	16	61 - 277	89.0	9.0	In-field and in transit between UK, field and Falkland Islands
Stage 2	6	61 - 277	112.0	12.0	
Stage 3	3	61 - 277	98.0	14.0	
Vessels associated with the oil export component of the Development					
Stage 1	0	n/a	n/a	n/a	In-field and in transit
Stage 2	7	10-277	103	8.0	
Stage 3	7	10-277	103	8.0	

10.11.5 Industry-standard mitigation measures

No industry-standard mitigation measures are in place to minimise the impact or likelihood of collision with marine mammals in UK waters, or those of UK Overseas Territories. Though there are 'Guidelines' issued by the National Oceanic and Atmospheric Administration (NOAA, US) (2014) providing guidance on collision reduction (for instance; reducing vessel speed to less than 10 kts for large vessels while traveling through known whale habitats, see section 10.11.7 below).

As part of Premier's operating procedures, speed restrictions will be applied to vessels entering Berkeley Sound. Within the Sound, the maximum permitted speed will be eight knots.

Additionally, vessels will only transit the Sound during daylight hours, with daylight only berthing and night time departure by exception only. This will aid visual detection of whales by the on-board MMOs. Although these procedures are not intended as direct mitigation against whale-strike they will help to reduce the likeliness and consequences of collisions and are factored into the initial risk assessment below.

In addition, during the transit of Berkeley Sound, there will be two personnel posted on the forecastle of the vessel. They will be qualified as MMO's and advise the Ship's Master on the bridge of the need for evasive action.

10.11.6 Risk assessment

The following section draws upon all the information provided above to assess the 'Sensitivity of the Receptor', the 'Severity of Effect' and the 'Likelihood of Occurrence' to determine the overall 'Risk'. A summary of the impact and risk assessment outcomes is tabulated in section 10.11.12 (Table 10.83), which shows the worst case risk for each activity and receptor.

Given the difference in the behaviour and location of the vessels used during installation, drilling, production and oil export, it is considered appropriate to assess the risks of collisions with cetaceans separately.

10.11.6.1 Risk of collision during drilling, installation and production

Given that, for varying lengths of time, drilling, installation and production will occur over all seasons, the use of vessels will coincide with periods of highest abundance of both right whales, sei whales, and other cetacean species, in the Falkland Islands waters. With regard to the sensitivity of each receptor, southern right whales are considered to be susceptible due to their behaviour (section 10.11.4.3.1). Although the number of animals utilising Falklands waters appears to be increasing, in line with the population in the South Atlantic as a whole, this species is listed as 'Least Concern' by IUCN. The sei whale population in the southwest Atlantic is also believed to be increasing and relatively high numbers of sei whales have been encountered in inshore waters around the Falkland Islands for a number of years (section 10.11.4.3.2). Sei whales are listed as an IUCN 'Endangered' species. Despite the differences in the international conservation status of these species, all marine mammals are conservation priority species in the Falkland Islands and therefore, the **sensitivity of the receptor** is considered to be **'High'**.

As shown in section 10.11.4.5 above, the number of vessels will be highest during Stage 1 of the Development which is to last for 39 months. Nonetheless, while the number of vessels decreases in Stages 2 and 3, the mean vessel lengths increase and Stage 3 will last for 17.5 years (section 10.11.4.5). Further, many of these vessels are >80 m in length and are capable of maximum speeds of >14 knots, both of which are thresholds noted by Laist *et al*., (2001) (section 10.11.4.4.1). While it is unlikely that vessels will be operating at their maximum speeds when in-field or approaching inshore waters, a 50 % probability of lethal injury is still likely at only 12 knots (section 10.11.4.4.1, Figure 10.48). Additionally, the larger vessels used (e.g. the LTV) would only be able to manoeuvre to avoid a collision in less than 50 % of scenarios even if the animal was observed at low speed (Figure 10.49).

Although a whale may be better able to avoid a slow moving vessel, the kinetic energy (proportional to mass x speed2) of the largest vessels employed during the Development will be higher than that of smaller vessels moving at considerably faster speeds. Therefore, the potential for injury or lethal impact is higher for the largest vessels and following a precautionary approach it is considered that any collision will lead to lethal injury.

Given the long generation time of the species concerned, any collision that could result in mortality would have a 'moderate effect in the local area'. Nonetheless, given that the population of sei whales is believed to be increasing (section 10.11.4.3.2), it anticipated that there would be a 'temporary and reversible impact on the species' and it is not believed the loss of individual animals would have a long-term impact on the local population. The **severity of effect** of collisions between ships and cetaceans is therefore considered to be **'Moderate'**.

The overall **significance of the impact** of collisions between vessels and cetaceans therefore is assessed as **'Upper Moderate (12)'**.

With regard to the likelihood of collision, vessels used during the offshore component of the Development (e.g. installation vessels in Stage 1 and supply vessels throughout), are most likely to be operational at very slow speeds in the field. Nevertheless, vessels will be travelling between the offshore Sea Lion Field, Berkeley Sound (LTV's and installation vessels) and Stanley Harbour throughout the project and it is while steaming through inshore waters that the likelihood of encountering cetaceans is highest. Vessel speed will decrease and watch-keeper vigilance will be heightened as vessels approach land in response to the increased risks of navigating in coastal waters, which increases the likelihood of detecting and avoiding cetaceans. Despite the lack of documented records, it is assumed that whale-strikes have occurred around the Falklands, although without further evidence these are considered to be very rare events. Given the competence standards that are required as part of the contractual process within the O&G industry, the overall **likelihood of a collision** has been assessed as **'Unlikely'**.

Therefore, the overall **significance of the risk** associated with the offshore component is considered to be **'Moderate (8)'**.

10.11.6.2 Risk of collision in Berkeley Sound

The sensitivity of the receptor and severity of effect are as described for the risk of collision with production and drilling vessels (section 10.11.6.1). Therefore, the overall **significance of the impact** of collisions between vessels and cetaceans therefore is considered to be **'Upper Moderate (12)'**.

With regard to likelihood, some vessels (LTVs and installation vessels) are required to transit to, and manoeuvre in, inshore areas (Berkeley Sound) where there is a seasonally high likelihood of encountering large whales. However, vessel speed in the vicinity of Berkeley Sound will be limited to a maximum of eight knots.

In addition to the lookouts posted on the forecastle of the vessels as already referred to in section 10.11.5, all vessels will be in a state of heightened awareness due to the risks associated with mooring operations, which will aid early detection of hazards to navigation, such as non-project vessels or cetaceans. The relatively slow vessel speed reduces the likelihood of collisions, and the impact energy. Therefore, the overall **likelihood of a collision** during the inshore operations is considered to be **'Unlikely'**.

Therefore, the overall **significance of the risk** associated with the oil export component is considered to be **'Moderate (8)'**.

10.11.7 Project-specific mitigation measures

While collisions within the Falkland Islands waters between vessels and whales is considered **'Unlikely'**, the overall significance of the risk is **'Moderate (8)'** owing to the sensitivity of the receptors and the potential severity of effect. Equally, a precautionary approach was taken during the assessment because, while collisions have not historically been a recorded around the Falkland Islands (section 10.11.4.1), oil production and export developments, with the incumbent vessels, have not been in the area for any extended period of time either. It is therefore necessary for project-specific mitigation measures to be implemented.

While there are no relevant industry-standard requirements or guidelines, other areas where this issue has posed a threat to cetaceans may be used as a template for learning and best practise.

Off the eastern seaboard of the U.S., this issue has posed a threat to the survival of the northern right whale and mariners are legally bound by the US Marine Mammal Protection Act (MMPA) 1972 to follow area and time specific measures.

Guidelines issued under the MMPA by the National Oceanic and Atmospheric Administration (NOAA) (2009) include:

- 'Compliance Guide for Right Whale Ship Strike Reduction Rule' which require that vessels greater than 19.8 m entering dense shipping areas reduce their speed to 10 knots;
- 'Guidelines for Mariners' detailing precautionary measures which should be taken to avoid northern right whales; and
- 'Mandatory Ship Reporting System for North Atlantic Right Whales' which are relevant to key areas known to be of importance to northern right whales.

The measures outlined in the above include:

- The re-alignment of traffic separations schemes;
- The creation of areas to be avoided;
- Mandatory ship reporting systems;
- Advisories to mariners; and
- Speed restrictions.

While the US MMPA is not relevant to the waters of the Falkland Islands a number of common sense precautions, based on the NOAA Guidelines (2009), should be taken to reduce the likelihood of collisions with cetaceans, as follows:

- Mariners should be made aware of the issue and how it relates to the Falkland Islands, educational materials, such as posters, will be produced to be displayed on the bridge of contracted vessels (see IFAW (2013) for example);
- Along with the usual duties of a watch-keeper, additional vigilance is required to detect cetaceans in inshore waters and all cetacean sightings will logged and collated annually;
- A lookout should be posted while transiting areas of high cetacean abundance; and
- If whales are spotted, speed should be reduced and animals given a wide berth.

While these measures may be effective in hours of daylight and calm seas they become less effective as sea state rises. Furthermore, mitigation based on visual observations is not possible during the hours of darkness when feeding baleen whales may be nearer the surface (section 10.11.4.3, Table 10.81). Additionally, even where these measures can be applied, modelling suggests that collision avoidance strategies dependent on detecting and avoiding whales are ineffective for large ships with limited manoeuvrability (section 10.11.4.4.1).

Therefore, as also indicated by the NOAA Guidelines (2009), there may be benefit in management actions designed to reduce the speed of larger vessels below a maximum of 14 knots (section 10.11.4.4.1) in certain areas to reduce the potential for lethal injury, and therefore the impact, should a collision occur.

Equally, to prevent collisions going unrecorded the IWC encourage mariners to report all collisions with cetaceans.

The objectives of collecting this information are to;

- Lead to more accurate estimates of the incidence of mortality and injuries, to help detect trends over time;
- Allow better modelling of risk factors (for example, vessel type, speed and size); and
- Identify high risk or unsuspected problem areas.

Any incidents of collisions with marine mammals will be reported to FIG and the IWC via:

- FIG Environmental Planning Department; and
- www.iwc.int\ship-strikes (shipstrikes@iwc.int).

In addition to a programme of environmental awareness for all personnel contracted to Premier, the use of qualified Marine Mammal Observers (MMO) will ensure that observations from vessels are recorded and analysed. Although it might not always be possible to take evasive action due to the slow response of a large vessel (section 10.11.4.4.1), these observations will help to determine whether an issue exists and inform further mitigation, if required.

10.11.8 Residual impacts and risks

10.11.8.1 Risk of collision during drilling, installation and production

Increased awareness and vigilance should help to reduce the risk of collisions between vessels and cetaceans. However, there are concerns that measures that rely on visual observations are ineffective in poor observation conditions and are open to human error. Therefore, it is doubtful that the likelihood of collisions will be reduced sufficiently enough to warrant downgrading and will remain **'Unlikely'**.

The implementation of voluntary speed restrictions for vessels passing through inshore waters, however, may reduce the probability of a lethal injury following any collision. As is indicated by the US MMPA speed restrictions, a relatively small change in vessel speed could result in a large reduction in the probability of a lethal injury. In this case, the severity may be reduced to **'Minor'** and therefore the overall **significance of the impact** will be reduced to **'Moderate (10)'** and the **significance of the risk** will be reduced to **'Low (6)'**. Vessels will be requested to report any incidents, which will help to quantify the scale of the impact and better inform future impact assessments.

10.11.8.2 Risk of collision during inshore operations

Although mitigation measures will reduce the likelihood of collisions between cetaceans and vessels, due to the unpredictable nature of cetacean behaviour and the limited manoeuvrability of very large vessels it is doubtful that the likelihood of collisions will be reduced sufficiently enough to warrant downgrading and will remain **'Unlikely'**. Vessel speed within Berkeley Sound will be well below that recommended in the US MMPA, however, lethal injury remains a possibility. Therefore, residual risk remains **'Moderate (8)'** for Inshore vessels.

Along with increased awareness of all personnel, the presence of a qualified MMO will help reduce the likelihood of collisions but perhaps more importantly will provide information to better assess the interactions between vessels and cetaceans. Although there is no evidence to suggest that a problem exists around the Falklands, uncertainty surrounding the issue has resulted in this very conservative assessment.

10.11.9 Cumulative impact

As described in section 7.7.3.2, there are already a reasonable number of fishing and other commercial vessels using Berkeley Sound, Port William and Stanley Harbour (close to 1,800 port visits in 2014). Therefore, there is the potential for cumulative impacts due to increased 'concentration' and increased 'extent and proportion' (section 8.10.1).

Existing vessel numbers peak between February and June, which also coincides with the period of highest large cetacean density (section 7.4.6.3.3). It is estimated that the Phase 1 Development will increase the amount of vessel traffic in and out of Stanley by less than 5 % at this time. The percentage increase in vessel activity within Berkeley Sound is highly variable due to fluctuations in *Illex* catches and therefore transhipment activity.

The percentage increase in the number of vessels is not the only important factor; size, spedd and behaviour of vessels is also important. Vessels associated with the Phase 1 Development within Berkeley Sound are similar in size to the largest vessels that currently use the Sound; however, the speed (maximum of eight knots) and movements of project vessels will be tightly controlled. Combined with vigilant observers, this should limit the risk of collisions with cetaceans.

10.11.10 Confidence

Data gaps exist regarding the inter-annual variation in density of the environmental receptors. Sei whales are a common sight throughout the inshore waters of the Falklands during the summer and autumn but a complete survey is yet to be undertaken. Recent reports of southern right whale presence around the Falklands indicate a change from previously understood spatial and temporal behaviour in Falkland Island waters, although it is unclear whether 2017 is an unusual year or the start of a long-term trend. Additionally, data regarding vessel movements is not collected systematically and therefore it is not possible to quantify the risk of collisions between cetaceans and vessels. It is clear that not all incidents of collisions between marine mammals and vessels are reported or even evident to the crew of the vessel. For these reasons, confidence in the risk assessment is **'Uncertain'**.

10.11.10.1 Monitoring required

The loss of cetaceans to collision with vessels is a global issue that requires further research in order to better understand and model the potential impact on the populations of cetacean species (IWC/ACCOBAMS, 2011). Although it is not thought that a significant problem exists in the Falklands at present, with the advent of O&G production in the region, further investigation to establish the causes, consequences and provisions for risk management is required.

Seabird and Marine Mammal Observers (SMMOs) will be based on Premier's vessels (most likely the MRSVs). The information gathered will help to verify the accuracy of this assessment and refine future policy and procedures. Hydrophones will also be installed in Berkeley Sound and a correlation of sightings with recordings will be undertaken.

A review of MMO reports conducted after 5 years and reports will be used to improve knowledge of locations and behaviour of marine mammals.

All vessels will be instructed to report any collisions with marine mammals to FIG and the IWC via:

- FIG; and
- www.iwc.int\ship-strikes (shipstrikes@iwc.int).

Detailed monitoring requirements have been established during the Environmental Monitoring and Management Plan (EMMP) workshop. All monitoring requirements agreed by Premier and FIG will be recorded and managed via the project-specific Phase 1 EMMP (an outline EMMP is provided in Chapter 15).

10.11.11 Offsetting

For significant residual and impact and risks (Moderate or above), offsetting via an Environmental Fund is proposed, see section 8.9 for further details.

10.11.12 Findings summary

Table 10.83: Summary of the risk assessment for collisions between large cetaceans and vessels

Activity	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Collision between vessels and cetaceans during drilling, installation, production and offload.	Collision between cetaceans and the installation vessels, supply vessels, CTT, or ERRV	Lethal injury	Unplanned	1, 2 & 3	High	Moderate	Unlikely	Moderate (8)	Low (6)	Uncertain	Industry-standard: None Project-specific: The premise of the NOAA (2009) guidelines will be followed, including: Awareness training for vessel crews; Increased vigilance by officer of the watch in high risk areas; Reduced vessel speed to max 8 kn in areas of high risk. Marine mammal observers on subsea installation vessels All collisions will be report to FIG and the IWC via: FIG's EPD; and www.iwc.int\ship-strikes (shipstrikes@iwc.int).
Collision between vessels and cetaceans during inshore operations	Collision between cetaceans and the LTVs and subsea installation vessels	Lethal injury	Unplanned	2 & 3	High	Moderate	Unlikely	Moderate (8)	Moderate (8)	Uncertain	

a See Chapter 8 for definitions of sensitivity, severity, likelihood and significance.

10.12 Introduction of marine invasive species

Table of Contents

10.12.1 Introduction

The introduction of invasive marine species an environment is a global phenomenon. In remote locations, like the Falkland Islands, where the vast majority of equipment, materials and vessels have to be sourced from overseas, there is a risk of non-native marine species 'hitch-hiking' from one biogeographical region to another. If a non-native species is released into a 'new' environment, reproduces and spreads it will be regarded as invasive. Marine invasive species are difficult to detect and once established, are almost impossible to remove.

The International Union for the Conservation of Nature (IUCN) has identified the introduction of non-native species as one of the major threats to native biological diversity. Further, in 2015, a review of the Falklands Biodiversity Framework upgraded invasive species and biosecurity from a medium to high priority threat (FIG, 2015b).

Numerous vessels will be used throughout the Phase 1 Development and while the use of vessels is a planned event, the introduction of marine invasive species would be an unplanned event. It is therefore necessary to consider this as a risk. Notably, the potential for the introduction of non-native species was raised as a concern by stakeholders during scoping consultations (Chapter 6).

This chapter assesses the potential for the vessels used during the Phase 1 Development to introduce non-native marine species to the Falklands' marine environment that, in time, could become invasive.

Note: there is also a risk that native species will be transported elsewhere when vessels depart from the Falklands. However, the impact on the ecosystem of remote Islands, where species have evolved in isolation, is deemed to be of greater significance than the impacts of non-native species in regions that adjoin continental land masses. Therefore, the risk of exporting species from the Falkland Islands is not considered further, see Chapter 9.0.

Note: The Phase 1 inshore activities include the entry and anchorage of up to four Large Transport Vessels in Berkeley Sound, the intermittent entry of a Subsea Construction Vessel (c 11 trips) and coasters arriving in Stanley etc.

As

Note: the other impacts associated with vessel use are described elsewhere in this document, as described in section 9.2.

10.12.1.1 Legislation and guidelines regarding the risk of marine species invasion

Currently, specific legislation relating to the management and control of invasive species has not been established for the Falkland Islands. However, the issue of biosecurity is becoming more significant and dedicated legislation to govern marine and terrestrial biosecurity is likely to be drawn-up and enforced in the near future (R. James (Biosecurity Officer) pers. comm.).

Nonetheless, there is a range of international legislation and conventions relevant to invasive marine species management either through general environmental management, biodiversity protection requirements, or through more specific management requirements. These include:

- International Maritime Organisation (IMO) – International Convention for the Control and Management of Ships' Ballast Water and Sediments (the Ballast Water Management Convention);
- IMO International Convention on the Control of Harmful Anti-fouling Systems (AFS) on Ships (2001) - The AFS Convention does not address the prevention of introducing invasive aquatic species directly but focusses on the AFS used on ships and on the prevention of adverse impacts from the biocides they may contain;
- Convention on Biological Diversity (CBD) - specifically identifies the need to 'control or eradicate those alien species which threaten ecosystems, habitats or species';
- United Nations Convention of the 'Law of the Sea', specifically on the 'protection and preservation of the marine environment';
- Department for Environment, Food and Rural Areas (Defra), Great Britain Non-native Species Secretariat – Invasive Non-Native Species Framework Strategy for Great Britain; and
- United Kingdom Overseas Territories (UKOTs) – Biodiversity Strategy.

Under the above, there are numerous compliance requirements which will be applied within Falkland Islands waters, as described below.

Note: the IMO has developed guidelines for the Control and Management of Ships' Biofouling to Minimise the Transfer of Invasive Aquatic Species. These are guidelines for industry-standard best practice that will be followed by Premier and are described below in section 10.12.5.2.

10.12.1.1.1 Ballast water exchange

IMO's Ballast Water Management (BWM) Convention came into force in September 2019 following ratification by Finland in September 2016. Further, the provisions of the BWM Convention are reflected in the UK by Marine Guidance Note 363 (M+F) (MCA, 2007) and at the IMO level in Marine Environment Protection Committee Resolution 127 (53), (IMO, 2005).

The Convention provides three performance standards for the discharge of ballast water, namely regulations D1, D2 and D3.

10.12.1.1.1.1 IMO BWM - Regulation D1 – ballast exchange

The D1 standard is for ballast water exchange, and specifies the volume of water to be replaced. The standard requires that ballast water be exchanged with local water prior to entry into inshore waters as a mitigation against the introduction of non-native species.

Specifically, all ships using ballast water exchange should:

- Conduct ballast water exchange at least 200 nautical miles from the nearest land and in water at least 200 metres in depth, taking into account the suite of Guidelines developed by the IMO to support the BWM Regulations; or
- Where the ship is unable to conduct ballast water exchange as above, the exchange should occur as far from the nearest land as possible, and in all cases at least 50 nautical miles from the nearest land and in water at least 200 metres in depth.

Ballast water exchange can either be via a 95 % exchange of volume or, where the tanks are continuously flushed through, by a volume equal to three times that of the tank, to take account of incomplete displacement of water during flushing.

10.12.1.1.1.2 IMO BWM - Regulation D2 – ballast water treatment

The D2 standard specifies levels of viable organisms which may be left in the ballast water after treatment and specifies approved ballast water treatment systems.

The standards for ballast water cleanliness are:

- No more than 10 viable organisms per cubic metre greater than 50 µm in size and no more than 10 viable organisms per millilitre between 10 - 50 µm in size; and
- Indicator microbes, as a human health standard and expressed as colony forming unit (cfu), shall not exceed:
  - Toxigenic Vibrio cholerae (O1 and O139) with less than 1 cfu per 100 millilitres or less than 1 cfu per 1 gram (wet weight) zooplankton samples;
  - Escherichia coli, less than 250 cfu per 100 millilitres; and
  - Intestinal Enterococci, less than 100 cfu per 100 millilitres.

In order to meet the standards described above, ballast water treatment will be required. According to the MCA (2012) ballast-water treatment options may include:

- Mechanical filtration and separation;
- Treatment methods such as sterilisation;
- Chemical treatment; or
- A combination of these methods.

Compliance with D2 will take time (up to five years from September 2019) to cascade through the global fleet, but, by the time of Sea Lion First Oil, it is expected that the vast majority of vessels will have the treatment systems installed and Premier will contract with those vessels that have the system in place.

10.12.1.1.1.3 IMO BWM - Regulation D3 – ballast water management systems

In the event that a BWM System is used to comply with the BWM Convention, Regulation D3 requires that:

- The management system must be approved by the IMO Administration taking into account the ‘Guidelines for approval of ballast water management systems’ (MEPC, 2008a); and
- The use of active substances shall be approved by IMO in accordance with the ‘Procedure for approval of ballast water management systems that make use of Active Substances’ (MEPC, 2008b) to ensure that the ballast water management system does not pose unreasonable risk to the environment, human health, property or resources.

Compliance with the above will lead to the award of the International Ballast Water Management Certificate.

10.12.1.1.2 Biodiversity

The UK ratification of the CBD was formally extended to the Falkland Islands on the 29th June 2016. The CBD is effectively an agreement on environmental management and best practice and originated from the 1992 Rio Conference on environment and development.

The CBD sets out a plan for achieving 20 targets, known as the 'Aichi Targets', which are grouped under five strategic goals. Under Strategic Goal B to 'Reduce the direct pressure on biodiversity and promote sustainable use', Aichi Target 9 requires that:

'By 2020, invasive alien species and pathways are identified and prioritised, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment' (UNEP CBD, 2010).

The CBD is supported by the FIG Biodiversity Framework 2016-2030 (FIG, 2016a) and supporting strategies. This Biodiversity Framework was formally endorsed by FIG in January 2016 and identifies priority conservation objectives for the Falkland Islands. Importantly, the Biodiversity Framework is a threat-based document which outlines the priorities required with regard to the wider Falkland Islands' environment. The introduction of non-native species was identified as a high priority threat.

10.12.2 Sources of marine invasive species

Throughout the different Development Stages, numerous vessels will be used (see section 5.11.2) which have the potential to introduce non-native species. These include:

- Vessels contracted to Premier:
  - Mobile Offshore Drilling Unit (MODU);
  - Anchor Handling Tugs (AHTs) to tow the MODU;
  - Floating, Production, Storage and Offload vessel (FPSO);
  - Multi-Role Support Vessels (MRSV);
  - Emergency Rescue and Response Vessel (ERRV);
  - Transportation and Installation (T&I) vessels;
  - Coaster vessels;
  - Large Transport Vessels (LTVs, used as temporary floating logistics vessels).
- Third-party vessels:
  - The purchaser's Conventional Trading Tanker (CTT).

A full inventory of the vessels used during Stages 1 to 3 of the Development is provided in section 5.11.2.

10.12.3 Potential receptors

The ENVironmental Impact IDentification (ENVIID) workshop was used to identify the specific receptors upon which the impact / risk of marine invasive species warranted further investigation (Chapter 9.0). The specific receptors that may be impacted include:

- Marine flora, fauna and biodiversity of the region (section 7.4).

10.12.4 Characterising and quantifying the risk of marine invasive species

When characterising and quantifying the risk of introducing marine invasive species, it is necessary to consider the:

- Process of marine species introduction and invasion;
- Potential consequences of marine species invasion:
  - Case studies of marine invasive species.
- Factors influencing the introduction and invasion of species:
  - Origin and activity of Phase 1 Development vessels.

10.12.4.1 The process of marine species introduction and invasion

Two steps are involved in the process by which a non-native marine species may become invasive and impact upon an existing ecosystem:

4) The species has to be transported into the region; and
5) The species has to find a niche, become established and spread.

10.12.4.1.1 Species introduction

There are two main pathways by which non-native marine species are transported and introduced into new environments;

- In vessel ballast water; and / or
- Biofouling on the surfaces of vessels.

While the species that may be introduced by these routes differ, the process by which they can be introduced and / or become invasive is similar and is summarised in Table 10.84 at the end of this section. Both routes are recognised as serious issues by the International Maritime Organisation (IMO), which has developed guidelines to guard against such introductions (section 10.12.5).

10.12.4.1.1.1 Ballast Water

Ballast is taken on-board or discharged, as necessary, to trim and stabilise a vessel. When a vessel is not carrying any cargo, it is necessary to compensate by taking on ballast water, and equally, it will be necessary to discharge ballast water when cargo is taken on board. Therefore, ballasting operations are most often required in coastal or inshore waters where cargo is loaded and unloaded. Typically, a crude tanker is ballasted with 30-35 % of its cargo capacity carried as water in the ballast tanks that are located between the inner and outer hulls in the double hull design. Ballast water and cargo are therefore carried in separate tanks so there is no risk of cross contamination of ballast water with oil.

Ballast exchange practices are specific to each vessel but, in all vessels, planktonic organisms, larval stages, eggs, cysts and micro-organisms can be transported from one location to another in the ballast tanks. To combat the spread of non-native species, the IMO Regulation D1 will require all vessels transiting through international waters to exchange ballast water on the high-seas (section 10.12.5), however, the exchange is not 100 % effective due to the mechanics of exchanging ballast. Furthermore, sediment remaining in the ballast tanks can still contain these organisms. As sediments can be re-suspended in the tanks during subsequent ballast water exchanges, these organisms may still be introduced to the environment.

In addition, IMO Regulation D2 (section 10.12.5) will require all vessels to install ballast treatment systems at their first survey / docking after the IMO BWM enforcement. Most ballast water treatment systems (BWTS) include a primary filtration step to remove organisms larger than 20–55 µm in size, such as eggs, larvae and adults of many benthic or pelagic plankton, that are likely to survive secondary treatments such as UV irradiation, ozonation or electro-chlorination (Grob and Pollet, 2016). Regardless of the BWTS used, there is sufficient evidence to say that there is not one ballast water treatment method, or even a combination of primary and secondary methods that can guarantee a 100 % kill of all marine organisms (Grob and Pollet, 2016). However, ballast water treatment methods work to prevent unreasonable risk of introduction e.g. through a reduction in concentration of organisms.

10.12.4.1.1.2 Biofouling

Biofouling is the growth of marine organisms on man-made structures (Figure 10.51) and can be divided into:

- Hard (calcareous) fouling types e.g. barnacles, encrusting bryozoans, tube worms, mussels and other molluscs; and
- Soft (non-calcareous) e.g. seaweed, hydroids, algae and biofilms (i.e. any group of micro-organisms in which the cells stick to each other to create a 'slime' on a surface).

Together, and untreated, these two groups can encrust the hulls of vessels. Biofouling organisms can have deleterious impacts on industry; such as blocking of water intakes or increasing drag on a vessel, which then increases fuel consumption. While biofouling is often prevented with anti-fouling coatings or is mechanically removed from vessels to miminise these impacts, fouling organisms are likely to remain in 'nooks and crannies' such as the sea chest on vessels or around propeller shafts (Figure 10.52).

Therefore, these animals remain on the vessel as it transits to other regions where they can then be introduced by falling off the vessel (sometimes via hull cleaning) or by maturing and spawning into the new environment. Further to this, where vessels are travelling slowly (such as MODUs), mobile organisms such as fish have been known to follow a vessel to new regions (Wanless *et al*., 2010).

The IMO's requirements for exchanging ballast water and managing biofouling organisms (section 10.12.5) will greatly reduce the likelihood of introducing non-native species; however, as stated above, these guidelines do not guarantee 100 % removal of non-native species. Recently, there has been a growing recognition that biofouling is a major pathway in the introduction of non-native species, some of which may become invasive. For example, it is estimated that biofouling is responsible for approximately 75 % of non-native marine invertebrates in Hawaii and 78 % of non-native marine species in Port Phillip Bay, Australia (OGP/IPIECA, 2010).

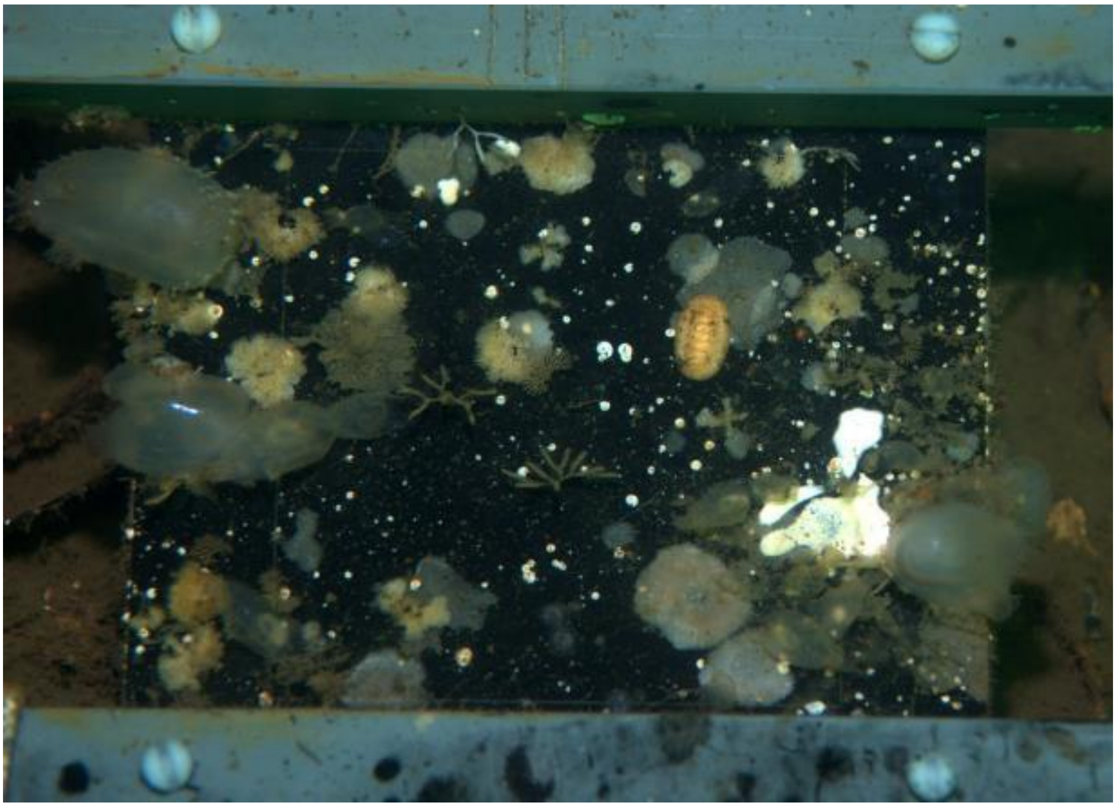


Figure 10.51: Biofouling on a settlement plate used to monitor for non-native species; note the presence of the invasive vase tunicate (Ciona intestinalis), transparent balloon like organisms (Source: SMSG)

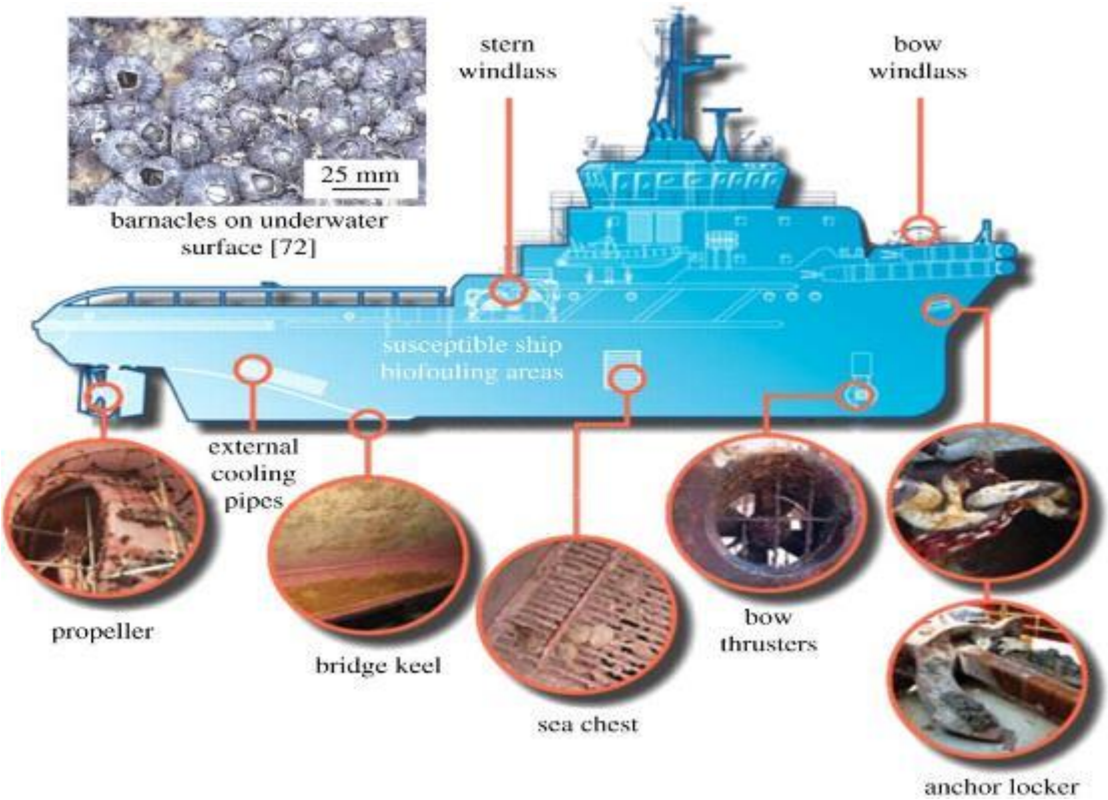


Figure 10.52: Regions on a ship that may remain fouled following mechanical cleaning (Source: rsta.royalsocietypublishing.org)

10.12.4.1.2 Species invasion

Not all non-native species that arrive in the Falklands are able to survive, reproduce and spread to the point that they become invasive. For a non-native species to become invasive it is necessary for it to gain a foothold (Table 10.84), which is more likely when the recipient region is similar to the donor region with respect to parameters such as salinity and temperature.

However, many of the most prevalent invasive species can become established in many different regions of the world and share biological characteristics such as rapid reproductive capacity and fast growth, which enable them to out-compete native species. Additionally, non-native species may not have any natural predators in the receiving environment, which further aids survival and growth.

Table 10.84: The process of non-native species introduction and invasion [a]

Region	Process	Key factors	
		Ballast water	Biofouling
Donor	Colonisation of vessel	Quantity of ballast water uptake; Salinity (fresh or sea water); and Location from which ballast water is taken.	Presence or absence of anti-fouling; Age and type of anti-fouling; Hull location; and Residency period (inshore waters).
Translocation		Ballast water exchange en route; and Treatment of ballast water.	Voyage route; Voyage duration; and Vessel speed.
Recipient	Transfer	Ballast water exchange (inshore waters).	Residency period (inshore waters); and Defouling activity (e.g. in-water cleaning).
	Colonisation	Availability of suitable environmental conditions; Availability of suitable substrate; Biotic resistance; and Water currents.	
	Establishment	Availability of suitable substrate; Environmental conditions; Predation pressure; Control measures.	

a adapted from Lewis and Coutts (2010)

10.12.4.2 Potential consequences of invasive marine species

Invasive species may impact upon biodiversity by:

- Outcompeting native species for space and resource and therefore exclude native species;
- Predating upon native species;
- Causing indirect changes to the ecosystem e.g. smothering by plankton blooms; and / or
- Causing toxicity for native species e.g. Harmful Algal Blooms (HAB).

The impacts of the above can be immense and are often irreversible (Hilliard, 2004; OGP/IPIECA, 2010). Further, impacts to biodiversity tend to be disproportionately worse for islands as compared to continents (Russell *et al*., 2017) and in island ecosystems like the Falklands, where native species have evolved in biological isolation, they can be particularly severe. Although there are cases where planktonic invasive species such as dinoflagellates or salps can impact offshore waters e.g. by HAB, most marine invasive species impact upon inshore benthic communities of native species, and the extent of the impact is often difficult to detect and monitor.

In addition, there are many examples from around the world where marine invasive species have had serious economic impacts (e.g. Lowe *et al*., 2004) and OGP / IPIECA (2010) provides a comprehensive review of the risks that the Oil and Gas (O&G) industry poses regarding the introduction of non-native species.

While there is little commercial exploitation of inshore marine species or industries such as aquaculture in the Falklands, some species that are exploited offshore do spawn in inshore waters. The species of greatest concern off the east coast of the Islands is loligo (*Doryteuthis gahi*; section 7.7.3.2.1.1). A loss of spawning habitat (e.g. kelp beds) or predation of eggs could have socio-economic impacts for the human population (it should be acknowledged that although kelp beds are a known spawning location for loligo, the location and full extent of loligo spawning areas are not fully understood). While this direct impact would require the introduction of species likely to use kelp beds or predate on the eggs, the introduction of any species that became invasive would impact biodiversity overall, with indirect impacts for many species.

10.12.4.2.1 Case studies of marine invasive species

Human trade and travel has introduced alien species to areas like the Falklands where the native species are not adapted to the new threat. On the nearby central Patagonian coast, for example, most marine ecosystems have been modified by invasive species (Orensanz *et al*., 2002).

The Falkland Islands have been a strategic point for international shipping traffic for over 200 hundred years and human activity has seen both the deliberate introduction of non-native species, such as the brown trout, and unintentional introductions. Until recently however, there were no baseline environmental surveys of the Falklands, so determining those species that are native and those that are invasive is not always straightforward. Nonetheless, it is clear that several invasive species are already established within Stanley Harbour and Mare Harbour, such as the tunicate (*Ciona intestinalis*) and the parchment tubeworm (*Chaetopterus variopedatus*, Figure 10.53), both of which have the potential to out-compete and smother native species. The 2011 SMSG survey looked at a number of sites around the Falklands to determine the presence of the parchment tubeworm and results are shown in Figure 10.54 below. Results showed the species was present island-wide, although concentrations are markedly higher nearer ports of entry (SMSG, 2011).

Elsewhere in the world, the impact of invasive species has been far more dramatic. For instance, the European shore crab (*Carcinus meanus*) has been transported all over the world. Once established, they displace native species of crab and depredate native invertebrates resulting in both the loss of native biodiversity and impacts upon crab and shellfish industries (CABI, 2014).

Another example is the sea walnut (*Mnemiopsis leidyi*) which is a stingless jellyfish-like animal (a comb-jelly) native to the Atlantic coasts of North and South America. This organism was transported to the Black Sea by ballast water and spread to the Caspian Sea. In both places, this species multiplied to form immense populations which, because they feed on zooplankton that commercial fish also consume, contributed to the collapse of local fisheries (Pang and Martindale, 2008). This comb-jelly has now also been discovered in the Mediterranean, Baltic, and North Seas (Pang and Martindale, 2008).

Figure 10.53: Parchment worms (*Chaetopterus variopedatus*) smothering native species (Source: SMSG)

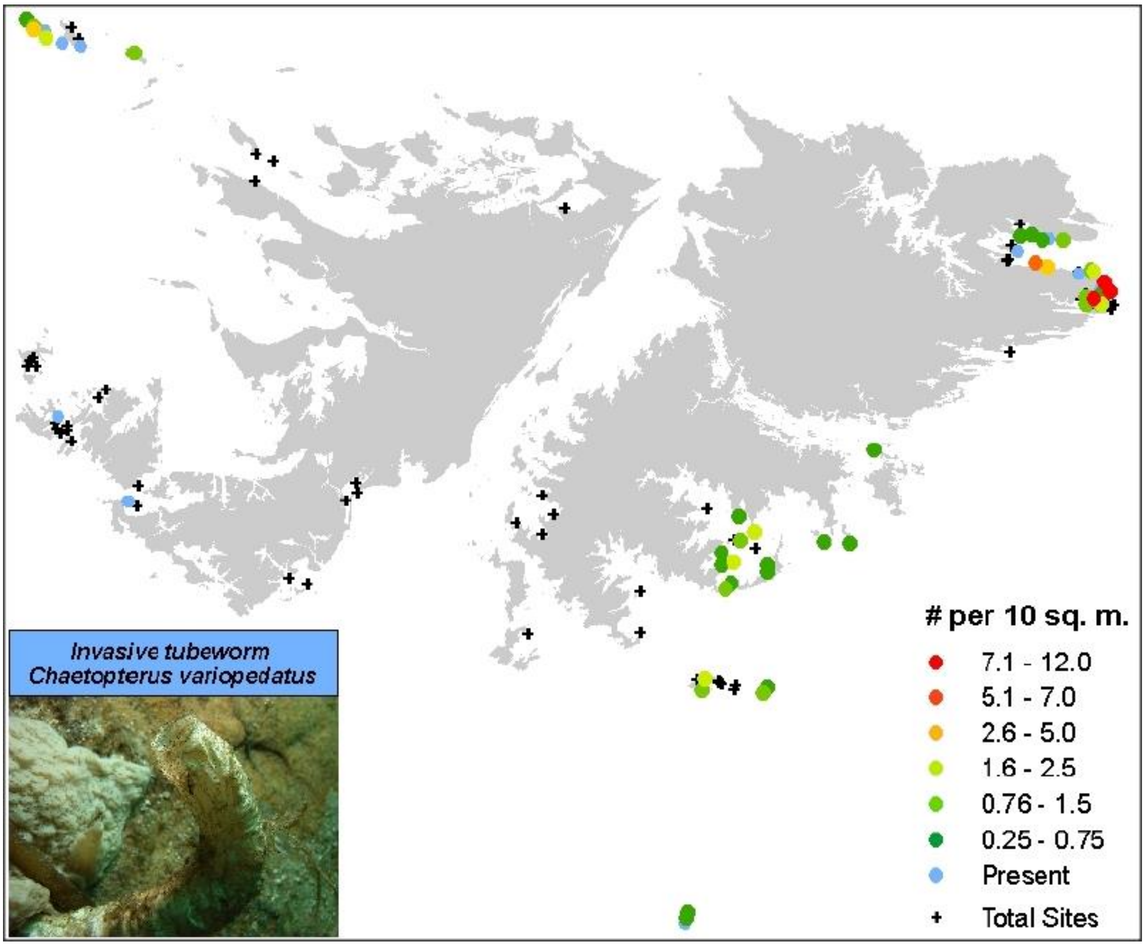


Figure 10.54: Distribution map of the parchment tubeworm (Source: SMSG, 2011)

10.12.4.3 Factors influencing the introduction and invasion of species

In order to conduct an assessment of the risk posed by Phase 1 vessels introducing non-native species, and these species becoming invasive, three main factors need to be considered:

- The origin of the vessel;
- The activity of the vessel when in the region; and
- Whether or not the vessel is ‘new’ to the Falkland Islands.

With regard to the origin of the vessel, the geographical location of the last vessel deployment is of great importance as this will affect the likelihood of any introduced species becoming invasive. Vessels coming from temperate regions with similar climates pose the greatest risk to the Falkland Islands as the species that may be introduced are most likely to be able to survive, become established, and thus become invasive. Importantly however, the origin of the vessel can also present natural barriers to the introduction of non-native species. For example, with regard to biofouling, where vessels are travelling from a northern hemisphere temperate climate to a similar climate in the southern hemisphere, the vessel will pass through the Tropics such that the gradual changes in salinity and temperature may help to remove many biofouling organisms (Minchin and Gollasch, 2003). Although this may serve as a natural barrier to effective translocation there are instances of species flourishing in both tropical and Falklands waters. As such, the temperature barrier is no guarantee and should not be relied upon as a means of preventing introduction. With regard to ballast water, the time that water is held in the tanks is significant such that the distance of the vessel origin from its destination is a factor. Many organisms may die *en route* while other, mostly micro-organisms, may reproduce and multiply (Gollasch *et al*., 2000; Grob and Pollet, 2016).

With regard to activity, vessels that spend long periods of inactivity in coastal waters (wherever these may be) are more prone to biofouling than those that are active offshore and ballast water taken onboard in coastal waters is likely to contain a far higher density of planktonic organisms than water taken onboard in offshore waters. While the risk of introducing ballast organisms is less dependent upon the location of the discharge as micro-organisms may colonise anywhere, the risk of biofouling organisms becoming established in the Falklands is greatly increased when vessels are inshore, as most biofouling species require hard substrates to attach to. Another consideration with regard to the activity of vessels is the volume of ballast water carried. Vessels arriving laden with a cargo e.g. coaster vessels, will be carrying less ballast water, while those arriving empty, or partially full, and awaiting receipt of a cargo e.g. the CTT, will be carrying a larger volume of ballast water.

Finally, the greatest risk of marine species introduction is associated with the arrival of potentially contaminated vessels 'new' to Falkland Islands waters. Vessels that have been in the region for extended periods of time are more likely to carry native species in their ballast water. However, biofouling organisms may continue to grow in situ where conditions are conducive and may eventually fall off or spawn into the environment of the recipient region. Vessels that are arriving in the Falkland Islands for the first time are considered 'new'. Similarly, those that repeatedly leave the region and exchange ballast waters elsewhere, or have the opportunity for the hull to become recolonised, and then return to the Falklands will be considered 'new' each time they return.

10.12.4.3.1 Origin and activity of Phase 1 Development vessels

A summary of the Phase 1 vessels' origin and behaviour is provided in Table 10.85. While all vessels pose a risk, those vessels that are 'new' each time and which come inshore (particularly for prolonged periods) are those that pose the greatest risk. Therefore, the coaster vessels and the LTVs are expected to pose the greatest risks (Table 10.85).

The coaster vessels will arrive laden with cargo and will not be 'in-ballast' such that the greatest risk with these vessels is species introduction via bio-fouling. The coasters pose a risk because:

- They will be 'new' to the Falkland Islands on each visit having been in other biogeographical regions where they will have taken on ballast water and perhaps have become colonised with flora and fauna local to the region;
- They will most likely originate in the UK which is a compatible donor region;
- They will spend time passing thorough the Tropics, which may provide a natural barrier to the introduction of bio-fouling species, but cannot be relied upon; and
- They will spend time at the Temporary Dock Facility (TDF) and Falklands Interim Port And Storage System (FIPASS) to the east of Stanley while cargo is transferred and while they refuel, allowing opportunity for the transfer of bio-fouling organisms.

Similarly the LTVs are considered to pose a risk with regard to species introduction from bio-fouling because:

- They will be 'new' to the Falkland Islands, on each visit, having been in other biogeographical regions where they will have taken on ballast water and perhaps have become colonised with flora and fauna local to that region;
- Regardless of their origin, they may harbour viabile organisms, while those from dissimilar climates may be less able to thrive some tropical organisms are known to be able to flourish in temperate climates; and
- The LTVs will enter Berkeley Sound where they will anchor for a period of weeks to several months, allowing time for the potential translocation of bio-fouling organisms to the substrate in the Sound.

Table 10.85: Factors that may influence species introduction and / or invasion from Phase 1 vessels

Vessel	Donor region	Influencing factors						
		Donor / recipient climates similar	Passing through dissimilar climates en route	Activity of vessel	Carrying ballast on arrival	Time spent inshore	'New' to region:	
							Once	Each time
MODU	Unknown [b]	Unknown [b]	Unknown [b]	Drilling offshore	Y		✓	
FPSO	Unknown [b]	Unknown [b]	Unknown [b]	Production offshore	Y		✓	
Coaster vessels	UK	Y	Y	Delivery of cargo to TDF	N[a]	✓		✓
Anchor Handling Tugs	West Africa	N	Y	Tow of MODU to region, may need to refuel inshore	Y	✓	✓	
Multi-Role Supply Vessels	Unknown [b]	Unknown [b]	Unknown [b]	Supply vessels operating between field & TDF	Y	✓	✓	
Emergency Rescue and Response Vessel	Unknown [b]	Unknown [b]	Unknown [b]	On standby for FPSO and MODU, may need to refuel inshore	Y	✓	✓	
Installation vessels	Norway	Y	Y	Transit back and forth between field and LTV's to collect cargo for installation in field	Y	✓	✓	
Large Transport Vessels (LTVs)	Europe	Y	Y	Arrival and standby in Falkland Islands for use as floating logistics barges at an inshore location	N [a]	✓	✓	✓[c]
Fast Transit Carrier (FTC)	Spain	Y	Y	Arrival and standby in Falkland Islands	N [a]	✓	✓	

[a] Vessels arriving laden with cargo are assumed to be carrying little or no ballast.
[b] The initial location is unknown at the time of writing and it is not possible to estimate which donor region could be considered to be worst case as numerous factors influence the process.
[c] Note that the individual LTV's may be changed out for other LTV's and therefore, each LTV could be 'new' to the Islands.

10.12.5 Industry-standard mitigation measures

In line with its Contractor Management Standard (CP-BA-PMO-HS-ZZ-ST-0004), Premier will carry out pre-selection and/or pre-mobilisation audits. These audits will be used to ensure that all contracted vessels arriving in the Falklands are compliant with the current expectations under IMO (section 10.12.1.1).

In line with the legal compliance requirements and published IMO guidelines, the following will be in place for all vessels, to prevent, or minimise, the introduction of non-native species:

- Ballast Water Management Plan (BWMP); and
- Biofouling Management Plan (BFMP).

The use of these plans is factored in to the initial risk assessment below. However, it should be noted that while the measures in the above plans will reduce the likelihood of non-native species introductions, neither can completely eliminate the risk.

Lastly, it should also be noted that FIG will implement their own biosecurity inspection and management process and may refuse visits, or quarantine assets if they believe the biosecurity risk is too high.

10.12.5.1 Ballast Water Management Plan

The IMO BWM regulations were enforced part-way through the Phase 1 Development entering the 'project execution' process (section 10.12.1.1) and the requirements within are already assumed by many as industry-standard best practice. The BWMP is key to the safe and effective exchange of ballast water. BWMPs are specific to each vessel and include a detailed description of the actions to be taken to implement the BWM requirements and supplemental practices.

The BWMP should describe:

- The duties of key shipboard control personnel undertaking ballast water exchange at-sea:
- Such personnel should be fully conversant with the IMO BWM and the safety aspects of ballast water exchange and in particular, the method of exchange used on-board their ship.
- The need for a Ballast Water Record Book (BWRB) to record the following (in compliance with the IMO BWM Regulation D1 (section 10.12.1.1.1.1)):
- When and where ballast water is taken on board, circulated or treated for BWM purposes and discharged to sea;
- When Ballast Water is discharged to a reception facility;
- Accidental or other exceptional discharges of Ballast Water; and
- When sediment in ballast tanks should be removed and how it is disposed of.

Detail on the ballast water treatment (in compliance with the IMO BWM Regulation D2 (section 10.12.1.1.1.2):

- The method will be class-certified under Marine Environment Protection Committee MEPC (2008a) (Note: Premier will discuss with the Harbour Authority whether alternative methods would also be acceptable).

Although not a requirement of the IMO, Premier has committed to taking samples of ballast for analysis from all vessels coming inshore and arriving 'in-ballast' as detailed in section 10.12.10.1.2. Ongoing review of sampling results will be drawn into the EMMP (Chapter 15).

10.12.5.2 Biofouling Management Plan

The IMO Guidelines for the Control and Management of Ships' Biofouling to minimise the Transfer of Invasive Aquatic Species do not describe legal requirements but are considered to indicate best practice. These guidelines were adopted by the MEPC in 2011.

The purpose of the BFMP is to outline measures used to control and manage biofouling on vessels to minimise the transfer of non-native aquatic species.

The BFMP should provide:

- Details of the Anti-Fouling Systems (AFS) and operational practices or treatments used, including those for niche areas and sea chests;
- Hull locations susceptible to biofouling, schedule of planned inspections, repairs, maintenance and renewal of AFS;
- Details of the recommended operating conditions suitable for the chosen AFS and operational practices;
- Details relevant for the safety of the crew, including details on the AFS used;
- The need for the use and maintenance of a Biofouling Record Book (BRB); and
- Details of the documentation required to verify any treatments recorded in the BRB (see MEPC, 2011 - Appendix 2).

10.12.5.2.1 Antifouling coatings

Until recently, the majority of the world shipping fleet use tributyltin based antifouling treatments, which proved to be very effective but had serious environmental side-effects. Since 2008, tributyltin coatings have been banned (IMO, 2001) and alternative treatments are now used to prevent biofouling (see Yebra *et al*., 2004 for a review). One of the most effective inhibitors of marine growth is copper, which is inherently toxic to marine organisms. Copper based coatings slowly release copper into the marine environment and are effective long-term solutions to prevent biofouling (Brooks and Waldock, 2009). Although there is potential for a localised elevation in the concentration of copper, the overall amounts released from antifouling paint are small in comparison to natural inputs (mostly runoff from sources on land).

The potential impacts of copper anti-fouling on non-target organisms have been the subject of debate (see Brooks and Waldock, 2009). Overall, copper toxicity from an antifouling source only becomes a problem in the marine environment in isolated water bodies, such as enclosed marinas and harbours that experience little water exchange with high levels of boating activity.

An anti-fouling coating philosophy for semi-stationary and long-term objects (e.g. the FPSO and Turret Buoy) will be developed and all project vessels will be treated with IMO-compliant antifouling treatments, such as slick self-polishing polymer paints. Many of these systems include copper to inhibit marine growth, which is released slowly and is deemed compliant under the IMO standards, which consider environmental risks. Therefore, the small quantities of copper released into dynamic marine conditions are considered to pose no risk to non-target marine organisms and are not assessed further in this EIS.

10.12.6 Risk assessment

The following section draws upon all the information provided above to assess the 'Sensitivity of the Receptor' and the 'Severity of Effect'. Assessment of unplanned events includes an assessment of the overall impact followed by an assessment of the 'Likelihood of Occurrence' to determine the 'Risk'.

A summary of the risk assessment outcomes for this Development is tabulated in section 10.12.12 (Table 10.86), which shows the worst case impact / risk for each activity.

As identified in section 10.12.4.3 (and Table 10.85), not all vessels present an equal risk of introducing invasive species and the coaster vessels and the LTVs are those considered to pose the greatest risk. Nonetheless, for the purposes of the risk assessment, the Phase 1 vessels can be broadly split into four groups:

- Sea Lion in-field vessels that visit the Falklands once and work within the Falklands Conservation Zones e.g. the MODU, FPSO, MRSVs, supply vessels, etc.;
- Coaster vessels that will visit the Falklands several times a year but carry little or no ballast water;
- Semi-stationary floating storage vessels (LTVs) that visit the Falklands once and anchor temporarily in inshore waters (for a combined period of up to 12 months); and
- CTT vessels that will visit the FPSO multiple times per year carrying large quantities of ballast water.

The impact of marine invasive species would be the same for all the vessel types above, however the likelihood of introducing the non-native species differs depending upon the influencing factors described in section 10.12.4.3 above such that the associated risks may differ. Therefore, the impact of species introduction is assessed once for all vessels while the likelihoods, and therefore the risks, are considered separately below.

10.12.6.1 The impact of introducing invasive species, all vessels

With regard to the sensitivity of receptor, the immediate impact may be to one species only, however broader impacts could exist for the biodiversity and ecosystem as a whole which are difficult to estimate with so many variables in the process. Equally, it is not easy to determine the zone of influence of the Development as this would depend upon the proliferation of the invading species. While the impact would greatly depend upon which species were introduced (section 10.12.4.1), the potential for impacts to marine biodiversity as a whole could be such that the **sensitivity of the receptor** is considered to be **'High'**.

If invasive species were introduced during the Phase 1 Development the impact on the ecology of the Islands may not be evident for a number of years. However, the long-term implications for the Islands' marine ecology could be severe and irreversible (section 10.12.4.2). Given the potential impact of invasive species, as seen in previous case studies around the world (section 10.12.4.2.1), there is the possibility that invasive species could have an 'extensive effect over a large (regional) area with the potential for long-term irreversible damage to species / regional population / habitat / ecosystem'. Therefore, following the precautionary principle, the **severity of the impact** is considered to be **'Major'**.

Therefore, overall the **significance of the potential impact** is assessed as **'High (20)'**.

10.12.6.2 Likelihood of occurrence

Given the number of vessels that visit Stanley from all around the world (e.g. fishing vessels and cruise ships) and the apparently few invasive species in the Harbour (SMSG, 2011), the introduction of invasive species appears to be an uncommon event thus far. However, introduction of invasive species has happened both in the Falklands and by the O&G industry elsewhere.

The following assessment of the likelihood of the introduction of marine invasive species by different vessels assumes that industry-standard IMO guidelines are followed (section 10.12.5). Phase 1 vessels will comply with the BWMC and the associated culture change across the whole shipping industry will reduce the overall likelihood of introducing non-native species in ballast water.

Nonetheless, when assessing the likelihood of marine species invasion, it is important to consider:

- The process by which species become invasive (section 10.12.4.1);
- The factors that influence the likelihood of species introduction / invasion (section 10.12.4.3); and
- How these apply to the Phase 1 vessels (section 10.12.4.3.1).

After all, not all species that are introduced via biofouling or ballast water will become invasive and therefore, the likelihood of species introduction is not the same as the likelihood of species invasion and both outcomes must be taken into account. However, it is important to note that while these influencing factors are taken into account for each of the assessments below, the likelihoods rarely differ enough to justify a lower category of likelihood according to the definitions provided in the EIA methodology (section 8.6.2).

10.12.6.2.1 The risk of invasive species introduction by Sea Lion in-field vessels

As described above, the significance of the impact of species introduction is considered to be 'High (20)'.

The origin of many of the in-field vessels remains unknown but it is likely that they will arrive with cargo and therefore little ballast water (Table 10.85 above) although there is a risk that vessels could be carrying bio-fouling organisms on arrival. However, as these vessels will be under direct charter to Premier the maintenance history of biofouling and hull cleaning will be known. Importantly, these vessels will remain within Falklands waters while supporting the Development and therefore the risk of transporting non-native species is further reduced. However, while these influencing factors may somewhat reduce the likelihood (section 10.12.4.3), some potential does remain and therefore, to take a precautionary approach, the likelihood of in-field vessels introducing potentially invasive species is considered to be 'Unlikely'.

Therefore, the overall significance of the risk of introducing non-native marine species via Sea Lion in-field vessels, which may then go on to become invasive is considered to be 'Moderate (10)' and therefore, additional mitigation measures are required.

10.12.6.2.2 The risk of invasive species introduction by coaster vessels

As described above, the **significance of the impact** of species introduction is considered to be **'High (20)'**.

It is likely that coaster vessels will be shipping from temperate climates of northern Europe throughout all three Stages of the Phase 1 Development such that the 'donor climate' may be compatible with the Falkland Islands climate (Table 10.85 above). While these vessels will travel through the potential natural barrier of the Tropics and will be carrying little ballast, each vessel will be 'new' to the Islands with each return trip. Therefore, the coaster vessels can present multiple pathways for the introduction of non-native species, especially in regard to biofouling organisms. While these influencing factors may, on balance, reduce the **likelihood** (section 10.12.4.3), some potential does remain and therefore, to take a precautionary approach, the likelihood of coaster vessels introducing marine non-native species that go on to become invasive is considered to be **'Unlikely'**.

Therefore, the overall **significance of the risk** of introducing non-native marine species via coasters, which may then go on to become invasive is considered to be **'Moderate (10)'** and therefore, additional mitigation measures are required.

10.12.6.2.3 The risk of invasive species introduction by Large Transport Vessels (LTVs)

As described above, the significance of the impact of species introduction is considered to be **'High (20)'**.

A maximum of four LTVs will be used inshore in Berkeley Sound to act as floating logistics vessels to store equipment before it is required to be installed offshore however, due to work phasing, only up to two will be present at any one time. The subsea construction schedule dictates that up to two LTVs will be present for up to twelve months (currently scheduled for eight months in campaign one and four months in campaign 2) to avoid peak fishing season). It is likely that these vessels will travel from European ports (Table 10.85 above) and therefore the donor climate may be compatible with the Falklands. Further, although these vessels will be laden with cargo on arrival (therefore carrying minimal ballast water), and will only be 'new' to the Islands once, a prolonged stay in inshore waters may give any biofouling organisms the opportunity to be transferred or to spawn. Further, the LTVs will be changed out over the duration such that vessels which are 'new' to the Islands arrive more than once. While these influencing factors may balance out to reduce the likelihood (section 10.12.4.3), the likelihood does remain and therefore, to take a precautionary approach, the likelihood of LTVs introducing marine non-native species that go on to become invasive is considered to be **'Possible'**.

Therefore, the overall **significance of the risk** of introducing non-native marine species via LTVs, which may then go on to become invasive is considered to be **'Upper Moderate (15)'** and therefore, additional mitigation measures are required.

10.12.6.2.4 The risk of invasive species introduction by purchaser's vessels (CTTs)

As described above, the significance of the impact of species introduction is considered to be **'High (20)'**

The selection of Direct Offtake as the oil export option has eliminated entry of the CTT to inshore waters. The risk of introducing marine invasive species under the current proposal is therefore much lower than earlier project proposals.

Offshore, CTTs will arrive at the FPSO at regular intervals throughout Stages 2 and 3 of the Phase 1 Development from, as yet, unknown locations. While the CTT may travel from a tropical clime, it is still possible for non-native species in the ballast water or fouling the hull to take hold (section 10.12.4.3). Notably, the vessel will be carrying a large volume of ballast water and each visit by a CTT will be 'new', thus representing a new pathway for the transport of potentially invasive species (Table 10.85 above). Given the use of standard flushing procedures and treatment (section 10.12.5), the resulting likelihood of introducing non-native species in ballast water will be reduced. Further, Premier will apply a vetting system whereby the Oil Companies International Marine Forum (OCIMF) Ship Inspection Report Programme (SIRE) process is applied, which requires the inspector to verify that the vessel complies with the BWMC and that ballast water management plans, record books, certificates and biofouling management plans are in place and up to date for the incoming CTTs. However, while these influencing factors and mitigations may somewhat reduce the likelihood (section 10.12.4.3), the **likelihood** does remain and therefore, to take a precautionary approach, the likelihood of the CTT introducing marine non-native species which then go on to become invasive is considered to be **'Possible'**.

Therefore, the **overall significance** of the risk of introducing non-native marine species via CTTs, which may then go on to become invasive is considered to be **'Upper Moderate (15)'** and therefore, additional mitigation measures are required.

10.12.7 Project-specific mitigation measures

When followed, the changes in legislation to regulate ballast water management practices and guidelines to manage biofouling outlined above (section 10.12.5) will greatly reduce the likelihood of introduction. However, the true impact of these changes is currently unknown as the Convention only came into force in September 2019, although they are likely to reduce the risk to ALARP. Therefore, the initial assessment presented above remains very precautionary; largely due to the potential for long-term (irreversible) impact and the history of non-native species introductions by shipping around the world.

Given that the risks of introducing marine invasive species are considered to be **'Moderate (10)'** and **'Upper Moderate (15)'** despite the legislation and use of industry-standard mitigations, it is necessary to consider project-specific mitigation measures for all vessels and both types of species introduction.

10.12.7.1 Ballast water

It is suggested by Behrens *et al*., (2005) that 'open ocean' exchange will always be preferable over exchanges in coastal waters, even those meeting the IMO criteria. Therefore, the project will commit to requiring coasters and CTTs to undertake open ocean exchange 200 nautical miles from the nearest land and in water at least 200 m in depth *en route* to Falklands waters

10.12.7.2 Biofouling

It is recognised that the initial risk assessments for all vessel types are considered to be significant. However, due to the physical difficulty of accessing and monitoring the niche spaces where biofouling organisms are most likely to persist, the introduction of non-native species via biofouling is arguably more difficult to mitigate than introduction through ballast water. The risk posed by each vessel is linked to its previous history (geographical location and activity), maintenance schedule (dry-docking and condition of antifouling coatings) and residence time. For these reasons, the risk posed by each vessel should be assessed on a case-by-case basis.

In order to specifically mitigate the **'Upper Moderate'** risk of species introduction via bio-fouling which is posed by the LTVs used as floating logistics barges, these vessels will be required to have a hull inspection prior to transport to Berkeley Sound and consideration will be given to hull cleaning, depending on the results of the survey. If hull cleaning is required, this would not be done in Falklands waters.

10.12.8 Residual impacts and risks

Following the project-specific mitigation outlined above, the likelihood of introducing non-native marine species remains the same but, once established, it can be almost impossible to remove invasive marine species and therefore the focus of mitigation should be on prevention (i.e. reducing the likelihood of species introduction) rather than cure (i.e. reducing the severity of effect of species that have become invasive).

10.12.8.1 Sea Lion in-field vessels

Given that the risk posed by in-field vessels is a one-off and Premier is likely to have stricter control of auditing and maintenance procedures prior to deployment, the initial assessment is considered to be ALARP. Project specific measures are largely based on monitoring which may help to detect any breaches of biosecurity but do not warrant a change in the likelihood. Therefore, it is considered appropriate and precautionary, for the overall significance of the risk to remain **'Moderate (10)'**.

10.12.8.2 Coaster vessels

Throughout the course of field life, the project-specific measures cannot eliminate the risk entirely and introduction of invasive species world-wide is a frequent occurrence. Further, given the number of 'unknowns' within the assessment, it is considered appropriate and precautionary, for the overall significance of the risk to remain **'Moderate (10)'**. Outcomes of sampling and monitoring throughout field life (section 10.12.10.1) will enable this assessment to be 'ground-truthed' throughout the Development.

10.12.8.3 Large Transport Vessels

Hull inspections for potentially invasive species for Large Transport Vessels prior to departure for the Falklands, together with appropriate action if required, will reduce the likelihood of introducing biofouling non-native species. However, hull inspections and treatments are still limited in the extent to which they can eliminate biofouling and therefore, the post mitigation likelihood of introducing invasive species can only be reduced from **'Possible'** to **'Unlikely'**. Therefore, with a **'High'** impact and a likelihood rating of **'Unlikely'**, the residual risk for in-field vessels is only lowered to **'Moderate (10)'**.

10.12.9 Cumulative impact

Numerous vessels arrive in Stanley Harbour and Berkeley Sound from all over the world and there is the potential for this to lead to cumulative impacts through increased 'concentration' and increased 'extent and proportion' (section 8.10.1). To varying degrees (according to the influencing factors described in section 10.12.4.3 above), all of these vessels, which may not have stringent management systems in place, have the potential to introduce non-native species.

Vessels that spend prolonged periods laid-up in ports have the greatest potential as vectors for non-native species, especially biofouling. However, vessels associated with the Phase 1 Development will increase the number of introductory pathways for non-native species, which adds to the existing threat from other vessels. Between 2010 and 2015 an average of 428 vessels visited Berkeley Sound annually. In support of the Stage 1 and 2 subsea construction campaigns, four LTVs will be anchored in Berkeley for a combined period of up to 12 months and c. 11 trips will be made by a Subsea Construction Vessel to transport subsea equipment offshore; there will also be c. 25 coaster visits. That results in a total of an additional 40 vessel visits over the existing average, an increase of approximately 9%.

There is also potential for vessels based in the Islands to accelerate the spread of invasive species that are already present in the region. For example, the invasive vase tunicate (*Ciona intestinalis*) was historically introduced to Stanley Harbour and Mare Harbour (SMSG, 2011). This species has a high potential for natural dispersion and is known to be established in Port William and may have reached Berkeley Sound already (P. Brickle pers. comm.). Vessels based in Stanley Harbour but travelling elsewhere have the potential to accelerate the natural spread of this, and potentially other invasive species, to other parts of the archipelago. It may be too late to prevent the further spread of the invasive vase tunicate to Berkeley Sound but future monitoring should focus on the potential pathways to spread invasive species within the Islands and identify pre-existing non-native species and trends. Although this is not solely an O&G specific issue, Premier has committed to monitoring of non-natives connected with their activities (section 10.12.10.1).

At present, there is limited exploitation of inshore resources and aquaculture in the Falklands but this could develop in the future and the introduction of parasites, disease, competitors or predators could impact these industries.

10.12.10 Confidence

While the nature of the impact of invasive species on the marine environment will depend on the species involved, it is understood that the introduction, and potential invasion, of any non-native species can be detrimental and the impacts are well documented.

However, predicting the likelihood of introducing a species, the likelihood of it becoming invasive and then the extent of the impact of any particular invasive species on the local environment is very difficult. The likelihood of vessels carrying potentially invasive species is very vessel-specific and depends on a number of factors (as described in section 10.12.4.3), many of which are currently unknown e.g. origin and history of vessels etc. Therefore, while, the mitigation practices proposed are used internationally and are regarded as best-practice, the number of unknowns is such that the confidence in the overall assessment is considered to be **'Uncertain'** such that monitoring is required.

10.12.10.1 Monitoring required

The vetting of third party vessels will require scrutiny of ballast water exchange logs, biofouling management plans and biofouling record books during pre-selection and pre-mobilisation audits (section 10.12.5).

While the IMO requirements implement preventative mitigation against the introduction of non-native species, experience in other regions, such as parts of the UK, has shown that it is still prudent to undertake monitoring. This should be carried out to:

Identify 'background' levels of non-native species so that existing problems or trends are not inappropriately attributed to the Phase 1 Development;

Confirm that valuable sites are not being put at risk from non-native species resulting from the proposed Development; and

Confirm that non-native species are not being introduced by the proposed operation in general.

Monitoring specifically related to this project requires:

- The deployment of settlement plates in Stanley Harbour, Berkeley Sound and other appropriate locations;
- The use of metagenomic technology to detect genetic material from non-native species in the environment (water samples); and
- In the event that marine invasives are found, pathway analyses will be conducted to determine where / how invasives are being brought in to the Islands.

In order to inform the monitoring strategy, ballast water modelling was carried out, following practices used by analogous operation sites e.g. Scapa Harbour in Orkney (Scapa Harbour Authority, pers. comm. 2016). Modelling was undertaken using the Marine Environmental Modelling Workbench (MEMW) version 8.0.

Additionally, ballast water sampling will be carried out as described in section 10.12.10.1.2 below.

10.12.10.1.1 Ballast water modelling

The intent of the modelling is to identify those areas that:

- Are most likely to encounter the ballast water plume;
- Are exposed to ballast water at the highest concentrations; and
- Are exposed for the longest durations.

Identification of the above will enable a more focused and informed monitoring strategy to target exposed and unaffected areas.

Note: This section describes predictions of ballast water that were previously modelled, for the CTTs involved in Inshore Transfer, and presents the conclusions that can be drawn for the LTVs.

A discharge of 35 % of a full CTT ballast tank volume in Berkeley Sound was assumed (i.e. the total expected volume of ballast water required for tanker stability) and its dispersion was modelled over a period of 12 hours. Outputs of the model are represented by 'dilution' rather than the concentration of a substance (e.g. an organism), since the concentration of organisms cannot yet be known or even estimated. The dilutions are expressed in 'parts per million' (ppm) which shows how many 'parts' of ballast water there are per million 'parts' of seawater. If necessary, the dilution data shown by the model could be used as a guide to concentration, if desired, by applying it to a known initial concentration once sampling results of the vessel are known (section 10.12.10.1).

The following describes the key outcomes of the model. The full model report is contained in Premier Inshore Environmental Modelling report, FK-SL-PMO-EV-REP-0010 (Premier, 2017d).

Figure 10.55 shows the overall time-averaged minimum dilution for a suite of 100 stochastic model runs, whereby the discharge has been modelled through 100 different slices of metocean data. This figure reports the minimum of all the short-term average dilutions identified in the model during which the concentrations were stable. The reason that the model developers used this moderately complex approach was to:

- Balance out highly variable short-term conditions caused by turbulence and movement of the plume; and
- To take account of the duration of exposure, which can be considered more important than instantaneous spikes in concentration.

The key conclusion from this output is that once discharged, the ballast water dilution is least to the south, southeast and north of the discharge point, which reflects the prevailing surface current trends. Dilutions in upper Berkeley Sound are all greater than 20,000 ppm (i.e. 20,000 parts of ballast water for each million parts of receiving seawater) and this is also true beyond the headlands towards the sea. Dilutions are around 2,000 - 10,000 ppm around Cochon Island. There is a small chance of very dilute ballast water entering Stanley Harbour, but coasts south of Cape Pembroke are unlikely to be exposed. Highly diluted ballast water may migrate along the northern coastline past Volunteer Point.

The cross section beneath the map is taken north-south across Berkeley Sound through the release point and reveals the degree of vertical mixing, which is relatively slight. The surfaces most exposed, and on which the monitoring should be focused, are predicted to be those nearest to the inter-tidal zone. There is a predicted dilution of 100,000 ppm towards the 'flat' seabed of Berkeley Sound around two km from shore.

As described, these results will inform the monitoring strategy and all monitoring requirements agreed by Premier and FIG will be recorded and managed via the project-specific Phase 1 Environmental Monitoring and Management Plan (EMMP) (an outline EMMP is provided in Chapter 15).

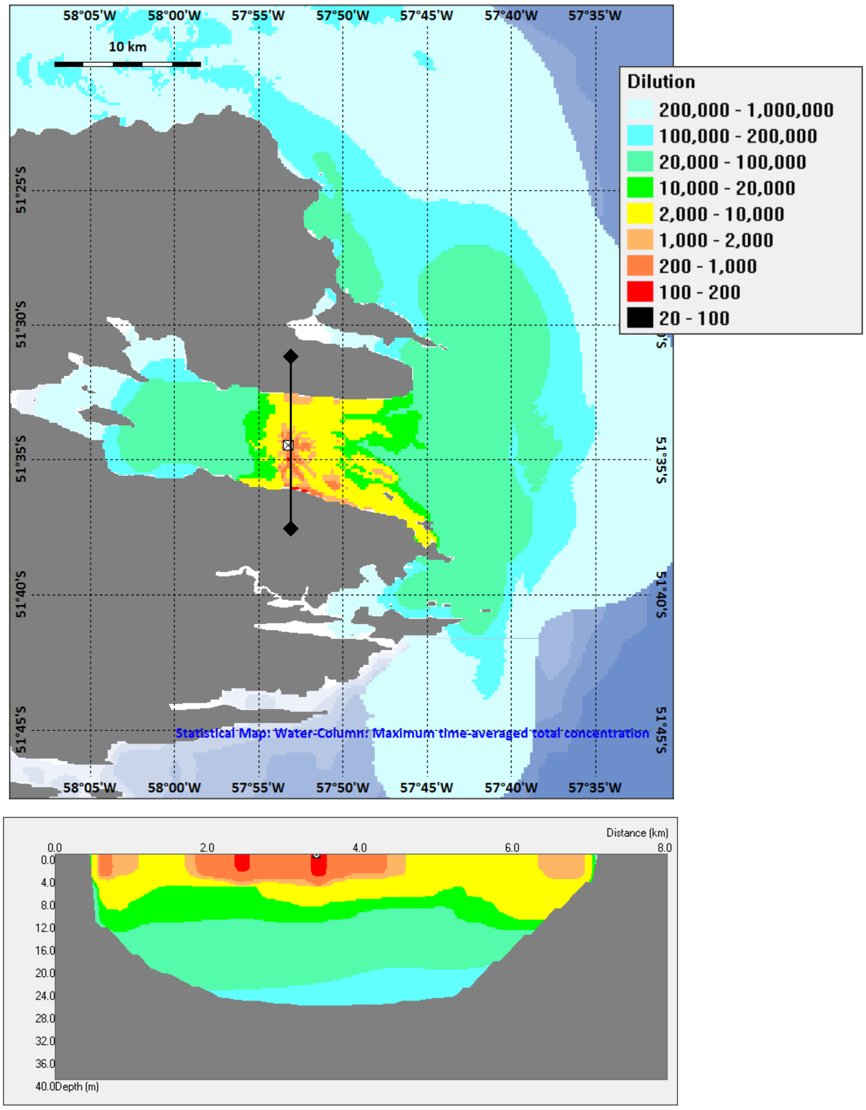


Figure 10.55: Minimum time-averaged dilution for 100 model runs: plan and cross section

10.12.10.1.2 Ballast water sampling

While sampling of each discharge is not required by IMO, to ensure assessment of ballast waters against IMO Regulation D2 (section 10.12.10.1), Premier will ensure samples are taken of discharges in Berkeley Sound when the LTVs arrive in the Sound. These samples will be analysed in a specialist laboratory for monitoring purposes and results shared with FIG Biosecurity. While the length of time required for transporting and analysing the sample means the results are not known until after the ballasting operation, the results are used as a guide to future operations.

10.12.11 Offsetting

For significant residual and impact and risks (Moderate or above), offsetting via an Environmental Fund is proposed, see section 8.9 for further details.

10.12.12 Findings summary

Table 10.86: Summary of the impact and risk assessment for introduction of marine invasive species

Activity	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Introduction of invasive species by Premier's Sea Lion in-field vessels	Marine Invasive species (biosecurity)	Introduction of marine invasive species through ballast water or biofouling Potential to have irreversible impact on biodiversity	Unplanned	1	High	Major	Unlikely	Moderate (10)	Moderate (10)	Uncertain	Industry-standard: Pre-selection and pre-mobilisation audits. Project-specific: Oil Companies International Marine Forum (OCIMF) Ship Inspection Report Programme (SIRE) will be applied to audit BWMP and the BFMP and all associated records ; Ballast water modelling; LTVs used as floating logistics vessels will have their hulls inspected prior to departure for the Falklands; Non-natives species monitoring programme and ballast sampling.
Introduction of invasive species by coaster vessels			Unplanned	1, 2 & 3	High	Major	Unlikely	Moderate (10)	Moderate (10)	Uncertain	
Introduction of invasive species by floating logistics vessels (LTVs)			Unplanned	1 & 2	High	Major	Possible	Upper Moderate (15)	Moderate (10)	Uncertain	

a See Chapter 8.0 for definitions of sensitivity, severity, likelihood and significance

10.13 Introduction of terrestrial invasive species

Table of Contents

10.13.1 Introduction

Numerous vessels and charter flights will be used throughout Stages 1, 2 and 3 of the Phase 1 Development to deliver supplies to the Falklands. While the delivery of cargo is a planned event, the introduction of non-native terrestrial species associated with cargo would be an unplanned event and it is therefore necessary to consider this risk. The potential for the introduction of non-native species was also raised as a concern by stakeholders during scoping consultations (Chapter 6).

Historically, many species have been introduced to the terrestrial environment of the Falklands, some intentionally and some unintentionally. Species introduced from similar climates and which have the potential to flourish in the Falkland Islands are of particular concern. For example, ecologically, the terrestrial habitat of the Falklands is comparable with that of the UK and species that may be transported from the UK are very likely to survive and potentially become established in the Falklands (c.f. European earwig, see section 10.13.4.1.1).

Introduced species can impact on native species through predation, competition and habitat loss which can affect the biodiversity of the Islands. Russell *et al*. (2017) note that impacts to biodiversity tend to be disproportionately worse for islands, as compared to continents, due to the relatively high number of endemic species. In 2015, a review of the Falklands Biodiversity Framework upgraded invasive species and biosecurity from a medium to high priority threat (FIG, 2015b). Equally, micro-organisms could introduce disease to Falklands' livestock. Since 2002, the Falklands Islands have been EU accredited for the exportation of mutton and lamb and approval to export beef has recently been achieved. Countries to which these products are exported must be assured that the goods received are free from pests and disease and therefore biosecurity plays a key role in safeguarding the export industry. In recent years, there has been a concerted effort by the Falkland Islands Government (FIG) to reduce the risk of materials arriving on the Islands unintentionally introducing more non-native species and consequently, biosecurity procedures have become more stringent.

This chapter specifically assesses the risk of introducing non-native species to the terrestrial environment via cargo deliveries associated with the Sea Lion Phase 1 Development.

Note: The risk of introducing non-native species to the marine environment is assessed in section 10.12 and other impacts associated with vessel use and fixed-wing flights are described elsewhere in this document, as described in section 9.2.

10.13.1.1 Falkland Islands legislation and guidelines

The import of goods that potentially pose a biosecurity risk is to some extent controlled by:

- The Plant Disease Regulation and Plant Import Regulation Ordinance; and
- The Prohibited Goods Ordinance 1992.

As FIG officials, Biosecurity Officers are also invested with the powers of Customs Officers, which allows them to work under the Customs Ordinance 2003.

While no specific legislation exists to safeguard against the introduction of non-native terrestrial species to the Islands, preventative guidelines are provided in:

- 'Falkland Islands Biosecurity; protecting our home, environment and economy' (FIG, 2015r).

The Falklands rely on imported goods, which are categorised into groups depending on their perceived biosecurity threat. The import of higher risk items is controlled to ensure that threats to the Islands' biosecurity are minimised. Some categories of import may require an Import Permit such as live animals, meat, dairy products, eggs and plant materials, which include fruit and vegetables. FIG (2015r) specifies the requirement for importers to notify the Biosecurity Officer of arrivals in advance so that inspections can be arranged. All cargo is inspected for 'pests, diseases and invasive species' prior to being released.

Further, in compliance with the FIG biosecurity declaration, all visitors to the Falklands, whether by air or sea, are briefed on what is / is not allowed to be imported to the Islands. Each passenger must sign a declaration to the effect that they are complying with the regulations. Additionally, visiting vessels are also briefed on the disposal of organic waste, and other waste streams, via the 'Falkland Islands Ports and Harbours Information' (FIG, 2017).

10.13.2 Sources of non-native species introduction

The key potential source of non-native species introduction associated with the Phase 1 Development is the delivery of cargo to the Falkland Islands. Any cargo arriving from outside the Islands in support of the Sea Lion Development poses a risk of unintentionally introducing non-native species. Deliveries of cargo will occur via:

- Transport and Installation vessels e.g. Large Transport Vessels, Fast Transit Carriers etc.;
- Coaster vessels; and
- Charter flights.

A full inventory of the vessels used during Stages 1 to 3 of the Development is provided in section 5.11.2.

Non-native species may be found within the intended cargo, within the associated packaging or within inadvertently adhered materiel e.g. mud from the site of origin on the bottom of a container. With regard to cargo therefore, introduction of species can result from the:

- Importation of materials and equipment;
- Importation of food stuffs:
  - Fruit and vegetables; and
  - Food of animal origin.
- Disposal of international catering waste.

10.13.2.1 Importation of materials and equipment

All non-food materials related to the Development are likely to be extensively packaged in containers, wood and plastics, all of which can be contaminated with invertebrates, seeds and soil (containing micro-organisms) that can adhere to the outside of packaging and / or may be hidden within cargo.

10.13.2.2 Importation of foodstuff

10.13.2.2.1 Importing fruit and vegetables

It is anticipated that fresh fruit and vegetables will be imported into the Falkland Islands on the charter flights utilised during the Development. While fresh fruit and vegetables entering the local market via this route has been welcomed by local residents during previous exploration campaigns and was considered a positive impact during informal consultations on the Phase 1 Development (Chapter 6.0), it also represents one of the greatest risks of introducing non-native species within the produce, adhering soil or packaging.

Additionally, it may be necessary to air freight other cargo from the UK to Mount Pleasant via the charter flight. While this is not the preferred method for importing materials to the Islands, it may be used if urgent supplies are required.

10.13.2.2.2 Importing Food of Animal Origin (FOAO)

During previous exploration campaigns, frozen meat for human consumption, was acquired from outside the EU (albeit EU certified) and was imported to the Falklands as 'in-transit' goods. In accordance with the Falklands biosecurity policy, these in-transit goods were kept secure (under Customs seal) on land, and were transferred to the drilling rig support vessel under supervision from the Biosecurity Officer or Customs.

All FOAO supplied during the Phase 1 Development will be contractually required to meet UK / EU standards and will be sourced from inside the UK / EU.

10.13.2.3 Disposal of International catering waste

If any food stuff arrives on-board vessels or is imported from outside the Falklands, passing through the Islands in-transit, there is the potential for the introduction of harmful pathogens within the food or packaging. This is an important consideration when managing waste (section 10.10).

10.13.3 Potential receptors

The ENVironmental Impact IDentification (ENVIID) workshop was used to identify the specific receptors upon which the risks of terrestrial invasive species warranted further investigation (Chapter 9.0). The specific receptors that may be impacted include:

- All terrestrial flora and fauna, and therefore biodiversity in general (section 7.47 and section 7.5);
- Livestock and agriculture (section 7.7.2.4); and
- Human population (section 7.7.2).

The above may be affected in the event that:

- Non-native species which thrive to the point of becoming invasive tend to outcompete or depredate native species (although the precise receptor species would depend on the species introduced);

- The introduction of agricultural disease or pests impacted on livestock (Tangible Property) and associated exports with socio-economic implications; and
- Agricultural export became unviable which would indirectly affect the culture or 'way of life' on the Islands.

10.13.4 Characterising and quantifying the risk of non-native species

When attempting to characterise and quantify the risks of non-native terrestrial species introduction, it is necessary to assess:

- Potential consequences of species introduction; including
- Previous examples of species introduction; and
- Cargo delivery routes.

10.13.4.1 Potential consequences of species introduction

All invasive species have the potential to impact dramatically on both biodiversity and tangible property with regard to livestock. With regard to the potential impact of a non-native species introduction there are three main outcomes:

6) The species arrives on the Islands but is noticed immediately upon arrival and is removed via containment and treatment;
7) The species is unintentionally introduced to the Islands, is not noticed immediately and begins to 'take hold' but is effectively removed and disposed of once its presence is discovered; or
8) The species is unintentionally introduced, finds a niche and becomes established within the Falkland Islands and is thus considered 'invasive'.

While all species might fall under any of the categories above, it is generally understood that small mobile organisms (such as invertebrates), pathogens (micro-organisms) and plants are the most difficult to detect, and are the most difficult or costly to eradicate once established. Eradication of invasive species on islands is possible in the early stages of introduction, particularly for mammals, but for other invasives control may be the only option (Russell *et al*. 2017).

With regard to pathogens, it is possible that food of animal origin can harbour disease or pathogens that could be disastrous for the agriculture in the Islands. For example, if foot and mouth were to be introduced, it could result in large numbers of animals being destroyed and devastate the meat export industry.

10.13.4.1.1 Previous examples of non-native terrestrial species introduction

There are numerous examples in the Islands where invasive species have had both socio-economic impacts and impacts on the biodiversity of the Islands. For example, brown rats (*Rattus norvegicus*) arrived in the Islands with early visitors and became established and spread to many Islands in the Falklands archipelago. These rats are known to be detrimental to native birds (e.g. Cobb's wrens, *Troglodytes cobbi*, and tussock birds, *Cinclodes antarcticus*) and recent studies have shown that islands with invasive rats show a reduction in species richness and a different community structure within the bird species than on islands on which rats have not become established (Tabak *et al*., 2016).

More recently, the invasion by the European earwig (*Forficula auricularia*) of Stanley is a timely reminder of the risks posed by non-native species. European earwigs were first accidentally introduced to Stanley in the early 2000s. Since then, they have spread throughout the town and to outlying settlements and increased hugely in number. These pests have had a number of consequences for the residents of Stanley such as:

- A direct nuisance from home invasions;
- The loss or damage of fruit and vegetable crops, eaten by earwigs; and
- The long-term indirect impact on native invertebrates from the use of chemical pesticide treatments.

The implications for the Islands should earwigs spread beyond settlements are unknown. To date FIG has expended much time and resource to combat the spread of earwigs with limited success. A trial to conduct biological control, with a parasitic fly, has been undertaken. It has been assessed that this method has the potential to control (but not eradicate) earwigs without impacts on other environmental receptors (CABI, 2013).

10.13.4.1.1.1 Previous biosecurity 'near misses' within the Falklands Oil & Gas (O&G) industry

There have been cases of non-native species arriving on cargo associated with the previous exploration drilling campaigns. During the 2015 campaign, three biosecurity incidents were reported:

- Contaminated dunnage (packaging wood) was delivered with a certificate to state it had been treated; however, an infestation of beetle larvae was clear upon arrival. The dunnage was segregated and treated by a local company under advice from the FIG Biosecurity Officer;
- The 'Snoozebox' intended for use as temporary accommodation was delivered with mud from its previous location still compacted to the base; and
- A second-hand imported vehicle was delivered with mud and road grime (including vegetation) on the under axel. In this instance, the trailer was washed down by a pressure washer on the supply base in the designated washing area with approval and advice from the FIG Biosecurity Officer (S. Cockwell *pers. comm*., 2015).

These incidents were reported to the FIG Biosecurity Officer and treatment was applied to remove the possibility of non-native species spreading and becoming established.

10.13.4.2 Cargo delivery routes

Cargo associated with the Phase 1 Development will be delivered to the Falkland Islands via marine and air freight (section 10.13.2), each of which may have the potential to introduce non-native species:

- **Transportation and Installation vessels (LTVs)** will be used in Stages 1 and 2 to deliver the subsea infrastructure that requires installation on the seabed. Up to two LTVs at any one time will carry down the installation equipment and anchor in Berkeley Sound acting as floating storage vessels while the installation processes take place.

- **Coaster vessels** will arrive in Stanley, from the UK, throughout the life of the Development. During Stages 1 and 2, it is anticipated that 22 coasters will deliver cargo to Stanley. During Stage 3, steady production, it is anticipated that the frequency of coaster visits will drop to four per year (for 17.5 years). Each vessel will carry a range of cargo to facilitate all aspects of the Phase 1 Sea Lion Development.
- **Charter flights** will arrive regularly throughout the Development to deliver personnel, each flight may carry a shipment of fresh fruit and vegetables.

Detailed cargo manifests are not yet available but will include items such as:

- Subsea equipment for installation during Stage 1:
- Drilling equipment and supplies during Stages 1 and 2;
- Bulk chemicals during all stages;
- Food during all stages.

As described in section 10.13.2, all the above may carry non-native species if not inspected and treated appropriately at the point of shipment, and may introduce species if the material itself and the associated packaging is not managed appropriately.

It is clear that many species have been introduced in the past. However, quantifying the risk is not straight-forward. It is likely that many cargos arriving in the Falklands may be harbouring some non-native species. However, whether these become invasive depends upon whether the species is:

- Exposed to the wider environment;
- Able to survive and breed; and
- Find a niche to exploit in the Falklands.
- Therefore, the impact of any introduction should be assessed on a case-by-case basis.

10.13.5 Industry-standard mitigation

As part of the planning consent for the Temporary Dock Facility (TDF), a Biosecurity Management Plan (BMP) was developed and implemented by Noble Energy Falklands Ltd. and Premier Oil (BSP, NEFL, 2015, 021-15-EHSR-BSP-PA-T4) and has continued to develop over the life-time of the facility. As an example, an integral part of this plan is the instruction given regarding the preparation of a cargo before it leaves the UK (e.g. all wood is treated; equipment is steam washed and containers fumigated). Equally, personnel in Stanley are made aware of the importance of biosecurity and inspect cargo as it is unloaded. The TDF is also equipped with monitoring devices and equipment to clean any cargo that does not meet the specified standards.

The biosecurity procedures followed by Premier will adhere to the guidelines drawn-up by Noble Energy (NEFL, 2015), with review by FIG, to cover the operation of the TDF during the Phase 1 Development.

It is recognised that whilst the previous iteration of the BMP was in place for exploration drilling there were near misses (see section 10.13.4.1.1.1). The next revision of the BMP will incorporate lessons learned from these near misses, with greater focus on pre-export improvements, and the BMP improved as a result.

10.13.5.1 TDF Biosecurity Management Plan

10.13.5.1.1 Planning and preparation

An integrated management approach will be implemented and will include:

- Prevention:
  - Prevention is the most effective way to avoid impacts to the ecosystem. Preventative measures include; identifying potential pathways and implementing controls to minimise the impact of invasive species.
- Monitoring, detection and elimination:
  - It is important to set adequate schedules for monitoring.
  - Glueboards (or an equivalent vermin attraction / containment / detection devices) will be used on vessels to monitor pest populations and activity. Visual inspections of the devices will identify specific areas of infestation, if any, and assess the need for further action.
- Management and controls:
  - Controls to minimise the potential for invasive species incursion will be implemented, including pest infestation controls and eradication measures. Additionally, if a potential infestation is identified a risk / impact assessment will be conducted for the specific non-native species involved. This will ensure the most appropriate mitigation measures are identified, selected and implemented.
  - Prior to the loading of any material or equipment (intended for transport to the Falkland Islands), appropriate pre-treatment activities will be conducted. These measures include:
    - Wood / dunnage material will be heat treated or fumigated with pesticides and marked with an accredited seal, when applicable.
    - Equipment will be steam / pressure washed and cleaned thoroughly.
    - Any container destined for offloading in the Falkland Islands will be fumigated prior to being secured for transport.
    - Rat guards will be used when vessels are berthed at the TDF in Stanley Harbour.
    - Pesticides may be applied if pest / insect populations exceed an acceptable level and will be applied if an infestation is observed prior to arriving at the TDF. Additionally, the TDF Operator will ensure steam / pressure washing equipment is installed and available at the TDF. This will be utilised in cases where it is necessary to mechanically clean material or equipment that is being offloaded at the TDF.
  - Awareness campaigns and training will be used to highlight biosecurity risks.

- Regulatory inspections:
  - If a vessel with an observed / documented infestation arrives to be offloaded at the TDF, the TDF Operator will coordinate the relevant governmental agencies / regulatory bodies to ensure appropriate measures are taken.

10.13.5.1.2 Importation of food and food waste disposal

The importation of all goods and food stuffs will follow the guidelines outlined in FIG's 'Falkland Islands biosecurity: protecting our home, environment and economy: A guide to importing goods' (2015r).

During the 2015 exploration campaign, there were some issues regarding in-transit food of animal origin. As these products have not been through the usual importation procedures and may be sourced from outside the EU they may pose a risk of introducing disease or pathogens to the Falklands. The long-term storage of food in-transit is not appropriate as it requires continuous supervision; FIG officials are present every time food is moved. This issue can be easily mitigated by procuring meat that is UK / EU certified and sourced from the UK / EU as it can therefore go through the usual import process, or source meat locally, which is also EU certified. The next revision of the BMP will detail these improvements, with greater focus on pre-export improvements.

Food, galley waste and associated packaging sourced from outside the Falkland Islands EEZ are termed International Catering Waste (ICW). ICW carries a risk of introducing pests and diseases and must be disposed of accordingly. At-sea, food waste may be disposed of in accordance with MARPOL regulations and discharged to sea but packaging and associated wastes will be returned to shore for incineration in accordance with the Waste Management Plan (section 10.10).

10.13.6 Risk assessment

The following section draws upon all the information provided above to assess the 'Sensitivity of the Receptor', the 'Severity of Effect' and the 'Likelihood of Occurrence' to determine the overall 'Risk'.

A summary of the risk assessment outcomes for this Development is tabulated in section 10.13.12 (Table 10.87), which shows the worst case risk for each activity

10.13.6.1 Introducing terrestrial non-native species in marine or air freight

If invasive species were introduced during the Phase 1 Development the impact on the ecology of the Islands through parasites, disease, competitors or predators may not be immediately evident but may have long-term implications. Initially the impact would be felt locally, however, once established invasive species may spread 'naturally' or with anthropogenic assistance to other parts of the Falklands archipelago. There is potential to have an impact on a national scale and therefore the **sensitivity of the receptors** to invasive species is considered to be **'High'**.

If found, potentially invasive species can be removed and disposed of before becoming established. However, detecting microscopic or small mobile organisms (such as invertebrates) is very difficult once onshore. If such non-native species become invasive, the long-term implications for the Islands could be severe and difficult to reverse. In the terrestrial environment the possibility of detecting invasive species, and eradicating them to reverse the effect, is feasible but may be costly, in both time and money. On this basis, the severity of effect is initially considered to be **'Serious'**. However, taking into account the measures implemented as part of the Biosecurity Management Plan (BMP), the severity of effect is considered to be **'Moderate'**.

Therefore, the worst case **significance of the impact** has been assessed as **'Upper Moderate (12)'**.

Vessels and charter flights will be arriving in Stanley throughout the life of the Development and a large amount of cargo will be taken onshore. The transportation of invasive species to the Falklands has happened in recent years, and the introduction of invasive species has occurred in the oil and gas (O&G) industry elsewhere in the world. Indeed, non-native species (with the potential to become invasive) have arrived in the Falklands in cargo associated with the 2015 exploration drilling campaign. Although a number of biosecurity incidents were detected and remedial action taken, no biosecurity plan is absolutely fool proof and it is possible that other minor breaches went undetected. Therefore, despite improvements to biosecurity procedures, the **likelihood of invasive species becoming established** as a result of the Sea Lion Development is considered to be **'Possible'**.

The movement of large quantities of cargo has discernible environmental and social risks in terms of the potential to introduce non-native species. While there are means of reducing the risk, the **overall significance of the risk** of introducing non-native terrestrial species, without project-specific mitigation, has been assessed as **'Upper Moderate (12)'**.

10.13.6.2 Introducing disease or pathogens in food of animal origin

As described in section 10.13.4.1, the consequences of introducing a pathogen from FOAO could be disastrous. The Tangible Property receptor (agriculture) has little or no capacity to absorb change on this scale and this situation would be unacceptable to all stakeholders. Therefore, the **sensitivity of receptor** impacted by the introduction of animal disease or pathogens is considered to be **'Very High'.**

Although an outbreak of disease may be recoverable over time, the resulting loss in confidence from consumers (i.e. foreign buyers of meat products) could be very long-lasting and potentially jeopardise the industry. Therefore, the potential for a long-term negative effect on livelihood means that the **severity of effect** is initially considered to be **'Serious'**. However, taking into account the measures implemented as part of the Biosecurity Management Plan (BMP), the severity of effect is considered to be **'Moderate'.**

Overall, the **significance of the impact** of introducing disease or pathogens that could infect livestock has been assessed as **'Upper Moderate (15)'**.

Ensuring that all FOAO is acquired from UK/EU certified sources and goes through the usual import permitting process for FOAO entering the Falklands the likelihood of introducing pathogens is reduced to **'Very Unlikely'**, and the residual risk is reduced to **'Low (4)'.**

10.13.7 Project-specific mitigation

10.13.7.1 Introduction of terrestrial non-native species in marine or air freight

All industry-standard and legally required mitigation measures available to reduce the risk of introducing terrestrial non-natives to ALARP are already in place (development of the BMP and adherence to FIG biosecurity guidelines), although it is acknowledged that improvements will be made to the BMP wherever possible during its development. This, along with the Premier HSES-MS, are factored into the initial risk assessment. Therefore, the impacts and risks, as determined from the initial assessment, are considered to be ALARP.

10.13.8 Residual risk

10.13.8.1 Introducing terrestrial non-native species

The initial assessment of the introduction of non-native species through marine or air freight takes account of all the mitigation measures which are built-in to the basis of design and while SMART goals may serve to reduce risks in future, at this time, they cannot change the initial assessment. Further, given the number of 'unknowns' within the assessment, it is considered appropriate and precautionary for the significance of the risk of introduction of invasive species by marine or air freight to remain **'Upper Moderate (12)'**.

10.13.9 Cumulative effects

The Sea Lion Development will add to the existing risk of introducing invasive species to the Falkland Islands and there is the potential for this to lead to cumulative impacts through increased 'concentration' (section 8.10.1). Any cargo coming into the Falklands has the potential to transport non-native species into the Islands. The risk posed by each vessel will be related to the type of cargo carried, the origin of that cargo and the condition of the cargo when loaded (clean or soiled / contaminated). Pre-loading preparation and checks of cargo are critical factors but very open to human error, which introduces a degree of uncertainty. It is assumed that each vessel associated with the Sea Lion Development will be carrying similar cargo and therefore each vessel will pose a similar risk of introducing non-native species. The risk of each vessel introducing non-native species may be low; however, with each vessel arriving, the probability of introducing non-native species increases (i.e. each load of cargo coming ashore increases the risk of introducing 'hitch hiking' non-native species).

10.13.10 Confidence

The nature of the impact of currently established invasive species on the terrestrial environment of the Falklands is understood. It is known that during the 2015 exploration drilling campaign the O&G industry introduced non-native species to the Islands. However, it is difficult to predict the impact of the arrival of additional non-native species, as it will depend on the species involved and measures taken to remove them, and this is acknowledged as a data gap. Additionally, many of the mitigation measures rely on the diligence of the personnel handling the cargo, which is prone to human error. Therefore, there is a degree of uncertainty regarding the sensitivity of environment receptors. Confidence in the assessment is therefore assessed as **'Probable'**.

10.13.10.1 Monitoring required

Monitoring will be an inherent part of the project-specific biosecurity plan. Monitoring as cargo is prepared and loaded and of incoming cargo will help to evaluate the effectiveness of the biosecurity protocols and indicate if revision is required. Detailed monitoring requirements have been established during the Environmental Monitoring and Management Plan (EMMP) workshop. All monitoring requirements agreed by Premier and FIG will be recorded and managed via the project-specific Phase 1 EMMP (an outline EMMP is provided in Chapter 15).

10.13.11 Offsetting

For significant residual and impact and risks (Moderate or above), offsetting via an Environmental Fund is proposed, see section 8.9 for further details.

10.13.12 Findings summary

Table 10.87: Summary of the impact assessment for terrestrial invasives

Activity / Event	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Introduction of terrestrial non-native species by marine and air freight	Terrestrial biosecurity	Introduction of invasive species with potential to negatively impact biodiversity	Unplanned	1, 2 & 3	High	Moderate	Possible	Upper Moderate (12)	Upper Moderate (12)	Probable	Industry-standard: Implementation of Biosecurity Management Plan (BMP) Project-specific: None proposed
Introduction of pathogens species in FOAO	Terrestrial biosecurity	Introduction of disease or pathogens via food of animal origin to negatively impact tangible property e.g. agricultural livestock	Unplanned	1, 2 & 3	Very High	Moderate	Very Unlikely	Low (4)	Low (4)	Probable	Industry-standards: Implementation of Biosecurity Management Plan (BMP) Source food of animal origin from UK / EU certified sources and from within the UK / EU. Project-specific: None proposed

a See Chapter 8 for definitions of sensitivity, severity, likelihood and significance.

11 SOCIAL IMPACT & RISK ASSESSMENT

Table of Contents

11.1 Disturbance to other users of the sea offshore

Table of Contents

11.1.1 Introduction

The waters of the North Falkland Basin (NFB) are used extensively for commercial fisheries. The development of the Oil and Gas (O&G) industry will require the placement of installations offshore (both topside and subsea) and will lead to a long-term increase in vessel traffic throughout these waters.

The presence of Premier installations and vessels may lead to disturbance of other users of the sea and / or an increased risk of collisions offshore. The presence of subsea infrastructure could lead to the snagging of fishing gear, which alongside damage to tangible property could lead to environmental impact such as oil spill (section 12.1). The use of exclusion zones around offshore installations is a key mitigation against such risks, but may lead to impacts in their own right in terms of fisheries and shipping lanes. Impact on other users of the sea was raised by stakeholders during scoping consultations held in 2014, 2015 and 2016 (Chapter 6).

Owing to the differences in the proposed use of the offshore and inshore locations and the variety of potential impacts and risks, the assessment of impacts and risks on other users has been split into two chapters (offshore and inshore) as shown in Table 11.1.

This chapter assesses the impacts and risks to the Human Population and Tangible Property during the *offshore* activities, and focusses on other users of:

- The offshore Phase 1 location (the Sea Lion Field); and,
- The shipping routes between the Sea Lion Field and inshore operations.

Note: The other impacts associated with vessel use, competition for resource and the installation of subsea infrastructure etc. are described elsewhere in this document, as described in section 9.2.

11.1.1.1 Relevant legislation

Legislation relevant to the potential for disturbance to other sea users includes:

- International conventions:
  - United Nations Convention on the Law of the Sea (UNCLOS), 1982;
  - International Convention for the Safety of Life at Sea (SOLAS, 1974, as amended);
  - Standards for Training, Certification, and Watch-keeping (STCW), 1978;
  - International Regulations for Preventing Collisions at Sea (Collision Regulations or ColRegs), 1972;
  - Maritime Pollution Regulations (MARPOL), 1973; and
  - International Convention on Maritime Search and Rescue (SAR), 1979;
- UK legislation:
  - Petroleum Act 1987; and
  - Petroleum Act 1998 (as amended by the Energy Act 2008).
- Falkland Islands specific maritime legislation and guidelines:
  - The Offshore Minerals Ordinance (1994) specifies the requirement for an exclusion (safety) zone of 500 m radius around offshore installations.

Note: While the use of exclusion zones is required by legislation, no legislation exists with regard to minimising the impacts of these on other users of the sea.

– OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations.

Table 11.1: Summary of potential impacts and risks to other users of the sea

Location	Receptor	Potential impact	Potential risk	Assessed in
Offshore	Vessels on passage	Requirement for vessels to navigate around exclusion zones.	Vessel collisions with FPSO and / or MODU	This chapter
	Fishing vessels	Fishing prohibition within the exclusion zones may impact upon fisheries revenue.	Exclusion zones are not respected resulting in snagging on subsea infrastructure and potential for loss of vessel and / or gear	This chapter
Stanley Harbour	Fishing, Reefer, Cruise, Cargo and Recreational vessels	Competition for berthing space in Stanley Harbour	Potential for collision between vessels in confined waters	Section 11.2
Port William	Fishing, Reefer, Cruise, Cargo and Recreational vessels	Competition for anchorage space	Potential for collisions between vessels in confined waters	
Berkeley Sound	Fishing, Reefer, Tanker vessels, Cruise ships and Recreational vessels	Competition for anchorage space	Potential for collisions between vessels in confined waters	

11.1.1.1.1 Navigation compliance (‘Rules of the Sea’)

The International Regulations for Preventing Collisions at Sea 1972 (ColRegs) are published by the International Maritime Organisation (IMO) and set out, among other things, the ‘Rules of the Sea’ or navigation rules to be followed by ships and other vessels at sea to prevent collisions between two or more vessels. All vessels should conduct themselves in the following manner:

- Every vessel shall at all times maintain a proper look-out by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision;
- Every vessel shall at all times proceed at a safe speed so that she can take proper and effective action to avoid collision and be stopped within a distance appropriate to the prevailing circumstances and conditions; and
- Vessels must use all available means to determine the risk of a collision, including the use of radar (if available) to get early warning of the risk of collision by radar plotting or

equivalent systematic observation of detected objects. (e.g. Automatic Identification System (AIS)).

11.1.1.1.2 Offshore exclusion zones (safety zones)

Exclusion zones are required under the Petroleum Act (1987) and the Falkland Islands' Offshore Minerals Ordinance (1994). An offshore exclusion (safety) zone is an area extending a minimum 500 m from any part of offshore O&G installations and is established automatically around all installations which project above the sea at any state of the tide.

Under the Ordinance, subsea installations also require safety zones to protect them. Offshore exclusion zones are 500 m radius from a central point and vessels of all nations are required to respect them. It is an offence (under section 23 of the Petroleum Act 1987) to enter an exclusion zone except under the special circumstances outlined below (HSE, 2008).

Details of exclusion zones must be recorded in:

- Hydrographic Office Admiralty charts;
- Use of Admiralty 'Notes to Mariners' to advertise the position of the Sea Lion Development and exclusion zone to vessels operating in the NFB; and
- Radio navigation warnings.

Further, under the Falkland Islands' Offshore Minerals Ordinance (1994), any fishing vessel that strayed into the exclusion zone would be committing a legal offence and the owner and Master of the vessel would be liable to a fine without limit.

11.1.1.1.3 Decommissioning

Under the petroleum Act 1998 and OSPAR Decision 98/3 it is necessary to remove all subsea pipelines and installations at the end of Field Life. While comparative assessments may be used to justify the leaving of certain pipelines *in situ*, and Derogation from the OSPAR requirement to remove installations may be sought under very specific circumstances (OSPAR, 1998), all Phase 1 installations will be constructed with a view to complete removal (section 5.12).

Therefore, at the end of Field Life all subsea equipment associated with the Phase 1 wells, SPS (Subsea Production Systems) and SURF (Subsea Umbilical, Risers and Flowlines) will be removed so that nothing is left in place which may pose a risk to other users of the sea. Where necessary, and in line with the legislation, equipment placed beneath the seabed e.g. well conductors, will be cut to a depth which will ensure that the object will remain below the level of the seabed in the face of prevailing currents.

Note: impacts and risks associated with decommissioning will be covered by a dedicated EIA, which will be written towards the end of Field Life and in support of the Decommissioning Programme.

11.1.2 Sources of disturbance to offshore users of the sea

Sources of impact and risk to other users of the sea offshore include:

- The physical presence of offshore infrastructure including:
  - Short-term anchored installations e.g. the Mobile Offshore Drilling Unit (MODU);

  - Long-term anchored installations e.g. the Floating Production, Storage and Offloading (FPSO) vessel; and
  - Subsea infrastructure e.g. anchor arrays, manifolds, wellheads, flowlines etc..
- 500 m exclusion zones around the above;
- Additional vessel traffic in:
  - The Falklands Conservation Zones; and
  - In transit between the Sea Lion Field and Stanley Harbour and also between the Sea Lion Field, Stanley Harbour and Berkeley Sound (during the offshore construction phase).

11.1.2.1 Physical presence of offshore installations

Offshore installations associated with the Sea Lion Development will present a navigational obstacle to vessels on passage through the NFB for the entire duration of their presence. During Stage 1 there will be a MODU with support vessels, in Stage 2 both a MODU (again with support vessels) *and* an FPSO and in Stage 3 an FPSO with support vessels.

11.1.2.2 Offshore exclusion zones

In line with the requirements of the Petroleum Act 1987 (HSE, 2008) and FIG's Offshore Minerals Ordinance (1994), a 500 m exclusion (safety) zone will be established around installation extremities. For the FPSO this includes the length of hose connecting the FPSO and tanker, and the tanker itself. All anchors, mooring lines and flowlines will be surrounded by a 200 m exclusion zone as per industry accepted best practice. The overall extent of the offshore exclusion (safety) zone is illustrated in Figure 11.1, third-party vessels, such as fishing, will be prohibited from entry into the exclusion area.

During construction and in Stage 2 when numerous vessels and both the FPSO and MODU will be in the field, Premier may request FIG to implement a temporary Offshore Development Area (ODA). ODAs act as a means of advising mariners not to enter particular areas because of the high levels of activity associated with the establishment of offshore installations. In the UK, ODAs have no statutory force and are advisory only, but have been used to supplement statutory 500 metre safety zones.

ODA status is only granted for a specific period of time, and so Premier will need to specify the length of time they require when applying for ODA status.

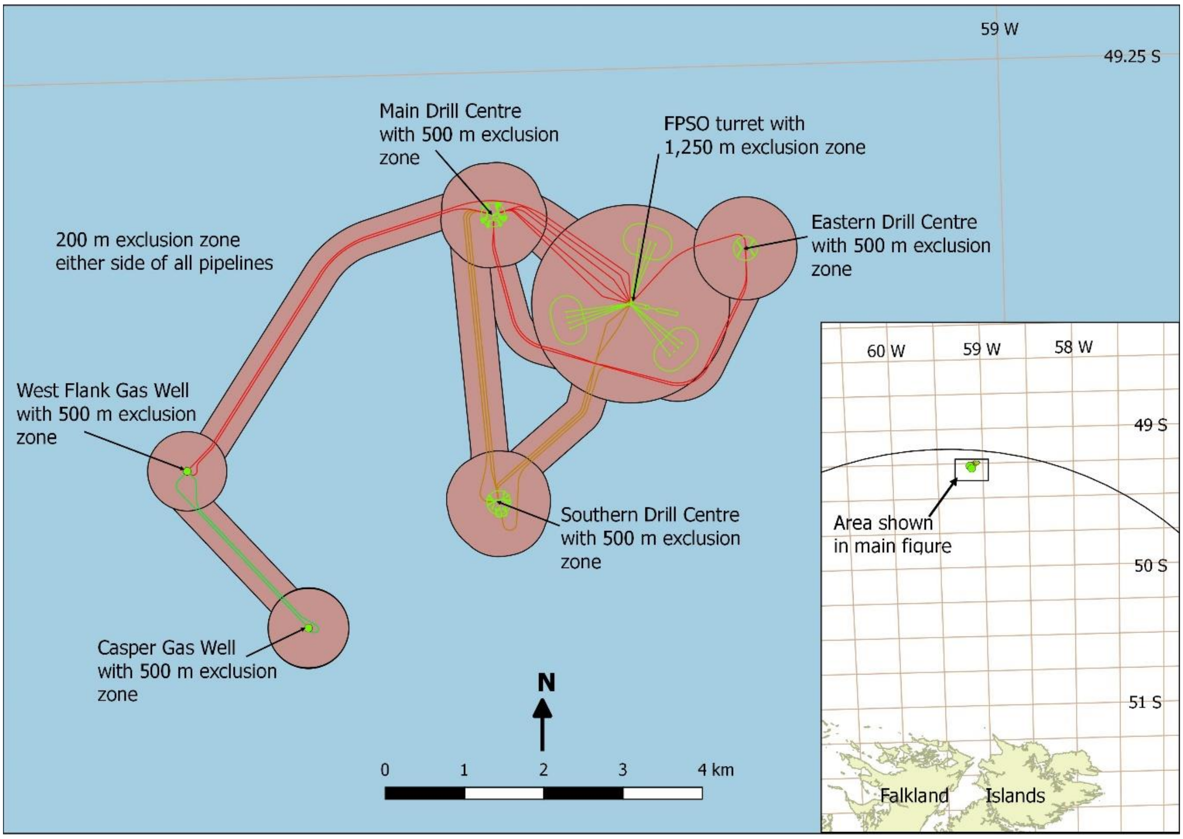


Figure 11.1: Offshore exclusion zones associated with the Sea Lion Development

11.1.2.3 Additional vessels

Numerous different vessels will be deployed offshore for specific tasks during the life of the Phase 1 Development. These range from the use of installation vessels during Stage 1, to the use of Emergency Rescue and Response Vessels (ERRVs) and supply vessels to support the MODU and FPSO throughout Field Life.

A detailed inventory of all vessels required is provided in section 5.11.2 and a summary for the purposes of this chapter, with division according to the locations of the vessel activity, is provided in section 11.1.4.1.

While at-sea, all Premier project vessels which are not at anchor (i.e. on passage or waiting to attend the FPSO or MODU) will maintain 24-hour watch-keeping using radar, AIS and visual sightings. If a third-party vessel is detected on a collision course, they will follow the international collision regulations and give way if appropriate, like any other sea-going vessel. Therefore, this source of risk should be similar to that posed by any vessel steaming at-sea, and has not been considered further.

11.1.3 Potential receptors

The ENVironmental Impact IDentification (ENVIID) workshop was used to identify the specific receptors upon which the impacts and / or risks to other users of the sea warranted further investigation (Chapter 9). The specific receptors that may be impacted include:

- Vessels licensed to fish the waters surrounding Sea Lion Development (section 7.7.3.1.1.1):

- Fishing vessels targeting *Illex* squid.
- Vessels transiting through the NFB (section 11.1.4.4.1):
  - Fishing vessels;
  - Cargo vessels;
  - Tankers; and
  - Cruise ships.

11.1.4 Characterising and quantifying the impacts and risks to offshore users of the sea

When characterising and quantifying the impacts and risks to other users of the NFB, it is necessary to further consider the:

- Type, location and behaviour of Phase 1 vessels used offshore;
- Impact of offshore exclusion zones on fisheries in the Sea Lion Field:
  - Potential for loss of fishing ground.
- Potential for interference between fishing vessels and offshore subsea infrastructure:
  - Overtrawlability studies.
- Modelling of third-party vessel collisions with FPSO which includes:
  - Identification of the shipping routes passing the Phase 1 location;
  - Estimation of the Phase 1 infield vessel activity;
  - Estimation the offshore vessel and FPSO collision risk frequencies; and
  - Estimation of the consequences of a collision.

11.1.4.1 Type, location and behaviour of Phase 1 vessels offshore

In order to inform the assessment of impacts and risks, it is necessary to have an appreciation of the additional offshore vessel traffic incurred as a result of the proposed Phase1 Development. A detailed inventory of the offshore vessels used is provided in section 5.11.2 and a summary of the vessel type, purpose and specification is provided in Table 11.2.

Table 11.2: Summary of the type, purpose and behaviour of offshore Phase 1 vessels used to inform the impact and risk assessment

Vessel / installation type	Vessel purpose	Analogous Vessel	Vessel specification			Total number of operations / visits		
			Length (m)	GRT (tonnes)	Max. speed (kn)	Stage 1 (39 months)	Stage 2 (30 months)	Stage 3 (17.5 years)
AHT x 2	MODU tow, supply and ERRV	*Pacific Wyvern*	68.9	2,332	15	180	258	n/a
PSV	MODU Supply, ERRV and standby	*Pacific Wyvern*	68.9	2,332	15	90	n/a	n/a

Vessel / installation type	Vessel purpose	Analogous Vessel	Vessel specification			Total number of operations / visits		
			Length (m)	GRT (tonnes)	Max. speed (kn)	Stage 1 (39 months)	Stage 2 (30 months)	Stage 3 (17.5 years)
MODU (anchored)	Drilling	*Eirik Raude* (Dynamic Positioned)	120	37,000	8	500 m exclusion zones - main well cluster and single gas well	500 m exclusion zones - main well cluster and single gas well	n/a
Subsea	Production	n/a	n/a	n/a	n/a	500 m exclusion zone around installation extremities (see Figure 11.1)		
FPSO	Production	FPSO *Turritella*	279	81,074	0	n/a	Anchored on site with 500 m exclusion zone	
Supply vessel (MRSV) (x 2 in Stage 3)	Delivery of supplies from Stanley to MODU / FPSO	*Nor Solan*	97	5,179	14	n/a	129	910
SURF Installation vessel (x2 in Stage 1)	Install offshore infrastructure	*Seven Arctic*	162	10,000	15	14	4	n/a
SURF Installation AHT x 2	Assist Installation Vessels	*Pacific Wyvern*	68.9	2,332	15	8	2	n/a
ADT	Hold-back tug for direct offtake	*Rampage Class Tug*	30.8	360	14	n/a	129	455

11.1.4.2 Impact of offshore exclusion zones on fisheries

The presence of exclusion zones around the surface and subsea infrastructure (Figure 11.1) has the potential to lessen the availability of fishing grounds.

The Falkland Islands Fisheries Department (FIFD) closely monitors all vessels licensed to fish within Falkland Islands waters. An average of 54 fishing vessels pass through the Sea Lion area annually, according to the FIFD Vessel Traffic Monitoring System (VTMS). The data show that vessels passing through the area were travelling at speed and so were not actually engaged in fishing in this region. Therefore, it is recognised that the Sea Lion Field is located in the centre of a route well used by fishing vessels on passage from the high seas to / from the main harbours of the Falklands. Vessels which *were* engaged in fishing were located approximately 30 nm to the south and west of the Sea Lion Field along the 200 m depth contour at the edge of the continental shelf which is known as a productive fishing ground (see Figure 11.2 below).

11.1.4.2.1 Potential for loss of fishing ground

The drill centre for the Phase 1 Sea Lion Field Development is located on the border between FIGFD grid squares XEAK and XFAK, approximately 20 to 37 nautical miles northeast of the 200m depth contour line, in water approximately 450 m deep. These fisheries statistical squares surrounding the Sea Lion Development (XEAK and XFAK) have only been open to vessels with Type B licences which allow vessels to fish for Argentine Shortfin squid *Illex* and, rarely for the sevenstar flying squid (*Martialia hyadesii*). Data extracted from the Fisheries department database in (Table 7.40) indicates that both jiggers and trawlers have fished the area, but there is considerable inter-annual variation in fishing effort and catch in the area. Catches and fishing effort in the grid squares occupied by the Sea Lion Field (XEAK and XFAK) are relatively low (FIG, 2019a). Exceptionally high catches of *Illex* squid were made in 2014, 2015 and 2017 reflecting high catches throughout the zone during these seasons. Data indicate that generally the area of the Sea Lion Field is rarely fished.

Therefore, while fishing vessels may prospect in the area, the region of the Sea Lion Field is not considered to be a regular fishing ground such that no impacts upon future fish catches are anticipated.

11.1.4.3 Potential for interference between fishing gear and subsea infrastructure

Illex jiggers use powerful lights and light weight 'jigging' lures to lure squid to the surface and are not believed to be a risk to or at risk from subsea installations. Trawlers generally target *Illex* with light-weight pelagic (mid-water) trawls, although the nets can be 'flown' close to the seabed. However, the one vessel currently licensed to fish for *Illex* operates a demersal trawl, which drags heavy nets, chains and trawl doors across the seabed and therefore this type of gear poses a greater risk of interacting with subsea infrastructure. It is not possible to predict whether the number of *Illex* trawlers will increase in the future.

Given that the behaviour of fishing vessels can be unpredictable, it is not uncommon for vessels to fish in areas where they are not permitted. In the unlikely event that *Illex* trawler, or any other vessel, were to ignore exclusion zones with the intent to operate in the vicinity of the Phase 1 Development they would be chased away by installation guard vessels (MRSVs). However, if unchallenged the gear has the potential to interfere with the:

- Subsea Production System (SPS), the Subsea Umbilicals, Risers and Flowlines (SURF), and the wellheads and X-mas trees which will, in total, cover a total combined area of 0.007 km^2, with a linear spread of approximately 7.6 km;
- Main Drill Centre (DC) located 1.6 km to the south of the FPSO;
- Second DC located 3 km to the south of the main DC; and
- GPI well(s) located approximately 6.4 km and 4 km to the south-west of the FPSO (section 5.1).

Snagging of fishing gear could result in:

- Damage to the SPS;
- Loss of the fishing gear (Tangible Property); and

- The potential for damage to the fishing vessel and injury / loss of life to crew.

Note: Importantly, it is outwith the scope of this EIA to assess the safety implications with regard to the injury or loss of life on fishing vessels. Safety implications will be addressed by other Premier processes, other legislation and other industry good practices, while the EIS is focussed on the environmental impacts and risks.

11.1.4.3.1 Overtrawlability studies

Premier and their JV partner commissioned three separate studies which aimed to define the level of fishing activity in the Sea Lion area and to recommend the type of mitigation required to protect subsea equipment and flowlines as well as fishing vessels and their trawling gear.

These studies comprised the:

- AGR Petroleum Services screening study - Falkland Islands fisheries and risk to subsea infrastructure (AGR, 2012);
- Pale Maiden Consulting Ltd - Fishing Activity Report that uses VMS data (Pale Maiden, 2013); and
- Jee Subsea Consultants - Sea Lion Development: Fishing and trawl risk assessment (Jee, 2013) based on published Falkland Islands fishery statistics and the results of the above studies (Jee, 2013).

The AGR (2012) report utilised pre-2006 fishing data, which due to changes in License conditions, is now regarded to be out-of-date. The Pale Maiden report (2013) used more recent data (up to 2012) to assess the level of fishing activity in the Sea Lion area. However, during this EIA, discrepancies between the reported position of vessels (i.e. the statistical square) and the actual position of vessels (derived from VMS data) were since identified, which place doubt on the fishing effort reported for the area in the Pale Maiden document. Nonetheless, the demersal trawler activity within the Sea Lion Field, as described in the Pale Maiden report, was confirmed by VMS data in 2012. The Jee report utilised information from the AGR and Pale Maiden reports alongside additional scoping with the statutory consultees and interest groups.

In summary, the Jee report (2013) concluded that there is negligible risk of snagging with subsea infrastructure and that there is therefore no need to make the subsea infrastructure overtrawlable. The Jee report (2013) recommended that further monitoring is conducted to ensure that the situation does not change in the future. The report concluded that the most appropriate way to safeguard subsea infrastructure, and to prevent the loss of fishing vessels (and all incumbent consequences) is via reliance upon exclusion zones and the use of a designated guard vessel once installation commences.

11.1.4.4 Modelling of third-party vessel collisions with FPSO

With regard to the impact on other users of the sea, Premier commissioned Anatec Ltd. to calculate the risk of collisions between the FPSO and third-party vessels passing the Sea Lion Field (both powered vessels and drifting vessels). Note that this model is also used to assess the likelihood of collisions between Premier vessels in the offshore oil spill assessment (section 12.1).

It should be noted that there are some small differences in the parameters used in the model and the current project proposal (including the planned position of the FPSO, which is approximately 2.6 km northeast of the modelled position). While the position of the FPSO is clearly an important consideration, it is unlikely that this will significantly affect the results of this assessment.

The modelling uses the Health and Safety Executive (HSE) research methodology together with:

- Site-specific inputs for the Sea Lion FPSO; and
- The use of a dedicated ERRV with both AIS and radar ship tracking.

Note: along with the FPSO, during Stages 1 and 2 a MODU will be stationed in the Sea Lion Field at several different locations. The combined risk associated with an FPSO and MODU infield simultaneously (approximately 1.6 km apart) has not been modelled.

11.1.4.4.1 Identification of shipping routes passing the Phase 1 location

Details of all of the shipping routes passing close to the Sea Lion Field were identified using detailed analysis of AIS (Automatic Identification System) data (Anatec, 2013). AIS is an automated tracking system used on ships and by vessel traffic services for identifying and locating vessels through the electronic exchange of data (e.g. unique identification, position, course and speed) with nearby ships, AIS base stations and satellites. The International Maritime Organisation's (IMO's) International Convention for the Safety of Life at Sea (SOLAS) requires AIS to be fitted onboard international voyaging vessels with a gross tonnage of $\geq$ 300 t. FIG Marine Authority does not consider that there has been any marked change in shipping routes or vessel activity since the Anatec Study was undertaken. (C. Locke *pers. comm.).*

Although the Sea Lion Field lies on the shipping routes between Stanley and both the fishing grounds and the South American mainland, the number of vessels using these routes is consistent with areas of low shipping activity (Anatec, 2013). The nearest area of high-density shipping activity is found approximately 30 nautical miles (nm) to the southwest of the Sea Lion Field (Figure 11.2). As shown, these vessels are primarily engaged in fishing activity (trawling) and generally move back and forth at low speeds (approximately four knots).

Looking more closely, there are four main shipping routes that pass within 10 nm of the Sea Lion Field, with a total of 85 ships per year travelling on these routes (Figure 11.3a; Table 11.3). This is equivalent to one vessel passing the Field every four days. The types of vessel using each of the four routes shown in Figure 11.3a are quite distinct and are described in Table 11.3. The number of vessel-hours that each square nautical mile surrounding the Sea Lion Field is exposed to on an annual basis is provided in Figure 11.3b.

The majority of vessel traffic comprises fishing vessels travelling to and from fishing grounds and reefers operating between ports in the area (routes 1 and 2 in Figure 11.3a), although it should be noted that there is likely to be considerable inter-annual variation in the number of these vessels. Route 3 is used by a small number (6 % of all vessel traffic) of large vessels (tankers and bulk carriers) exceeding 40,000 Dead Weight Tonnes (DWT). Vessels using Route 4 are typically cruise ships which are large fast moving vessels but generally have a lower mass than large cargo vessels.

The impact energy of a collision is related to the squared speed and mass of the vessels involved and is measured in Mega Joules (MJ). DWT is a measure of how much mass a ship is carrying or can safely carry.

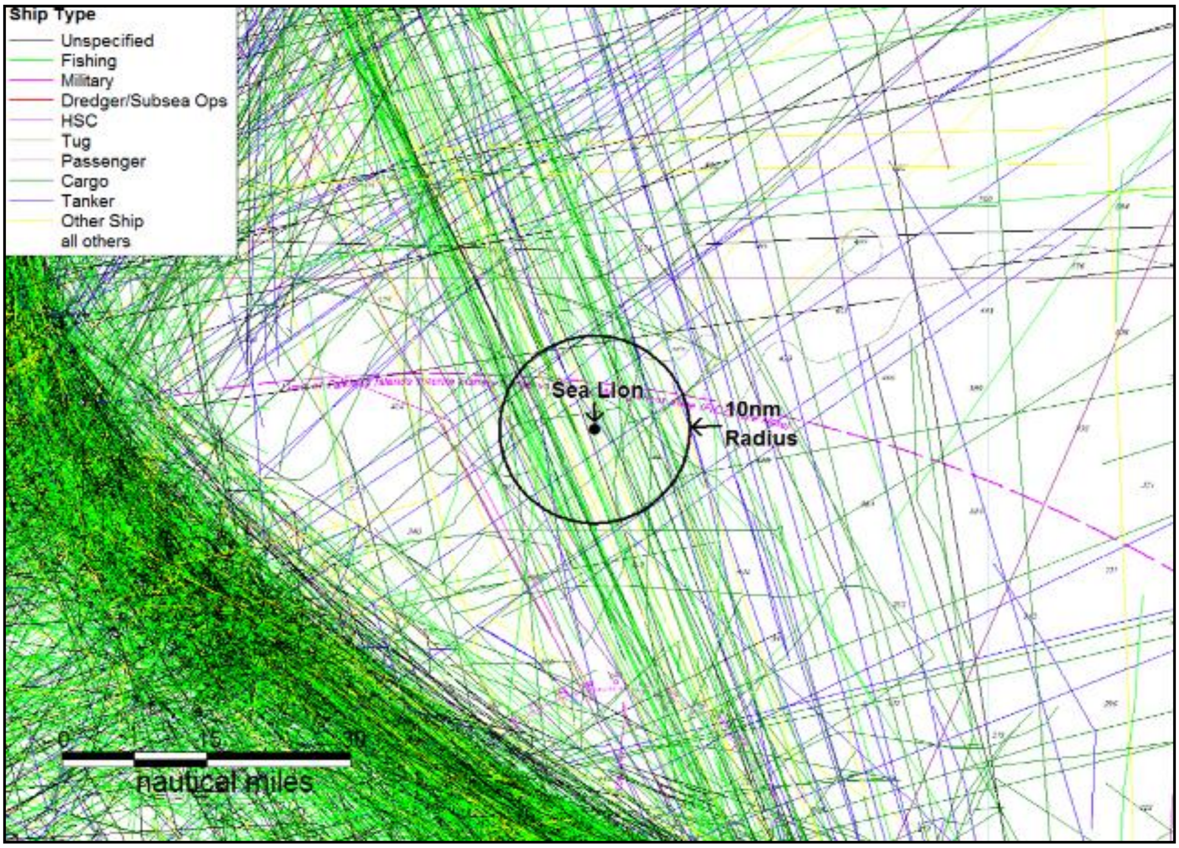


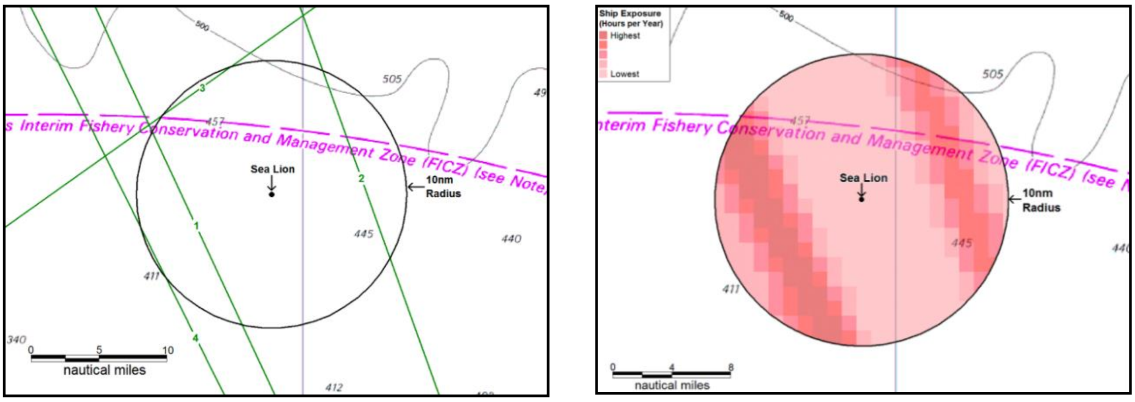
Figure 11.2: Overview of AIS shipping data for the Sea Lion Location (2011-12)

(Source: Anatec, 2013)

Table 11.3: Ship Routes Passing within 10 nautical miles of the Sea Lion Field (Anatec, 2013)

Route No.	Description	Type of vessel	CPA (nm)[a]	Bearing (°)	Ships per year	% of Total
1	Berkeley Sound – fishing grounds (north)	Fishing vessels	6.0	245	40	47 %
2	Berkeley Sound – Montevideo	Reefers	6.7	70	30	35 %
3	West Africa – N. America West Coast	Tankers	9.5	324	5	6 %
4	Berkeley Sound – Puerto Madryn	Cruise ships	9.8	245	10	12 %
Total					**85**	**100 %**

[a] Where two or more routes have identical Closest Point of Approach (CPA) and bearing they have been grouped together. In this case, the description lists the sub-route with the most ships per year.



a) Averaged shipping routes within 10 n miles

b) Annual shipping exposure levels (hrs)

Figure 11.3: Averaged shipping routes and annual exposure of vessels within 10 nautical miles of the Sea Lion FPSO (see Table 11.3 for detail on the shipping type associated with each route number) (Source: Anatec, 2013)

11.1.4.4.2 Estimation of vessel activity in the Sea Lion Field

At the time of the Anatec assessment (2013), detail on the specific vessels likely to be used was unknown. Therefore, the data used in the model are slightly different to the data provided in section 11.1.4.1. At the time of the modelling, the analogous vessels were based on typical vessels used in the UK North Sea and West of Shetland. Detail on the vessel activity assumed for the Anatec model is summarised in Table 11.4. The differences in modeled data with latest vessel predictions are not considered significant in terms of the risk assessment conclusions.

Table 11.4: Details of the analogous vessels used in the modelling (Anatec, 2013)

Vessel Type	Analogous vessel	Length (m)	Width (m)	Dead Weight Tonnage (DWT)	Estimated attendance
Supply	*Edda Frende*	85.8	19.2	4,200	Twice a week (6 hours each visit)
ERRV	*Grampian Frontier*	69.0	14.5	1,704	All year round
CTT	Suezmax type [a]	273	47	152,667	Every nine days in this model whereas the base case assumes two offloads every 14 day cycle in early field life reducing in frequency as the field ages.

[a] In the event that the Direct Offtake oil export option is utilised, the CTT will also be a Suezmax type tanker

11.1.4.4.3 Estimation of offshore vessel collision frequencies

The COLLRISK model was used to estimate collision risks on an annual basis (Anatec, 2013). The consequence of collisions was estimated by taking into account impact energy based on the size and speed of respective vessel types (section 11.1.4.4.4).

The model is based on the premise that the collision frequency is proportional to the volume of traffic interacting with the FPSO. This stems from a review of historical data, which indicated that failure in watch-keeping systems tends to be the cause of collisions between passing vessels and offshore installations.

The following provides only the detail required to enable appreciation of the results in the context of third-party vessel collisions with the FPSO. Details on the specific parameters used within the COLLRISK model with regard to metocean data are provided in section 7.3.5.

A summary of the main assumptions used in the model and the analysis, and the estimated collision frequencies between third-party vessels and the FPSO is provided in Table 11.5.

Table 11.5: Summary of the assumptions and results of the COLLRISK collision frequency model (Anatec, 2013)

Vessel type	COLLRISK Model basis and assumptions	Estimated collision frequency between vessel and FPSO
Third-party passing powered vessels	Vessels operating on these routes have ample room available to increase their passing distance from the Sea Lion Development. With no nearby offshore installations or exclusion zones in place the vessels have space to transit the area safely; this can be observed from the AIS data, where the routes taken by vessels are relatively diverse across the area. If vessels do increase their mean passing distance, the effect on navigation is expected to be negligible.	Due to the low levels of shipping in the area of the Sea Lion Field the potential frequency of events is relatively low. Passing powered collision frequency is **3.45×10^{-8} collisions / year**.
Third-party passing drifting vessels	The model for calculating passing drifting collision risk is based on the premise that the engine(s) on a vessel must fail before a vessel will drift. The model takes account of the likelihood of vessels having multiple engines based on fleet data for different ship types and sizes. Using this information it is possible to estimate the overall rate of breakdown in proximity to the location. The probability of a vessel drifting towards the installation and the drift speed are estimated using the wind rose for the area. Finally, the probability of a ship being repaired before reaching the location is estimated based on the time available. Ships that are not repaired within the time it takes to reach the FPSO are assumed to collide. Figure 11.3b above illustrates the number of vessel-hours that each square nautical mile surrounding the Sea Lion Field is exposed to on an annual basis. These data are used to model the risk of passing ships losing power and drifting into the Sea Lion Field and takes into account vessels within a 10 nautical mile radius.	Passing drifting collision frequencies are lower than those for vessels under power because it would require a vessel to lose propulsion close to the Development; many vessels have alternative modes of propulsion. Passing drifting collision frequency is **6.89×10^{-9} collisions / year**.

11.1.4.4.4 Consequences of a collision

The relationship between predicted damage to the FPSO and collision impact energy is summarised in Table 11.6. This assessment is based on research into collision resistance of structures, professional judgment and the experience of other FPSOs (Anatec, 2013).

Table 11.7 summarises the estimated collision frequencies for different vessel types and different energy levels. According to the model, ship collisions involving infield vessels may be more frequent than for passing ships and may occur with little or no warning, however, the consequences associated with these types of impacts tend to be less severe due to the speed of the vessels and the associated energy of the strike.

Table 11.6: Impact energy and predicted consequences

Energy	Description
<50 MJ	Due to the size of the Sea Lion FPSO, it is considered that events of this scale will not jeopardise the FPSO's integrity. Localised damage is likely to be experienced. Due to relatively small size, damage to the third-party colliding vessel may be more substantial.
50-200 MJ	Due to the size of the Sea Lion FPSO, it is considered that events of this scale will not jeopardise the FPSO's integrity. However, there is the potential for damage to topside equipment, which may lead to hydrocarbon release, particularly if the impact is direct. Due to their relative size, collisions of this scale are likely to result in serious damage or loss of the smaller classes of potential third-party colliding vessel.
>200 MJ	These are catastrophic events which could lead to significant levels of damage to the FPSO. These impacts are likely to threaten the integrity of the entire installation and evacuation is likely to be necessary.

Table 11.7: Vessel and FPSO collision frequencies (per year) at different impact energies (Anatec, 2013)

Impact Energy (MJ)	**Passing powered**	**Passing drifting**	**Infield Premier vessels**		**CTT**	**Total**
			Supply	**ERRV**		
0 - 1	1.9E-08	6.6E-09	6.7E-03	1.5E-03	1.7E-03	1.89E-02
1 - 4			6.8E-03	9.3E-04		
4 - 10			9.5E-04	5.5E-05		
10 - 50			2.4E-04	7.0E-05		
50 - 200	3.5E-09	2.3E-10	2.0E-04	Negligible (<1.0E-10)	1.4E-02	1.42E-02
>200	1.2E-08	2.7E-11	n/a	n/a	n/a	1.20E-08
Total	3.45E-08	6.86E-09	1.49E-02	2.56E-03	1.57E-02	3.31E-02
	1 in 28,985,507 years	1 in 145,137,881 years	1 in 67 years	1 in 390 years	1 in 64 years	1 in 30 years

11.1.5 Industry-standard mitigation

11.1.5.1 Exclusion zones

The use of exclusion zones is a legal requirement and is therefore a mitigation in itself against the risks of collision. No other industry-standard mitigations are required to minimise the impact of these on other users of the sea.

11.1.5.2 Interference between fishing gear and subsea infrastructure

No industry-standard mitigations are required to prevent the snagging of fishing gear over and above an ALARP demonstration of the risks and as per the legislative requirements described in section 11.1.1.1.

11.1.5.3 Vessel operations

In addition to the legislative requirements above, the following will be used as industry-standard to minimise the risk of collision:

- Exclusion zones in place;
- All exclusion zones added to admiralty charts for use by third parties;
- Installation of AIS in the field vessels to provide early detection of passing vessels, and improved information to aid in the management of this hazard. Systems will be installed on both the FPSO and ERRV;
- Availability of chart displays to monitor third-party vessel positions relative to the FPSO with alarm functionality.
  - It will also be considered beneficial, when possible, to relay the data to shore for use in both routine marine traffic management and emergency response;
- Use of field-specific AIS data to establish collision risk management procedures at Sea Lion giving account of the traffic pattern and the evacuation requirements on the installation.
  - Use of alarms which will be set by 'Time to the Closest Point of Approach' and 'Closest Point of Approach'.
- Installation of an AIS aid to navigation on the FPSO to ensure identification of the FPSO to passing vessels;
- Operational control:
  - Development of a full Marine Operations Manual for the Sea Lion Field including factors such as vessel selection and inspection, crewing and competency; and
  - Site-specific procedures for ERRV watchkeeping and emergency response.

Note: many of the industry-standard mitigations listed above were not assumed to be in place by the Anatec model such that the model can be considered to be precautionary in its results. Notably the model assumes only the use of the ERRV with AIS and radar ship tracking which, together, result in an estimated overall collision risk reduction of 71 % (compared to an unattended installation). The initial risk assessment below assumes that all the above will be in place.

11.1.6 Impact and risk assessment

The following section draws upon all the information provided above to assess the 'Sensitivity of the Receptor' and the 'Severity of Effect' in order to determine the overall 'Impact' of planned activities. Assessment of unplanned events includes an assessment of the 'Likelihood of Occurrence' to determine the 'Risk'.

A summary of the impact and risk assessment outcomes for this Development is tabulated in section 11.1.12 (Table 11.8), which shows the worst case impact / risk for each activity and receptor and details are provided below.

11.1.6.1 Impact assessment of offshore activities

11.1.6.1.1 Impact of offshore exclusion zones on fisheries

The Sea Lion Phase 1 Development sits within the fisheries statistical square XFAK that has historically been the subject of very low fishing effort (section 11.1.4.3). Currently, the area is only open to vessels licensed to fish for *Illex* squid and is rarely fished (section 11.1.4.3) such that few receptors (fishers) are likely to be exposed. In terms of impact on squid catch, the declaration of a 500 m exclusion zone around the Development FPSO, MODU and subsea infrastructure would therefore be insignificant to the fishing vessels concerned. The human population (fishing industry) is able to tolerate a change on this scale and it is anticipated that the exclusion zones will be acceptable to all stakeholders. Therefore, the **sensitivity of the receptor** is considered to be '**Very Low**'.

The application of monetary fines could be incurred if exclusion zones are ignored or strayed into (section 11.1.1.1). However, this would occur only in the event that all communication on the presence of exclusion zones was ignored, which is outwith Premier's control. With regard to impact upon catch, the historical level of fishing effort in the Sea Lion Field is such that the prohibition on fishing within the exclusion zone is anticipated to have no impact on the livelihood of fishers and the **severity of effect** is considered to be '**Slight**'.

Therefore, the overall **significance of the impact** of the exclusion zone on the human population is assessed as '**Very Low (1)**'.

Risk assessment of activities

11.1.6.1.2 Risk of interference between fishing gear and subsea infrastructure

Under 'normal' fishing conditions, the loss of fishing gear is not an unusual event. Therefore it is anticipated that the human population (fishers) would have a moderate capacity to absorb the loss of gear and the **sensitivity of the receptor** is considered to be '**Moderate**'.

If a demersal trawl net became snagged on subsea infrastructure, the fishing gear could be extensively damaged and possibly lost. Additionally, there could be damage to the seabed infrastructure, with consequential legal implications. Assuming a worst case event involving the loss of fishing gear, the severity of effect would be expected to have a medium-term impact on livelihood and therefore the **severity of effect on the human population** is considered to be '**Moderate**'.

The **significance of the impact** of a fishing vessel snagging gear on subsea infrastructure is therefore assessed as '**Moderate (9)**'.

Since 2013 statistical square XEAK and XFAK have only been open to vessels with Type B (*Illex*) licenses . Currently, one trawler is licensed to catch *Illex* but this could change in the future. While it is possible that a fishing vessel will approach the Sea Lion Development, if the vessel was to approach the exclusion zone, it would almost certainly be detected and intercepted by the MRSV before interfering with subsea infrastructure. Therefore the **likelihood of occurrence** of fishing gear becoming snagged on subsea infrastructure in considered '**Unlikely**'.

Therefore the **significance of the risk** is assessed as '**Low (6)**'.

11.1.6.1.3 Risk of third-party vessel collision risk with the FPSO / MODU

With any collision incident between passing powered or passing drifting vessels there is a range of possible outcomes, dependant on the size, speed and angle of approach of the vessels concerned (section 11.1.4.4.4). While the majority of these scenarios are unlikely to generate critical energies sufficient to cause an environmental impact (section 11.1.4.4.4) all have the potential to cause damage to the FPSO and would therefore, almost certainly, result in damage to and possible loss of a smaller third-party vessel. It is anticipated that such loss would be unacceptable to all stakeholders and therefore the **sensitivity of the receptor** to such an incident is considered to be '**Very High**'.

Following this worst case scenario, the effect on the livelihood of the receptor could be long-term and the **severity of effect on the human population** is considered to be '**Serious**'.

Therefore, the overall **significance of the impact** of a collision between a third-party vessel and the FPSO is assessed as '**High (20)**'.

The analysis of collision frequency undertaken by Anatec (2013) and summarised above (section 11.1.4.4.3) indicates that the likelihood of any collision is extremely low and is lower still for an event resulting in catastrophic damage (section 11.1.4.4.4). Incidents on this scale have occurred very rarely in the industry and the failure of numerous operational controls would be required. Further, as described above, the Anatec model does not take account of all the industry-standard mitigation practices such that it is very precautionary. Taking account of the modelling outcomes and the industry-standard mitigations described above, the **likelihood of occurrence** is considered to be '**Very Unlikely**.

Therefore, the **significance of the risk** is considered to be '**Low (5)**'.

11.1.7 Project-specific mitigation measures

With legislation and industry-standard mitigations applied, the impacts and risks assessed above are considered to be '**Low**' or '**Very Low**' and therefore project-specific mitigation is not proposed.

11.1.8 Residual impacts and risks

Not applicable.

11.1.9 Cumulative impact

The activities of Premier's vessels will add to the existing vessel traffic within Falkland Islands waters, leading to an increase in the 'concentration' of shipping activity (section 8.10.1). The offshore Sea Lion Development is situated in an area where shipping traffic is relatively low. With no nearby offshore installations or exclusion zones in place all vessels have space to transit the area safely. Vessels operating on these routes have ample room available to increase their passing distance around the Development site and therefore there is expected to be little cumulative impact.

11.1.10 Confidence

Owing to the use of data on historical fishing effort, the assessment of the impact of exclusion zones offshore is considered to be '**Certain**'.

Much of this assessment is informed by AIS data and collision risk modelling that is widely used and accepted, however, the modelling is based on short-term poor quality AIS data, collected between 2010 and 2014. Although representative, there is considerable inter-annual variation in vessel traffic, largely due to variations in *Illex* squid abundance.

Stakeholders within FIG and from the fishing industry have been consulted as part of the 2016 scoping consultation (Chapter 6.2). Their views have been taken into consideration and therefore confidence in the assessment is considered to be '**Probable**' and further monitoring of vessel movements and analysis will help to improve confidence in this assessment.

11.1.10.1 Monitoring required

An AIS based survey will be carried out at the location of the Sea Lion Development to confirm the shipping traffic pattern in the area once the exclusion zone is in place. The presence of Development infrastructure, project vessels and exclusion zones may have an influence on shipping routes, as vessels may deviate from established routes to avoid potential risks. This is a very low cost method of improving the confidence in collision risk analysis and understanding shipping behaviour.

Premier will also report and investigate all incident and near misses.

Detailed monitoring requirements have been established during the Environmental Monitoring and Management Plan (EMMP) workshop. All monitoring requirements agreed by Premier and FIG will be recorded and managed via the project-specific Phase 1 EMMP (an outline EMMP is provided in Chapter 15).

11.1.11 Offsetting

As no residual impacts or risks identified in this section are considered significant, i.e. Moderate or above, offsetting is not considered (see section 8.9).

11.1.12 Findings summary

Table 11.8: Summary of the impact and risk assessment for other users of the sea at the Sea Lion Field

Activity	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Offshore exclusion zones	Disruption to activities of other users of the sea	Reduction in the area available to *Illex* vessels and resultant impact on catch.	Planned	1, 2 & 3	Very Low	Slight	n/a	**Very Low (1)**	**n/a**	**Certain**	**Industry-standard:** Exclusion zones added to admiralty charts; and Status issued in 'Notes to Mariners' and on radio. **Project-specific:** None proposed.
Interference between fishing gear and subsea infrastructure	Snagging of fishing gear	Loss of fishing gear and potential subsea damage	Unplanned	2 & 3	Moderate	Moderate	Unlikely	**Low (6)**	**n/a**	**Probable**	**Industry-standard:** 500 m exclusion zone; Permanent presence of ERRV; Amended Admiralty charts, AIS and radio broadcasts; and
Offshore vessel collision	Third-party vessel collision	Damage to vessel and FPSO	Unplanned	2 & 3	Very High	Serious	Very Unlikely	**Low (5)**	**n/a**	**Probable**	

Activity	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
		Damage to vessel and MODU	Unplanned	1 & 2	Very High	Serious	Very Unlikely	**Low (5)**	**n/a**	**Probable**	Collision risk management procedures. **Project-specific:** None proposed

[a] See Chapter 8 for definitions of sensitivity, severity, likelihood and significance.

11.2 Disturbance to other users of the sea inshore

Table of Contents

11.2.1 Introduction

The inshore waters of the Falkland Islands, and the amenities in Stanley Harbour, are used extensively for commercial operations (e.g. vessels associated with fisheries, trade and tourism), for Ministry of Defence (MoD) activities and for recreational use by visiting yachts and the general public. The development of the Oil and Gas (O&G) industry will lead to a long-term increase in vessel traffic throughout these waters in Stanley Harbour and short-term increases in Berkeley Sound.

The presence of Phase 1 vessels may lead to disturbance of other users of the sea and Stanley Harbour and / or an increased risk of collisions inshore. Further, the use of exclusion zones around the temporary Large Transport Vessel (LTV) operations, which themselves are a base case mitigation against collision risks, may lead to impacts and risks in their own right in terms of fisheries and shipping lanes. Impacts on other users of the sea, and Berkeley Sound in particular, were raised by stakeholders during scoping consultations held in 2014, 2015 and 2016 (Chapter 6).

Note: The concerns about project acitivity in Berkeley Sound in particular were raised by stakeholders at a time when the project was considering inshore Ship-to-Ship crude oil transfers between tankers. This aspect of the project has been superceded by Direct Offshore Transfer as described elsewhere in this document.

Owing to the differences in the proposed use of the offshore and inshore locations and the variety of potential impacts and risks, the assessment of impacts and risks on other users has been split into two chapters (offshore and inshore) as shown in Table 11.9.

This chapter assesses the impacts and risks to the Human Population and Tangible Property during the *inshore* activities, and focusses on other users of:

- Stanley Harbour (including FIPASS); and
- The LTV site (Berkeley Sound).

Note: The other impacts associated with vessel use; for instance competition for resource are described elsewhere in this document, as described in section 6.3.

Table 11.9: Summary of potential impacts and risks to other users of the sea

Location		Receptor	Potential impact	Potential risk	Assessed in
Offshore		Vessels on passage	Requirement for vessels to navigate around exclusion zones.	Vessel collisions with FPSO and / or MODU	Section 11.1
		Fishing vessels	Fishing prohibition within the exclusion zones may impact upon fisheries revenue.	Snagging on subsea infrastructure and potential for loss of vessel and / or gear	Section 11.1
Inshore	Stanley Harbour	Fishing, Reefer, Cruise, Cargo and Recreational vessels	Competition for berthing space in Stanley Harbour (including FIPASS)	Potential for collision between vessels in confined waters	This chapter
	Port William	Fishing, Reefer, Cruise, Cargo and Recreational vessels	Competition for anchorage space	Potential for collisions between vessels in confined waters	This chapter
	Berkeley Sound	Fishing, Reefer, Tanker vessels, Cruise ships and Recreational vessels	Reduction in available sea room due to exclusion zones and competition for anchorage space	Potential for collisions between vessels in confined waters	This chapter
	Berkeley Sound	All vessels	Positive impact of vessel traffic management system	Positive benefit	This chapter

11.2.1.1 Relevant legislation

Legislation relevant to the potential for disturbance to other sea users inshore is the same as that for the offshore activities and is described in section 11.1.1.1 above.

Additional legislation relevant to the inshore operations alone are:

- Maritime Ordinance 2017
- Maritime (Amendment) Ordinance 2019
- Harbour and Ports Ordinance 2017
- FIPASS Ordinance (1989); and
- Falkland Islands Harbours Regulations.

11.2.1.1.1 FIPASS Ordinance (1989)

The Harbour Master (also acting as the Marine Officer) and FIPASS Manager have powers under the provisions of the FIPASS Ordinance 1989 to regulate shipping within FIPASS waters, which are defined as those waters within one nautical mile from FIPASS.

11.2.1.1.2 Falkland Islands Harbour Regulations

Under the Falkland Islands Harbour Regulations it is an offence for vessels within Falklands harbours (including Berkeley Sound) to:

- Spill or discharge oil or oily mixtures into the harbour;
- Dump garbage or refuse into the harbour; and
- Supply bunkers to another vessel if they are unlicensed to do so by Stanley Services Ltd. within the Territorial Waters of the Falkland Islands.

Further, all vessels using the harbours should be correctly marked with their name on port and starboard bow and at the stern with name and port of registry.

11.2.2 Sources of disturbance to inshore users of the sea

It is the intention of Premier to use the Temporary Dock Facility (TDF), which was used for the exploration drilling campaigns, to support Sea Lion Phase 1 activities. Further, Premier may propose future modifications to improve the Dock's functionality. As described in section 5.11.1.1.1, proposals to upgrade the TDF facilities will have to go through the planning process, and may require a full EIA, as advised by FIG.

For the purposes of this EIS however, it is assumed that operations at the TDF, and FIPASS, will continue on the same basis as in the 2015 exploration campaign.

Sources of impact and risk to other users of the sea inshore include:

- Additional vessel traffic in:
  - Stanley Harbour (including at FIPASS);
  - Port William; and
  - Berkeley Sound.
- Physical presence of long-term infrastructure in Berkeley Sound:
  - Large Transport Vessels (LTVs) anchored in Berkeley Sound, and associated construction vessels; and
- Exclusion zones in Berkeley Sound.

11.2.2.1 Additional vessels

Numerous different vessels will be deployed inshore for specific tasks during the life of the Phase 1 Development. Support vessels such as supply or coaster vessels will use Stanley Harbour and FIPASS (for bunkers in event a fuel line is not added to the TDF) and are further quantified in section 11.2.4.1.2 below.

11.2.2.2 Long-term physical presence in Berkeley Sound

There is no long term physical presence within Berkeley Sound. Up to three Large Transport Vessels (LTVs) may be present in the Sound for up to 12 months during the subsea infrastructure installation phase and, shoreline oil spill deflector boom anchor buoys may be deployed if IFO is present on any project vessels.

11.2.2.2.1 Buoys

Up to seven boom buoys close to shore may be put in place to enable rapid installation of deflection booms in the event of an IFO fuel oil spill may be installed for the period of the subsea installation campaign (section 5.5). However, Premier will try to eliminate the presence of IFO from project vessels thus negating the risk of IFO spills and the need for such buoys.

11.2.2.2.2 Large Transport Vessels

The LTVs will be required to transport the subsea equipment and the FPSO buoy and mooring system from various parts of the world (Europe and Asia) to the Falkland Islands. Upon arrival, they will be anchored in Berkeley Sound. Each vessel will have its own individual 500m exclusion zone and Premier will work with FIG / Fisheries to identify optimum locations within Berkeley Sound that will cause the least disruption to other users during periods of high marine traffic in the Sound. Although the exact location of the LTVs and associated exclusion zones are not yet agreed, indicative locations are shown below in Figure 11.4. The LTVs will act as floating logistics vessels for up to 12 months. At this time, the LTVs will be used to store equipment during the construction process with vessels visiting to collect infrastructure for its installation offshore (section 5.11.2).

Depending on transport opportunities and pick-up locations, up to four different LTVs over the course of the installation period may be required to transport all the equipment but not all will be anchored in Berkeley Sound at the same time. It is anticipated that a maximum of two vessels will be anchored in the Sound at any one time.

It is possible that the subsea infrastructure installation campaign will be split over two seasons. In this event, it is anticipated that, for the second season, a single LTV will be stationed in Berkeley Sound for a period of four to six months.

Premier will work in close liaison with the Falkland Islands Harbour Master to advise other users on where the vessels will be to prevent any conflict with other users of the Sound. In doing so, Premier propose a philosophy of exclusion zone management, see section 11.2.2.3 below.

The LTV specifications will range in size from 110 - 160 m long and beam: 20 - 28 m wide with a Gross Registered Tonnage (GRT) ranging from: 9,000 - 15,000 tonnes. All vessels will have two large cranes.

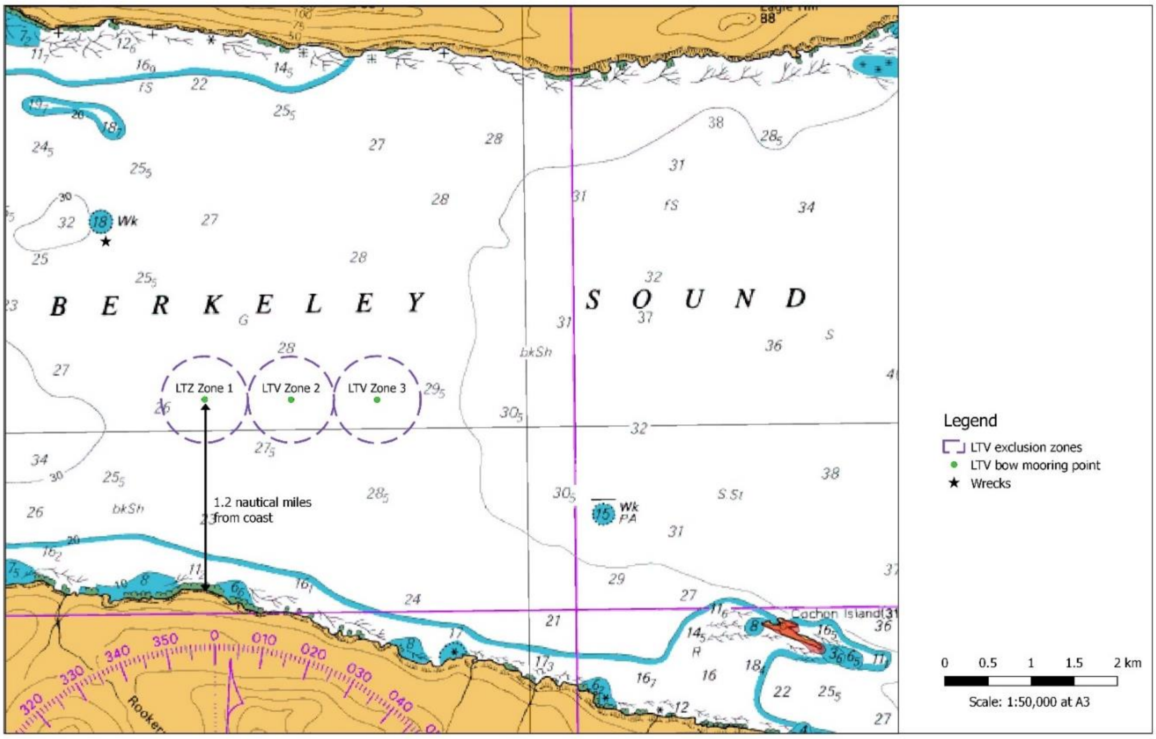


Figure 11.4: Indicative locations of LTVs and associated exclusion zones

11.2.2.3 Berkeley Sound exclusion zones

During Stage 1, the LTVs will require their own 500m exclusion zones (Figure 11.4). As noted above this will be arranged in consultation with FIG / Fisheries to minimise disruption to other users.

Table 11.10: Exclusion zones applying to Phase 1 Development facilities

Location	Facility	Stages	Permanent	Temporary
Inshore in Berkeley Sound	LTV movements and placements	1 and 2	n/a	500 m radius each (for up to twelve months)

11.2.3 Potential receptors

The Environmental Impact IDentification (ENVIID) workshop was used to identify the specific receptors upon which the impacts and risks to other users of the sea warranted further investigation (Chapter 9). The specific inshore receptors that may be impacted include:

- Users of Stanley Harbour (section 7.7.4.1.2):
  - Fishing vessels;
  - Cargo vessels;
  - Cruise ships;
  - MoD; and
  - Recreational craft.
- Users of Berkeley Sound (section 7.7.3.2):

  - Primarily vessels associated with the fishing industry (fishing vessels, reefers and bunkering tankers).

11.2.4 Characterising and quantifying the impacts and risks to inshore users of the sea

When characterising and quantifying the impacts and risks to other users of the sea in Stanley Harbour and Berkeley Sound, it is necessary to consider the:

- Quantification of inshore Phase 1 activities:
  - Type, location and behaviour of Phase 1 vessels / infrastructure used inshore; and
  - Phase 1 use of amenities in Stanley Harbour.
- Quantification of inshore third-party activity:
  - The number, type and behaviour of third-party vessels in Stanley Harbour and Berkeley Sound;
  - History of third-party vessel incidents in Stanley Harbour and Berkeley Sound; and
  - Stakeholder comments and third-party vessel behaviour.
- Nature of the impacts and risks associated with:
  - Phase 1 exclusion zones; and
  - Potential buoys in Berkeley Sound.

11.2.4.1 Quantification of inshore Phase 1 activities

11.2.4.1.1 Type, location and behaviour of Phase 1 vessels / infrastructure inshore

In order to inform the assessment of the impacts and risks, it is necessary to have an appreciation of the additional inshore vessel traffic incurred as a result of the proposed Phase1 Development.

A detailed inventory of the vessels used is provided in section 5.11.2 and the full oil export process is described in detail in section 5.10. A summary of the inshore vessel type, purpose and specification, segregated by location, is provided in Table 11.11.

Table 11.11: Summary of the type, purpose and behaviour of inshore Phase 1 vessels used to inform the impact and risk assessment

Vessel / installation type	Purpose	Analogous Vessel	Vessel specification			Total number of operations / visits		
			Length (m)	GRT (tonnes)	Max. speed (kn)	Stage 1 (39 months)	Stage 2 (30 months)	Stage 3 (17.5 years)
Stanley Harbour								
Coaster	Cargo supplies	*HHL Congo*	138	9,616	14	10	12	80
AHT (inc. ERRV) (x2)	Refuelling and resupply	*Pacific Wyvern*	69	2,332	15	180	258	n/a
SURF installation AHTs (x2)	Refuelling and resupply	*Pacific Wyvern*	69	2,332	15	18	4	n/a
ADT	Refuelling and resupply	*Rampage Class Tug*	30.8	360	14	n/a	129	455
Multi-Role Support Vessel (MRSV) (i.e. supply and ERRV vessel (x 2 in Stages 1 & 2))	Cargo collection	*Nor Solan*	97	5,179	14	n/a	129	901
PSV (i.e. Emergency Rescue and Response Vessel (ERRV))	Refuelling and resupply	*Fastnet Sentinel*	61	1,944	13	90	n/a	n/a
Berkeley Sound								
Large Transport Vessels (LTV)	Transport of infrastructure to Falklands and floating logistics barge	*Jumbo Fairplayer* (typical LTV / HLV)	144	15,000	17	Up to three vessels for up to 9 months	One vessel for up to 6 months	n/a
Subsea Installation vessels	Visiting LTVs to collect infrastructure for installation offshore	*Seven Arctic* Inst vessel	163	TBC	15	14	4	n/a
Potential for up to seven oil spill boom buoys around the coast [a]	To facilitate fast deployment of shoreline oil spill deflection booms	n/a	TBC	TBC	n/a	Installed in Stage 1 present throughout subsea installation phase if IFO present		

[a] Exact location of the boom buoys will be determined through stakeholder consultation and after a full survey of the coastline has been conducted for suitable locations

11.2.4.1.2 Phase 1 use of amenities in Stanley Harbour

As described above (section 11.2.2), the TDF may be upgraded in future to improve operability and to install a fuel line to the Temporary Dock Facility (TDF) which would mitigate against impacts on the use of amenities in Stanley Harbour. However, as a worst case scenario for the current EIA, it is assumed that refueling of Sea Lion Phase 1 related vessels using the TDF will take place at FIPASS.

In order to quantify the number of times the Phase 1 vessels will refuel at FIPASS, some assumptions have been made. It is assumed that coasters, supply vessels and ERRVs will refuel every time they visit the TDF and oil export support vessels will refuel monthly for larger vessels and fortnightly for smaller vessels. Based on these assumptions, the estimated number of refueling visits during each Stage of the Phase 1 Development by vessel type is shown on a monthly basis in Table 11.12.

Table 11.12: Estimate of the monthly number of refuelling visits to FIPASS

Vessel Type	Total number of refuelling operations (visits to FIPASS) per month		
	Stage 1	Stage 2	Stage 3
Coaster	0.4	0.5	0.3
Supply/ERRV vessels	8.0	6.0	6.0
Oil export vessels			
ADT	n/a	2	2
Total	8.4	8.5	8.3

11.2.4.2 Quantification of inshore third-party activity

11.2.4.2.1 Number, type and behaviour of third-party vessels inshore

11.2.4.2.1.1 Stanley Harbour

On entering, and exiting Stanley Harbour via Port William, vessels are required to report to the Harbour Master stating their intended movements. Information collected over recent years gives a good indication of the movements of vessels into and out of the Harbour, by type and on a seasonal basis (Table 11.13). The greatest seasonal variation in vessel numbers occurs in February due to an influx of jiggers into the Harbour for license inspections. Excluding jiggers and O&G related vessels, the number of vessel visits averaged 38 per month during 2014 and, as a comparison, 36 per month during 2018 (Table 11.13).

Section 11.2.4.1 shows the predicted number of Phase 1 vessel visits to Stanley Harbour during each Stage of the project. The monthly average number of visits will vary between Stages of the project. Assuming that vessel activity will be evenly distributed throughout the year, it is estimated that the following average number of Premier vessels will visit Stanley Harbour per month:

- Stage 1 – 12.7 vessel visits per month;
- Stage 2 - 18.5 vessel visits per month; and
- Stage 3 – 9.5 vessel visits per month.

Although at times this will add significantly to the number of vessels, traffic within the Harbour will remain at a low level throughout the year.

Table 11.13: Number of vessels entering Stanley Harbour during 2014 and 2018

Vessel Type		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Cargo	2014	4	2	5	5	3	2	5	4	1	2	2	3	38
	2018	2	2	3	3	2	3	2	5	4	3	5	3	37
Cruise ship	2014	9	12	8	1	0	0	0	0	0	6	14	14	64
	2018	21	5	9	1	0	0	0	0	0	5	18	12	71
Jigger	2014	0	92	15	3	1	0	0	0	0	0	0	0	111
	2018	0	103	4	6	1	0	0	0	0	0	0	0	114
Longliner	2014	1	4	5	3	1	5	7	9	3	4	4	1	47
	2018	3	3	4	6	3	3	3	6	4	2	3	1	41
Naval vessel	2014	0	3	0	2	0	3	0	0	0	1	1	2	12
	2018	0	2	0	0	1	1	0	0	0	0	0	1	5
Patrol vessel	2014	1	4	2	3	3	4	4	5	3	3	3	8	43
	2018	3	5	5	5	4	3	2	3	3	3	8	4	48
Research	2014	1	2	1	1	0	0	0	0	0	0	1	1	7
	2018	1	1	4	3	3	2	0	0	0	0	1	1	16
Tanker	2014	2	1	1	3	3	1	2	1	1	1	1	0	17
	2018	1	0	1	1	1	2	0	1	2	1	0	1	11
Trawler	2014	3	17	13	14	12	3	16	11	6	16	6	0	117
	2018	4	14	14	8	16	3	10	12	15	10	3	2	111
Tug	2014	0	0	3	2	0	1	0	0	0	3	5	2	16
	2018	0	1	0	0	0	1	0	0	0	0	0	2	4
Yacht	2014	8	6	11	7	1	0	1	1	3	6	4	13	61
	2018	9	7	13	6	2	2	0	1	3	6	14	8	71
Total	2014	38	149	68	46	26	19	35	31	17	44	46	47	566
	2018	51	146	59	42	33	20	17	28	31	31	55	38	551

(Source: FIG fisheries department data (FIG, 2015o) updated FIG Marine, DNR 2019)

11.2.4.2.1.2 Berkeley Sound

Detail on vessel types and activity in Berkeley sound are provided in the Environmental and Social Baseline (section 7.7.3.2) and are presented here as appropriate to this particular impact and risk assessment.

Vessel traffic data for Berkeley Sound has been supplied by the FIG Department of Natural Resources for the years 2010 to 2018 and is summarised in (Table 11.14). The data indicate that there was considerable inter-annual variation in the total number of ship visits between 2010 and 2018. The 2014-15 Illex seasons represent the peak in activity in recent years; as such 2014-15 data represents 'worst case' anticipated vessel traffic in Berkeley Sound.

The main types of vessels visiting Berkeley Sound in 2015 were:

- Jiggers – Far Eastern fishing vessels that use artificial light to catch *Illex* squid. These had a median size of 955 gross tonnage (GT). There were 122 individual vessels, making an average of four visits per vessel year, typically two weeks apart, mainly during the fishing season of February-May. There is considerable inter-annual variation in the number of jigger visits, depending on the quantity of squid caught;

- Reefers – refrigerated storage vessels for the catch from the jigger fleet. These had a median size of 8,500 GT. There were 59 individual vessels, making an average of 1.7 visits per vessel year, mainly during the fishing season of February-May;
- Trawlers – vessels fishing for finfish and loligo squid. These had a median size of 870 GT. There were only 23 individual vessels, making an average of two visits per vessel year;
- Tankers - of the tanker visits, 54 were by two 3,978 GT vessels, MV *Sealion* and MV *Jason*. There were also two visits by an 11,000 GT fishing fleet tanker, and three by 7,600 GT tankers;
- 'Cargo vessels' - in total, there were nine visits by other cargo vessels, including one 34,000 GT bulk carrier, one 23,000 GT cargo ship, one 9,600 GT cargo ship, and six visits by a 2,600 GT cargo ships; and
- Other vessels - the only other vessel of note was a 6,500 GT passenger ship. There were just four other small vessel visits, with a median size of 2,000 GT.

Therefore, it can be seen that Berkeley Sound is utilised predominantly by fishing vessels and associated support vessels (reefers and tankers), which use the Sound as an anchorage for the transhipment of fish and squid, and to bunker fuel. The number of fishing and fisheries support vessels present varies considerably on a seasonal and annual basis. Seasonally the number of vessels peaks between March and June (Figure 11.5), while the annual variation is related to the catch recorded in the *Illex* jigging fishery which has varied hugely over the past ten years; from virtually zero in 2009 to over 330,000 tonnes in 2015 (FIG, 2016c) (Table 11.15).

Table 11.14: The number of vessel visits to Berkeley Sound recorded in 2014 and 2018

Ship type	No. of ship visits to Berkeley Sound								
	2010	2011	2012	2013	2014	2015	2016	2017	2018
Bulk carrier	0	0	0	0	0	1	0	0	0
Cargo	7	5	9	8	8	8	6	5	7
Cruise	1	0	0	1	1	1	1	0	3
Jigger	21	166	72	243	538	491	28	67	46
Longliner	0	0	1	0	0	6	0	4	1
Patrol/Chase Boat	8	6	3	7	3	3	3	3	0
Supply	2	4	8	10	2	0	1	0	0
Reefer	36	42	52	56	121	102	20	34	43
Standby	0	0	1	0	0	1	1	0	0
Survey/Seismic	0	3	0	6	2	0	0	0	0
Tanker	23	18	45	40	42	59	18	35	36
Trawler	32	28	34	34	67	52	7	26	67
Tug	0	1	1	0	0	0	1	0	0
Warship	4	4	2	10	5	0	5	1	3
Yacht	1	0	0	0	1	0	0	0	0
Totals	**135**	**277**	**228**	**415**	**790**	**724**	**91**	**175**	**206**

(Source: FIG fisheries department data (FIG, 2015o) updated FIG Marine, DNR 2019)

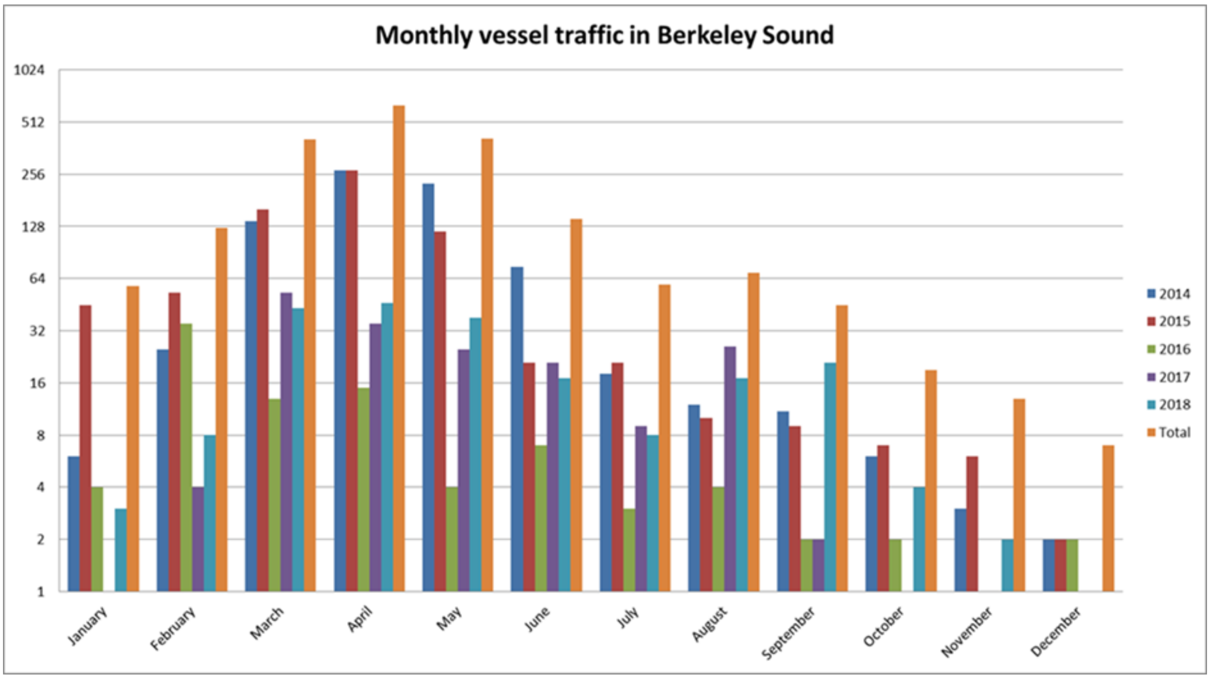


Figure 11.5: Monthly vessel traffic in Berkeley Sound

Table 11.15: Annual *Illex* catch by the jigger fleet [a]

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Catch (tonnes)	81,766	157,637	100,348	4	11,645	73,704	84,619	139,137	291,796	332,868

[a] **Note:** these figures are for jiggers only as while trawlers do also fish for *illex*, there is one trawler and over 100 jiggers. Finfish and loligo trawlers tend to tranship in Stanley or Port William

11.2.4.2.2 History of incidents in inshore waters

11.2.4.2.2.1 Stanley Harbour

Space for vessel manoeuvres in Stanley Harbour and through the passage into Port William (The Narrows) is restricted and there have been a number of incidents involving vessel collisions and groundings within these areas (M. Jamieson *pers. comm*.). Although an official record does not exist, anecdotal reports of some of these incidents in recent years are listed in Table 11.16. It is believed that the majority of these incidents were due to human error and / or mechanical failure.

Table 11.16: Anecdotal data on incidents involving vessels in Stanley Harbour and Port William [a]

Date	Vessel type	Type of incident	Outcome	Environmental impact
Unknown	Tanker	Grounding Stanley Harbour	Refloated	None
Unknown	Tanker and research vessel	Collision at FIPASS	Damage to research vessel above the water line	None
Unknown	Jigger	Grounding Stanley Harbour	Refloated	None
Unknown	Reefer	Grounding Port William	Refloated	None
Feb 2014	Jigger	Grounding Port William	Refloated	None
Apr 2014	Trawler	Grounding Port William	Refloated	None
Feb 2017	Jigger	Grounding Stanley Harbour	Refloated	None
Feb 2017	Jigger	Grounding Stanley Harbour	Refloated	None
July 2017	Trawler	Grounding, Port William	Refloated	$3m^3$ MGO released to sea.
Feb 2017	Jigger	Collision Stanley Harbour; 2 jiggers coming into contact	Slight damage	None
September 2019	Trawler	Collision with FIPASS	Damage to vessel and FIPASS	Not reported
Unknown	Numerous vessels	Heavy contact with FIPASS	Slight damage to FIPASS and vessels	None

[a] M. Jamieson *pers. comm*. and A. Black *pers. obs*.

11.2.4.2.2.2 Berkeley Sound

Historically, there have been a number of incidents within Berkeley Sound (Table 11.17). Several fishing and reefer vessels have either collided with rocks or experienced fires while in Berkeley Sound and following these events, fuel oil leaked from ruptured tanks or sunken vessels, which resulted in environmental impacts.

Table 11.17: Anecdotal data on incidents involving vessels in Berkeley Sound [a]

Date	Vessel type	Type of incident	Outcome	Environmental impact
April 2005	Reefer	Grounding in Berkeley Sound (Cochon Island)	Refloated with damage to hull	Fuel oil leak
May 2008	Trawler (Ocean 8)	Fire in Berkeley Sound	Vessel eventually sank	Fuel oil leaks (c.137 Tonnes)
Unknown	Jigger	Struck a rock and sank	Vessel sank	Fuel oil leaks

[a] M. Jamieson *pers. comm*. and A. Black *pers. obs*.

11.2.4.2.3 Stakeholder comments and third-party vessel behaviour

Scoping consultations were conducted in August 2016 with representatives of FIG's Fisheries Department and the fishing industry regarding all aspects of the project. During these sessions, a number of comments were made regarding the seamanship displayed by the jigging fleet in Berkeley Sound (Chapter 6). There are often language problems and insufficient or out-of-date charts on board these vessels, officers on watch are often exhausted and have been known to fall asleep, and electronic and mechanical equipment is not always in good working order (A. Black *pers. obs.).* Furthermore, there is a history of non-compliance with regulations within this fleet.

11.2.4.3 Nature of the impacts and risks associated with Phase 1 exclusion zones and buoys in Berkeley Sound

11.2.4.3.1 Exclusion zones

In order to mitigate against the risk of the collisions between third-party vessels and Phase 1 vessels / infrastructure, temporary exclusion zones will be implemented within Berkeley Sound according to the ongoing activity (section 11.2.2.3). However, exclusion zones bring impacts and risks of their own with regard to:

- Reduced anchorage availability; and
- Reduced sea room and increased risk of collisions / groundings of third-party vessels.

The following sections describe the nature of the above in terms of the restrictions that exclusion zones place on *third-party* vessels operating within Berkeley Sound.

11.2.4.3.1.1 Reduced anchorage availability

Numerous vessels anchor within Berkeley Sound for the purposes of fuel bunkering and the transfer of fish catches (section 7.7.3.2.1). When in use, the temporary exclusion zones have associated with the LTVs the potential to restrict, or be seen to restrict, the available space in the Sound during peak seasons.

11.2.4.3.1.2 Reduced sea room and increased risk of collision / grounding of third-party vessels

Collisions are most frequently caused by a navigational failure of one or both vessels involved in the collision. The main factor that influences collision frequency is the density of vessel traffic and the probability of a collision increases with the vessel density squared (i.e. if the density doubles, the probability of a collision quadruples; DNV, 2010).

Groundings are effectively collisions with land, the likelihood of which is related to the proximity of a vessel to land or subsea hazards (such as rocks).

Other factors that influence the collision or grounding frequency include:

- Non-compliance with regulations (e.g. ColRegs) – education issues;
- Poor communication between vessels;
- Visibility (rain, snow, fog);
- Restricted manoeuvrability;
- Metocean conditions (wind, tide, swell);
- Lack of navigational aids (shore based radar, marked channels);
- Mechanical failure (black-out, steering failure); and
- Vessel standard (hardware and software).

The use of exclusion zones effectively reduces the space available to other users of Berkeley Sound to the north and south of the LTVs. This may force vessels into closer proximity to each other and to the coastline and therefore increases the risk of collisions and groundings.

To date, vessels using Berkeley Sound generally do not venture within 1.5 km of land for safety reasons and the area utilised by vessels covers approximately 100 km^2 (Figure 11.6). However, it is recognised that restricting the sea-room available to vessels may increase the likelihood of third-party incidents.

11.2.4.3.1.3 Effect on vessel density

If the maximum number of LTVs (i.e. two) are in the Sound at any one time, the area required for the three 500 m exclusion zones (see Figure 11.4) is 2.36 km2, which is <3 % of the area used by other vessels. The LTV exclusion zones make little difference to the area available to third-party shipping and the increase in the risk of collision or grounding is likely to be insignificant (Table 11.18).

The density of vessels within the remainder of the Sound will increase by a factor of 1.02, which increases the risk of collision by a factor of 1.04 (i.e. 1.022). The area occupied by the LTV exclusion zones will force vessels to use a slightly narrower channel to the north of the anchorage.

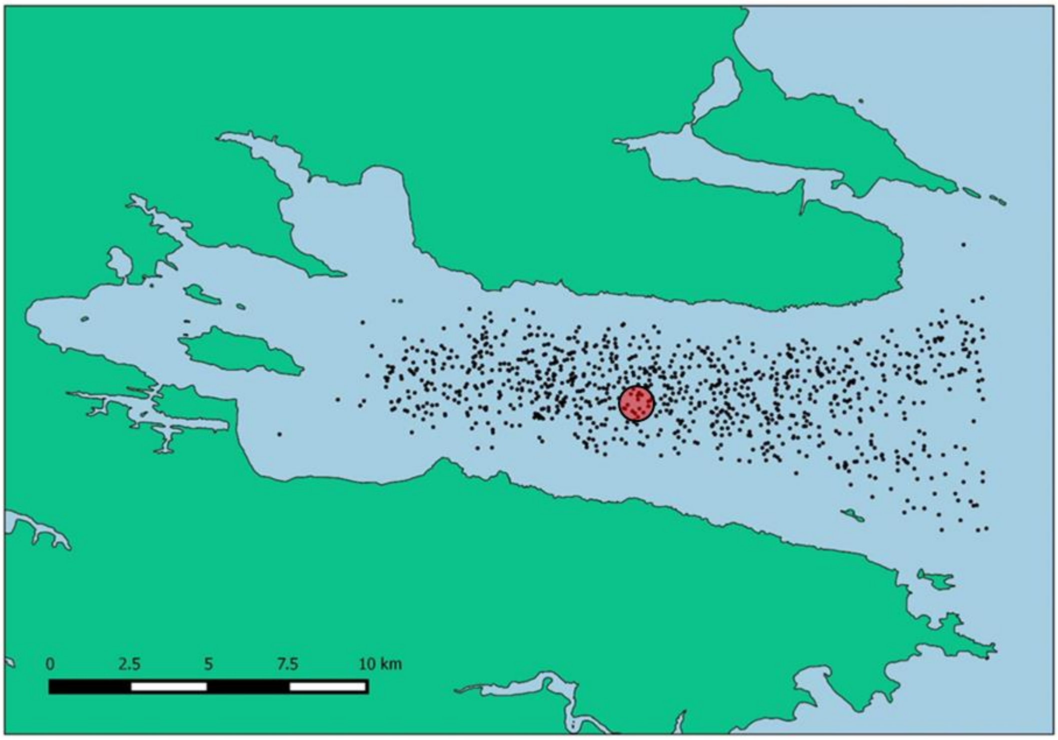


Figure 11.6: The extent of the exclusion zones associated with the anticipated LTV site in relation to the position of vessels (from AIS) between May 2014 and May 2015

Data from 2014 was used as a worst case example to illustrate the influence of the exclusion zones on vessel density (Table 11.18). However, it should be noted that this data refers to all visits during each month and not all vessels will be present at any one time.

Table 11.18 indicates that the influence of the exclusion zones in Berkeley Sound will mostly be felt in the months where the most vessels are present i.e. from March – June, so during those months vessels will have less sea room than at other times of year.

Table 11.18: The influence of exclusion zones on vessel 'density[a]' on a monthly basis, data from 2014

Scenario	Month											
	J	F	M	A[b]	M[b]	J	J	A	S	O	N	D
No. of vessels	6	25	137	270	225	75	18	12	11	6	3	2
Vessels / km^2 no exclusion zones	0.06	0.25	1.37	2.70	2.25	0.75	0.18	0.12	0.11	0.06	0.03	0.02
Vessels / km^2 with LTV 500 m exclusion zone	0.06	0.26	1.40	2.77	2.30	0.77	0.18	0.12	0.11	0.06	0.03	0.02

[a] Note: densities are rounded to two decimal places

[b] Premier will strive to avoid using Berkeley Sound during peak fishing months

11.2.4.3.1.4 Stakeholder opinion on exclusion zones

Responses from stakeholders to the proposed exclusion zones within Berkeley Sound were mixed with some positive and some negative representations made during scoping consultations (Chapter 6). However, it should be noted that these representations were made in response to the proposed larger, and more enduring, Inshore Transfer-related exclusion zones. The LTV operations and associated exclusion zones proposed were not discussed explicitly during the 2016 scoping consultations.

Specifically, concern expressed in 2016 in relation to the Inshore Transfer operation was regarding the space available to other users of Berkeley Sound and the unpredictable behaviour of, and communication with, the fishing fleet was highlighted as an issue. However, the overall consensus was that the anticipated tighter regulation and management would be positive for all users of the Sound, although, while all agents of vessles operating in the Sound were consulted via FIFCA, it should be noted that not all the vessel Captains or vessel owners were consulted directly.

11.2.4.3.2 Additional Phase 1 buoys in Berkeley Sound

As described in section 11.2.2.2.1, boom buoys may be installed around the coast for rapid spill deflection boom deployment.

The oil spill boom buoys may be installed around the Sound at strategic points to allow shoreline booms to be reeled out from a Rigid Inflatable Boat or other small vessels. The buoys will be situated at the edge of the kelp line, and no further into the Sound than 250 m (the length of the booms) to prevent vessels having to drive through the kelp to access the shoreline booms, thus allowing faster deployment of the shoreline booms. Notional locations of the booming locations have been identified (Figure 11.7), although these are subject to change pending stakeholder consultation and a full coastline survey. Although these buoys may present additional obstacles in the Sound, their placement at the edge of the kelp-line means they will be outwith areas that vessels would utilise under normal circumstances.

11.2.4.4 Collision risk associated with oil export vessels

The consultancy DNV-GL was commissioned by Premier to conduct a Quantitative Risk Assessment (QRA) based on modelling outputs for the oil export activities associated with the Sea Lion Development (DNV_GL, 2016). The QRA assesses the risk of navigational accidents between the Phase 1 oil export vessels and third-party vessels and forms the basis of the risk assessment.

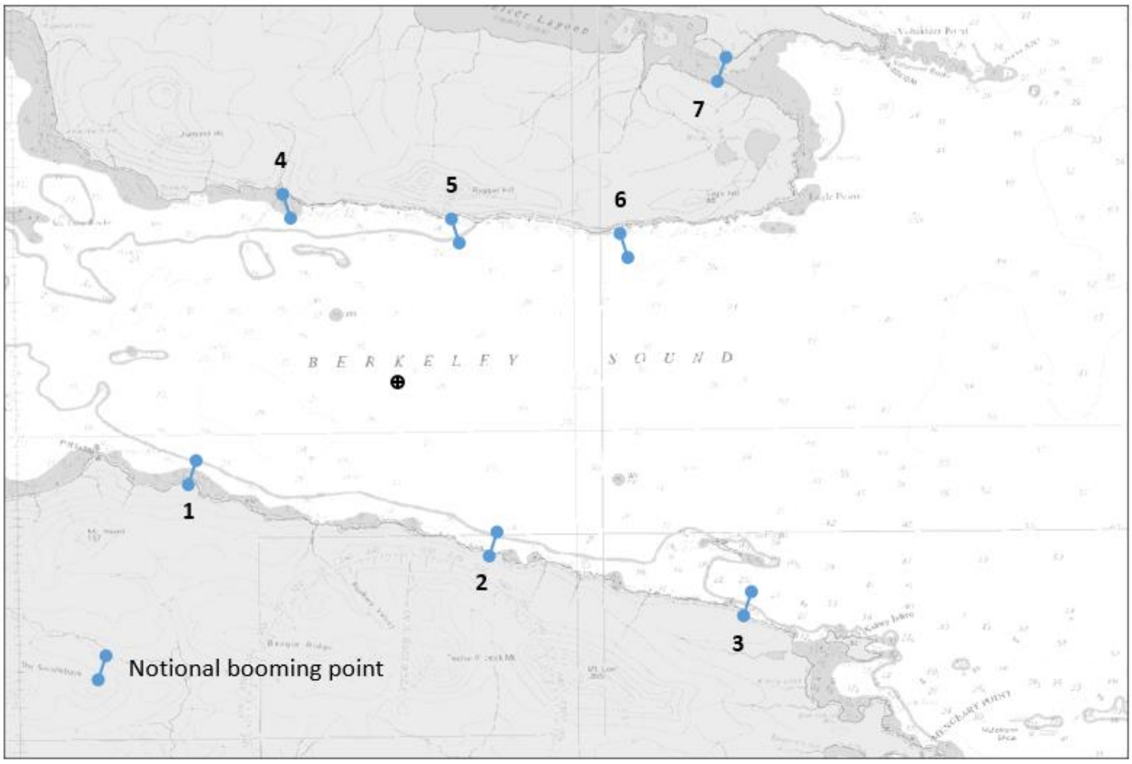


Figure 11.7: Notional shoreline booming and boom buoy locations in Berkeley Sound

11.2.4.4.1.1 Collision frequencies

Table 11.19 gives the accident frequencies calculated by DNV for oil export. The overall frequency of collisions with third-party vessels is 9.2 x 10^{-5} per year, for 27 transfer operations per year (in peak production), which equates to one collision every 10,000 years.

Table 11.19: Collision risk frequency between third-party vessels and tankers during different aspects of the oil export process

Aspect of oil export	Collision risk (per year, during peak year)
CTT in ballast at sea, steaming towards Falklands waters	4.6 E-05
CTT laden at sea, departing Falklands waters	4.6 E-05
Total	**9.2 E-05**

11.2.4.4.1.2 Consequences of a collision

The consequences of a collision are dependent on the size, speed and orientation of the vessels involved (i.e. whether the impact is full-on or glancing). There are two main potential types of collision with third-party vessels and the CTT:

- Powered collisions, where the third-party vessel suffers some form of watch keeping failure, so that it is unaware of the presence of the tankers. This typically results in collision at full speed after having failed to take any avoidance action. Typical causes are:
  - Watch keeper making ineffective use of radar in bad visibility ('blind'), possibly combined with excessive speed that prevents avoidance once the tankers become visible; and

  – Watch keeper distracted or incapacitated (e.g. ill or asleep) and not keeping an effective watch in good visibility ('errant').

- Drifting collisions, where the third-party vessel suffers some form of breakdown and drifts into the tankers.

With the information available, it is not possible to accurately predict the consequences of a collision but it is assumed that a small vessel, such as a jigger, colliding with a far larger vessel, such as a tanker, would suffer considerable structural damage.

11.2.5 Industry-standard mitigation

11.2.5.1 Exclusion zones

The use of temporary exclusion zones for the LTV operation is a mitigation in itself against the risks of collision. No industry-standard mitigations are required to minimise the impact of these on other users of the sea.

11.2.5.2 Vessel operations

The industry-standard mitigations used to prevent collisions between vessels inshore are the same as those described in section 11.2.1.1 above.

Additionally, a Falkland Islands Berthing Master / Pilot will accompany the LTVs prior to entering Berkeley Sound. The Pilot will be trained in navigation of the Sound and local use of the area.

Falkland Islands ports and harbours information (FIG, 2017b) was produced to assist the Masters of all vessels using the Designated Ports around Stanley. These information sheets are available for Berkeley Sound, Port William and Stanley Harbour. In addition, a Harbour Management Plan will be developed by Premier to facilitate vessel operations in Stanley Harbour.

11.2.5.3 Presence of spill response buoys

All oil spill boom buoys will be equipped with standard navigation aids which are suitable for the type and size of the buoy and will be marked on charts to alert vessels to their presence.

11.2.6 Impact and risk assessment

The following section draws upon all the information provided above to assess the 'Sensitivity of the Receptor' and the 'Severity of Effect' in order to determine the overall 'Impact' of planned activities. Assessment of unplanned events includes an assessment of the 'Likelihood of Occurrence' to determine the 'Risk'.

A summary of the impact and risk assessment outcomes for this Development is tabulated in section 11.2.12 (Table 11.20), which shows the worst case impact / risk for each activity and receptor and details are provided below.

11.2.6.1 Impact assessment of inshore activities

11.2.6.1.1 Disturbance to other users within Stanley Harbour

Disruption to the activities of other vessels in Stanley Harbour may occur but is considered to be minimal. The human population (fishing, tourism and shipping industries) are tolerant to a change on this scale and it is anticipated that occasional use of FIPASS will be acceptable to the majority of stakeholders. Therefore, the **sensitivity of the receptor** is considered to be '**Low**'.

As described above, it is assumed that refuelling of Premier vessels will take place at FIPASS (if a dedicated fuel line is not added to the TDF). At times of high demand, berthing space at FIPASS can be oversubscribed and vessels have to wait for a berth to become available. Premier's use of FIPASS may further exacerbate this issue. However, while the impact will be short-term with minor effects on livelihood (due to possible delayed berthing), this may be considered unacceptable to a minority of stakeholders. The **severity of effect** is therefore considered to be '**Minor**'.

Therefore, the overall **significance of the impact** on resource use in Stanley Harbour is assessed as '**Low (4)**'.

11.2.6.1.2 Loss of anchorage space due to exclusion zones in Berkeley Sound

Berkeley Sound is heavily utilised by other users of the sea (the fishing industry) on a seasonal basis, with highest activity between March and June (section 11.2.4.2.1.2). Premier intend to avoid these winter months for offshore installation and thus avoid the periods with the most other users of Berkeley Sound. However, even with the exclusion zones in place, there is ample space available for vessels wishing to anchor and transit through the Sound in comparison with harbours elsewhere in the world. Berkeley Sound is largely unregulated and vessels using the anchorage are tolerant of change on this scale without detriment to its character and therefore the **sensitivity of the receptor** is considered to be '**Low**'.

The temporary 500 m exclusion zone surrounding the LTVs does not significantly restrict the area available to other vessels for anchoring or manoeuvring. Any inconvenience caused is expected to be relatively short-term and minor, although this may be unacceptable to some stakeholders. The temporary exclusion zones represent a moderate use of a finite resource for limited but predictable periods and, therefore, the **severity of effect** is considered to be '**Minor**'.

Therefore, the overall **significance of the impact** of the exclusion zones on the human population is assessed as '**Low (4)**'.

11.2.6.1.3 Potential positive impact of the presence of Phase 1 Vessels

In addition to the negative impacts and risks described above, the presence of the O&G industry may also offer potential benefits to other users of the sea. In particular, the presence of large ocean-going supply vessels may be useful in the event of emergency situations that require salvage, rescue or an oil spill response. As was observed during November 2015 following a fire onboard a cruise ship, vessels with the capability to aid rescue may help to prevent environmental damage, loss of property and life at-sea (A. Black, *pers. comm.*).

11.2.6.2 Risk assessment of collisions during inshore activities

11.2.6.2.1 Collisions in Stanley Harbour

Phase 1 vessels will increase the number of vessels using Stanley Harbour but it will remain a relatively quiet port. Nonetheless, a Harbour Management Plan is under development to manage vessel movements and other users of the Harbour are tolerant to change on the scale proposed. Therefore, the **sensitivity of receptors** is considered to be '**Low**'.

As a worst case scenario, a collision between vessels has been assumed. To date, incidents of this type are rare within the Harbour and have resulted in medium term inconvenience and expense due to the necessary repairs. Here as a worst case, we assume a similar impact and therefore **severity of effect** is considered to be '**Moderate**'.

Therefore, the **significance of the impact** on other users of Stanley Harbour is assessed as '**Moderate (6)**'.

The available information suggests that collisions or contact between third-party vessels in Stanley Harbour are rare events. However, while there have been a number of single vessel incidents, most of these have been due to human error or mechanical failure. The vessels used by Premier will be technologically advanced and manned by highly trained, competent crew, which reduces the likelihood of mechanical breakdown or human error leading to incidents. The base case for the Phase 1 Development is for all project vessels to dock at the TDF (or anchor) whenever visiting Stanley Harbour. This will separate the activities of Phase 1 vessels and other users of the Harbour and therefore reduce the potential for incidents. Although Premier may upgrade the TDF for operational flexibility and to include a fuel line, this proposal is yet to go through the planning process and therefore it is assumed as a worst case that refuelling will take place at FIPASS as it did during the 2015 exploration campaign. On rare occasions, there have been collisions between vessels using FIPASS, therefore the **likelihood of occurrence** of a major incident (such as collision) between Premier vessels and other users is considered to be '**Unlikely**'.

Therefore, the **significance of the risk** to other users of Stanley Harbour is assessed as '**Low (6)**'.

11.2.6.2.2 Reduced sea room due to temporary exclusion zones in Berkeley Sound

The temporary exclusion zone for the LTVs may lead vessels to navigate closer to the shoreline of Berkeley Sound than they would normally choose to (i.e. sea room is restricted). This increases the risk of watch-keeper error or problems in the event of a mechanical breakdown, which as a worst case could lead to a vessel grounding. If a vessel grounds, it could result in significant damage to, or loss of, the vessel. Due to the size of the Sound, the other users of Berkeley Sound have moderate capacity to absorb change without significantly altering their present operations, although some stakeholders may find this unacceptable. Therefore, the **sensitivity of the receptor** is considered to be '**Moderate**'.

If a vessel were to run aground, the salvage and repair could have a long-term effect on livelihood and therefore the **severity of effect** is considered to be '**Serious**'.

The significance of the impact of restricted sea room is assessed as '**Moderate (12)**'.

Given the circumstances described in section 11.2.4.2.3 above, it is difficult to estimate the likelihood of collisions that may result from reduced space caused by the LTV temporary exclusion zones. Although Berkeley Sound is a large open bay, watch-keeping and mechanical failures have resulted in vessels grounding in the past 20 years (section 11.2.4.2.2.2). The temporary LTV exclusion zones will reduce the space available to vessels and therefore may increase the likelihood of accidental events in the future. However, the zones do not limit sea room extensively and will only be in place for up to 12 months in total. The anticipated improved regulation in the Sound may serve to lessen the likelihood of collisions, and even alter behaviours. Therefore, on balance the likelihood of restricted sea room leading to vessel groundings is considered to be '**Very Unlikely**'.

Therefore, the overall significance of the risk associated with reduced sea room is assessed as '**Low (6)**'.

11.2.6.2.3 Collision with the Boom Buoys

The boom buoys may represent hazards to shipping but all will be adequately marked to enable third-party vessels to safely navigate around them. Additionally, the boom buoys are not likely to be located in an area regularly used by vessels. Other users of the sea are considered to be tolerant of changes of this nature without significantly altering the present character of activity within Berkeley Sound. Therefore, the **sensitivity of receptor** is considered to be '**Low'**.

The boom buoys will be located at the kelp line in order to minimise the likelihood of vessel impact however, in the event of an impact there is the potential that a propeller becomes fouled and sustains damage. This could result in a medium-term impact on livelihood if repairs are required and therefore the **severity of effect** is considered to be '**Moderate**'. The **significance of the impact** is therefore assessed as '**Moderate (6)**'.

Although mitigation will be in place such as notices to mariners (section 11.2.5.3), there is a real possibility that the message will be lost in translation or ignored given that the boom buoys will be normally unattended. Similar incidents have occurred in the past within the fishing industry, however, failure of numerous operational controls would be required. On balance, the **likelihood of** occurrence of a collision between a third-party vessel and the boom buoys is considered to be '**Very Unlikely**'.

Therefore, the overall **significance of the risk** is assessed as '**Low (6)**'.

11.2.7 Project-specific mitigation measures

With legislation and industry-standard mitigations applied, the impacts and risks assessed above are considered to be '**Low**' or '**Very Low**' such that project-specific mitigation is not actually required. However, the above assessment assumes that all third-party vessels using the Sound will operate within the 'Rules of the Sea' which, ordinarily, should be sufficient for vessels to adapt to the proposed changes without any negative impact.

However, experience has shown that this cannot be taken for granted when dealing with the fishing fleet. Scoping consultations in August 2016 highlighted several issues with vessels using Berkeley Sound regarding communication and compliance as major concerns (section 11.2.4.2.3). In order to help communicate the positions and restrictions associated with the exclusion zones, briefing notes will be issued in the first languages of the vessel Captains and a guard vessel may be used to patrol the temporary LTV exclusion zones in place in Stages 1 and 2.

11.2.8 Residual impacts and risks

The impacts and risks are unchanged from the initial assessment.

11.2.9 Cumulative impact

11.2.9.1 Stanley Harbour

The Sea Lion Development will increase the amount of vessel traffic within Stanley Harbour; however, the Port will remain relatively quiet compared with ports elsewhere in the world. Nonetheless, facilities within the Harbour are under-developed and competition for space may be an issue, potentially leading to cumulative impacts through increased ‘concentration’ (section 8.10.1). Any upgrade of the TDF (section 5.11.1.1.1) will reduce the reliance on FIPASS but may not completely negate the requirement for Premier project vessels to use FIPASS. Therefore, it is anticipated that there may be some cumulative impact to users of Stanley Harbour.

11.2.9.2 Berkeley Sound

Although there are no other exclusion zones in place within Falklands waters, any vessel at anchor effectively has an exclusion zone around it. Cumulative impact e.g. from increased ‘concentration’ (section 8.10.1), will vary on a monthly and annual basis depending on the number of other users within Berkeley Sound.

11.2.10 Confidence

11.2.10.1 Disturbance to other users within Stanley Harbour

The use of amenities in Stanley Harbour is possible to predict based on the known operation and therefore the confidence in the assessment is considered to be ‘**Certain**’.

11.2.10.2 Impacts and risks associated with exclusion zones

The nature of the impact is reasonably well understood but the unpredictable behaviour of the receptors (fishing vessels) introduces an element of uncertainty. This is particularly true for vessels using the offshore construction base site in Berkeley Sound where space is a limited resource. Therefore, the level of confidence in the predictions of these impacts is considered to be ‘**Probable**’.

11.2.10.3 Risk of collisions between vessels

Much of this assessment is informed by AIS data and collision risk modelling that is widely used and accepted, however, the modelling is based on short-term poor quality AIS data, collected between 2010 and 2014. There is considerable inter-annual variation in vessel traffic, largely due to variations in *Illex* squid abundance but 2014-15 was demonstrably a peak *Illex* fishing season, and as such represents a worst case in respect of expected vessel traffic and associated collision risk.

Stakeholders within FIG and from the fishing industry have been consulted as part of the scoping process for this EIA (Chapter 6). Their views have been taken into consideration and therefore confidence in the assessment is considered to be '**Probable**' and further monitoring of vessel movements and analysis will help to improve confidence in this assessment.

11.2.10.4 Monitoring required

The activities within Berkeley Sound are expected to be managed more rigorously than they have in the past, with the aid of AIS monitoring. It is likely that this initiative will be driven by FIG.

Detailed monitoring requirements have been established during the Environmental Monitoring and Management Plan (EMMP) workshop. All monitoring requirements agreed by Premier and FIG will be recorded and managed via the project-specific Phase 1 EMMP (an outline EMMP is provided in Chapter 15).

11.2.11 Offsetting

As no residual impacts or risks identified in this section are considered significant, i.e. Moderate or above, offsetting is not considered (see section 8.9).

11.2.12 Findings summary

Table 11.20: Summary of the impact and risk assessment on other users of the sea inshore

Activity	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Presence of vessels	Use of amenities in Stanley Harbour	Disturbance to other users of Stanley Harbour (e.g. competition for space at FIPASS)	Planned	1, 2 & 3	Low	Minor	n/a	**Low (4)**	**n/a**	**Certain**	**Industry-standard:** Vessels will adhere to the Stanley Harbour Management Plan. **Project-specific:** None proposed.
Inshore exclusion zones	Reduction in the area available to navigating and anchoring vessels	Loss of potential anchorage	Planned	2 & 3	Low	Minor	n/a	**Low (4)**	**n/a**	**Probable**	**Industry-standard:** Use of local pilots for Premier managed vessels in Berkeley Sound; and

Activity	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Improved regulation	Implementation of tighter controls and policing	Decrease in independent incidents involving third-party vessels	Planned	2 & 3	n/a			**Beneficial**	**n/a**	**Uncertain**	Status issued in 'Notes to Mariners' and on radio. **Project-specific:** Briefing documents issued in the language of the Captain.
Collision of vessels due to addition of Phase 1 vessels	Collision in Stanley Harbour	Damage to vessels	Unplanned	1, 2 & 3	Low	Moderate	Unlikely	**Low (6)**	**n/a**	**Probable**	**Industry-standard:** Vessels will adhere to the Stanley Harbour Management Plan. **Project-specific:** None proposed.
Collisions between vessels due to reduction in sea room	Temporary exclusion zone/s in Berkeley Sound	Damage to vessels	Unplanned	1 & 2	Moderate	Serious	Unlikely	**Low (6)**	**n/a**	**Probable**	**Industry-standard:** Avoid peak months; Use of local pilots for Premier managed vessels in Berkeley Sound;

Activity	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Collision between third-party vessels and buoys	Collision / entanglement with boom buoys in Berkeley Sound	Damage to vessels	Unplanned	1, 2 & 3	Low	Moderate	Unlikely	**Low (6)**	**n/a**	**Probable**	Use of exclusion zones; 'notes to mariners';and Collision risk management procedures. **Project-specific:** Briefing documents issued in the language of the Captain.

[a] See Chapter 8 for definitions of sensitivity, severity, likelihood and significance.

11.3 Resource competition – Accommodation

Table of Contents

11.3.1 Introduction

The Phase 1 Development onshore and offshore personnel will require temporary and longer-term accommodation in the Falkland Islands. This chapter investigates the requirement for personnel accommodation in comparison to the current level of housing stock, overnight bed accommodations and proposed levels of new housing provision in Stanley. The forecast difference between development need and the current excess capacity determines the level of competition and the sensitivity of the receptor.

As described in section 2.4, socio-economic impacts are out of scope for this EIS and Premier has conducted a separate Socio-economic Impact Assessment (SIA), building on and updating the previous work undertaken for FIG and Rockhopper by Regeneris (2013 & 2015) and Plexus (2012), for pre-sanction consideration alongside this EIS. Therefore, this assessment focuses on the social impact of resource competition and not the secondary implications of such competition which may be socio-economic in nature. Thus, the level of competition for housing is assessed but not the potential secondary effects such as competition on accommodation rental values.

Both the carrying capacity of existing infrastructure and competition for resources were raised as a concern during the scoping consultations (Chapter 6).

Note: impacts related to competition for other resources e.g. freshwater, electricity etc. are described elsewhere in this document, as described in section 9.2.

11.3.1.1 Relevant legislation

Resource competition is not legislated for within any specific Ordinance or Regulation. No statutory limits are defined through legislation.

Nonetheless, Falkland Islands legislation that is relevant to environmental and social impact assessments are as follows:

- Offshore Minerals Ordinance 1994 (1997 and 2011 Amendments).
- Planning Ordinance 1991.

11.3.1.1.1 Competition for resources assessment

As was agreed during the consultee scoping workshop with FIG in 2015 (Chapter 6), the social impacts of competition for resources such as accommodation was considered to be within the scope of the EIS as defined by the EPD EIA Guidance Note (FIG, 2015m).

11.3.1.1.2 Stanley Town planning

Aspects of resource competition are implicit within hierarchical planning legislation and planning policy that guides development and assessment of planning applications, setting them within an overall framework to achieve strategic development aims.

Planning policy is one of the key tools available to achieve the stated FIG aim of sustainable development. The Development Plan is a statutory document and provides a framework for the future spatial development of the Islands. It is made up of the Islands-wide Structure Plan, which provides the overall strategic approach, and Local Plans, such as the Stanley Town Plan, which provide more detail and land-use zoning for specific areas within the Islands (FIG, 2015u).

The Stanley Town Plan recognises and makes provision for the consideration of service utility capacity and housing needs. Prioritised and addressed within the Stanley Town Plan are:

- Expansion of housing stock;
- Diversification of accommodation types with specific reference to O&G requirements for transit-type accommodation; and
- Land-use zoning to encourage and facilitate appropriate development.

11.3.2 Sources of accommodation competition

Any activity or asset that requires personnel is a potential source of competition for accommodation resources. The personnel requirements of the project, whether based offshore and requiring to transit through the Falkland Islands, or whether based onshore in a support and logistical capacity, will determine the level of accommodation needed and thus the level of competition.

Sources of demand for accommodation, and thus competition for resource, during the Phase 1 Development include:

- Onshore / At-shore personnel:
  - Onshore baseline accommodation:
    - Port facility personnel (TDF) (section 5.11.1.1.1);
    - Onshore laydown yard personnel (section 5.11.1.2);
    - Logistical support and office staff;
    - Accommodation / hospitality / domestic support staff; and
    - Helicopter pilots and aviation support staff.
  - Transit accommodation outwith normal rotations:
    - Fixed-wing flight crew lay-over; and
    - Technicians for specialist onshore work or awaiting transfer offshore for specific technical tasks outside standard crew exchanges.
  - Onshore visitor accommodation:
    - Management utilising hotel accommodation.
- Offshore / Near-shore personnel:
  - In-transit accommodation for crew exchange:
    - MODU (Stage 1 and 2) (section 5.11.3.1.2);
    - FPSO (Stage 2 and 3) (section 5.11.3.1.2);
    - Supply Vessels (Stages 1, 2 and 3) (section 5.11.2); and,
    - Floating logistics vessels (LTVs) (Stage 1) (section 5.11.2).
- Contingency accommodation requirements:
  - Offshore down manning of MODU or FPSO; and

– Major oil-spill response & / or wildlife response.

11.3.3 Potential receptors

The ENVironmental Impact IDentification (ENVIID) workshop was used to identify those receptors upon which the impacts of resource competition warranted further investigation (Chapter 9)

Receptors that may be impacted by accommodation resource usage associated with the Phase 1 Development include:

- Human Population (in Stanley) (section 7.7.2); and
- Tangible Property (including utility services and infrastructure (section 7.7.4).

Any impact on utility infrastructure (e.g. provision of water utility services to residential accommodation), which may be classed as tangible property, will additionally impact upon the human population that is reliant upon it.

Further, inshore logistical support and associated accommodation requirements will be based within close proximity to Stanley, which is home to over 75 % of the Falkland Islands' population and the only location serviced by public utilities. Therefore, the assessment is based upon the human population of Stanley within the area covered by the Stanley Town Plan.

The assessment assumes a worst case accommodation requirement being resourced from within Stanley where the greatest levels of domestic competition are likely located. Personnel figures and the need for accommodation will continually be reassessed through the execute project phase and accommodation requirements may decline as operational logistics are finalised, also the potential for locally recruited staff would also reduce additional accommodation requirements. Current figures are assumed as a worst case scenario.

11.3.4 Characterising and quantifying the impact of accommodation resource competition

11.3.4.1 Nature of potential impact

Adequate accommodation is a basic human need and a necessity for all residents.

Within the scope of the current assessment, only the level of competition for housing resources will be considered. Whilst increased competition for housing undoubtedly has additional knock-on effects these are primarily socio-economic in nature, and further detail is not provided here. A fuller assessment of these associated impacts are covered by the Premier SIA, as described in section 7.7.

11.3.4.2 Quantifying the impact

In order to quantify the impacts of the Phase 1 accommodation needs on the Human Population and Tangible Property, it is necessary to have an understanding of the accommodation currently available in Stanley and to compare this to the Premier requirements, taking account of the accommodation that Premier intend to provide.

Full details on the baseline Stanley accommodation is provided in the Environmental and Social baseline (section 7.7.4.5.1), details on the Phase 1 Development needs and provisions are given in the Development Description (section 5.11.4.1). The key data are sumarised below.

Specifically, the following describes:

- Available accommodation in Stanley
- Phase 1 accommodation requirements;
  - Premier provision of accommodation;
  - Use of locally based personnel;
  - Proposals for accommodating long-term onshore personnel;
  - Development of new housing; and
- Stakeholder opinion.

11.3.4.2.1 Available accommodation in Stanley

Following the 2016 Census (FIG, 2017), the rental market in Stanley accounts for 36 % (367 households) of the housing stock whilst owner occupancy, including mortgaged premises, accounts for 58 % of the housing stock. The occupancy of these existing houses is relatively low at only 2.4 people / unit; and 70 % of the housing stock is detached housing units (FIG, 2017).

It is recognised that existing Stanley housing stock cannot meet either the volume or type of personnel accommodation needs of the Sea Lion Phase 1 Development due to:

- Low number of rental properties;
- Low density of existing housing type with predominance of detached properties; and
- Lack of flats and catered hostel type accommodation to suit and the needs of the oil and gas sector.

Within the exploration drilling campaigns, which were of a temporary nature, the accommodation of ‘long-term’ onshore personnel was fulfilled through private rentals within existing rental stock, which did serve to increase rental competition. At present, FIG housing lists are at capacity and residential building plots that have been released at Sappers Hill to date are fully subscribed (section 7.7.4.5). It is considered that there is an on-going shortage of affordable housing for purchase and rental, and that lack of housing provision already limits economic growth (Regeneris, 2013).

Current hotel bed-space is approximately 84 beds (section 7.7.4.5.1.3) and while hotels could be utilised to partially meet Premier needs, this would seriously impact tourism and other business sectors.

Further, in addition to the needs of the long-term resident population there is a significant existing demand from Work Permit Holders (WPH) who require rental accommodation for the duration of their contract. WPH are essential to the economy of the Falklands and fill many specialist management, technical, education and service sector posts across both the public and private sectors.

It is recognised by Premier that the existing accommodation is not sufficient to meet the needs for the Phase 1 Development, and thus has the potential to be a limiting factor with associated social impacts.

11.3.4.2.2 Phase 1 accommodation requirements

The peak demands for accommodation throughout Phase 1 are detailed in Table 11.21 below, alongside a description of the proposal for how these needs will be met. For the purposes of assessment the maximum in-flux personnel from overseas is assumed as this may represent the worst case scenario and the level of local recruitment for posts cannot be accurately quantified at this stage.

It is likely that a proportion of onshore personnel will be recruited locally in both permanent and temporary positions. The effect of local employment on accommodation provision is detailed in section 11.3.4.2.2.

The accommodation will likely have a central core requirement through-out the field life for onshore personnel, crew change delay and down-manning. Additional requirements to meet peak requirements in Stage 1 and Stage 2 may be removable. However, the exact configuration of accommodation is subject to solutions put forward through the contracting strategy and tender process. The fate and/or decommissioning of this additional surge accommodation once needs reduce is not yet confirmed and will be determined at that time.

Table 11.21: Estimated maximum accommodation requirement for personnel required during the Sea Lion Phase 1 Development

Personnel type	Accommodation Requirement [a]	Stage 1 42 months		Stage 2: 29 months		Stage 3: 17.5 years		Base-case provision of accommodation by Premier [d]
		Max no. people [b]	% Stanley pop [c]	Max no. people [b]	% Stanley pop [c]	Max no. people [b]	% Stanley pop [c]	
Permanent onshore personnel who live in Stanley (office, supply base, TDF)	The ability to accommodate all the personnel employed onshore will be required 9 months prior to the start of drilling activity and will endure for the duration of the Sea Lion Field life	35	1.4	35 [f]	1.4	30 [f]	1.2	Housing strategy to encourage private sector provision
Temporary rotational onshore personnel required during high intensity periods or stand-by personnel who live in Stanley for a short – medium period (a few weeks to a few months)	Routine and surge hostel-type accommodation for personnel employed onshore within support yards and logistics (on a 28 x 28 day rotation), who are on stand-by, and overnighting fixed wing air crew.	125	5	130	5.2	35	1.4	Temporary modular accommodation units initially provided by Premier, supplemented by local hotels. Transferring to in-transit accommodation as soon as available.
Offshore personnel (in transit) who require overnight accommodation prior to going offshore	Overnight hostel-type accommodation for personnel at the beginning and end of offshore rotations	60	2.4	50	2	30	1.2	In-transit accommodation unit provided by Premier. Maximum provision for 170, declining to 80 for Stage 3
Personnel down-manned to shore in the event of an emergency	Short term contingency accommodation in the event of an emergency down manning of the drilling rig or the FPSO. Required for Field Life	180 [e]		155 [e]		125 [e]		The above accommodation facilities can double up on occupancy for up three days
Visiting senior personnel	*Ad hoc* hotel accommodation	Not estimated as yet but anticipated to be similar to levels during the exploration campaign						None
Total requiring accommodation at any time		**220**	**8.8**	**215**	**8.6**	**95**	**3.8**	-

[a] Based on Premier's Sea Lion Phase 1 Development 'Accommodation Statement of Requirement' [b] Figures provided by Premier (Development Description, section **5.11.4.1**)
[c] Stanley population from the last census, 2,460 inhabitants (FIG, 2017). [d] See Development Description (section **5.11.4.1**) for detail
[e] Figures provided by Premier Logistics and Infrastructure Overview
[f] Reducing to 25 within 2 years after first oil

11.3.4.2.2.1 Premier provision of accommodation

Recognising the current pressure on housing stock and hotel accommodation, Premier is committed to provide accommodation that will meet the needs of:

- Rotational onshore personnel;
- Offshore personnel in transit; and
- Contingency accommodation in the event of a crew change delay or an emergency.

The contracting strategy will align with the Falkland Islands Local Content Code of Practice and accommodation provision will be tendered.

It is hoped that innovative solutions will be driven by the private sector and it is likely that all of the above accommodation needs may be serviced by 'hostel-type' accommodation. The location of new accommodation will take into account access and servicing requirements. Ideally the facility will have easy access to the By-pass / Airport Road to remove the need for transit through town and to provide easy access to the Temporary Dock Facility (TDF) and logistical bases, however this will be determined through tender and the Planning Permission process.

The hostel-type accommodation will be sufficient to provide contingency accommodation in the event of a crew change delay or an emergency because:

- Down-manning of the MODU or FPSO would be unlikely to occur coincidentally to crew change (2 days every fortnight) and hence transit accommodation would be available for down-manned personnel;
- All accommodation will be based on single room occupancy in normal conditions but will be equipped with a second fold-down bed to double accommodation capacity thus meeting full down-manning requirements;
- Durations of contingency accommodation requirement would be short as in extended down-manning it would be likely that crew would be flown out of the islands and repatriated on a specially chartered flight; and
- Use of additional vessel assets and third manning in rooms is feasible, though would not normally be required.

Planning policy is supportive of the provision of dedicated accommodation specifically designed for the requirements of the oil sector (FIG, 2015u). The Stanley Town Plan recognises the need to diversify the range of accommodation and supports, in principle, proposals for permanent structures to provide 'in-transit' and short-term surge accommodation on land identified and zoned for light industrial uses (FIG, 2015u).

Further, existing Stanley hotel accommodation will only be utilised for a small number of short visits e.g. by senior management, where hostel-type accommodation may not be suitable. This is foreseen to be at similar rates to those already experienced during exploration.

Therefore, at present, and as shown in Table 11.21, only longer-term onshore personnel, numbering approximately 35 at peak, are not covered by the bespoke accommodation provision. A specific housing strategy focused at promoting private sector provision will be adopted during sourcing processes and will be influenced by the degree of local versus expatriate personnel fulfilling these roles. In a worst case scenario this amounts to a 9 % rise in the number of Work Permit Holders requiring accommodation needs within Stanley.

11.3.4.2.2.2 Use of locally based personnel

Long-term residents holding either ‘Permanent Resident Permit’ or who have ‘Falkland Islands Status’ will already have access to accommodation. Therefore, the use of local personnel and transfer of employment might be considered as having no net effect on competition for accommodation. However, transferal of employment from a local position to Premier may require the local employer to source a Work Permit Holder (WPH) to fill the resultant vacancy. With an unemployment rate of just 1 %, and 18 % of the working population having double employment, there is a limited capacity for employers to recruit locally. Further, it is likely that those moving to Premier will be skilled and therefore the capacity to replace them from the local workforce may be limited. Therefore, it may be necessary for local employers to recruit externally if there is a significant movement of local personnel to the oil sector.

Ultimately, this would still result in a need for additional accommodation in Stanley, albeit now one-stage removed in impact from the O&G sector.

If, due to local recruitment into the O&G sector (rather than influx expatriate personnel), there is an increase in WPH accommodation requirements from third-party employers, the increase in competition may be greater in this case as occupancy rates would be lower resulting in a greater number of housing units being required.

In the worst case scenario all 35 permanent onshore posts will result in the need for more rental accommodation.

11.3.4.2.2.3 Proposals for accommodating long-term onshore personnel

With regard to the 35 onshore posts (declining to 30 during Stage 3) it is likely that some of these will be suited to more permanent housing rather than the purpose-built communal hostel units. Premier recognise that hostel-type accommodation may be less suitable for the low number of senior managers and longer-term technicians for whom self-contained flat accommodation, or housing accommodation shared by two personnel may be more appropriate. This would include;

- Premier Stanley office staff;
- Management staff of port facilities and yards;
- Contractor management staff;
- Helicopter personnel; and
- Component of onshore personnel remaining during Stage 3 field-life.

In addition, hotel or upgraded hostel accommodation may be appropriate for some staff that may be on a working rotation with only temporary periods of residence.

11.3.4.2.2.4 Development of new housing

Premier is committed to sourcing accommodation from available supply and potentially new build, however it is recognised that the supply side itself may respond as the project develops and this may be assisted by the contracting strategy to encourage provision of certain housing types appropriate to the needs of the O&G sector. Since the Phase 1 Field Development is long-term in nature, and thus more attractive to capital investment, it is expected that the private sector will support new build investment to fulfil these needs, encouraged and facilitated by the Premier contracting strategy in accordance with the Falkland Islands Local Content Code of Practice.

The Stanley Town Plan (FIG, 2015u) includes zoning for housing and residential areas with a potential capacity for up to 768 building plots identified (FIG, 2015). Thus, available land for residential building plots is not considered limiting for a demand of a maximum of 35 single units or 18 shared units (occupancy by two personnel) that may be of higher density incorporating flat or semi-detached properties.

Premier will encourage private sector market response through new development, rather than the use of existing housing stock, through pre-notification of housing needs to the private sector. The long-term contracting strategy will allow internal appraisal of whether tenderers / service contract providers can meet needs without potential impacts on the local market. The willingness of the private sector to meet such demands is already indicated by a number of outline planning applications for flats and mixed-use development that have already been progressed to Outline Planning Permission (including By-Pass / Kiel Canal Road, Dairy Paddock, Old Butchery / Mink Park, and Butchery Paddocks / ESRO Station (Chapter 7).

In summary, Premier will contract the construction / provision of transit accommodation and expect the private sector to respond to meet permanent onshore housing requirements.

11.3.4.2.3 Opinions of stakeholders

A review of stakeholder consultations with respect to scoping concerns is provided in Chapter 6.0 In general, queries relating to competition for resources and specifically accommodation related to information requests to provide further clarifications on personnel numbers whilst highlighting the current limited housing capacity available.

Further concerns were raised regarding timelines of construction and the need for aggregate, building supplies and construction labour if multiple infrastructure projects were to be progressed simultaneously. This fine scale planning detail is not available at present and lies outwith the scope of the current EIA, which is concerned only with development operations (section 2.4). Accommodation facilities will be subject to planning approval.

11.3.5 Industry-standard mitigation

Within larger economies, competition for resources is not generally considered to be significant as there is a country-wide network with the capacity to absorb and respond to increased demand. Therefore, no acceptable or permissible limits are set through industry codes of practice.

11.3.6 Impact and risk assessment

The following section draws upon all the information provided above to assess the ‘Sensitivity of the Receptor’ and the ‘Severity of Effect’ in order to determine the overall ‘Impact’ of planned activities. Assessment of unplanned events includes an assessment of the ‘Likelihood of Occurrence’ to determine the ‘Risk’.

A summary of the impact and risk assessment outcomes is tabulated in section 11.3.12 (Table 11.22), which shows the worst case impact / risk for each activity and receptor.

11.3.6.1 Impact assessment

11.3.6.1.1 In-transit, routine and surge accommodation

Premier appreciates that accommodation may be a limiting factor with regard to community resources.

As described above, the project basis of design includes the provision of high-density hostel-type accommodation units to house 'in-transit' and rotating onshore personnel within the planning and contracting scope of the development. These units are factored in to the impact assessment such that the arrival of 'in-transit' and rotating onshore personnel are expected to have **no impacts** with regards to competition for accommodation, as need will be met by a dedicated accommodation solution. As the accommodation provision will be separate from domestic housing the **sensitivity of the receptor** (of both Tangible Property and the Human Population) is considered to be '**Low**'.

As capacity will be designed to meet full onshore and transiting offshore personnel needs the **severity of effect** (on both Tangible Property and the Human Population) is considered to be '**Slight**'.

Therefore, the overall impact is considered to be '**Very Low (2)**'.

11.3.6.1.2 Impact of onshore (expatriate or local) personnel on Stanley's housing stock

Given current housing capacity in Stanley, there is limited capacity to absorb additional accommodation needs (section 7.7.4.5.1). Only a small number of personnel (*c.* 35) will be required to permanently live in Stanley and it is anticipated that these needs may be met by a contracting strategy that will promote and encourage housing built by the private sector. Dual occupancy or flat accommodation will reduce unit needs for expatriate personnel. Therefore, reliance on the existing housing stock is expected to be minimal and short term in nature until the private sector responds to increase supply and is not considered to be unmanageable or unsustainable. Further, the population is likely to be tolerant of the change without detriment to its character. Therefore, the **sensitivity of the receptor** (of both Tangible Property and the Human Population) is considered to be '**Low**'.

The provision of transit accommodation by the private sector will be actively promoted and managed within the development programme to ensure that the solutions are largely based upon bespoke accommodation rather than existing housing stock. However, there will be some short-term competition for rental accommodation in the early stages of Development, until the market responds and supply increases to meet demand. Therefore, the **severity of effect** (on both Tangible Property and the Human Population) is considered to be '**Minor**'.

Therefore, the overall **significance of the impact** of competition for accommodation on the resource of housing stock within Stanley is considered to be '**Low (4)**'.

11.3.6.2 Risk assessment

11.3.6.2.1 Contingency accommodation needs

The design of the purpose built accommodation is such that it incorporates full capacity requirements for contingency accommodation in the event of a down-manning or environmental incident (section 11.3.4.2.2.1).

Therefore, existing transit, routine and surge accommodation could be used to accommodate sufficient numbers of personnel in the short-term and there is anticipated to be **no risk of impact** from Phase 1 emergency events should they occur.

11.3.7 Project-specific mitigation measures

Project-specific mitigation measures are not proposed at this stage. Rather monitoring of accommodation use and socio-economic impact on the rental market will be incorporated within both the FIG Social Effects Monitoring Programme and Premier Socio-Economic Monitoring and Management Plan.

At present, Premier is reliant upon the private sector responding to the need for a small number of single flat-type units. Given the durations of the Sea Lion Development it is highly likely that this would occur; if monitoring shows that this has not occurred, private investment and development can be further stimulated by the contracting strategy and accommodation tender specification to encourage new provision over existing housing stock.

11.3.8 Residual impacts and risks

The impact of Sea Lion Phase 1 Development accommodation needs on Stanley's housing stock (Tangible Property) and the Human Population is considered to be '**Low**' such that there is no need for a residual assessment.

11.3.9 Cumulative impact

The assessment considers all direct project personnel and their accommodation needs. Included within the assessment is the potential effect of personnel drift from the local labour market to the O&G sector. This is considered an indirect impact as, were an external person on a work permit basis required to back-fill the post (vacated by the local individual) they will then have a requirement for local accommodation. It is assumed that market forces of supply and demand should respond to such needs. However, as demand levels (e.g. 'concentration', see section 8.10.1) are harder to forecast given the uncertainty in the likely level of local recruitment, it is expected that, at least in the short-term, some level of negative socio-economic impact may occur with respect to rental availability and values until markets respond.

With increased personnel active and passing through the Falkland Islands, there will be associated expansion in economic activity and other service sectors, this will undoubtedly require a commensurate increase in population and the amount of accommodation required. However, any impact of wider increased economic activity is outwith the scope of the current assessment. Such an assessment has previously been undertaken by FIG (Regeneris, 2013) and included as a component within the SEMP (Regeneris, 2015).

11.3.10 Confidence

Personnel accommodation needs have been defined. Planning policy is specifically supportive of hostel-style accommodation on land zoned for light industrial use and similar, temporary accommodation during exploration rounds has been approved and proven to be acceptable. Higher density flat accommodation has been identified as appropriate for residential areas and a number of speculative planning applications have been approved for outline planning permission. This shows the proactive willingness of the private sector to meet accommodation demand.

However, at the time of writing the accommodation contracting process has not yet been initiated and thus the final designs have not yet been confirmed nor progressed through planning controls by the contracted service provider. While assumptions can be made regarding private sector uptake of opportunities for rental development, these discussions have still to be conducted.

The level of confidence in the impact and risk predictions and efficacy of mitigation is therefore '**Probable**'.

11.3.10.1 Monitoring required

For a small proportion of the accommodation needs of onshore personnel Premier is reliant upon the private sector rental market to respond to contracting strategy calls for development of rental accommodation units. Monitoring of private rental use and indicators of rental competition are ways in which this can be monitored. If monitoring shows that competition may become an issue, private investment and development can be further stimulated by the contracting strategy and accommodation tender specification to encourage new provision over existing housing stock. All monitoring requirements agreed by Premier will be recorded and managed via the project-specific Phase 1 Socio-Economic Monitoring and Management Plan (SEMMP).

11.3.11 Offsetting

As no residual impacts or risks identified in this section are considered significant, i.e. Moderate or above, offsetting is not considered (see section 8.9).

11.3.12 Findings summary

Table 11.22: Summary of the impact assessment for accommodation resource competition

Activity / Event	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance[a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Accommodation for onshore surge personnel, in transit personnel and down-manning contingency provision	Need to accommodate transitory personnel	Competition with domestic housing needs	Planned	1, 2 & 3	Low	Slight	n/a	Very Low (2)	**n/a**	**Probable**	**Industry-standard:** None. **Project-specific:** None proposed.
Accommodation for semi-permanent, management and technical onshore personnel	Need to accommodate permanent personnel	Competition with domestic housing needs	Planned	1, 2 & 3	Low	Minor	n/a	**Low (4)**	**n/a**	**Probable**	**Industry-standard:** None. **Project-specific:** None proposed.

[a] See Chapter 8 for definitions of sensitivity, severity, likelihood and significance.

11.4 Resource Competition – Fresh Potable Water

Table of Contents

11.4.1 Introduction

Onshore infrastructure associated with the Development will require connection to the existing Stanley water utilities. In addition, onshore water supply (supplied from the at-shore Temporary Dock Facility (TDF) to the support vessels for transfer offshore) will support a proportion of water use by offshore assets including vessels and the Mobile Offshore Drilling Unit's (MODU) drilling requirements for muds, cements, brines and domestic use.

The Falkland Islands Government (FIG) is the single water utility supplier and the Stanley water filtration plant has a fixed capacity, limited by the existing infrastructure. Fresh potable water is therefore considered a limited resource and any use of fresh water above the current baseline usage has the potential to lead to competition with the local users in Stanley. Both the carrying capacity of existing infrastructure and competition for resources were raised as a concern during the scoping consultations (Chapter 6).

This chapter assesses the impact of the Phase 1 Development by comparing the forecast water use with the level of water available. The forecast difference between development demand and the current excess capacity determines the level of competition. The assessment relates to fresh potable water processed and supplied through the Stanley filtration plant. Some process usage and drilling does not require potable water, however as all freshwater supplied from shore in Stanley is from a potable main and no alternative unprocessed freshwater main system is available; all reference to water is assumed to be potable fresh water unless stated otherwise.

Note: As described in section 2.4, socio-economic impacts are out of scope for this EIS and Premier has conducted a separate Socio-economic Impact Assessment (SIA), building on and updating the previous work undertaken for FIG and Rockhopper by Regeneris (2013 & 2015) and Plexus (2012). Therefore, this assessment focuses on the social impact of competition for water on the human population and tangible property as receptors, and not any secondary, economic, implications of such competition or use of property.

Note: impacts related to competition for other resources e.g. accommodation, electricity etc. are described elsewhere in this document, as described in section 9.2.

11.4.1.1 Relevant legislation

Resource competition specifically is not legislated for within any Ordinance or Regulation. However, as was agreed during the consultee scoping workshop with FIG in 2015 (Chapter 6), the impacts of competition for resources such as water was considered to be within the scope of the EIS as defined by the EIS guidance (EPD EIA Guidance Note (FIG, 2015m).

11.4.2 Sources of freshwater use and competition for resource

Water may be used onshore by support services activity and infrastructure, or provided through the TDF to vessels for offshore use. Specific sources of freshwater use during the Phase 1 Development include:

- Drilling offshore by the MODU (section 5.4);

- Production offshore by the Floating Production, Storage and Offloading vessel (FPSO) (section 5.8);
- Use of vessels (section 5.11.2):
  - Multi-Role Support Vessels (MRSV) as MODU and FPSO supply vessels for the movement of materials and equipment;
  - MRSV for use in offshore Emergency Response and Rescue Vessel (ERRV) for the MODU and FPSO;
  - Construction and installation vessels (section 5.11.2);
  - Coaster vessels; and,
  - Inshore floating logistics vessels (LTVs) (section 5.11.2); and
- Onshore / At-shore usage;
  - TDF which is the point of delivery for offshore usage, although there will be minimal usage by the TDF directly (section 5.11.1.1.1);
  - Onshore laydown yards, storage bases and associated offices (section 5.11.1.2);
  - Personnel accommodation (section 5.11.4.1.1); and
  - Heliport aviation support (section 5.11.3).

11.4.2.1 Drilling

The MODU will require water for domestic use as well as for the drilling and cementing process, the mixing of drilling muds, brines and cement, well suspension, sweeps and completion. Freshwater used for drilling activity does not require to be potable water and buffer storage in TDF tanks that may not be certified for potable water storage is permissible.

It is anticipated that the MODU will be equipped with a desalination plant (water-maker), as was the *Eirik Raude* used during the 2015 drilling campaign. However, the water-maker is intended mainly for rig utilities and accommodation and is not sufficient to meet the specification of water needs required for drilling fluids. Indeed, the experience of exploratory drilling campaigns suggests that allowance for drilling requirements should be made from onshore freshwater sources. Note that while some drilling muds may be mixed onshore for shipment to the MODU by a supply vessel this does not modify total usage.

11.4.2.2 Production and the FPSO

During production, the FPSO will require water for domestic use and marine and topsides systems. It is estimated that the FPSO will require 60 m^3/day and to meet this need it will carry a water-maker. It is anticipated that the FPSO will be able to produce enough water to meet its own demand and thus be self-sufficient in water. Since water volume availability is critical for the process, water-maker volume requirements and redundancy will be incorporated within the FPSO design. In the event of complete failure of the water-makers, it is likely that water could be sourced, in the short term, from other vessel water makers and / or a large standby of bottled water from the supply base. Failing this, the FPSO would shut down until the water-makers could be reinstated.

Therefore, process water use on the FPSO is not factored into the following impact assessment with regard to competition for Stanley water resources.

11.4.2.3 Use of vessels

The numerous vessels required throughout the different stages of the Phase 1 Development will all require water for onboard domestic and vessel use. It is anticipated that the majority of vessels will have water-makers on board, though at times some net deficit and opportunistic tank top-up would be expected. Therefore, it is possible that these vessels will take on water at the TDF for delivery to the FPSO for domestic use in the event of water-maker failure and / or to supply the MODU in the event of water-maker failure. A nominal amount based upon exploration experience has been assumed for vessel usage and included within the assessment.

11.4.2.4 Onshore / At-shore usage

The resources onshore will require water for domestic and general usage such as cleaning. However, with the exception of the muds and brine plant that is included within offshore drilling estimates (Stages 1 and 2), no major onshore process use is expected. As described above, the at-shore TDF will act as a conduit supplying shore-side water to offshore assets via the supply vessels.

11.4.3 Potential receptors

The ENVironmental Impact Identification (ENVIID) workshop was used to identify those receptors upon which the impacts of resource competition warranted further investigation (Chapter 9)

Receptors that may be impacted by the use of the Stanley freshwater supply during the Phase 1 Development include:

- Human Population in Stanley (section 7.7.2); and
- Tangible Property (e.g. fresh (potable) mains water supply; section 7.7.4.5.2)

Interdependence exists between the two receptors. Any impact on the water supply will additionally impact upon the human population that is reliant upon it.

The onshore logistical support services (e.g. the TDF, supply base, offices etc.) and associated accommodation will be based within close proximity to Stanley which is the only location serviced by public utilities and where the majority of the population resides. Therefore, the following assessment is based upon the human population of Stanley and confined to the area within the coverage of the Stanley Town Plan and the public mains supply system.

11.4.4 Characterising and quantifying the impact of resource competition for water

11.4.4.1 Nature of potential impact

Water is an essential human requirement and access to clean fresh water can be considered as a basic human need and right.

As is detailed in the Environmental and Social Baseline Description (section 7.7.4.5.2), potable water supply is provided to Stanley through a single source water filtration plant. To safeguard against single point system failure, the Public Works Department (PWD) are remitted to hold two-days water supply in storage tanks. However, no alternative supply is available and water usage has been increasing in Stanley since 1980 (section 7.7.4.5.2.1).

The untreated (i.e. rain) water supply line from Moody Brook, where the dual catchments join, to the central Stanley filtration plant, was installed *c.* 1989. But since this time (1986), Stanley households have increased to a last recorded 1,026 households in Stanley in 2016 (FIG, 2017). The overarching trend indicates that Stanley water consumption is increasing with population growth.

Therefore, in practical terms, water must be treated as a limited finite resource.

11.4.4.1.1 Potential for water shortages

With a single point supply, limited by the finite supply rate and thus finite supply volume of the raw water delivery pipe from Moody Brook, the provision of potable water to Stanley residents and other commercial users is vulnerable to any increase in demand. Specifically, impacts to the local users may arise from:

- Increases in the volume of demand; and
- Increases in the rate of demand.

Increased volume of demand (m^3) may cause:

- Production deficits leading to temporary water restrictions to residents and commercial users;
- Draw down of storage tanks and loss of contingency reserves making users vulnerable to any short-term production interruption (the Public Works Department (PWD) are remitted to hold two-days water supply to safeguard against single point system failure);
  - Without excess processing capacity, subsequent recharge of reserve tank storage may take an extended time;
  - Loss of water quality if tanks are fully drawn down and tank and system sediment enters the system.
- Increased wear and tear of filtration plant infrastructure operating at capacity for extended periods in a system vulnerable to single point failure.

Increased demand rates (m^3/hr) may cause:

- Draw down of storage tanks if demand extraction rate exceeds processing refill rates, leading to possible water quality contamination through re-suspension of tank sediments and staining; and
- Loss of mains pressure to other users on a series spur main in extreme cases as water takes the path of least resistance to the greatest outlet.

11.4.4.1.2 Nuisance to other users

In addition to domestic users, commercial and high-volume users which may be affected by the above include:

- Falklands Interim Port and Storage System (FIPASS);
- Abattoir;
- Fish processing plants;
- Stanley Growers market garden (horticulture);
- Hillside MoD residential camp;
- Hotels;
- Public houses; and
- Car wash.

Nuisance to domestic users and logistical and financial implications to other commercial users may be caused by:

- Restriction in volume of water available;
- Reduction in mains pressure;
- Reduction in supply rate; and
- Reduction in water quality and clarity.

11.4.4.2 Quantifying the impact

When quantifying the potential for water shortage, and therefore impacts to other users, it is necessary to consider:

- Current freshwater supply *versus* current Stanley demand:
  - Current Stanley freshwater operating system;
  - Stanley freshwater use; and
  - Impact of past exploration drilling campaigns.
- Phase 1 freshwater provision and mitigations; and
- Estimated Phase 1 net water demand:
  - Estimated volume demands; and
  - Estimated rate demands.
- FIG 'workarounds'.

11.4.4.2.1 Current freshwater supply versus current recent demand trends

11.4.4.2.1.1 Current Stanley water operating system

The recent expansion of the Stanley water operating system to include a second rainfall catchment has increased catchment collection capacity by 60 % (section 7.7.4.5.2.2). Therefore, rainfall catchment is no longer considered to be a limiting factor and the source of supply is now considered secure and continuous year-round. However, despite this improvement, the total supply volume has not actually changed as it is still limited to a single supply pipeline with a *maximum* delivery rate of 55-60 m^3/hr from Moody Brook to the Dairy Paddock untreated Reservoir (DPR) with the current pumps and working pressures. (section 7.7.4.5.2.2). Working within this limiting factor, this impact assessment is based upon the following baseline operating system:

- The DPR is replenished (at the maximum rate of 60 m^3/hr) for a minimum of 14.5 hours each day to ensure the reservoir remains in balance i.e. the DPR receives 870 m^3/day from the catchment sources); and
- The manned water treatment (filtration) system at the DPR is operated at rate of 60 m^3/hr (so that water in and water out of the DPR are balanced) over the current 14.5 hour working day (and is therefore able to deliver 870 m^3/day to Stanley as necessary).

Note: there are a number of potential 'workarounds' that could be adopted by FIG to increase the baseline level of water available without capital investment. However, since these would require the DPR to operate on a daily cycle of temporary deficit followed by recharge within a 24 hour period, and since the DPR is an integral component of the Stanley two-day contingency supply, the use of these options would be at the discretion of FIG and outwith Premier's control. While this assessment assumes the current baseline level of water availability, the alternative 'workarounds' are summarised in section 11.4.4.3 below.

11.4.4.2.1.2 Stanley water use

Over the 22 year period between 1995 and 2014, annual average Stanley water consumption rose by 55%; from 492 m^3/day to 763 m^3/day. Stanley thus exhibits a long-term increase in water usage of approximately 2–3% per annum. Water used peaked in 2015 during oil exploration activities at 946m^3/day and subsequently dropped back in 2016 and 2017 to 860m^3/day, lower than the 2015 peak but in-line with the underlying average increasing trend in Stanley water usage (Figure 11.8).

With a daily supply limited to 870m^3/day under current standard working conditions the 2017 usage figure of 860m^3/day shows that there is only 10m^3/day of excess production capacity and that supply and demand is in equilibrium. With the forecast of continuing past growth of 2-3% p.a. water usage is extrapolated to pass current working practise limits in 2018/19 and overtime working has been required. (section 7.7.4.5.2.2).

11.4.4.2.1.3 Impact of past exploration drilling campaigns

As described above, water use in 2014 (in the absence of oil exploration activity) was 763 m^3/day. In relation to the baseline operating capacities of 870 m^3/day this provides an excess capacity of just 107 m^3/day. Therefore, a resultant 14 % increase in demand would exceed current capacity and require changes in working practices.

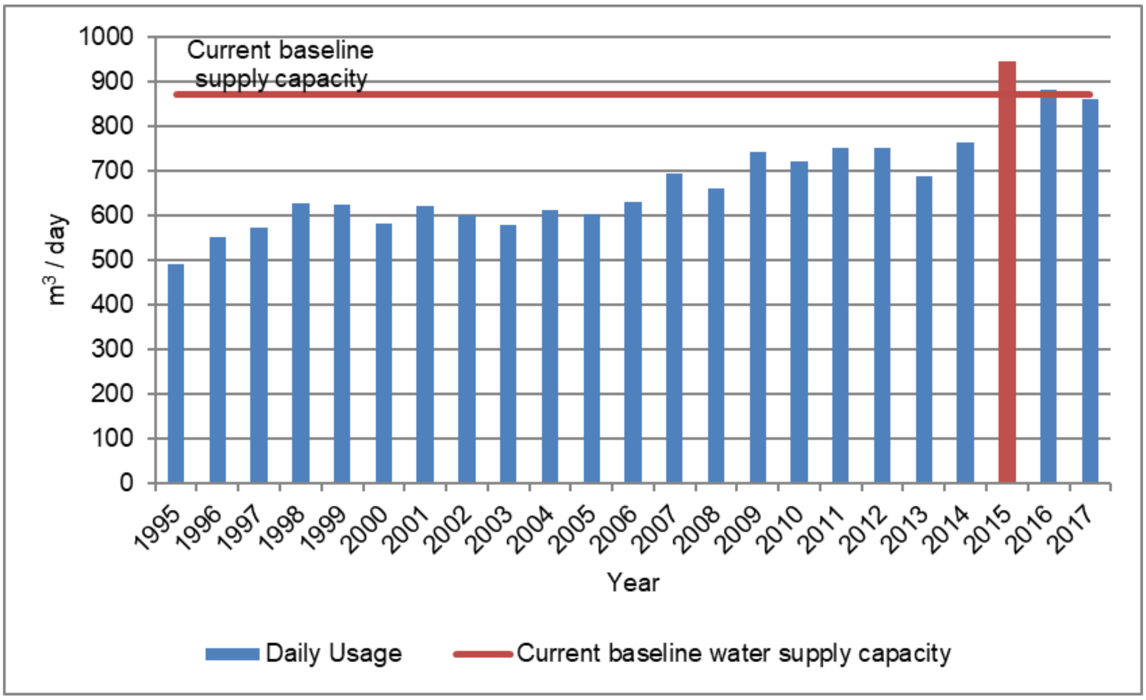


Figure 11.8: Average daily water consumption (m^3/day) by year from 1995 to 2017

Relating to past exploration rounds, annual average daily consumption figures for Stanley show peaks in 1998-99, 2010-12 and 2015 (Figure 11.8 above). Previous estimates by FIG suggest that *Ocean Guardian* (2010-12) and *Leiv Eiriksson* (2012) resulted in increases over the base water demand of *c.* 10-16 %. The spike in demand between 2014 and 2015 when the *Eirik Raude* was active was 24 % (183 m^3/day). While these overall figures represent all economic activity and may not be wholly attributable to oil development, they do serve to provide an indication of the likely overall trend associated with increasing Oil and Gas (O&G) activities. However, even if not attributed to and not associated to O&G activity, the additional increase would still represent an increase in Stanley domestic usage that would limit available excess capacity for O&G development usage.

During the last oil exploration campaign in 2015-16 the current standard filtration capacity was surpassed for the first time, leading to an average daily consumption of 946 m^3/day in 2015 (Figure 11.8 above).

This signifies that for periods of time, despite the base case mitigations used within the exploration rounds, it was necessary to extend the working day and pumping durations of the filtration plant and to operate the DPR with a temporary daily deficit.

11.4.4.2.2 Phase 1 base case mitigations

A number of measures have been built-in to the basis of design for the Phase 1 Development with regard to minimising the reliance on water from local resources. These are similar to those that were used for the 2015 exploration drilling campaign. However, it should be noted that while these mitigations can serve to reduce the water demands of any O&G campaign, they do not serve to eliminate the need for ‘top-up’ from the local water supply, as is evidenced by the above. A description of the base case mitigations, and the potential limitations of these measures is described in Table 11.23.

Table 11.23: Mitigations built-in to the Phase 1 Development basis of design

Built-in mitigation	Location	Background and description	Benefits and limitations in practice
MODU water-makers	MODU	All offshore assets will be equipped with desalination plants. Capacities and redundancy will be incorporated within design and contracting requirements, such that all should be largely self-sufficient in water provision. As described in section 11.4.2.2, the FPSO is the greatest long-term user of fresh water which is critical for both onboard processing and safety systems. Complete failure of water systems would result in shut-down of processing rather than drawing upon onshore resources.	While full offshore requirements need not be met by the Stanley supply, exploration usage would suggest a precautionary approach and therefore a contingency to take on water for vessel tank top up and the drilling needs of the MODU is included, as was required during the exploration drilling campaign (section 11.4.4.2.1.3). These estimated figures are however lower than were observed during the exploration campaigns mainly due to use of oil-based muds. Shut-down of the FPSO in the event of complete failure of water-makers and all other water sources would impact upon the operation but not upon onshore supplies.
FPSO water-makers	FPSO		
Vessel water-makers	All vessels		
Construction of a freshwater holding and header tank	Bulk water storage may be incorporated within; TDF hull tanks; mud/bulk plant header; and/or dedicated buffer tank in at-shore tank farm adjacent to the TDF causeway	The design assumption is that the header tank will have sufficient capacity to balance demand such that needs can be leveled off to a steady daily requirement. The project will likely incorporate a minimum of 3.5 days storage plus a contingency, based upon two vessel visits a week. The exact combination and volumes of the tanks will be determined within FEED.	Storage tanks do not reduce the overall quantity of water required. Storage only levels daily demand to the averaged constant demand such that daily spikes in demand, e.g. a vessel visit taking on 400 m^3, can be excluded from the consideration and only average demand assessed. The volumes of the tanks have yet to be confirmed and this will determine which of the 3 bulk storage options are used. The potential use of 3 storage options will provide flexibility to balance demand. Storage within the TDF is limited to non-potable process water for drilling. Further analysis of needs will determine whether this measure should be extended to give sufficient supply for the contingency of two vessels berthing in close proximity to take on water.

Built-in mitigation	Location	Background and description	Benefits and limitations in practice
Voluntary restrictions i.e. daily limits to store and buffer against water draw-down.	TDF	During exploratory drilling, a voluntary limit of 100 m^3/day at a supply rate of 10 m^3/hr was applied. TDF usage during exploration was sporadic and determined by the number of vessel visits. A volume of >100 m^3 of water was drawn on 24 % of days, whilst zero water was drawn on 42 % of days. Therefore, it can be seen that there is the potential to store a proportion of the 100 m^3 daily limit on days when full volume is not required, and thus buffer the drawdown against demand spikes. This has additional benefits as tanks can be refilled at the lower rate of 10 m^3/hr as a 'trickle' feed (which safeguards against a mains pressure drop to other users and against Stanley header tank level drawdown), but pumped to vessels above mains rates to reduce berthing durations. Water volumes are thus accumulated in advance at sustainable rates.	A close working relationship with the water department is required and a daily update of forecast water needs must be provided to assist with demand planning and Stanley header tank volume balancing. Through this liaison the voluntary limit may be exceeded on occasion if supply conditions permit. In consultation with FIG, appropriate limits and a liaison procedure can be established.
Sustainable design	Supply base, accommodation units	Potential to incorporate sustainable design features including: Water conservation design (low volume showers and toilet flush, shut-off timers, visible overflows so leaks are detected, etc.). and, Grey water recovery.	A *per capita* consumption of 300 litres / person / day is assumed. This is a conservative estimate and with water efficient design it is hoped to reduce domestic water use to the lower UK equivalent of 150 litres / person / day.
Salt-water substitution	Offshore drilling	Offshore drilling estimates assume use of process freshwater for drilling, cementing, well suspension and completion. However there is the potential to use salt-water in some components such as sweeps.	The investigation of where salt-water is appropriate to process will be continued through FEED and this will reduce offshore water demand for drilling activities from shore sources.
Alternative water sources	TDF and offshore	Whilst drilling usage requires freshwater it does not necessarily require fully treated potable water. In extenuating circumstances it may be possible to source raw untreated freshwater from alternative sources (for example the dual catchments sustain greater volumes than is supplied to Stanley) and to transfer raw water to the TDF by tanker. Any vessels coming into Falkland Island waters can do so with full water tanks	Stanley water filtration plant is the only source of treated potable water available on-island however pumping from raw water reservoir catchment source to a tanker may substitute for process water needs in extenuating circumstances.

11.4.4.2.3 Forecast Phase 1 freshwater usage

The Phase 1 Development freshwater usage has been estimated with consideration of water usage data from the 2015 exploration campaign. A full breakdown of the net water usage data from the 2015 exploration drilling campaign has been undertaken.

In forecasting the Phase 1 Stanley water usage, the use of construction batch plant buffering, the mud plant header-tank, TDF barge storage and possible dedicate buffer tank storage (if calculated volumes demand) will allow daily water use to be buffered and levelled to the average daily water use. It is therefore possible to ignore peak single day usage that occurred during exploration (e.g. a vessel taking on water) and consider only average figures.

In addition to average use figures over the entire period or Development Stage, peak *period* figures are also considered. Peak period figures are distinct from single day usage spikes as they consider the average daily use over a period of a month and take the highest expected monthly daily usage within each Development Stage. Due to the extended period of a month it is not possible to fully buffer against extended supply deficit and thus water supply must be able to cope with the demands of the highest period within each Stage.

Estimates were made for:

- Water volumes required by the Phase 1 Development; and
- Water usage rates during the Phase 1 Development.

11.4.4.2.3.1 Estimated volume demand

Both the highest average water demand and peak periods of direct water demand occur during Stage 1 (pre-first-oil drilling) and Stage 2 (simultaneous drilling and production operations), as would be expected during active drilling requirements and higher personnel demands during these two stages. Average water demand directly attributable to the main infrastructure centres ranges from 92 - 103 m^3/day, which is just within the excess Stanley capacity of 107 m^3/day that would be available for O&G development. Peak period usage ranges between 103 - 170 m^3/day, which would exceed current capacity.

During Stage 3 (steady state production), direct water use drops to between 39 m^3/day – 41 m^3/day and is within sustainable limits for supply.

In addition to the directly attributed water usage by the main infrastructure centres, a range of indirect uses could further increase demand such as:

- Increased water use by supply and services (e.g. laundry, heliops, etc.) as a result of increased personnel in Stanley; and / or
- Coincidental increases in water use due to other economic sectors or diversification.

During exploration, these associated services accounted for an average of 81 m^3/day over and above the directly attributable and metered centres. During the *Eirik Raude* exploratory campaign in 2015 the allocated O&G usage increased the overall Stanley water usage by 13-18 %. However, the overall Stanley usage spike during the same period was 24 % such that an additional 11 % increase in water usage may be attributable to activities *associated* with O&G.

However, there is a degree of uncertainty in the data regarding unattributed sources of water use.

Nonetheless, whilst the exact contribution of O&G activities to wider water use is unknown, all unrelated and domestic sources of increase to baseline water usage would still reduce the excess water capacity available.

In summary, while it is not possible to fully attribute associated water use, if levels during the Development are similar to those observed during exploration then average water use will certainly exceed current capacities in Stage 1 and Stage 2, and will likely exceed that in Stage 3 also. Additionally, the available spare capacity will decrease each year as Stanley exhibits an increasing water use trend (as Stanley use increases, excess decreases) so extrapolation to Stage 3 may not be fully accurate.

Table 11.24: Estimated shore water used by the Sea Lion Development by activity centre

Activity	Exploration 2015		Assessment	Stage 1		Stage 2		Stage 3	
	Average (m^3/day)	Peak [a] (m^3/day)		Average (m^3/day)	Peak [a] (m^3/day)	Average (m^3/day)	Peak [a] (m^3/day)	Average (m^3/day)	Peak [a] (m^3/day)
Offshore Demand (supplied from TDF)									
MODU drilling requirements inc. bulks, mud and brines	69	90	Drilling Estimates	33	87	21	21	0	0
Vessel requirements			Tank-top up allowance	10	10	10	10	10	10
FPSO (60 m^3/day)	n/a	n/a	Self-sufficient @ 60 m^3/day	0	0	0	0	0	0
Onshore Demands									
Laydown yards and warehousing	2.2	2.2	Exploration with proportional increase	7	7	7	7	2	2
Bulk, mud & brine storage	0	0	Included in offshore drill estimates	0	0	0	0	n/a	n/a
Personnel and accommodation	31	48	Per capita rate of 300 l/pp/day[c]	53	66	54	65	27	29

Activity	Exploration 2015		Assessment	Stage 1		Stage 2		Stage 3	
	Average (m^3/day)	Peak [a] (m^3/day)		Average (m^3/day)	Peak [a] (m^3/day)	Average (m^3/day)	Peak [a] (m^3/day)	Average (m^3/day)	Peak [a] (m^3/day)
Offshore Demand (supplied from TDF)									
Total demand vs. supply capacity									
Total O&G Demand	**102**	**140**	-	**103**	**170**	**92**	**103**	**39**	**41**
Percentage increase in Stanley usage (%)	13	18	-	13	-	12	-	5	-
Unallocated associated activity demand (**Note**: Only a proportion of this may be directly attributable to O&G activity)	*81*	-	Based on observed 2014 - 15 exploration total usage increase of 183 m^3/day (24 %)	*81*	-	*81*	-	*81*	-
Total forecast demand	**183**	**-**	-	**184**	**-**	**173**	**-**	**120**	**-**
Maximum Available Spare Capacity (for comparative purposes)	**107**	**-**	-	**107**	**-**	**107**	**-**	**107** [b]	**-**

[a] Peak usage relates to the month with the highest daily average usage during drilling and to accommodation during peak in-transit crew exchanges.

[b] Note the available spare capacity will decrease each year as Stanley exhibits an increasing water use trend (as Stanley use increases, excess decreases) extrapolation to Stage 3 may not be fully accurate.

[c] This is a high estimate and is used to account for observed direct & indirect increase in demand during exploration well campaign.

11.4.4.2.3.2 Estimated rate demands

In addition to total average consumption, consideration of daily spikes in water use (m^3/day) and usage rate (m^3/hour) can also be important.

The TDF and FIPASS are currently supplied from the Murray Heights low-level tank with a capacity of 1,232 m^3. Daily spikes or rapid utilisation (m^3/hr) in excess of refill rates may cause:

- Drawdown of the tanks;
- Reduction of reserves;
- Risk to water quality if tank sediment is re-suspended; and
- Reduction in mains pressure to other users in a worst case scenario.

It is useful to review the actual water demands during the recent exploration drilling campaign as a realistic guide. It should be noted, however, that the proposed development wells will use oil-based mud in the lower sections rather than water-based mud so overall water demand will be lower, and batch sequencing (section 5.4.5.2) will lead to continuous use of the mud systems which minimises pit cleaning requirements.

Whilst the TDF showed an overall average utilisation of 55 m^3/day during the *Eirik Raude* exploratory campaign, periods of higher daily usage were recorded. Daily usage ranged from 433 m^3/day (a single incident of accidental leakage caused by human error) or 306 m^3/day (actual operational peak demand), to zero when vessels were absent. During a number of periods extending for up to 21 days the average water use increased to 137 m^3/day, and monthly daily averages reached 90 m^3/day.

A voluntary limit of 100 m^3/day was applied during exploration with greater volumes requiring specific authorisation from the water section. Greater than 100 m^3 of water was drawn on 24% of days and zero water was drawn on 42% of days.

This favourable ratio of zero-use / under-use promotes the feasibility of using storage tanks to accumulate water during low demand to buffer against high demand on single days. Indeed, a similar system was used during exploration with water accumulated and stored within the TDF tanks. However, the system used during exploration would need to be refined and formalised for Development usage, as whilst tank storage onboard the TDF was utilised to buffer demand, pre-storage of water was not always possible when:

- Vessel water needs were not pre-notified;
- Vessels berthed in quick succession; and / or
- Potable water was required (TDF tanks limited subsequent water use to process water).

However, with dedicated potable water tanks, a robust system to maintain tank levels and pre-notification needs, these issues should be resolved.

Therefore, Premier has committed to the use of buffer storage tanks (section 11.4.4.2.2). Buffer storage can be provided within the TDF hull tanks, and as a header tank to the mud plant with the potential for additional dedicated buffer tanks in the at-shore bulk supply base. The necessary capacity of the tanks will be calculated based on the average daily demand which should ensure that daily spikes can be accommodated. Therefore, spikes in usage and the associated risks to supply can be excluded from the assessment.

During exploration, drawdown was voluntarily and nominally limited to 10 m^3/hr, this was to ensure that pressure drops to other users did not occur and that both FIPASS and the TDF could supply water at the same time. Higher rates (up to 45 m^3/hr) are feasible on the current mains system and were on occasion utilised. However, higher rates could compound tank drawdown issues and could only be achieved through careful coordination with the PWD water section to ensure tank volumes were maintained.

A loop main, programmed within FIG capital works budgets, that would connect the TDF and FIPASS to both the low-level system (as at present) and the high-level system (by extending the main from the laydown yards) would assist with balancing demand and rate because:

- Drawdown can be balanced from both tanks by:
  - Selecting the tanks with greatest stored volume; and
  - Sequentially drawing from both tanks, limiting depletion of any one tank.
- Drawdown from both tanks also allows both tanks to be filled from the filtration plant, thus maintaining peak filtration rates rather than having to prioritise just one tank for refill that would reduce filtration output to a single mains capacity;
- Supply can be split between TDF and FIPASS allowing both to take water at once from different systems without jeopardising mains pressure;
- High-level system has greater pressure-head, diameter and supply rate; and
- The additional proposed increase in high-level Sapper Hill storage tanks within the FIG capital program could be used to further buffer demand and also partially remove the DPR as a component of the mandated 2-days of supply hence facilitating additional overnight processing in the future.

11.4.4.3 FIG ‘workarounds’

As indicated in section 11.4.4.2.1.1 above, there are alternative solutions to increase the baseline level of water availability in Stanley, which are currently outwith Premier’s control.

At present, a filtration rate of 60 m^3/hr has been utilised as this is the supply rate of raw water from the rainwater catchments to the DPR. However, the filtration clarifiers can operate up to a peak of 77 m^3/hr (assuming relatively clear raw water and an output to both high and low level tanks).

To achieve this higher rate, water must be taken from the DPR at a faster rate than the DPR can be refilled from the catchment sources resulting in a deficit of 17 m^3/hr. Over a 14.5 hour day the accumulated deficit within the DPR would be 246 m^3. Whilst the water clarifiers must be attended by an technician during the staffed 14.5 hour day, the DPR can be unattended such that the deficit could be replenished overnight by ‘leaving the tap on’ for approximately four hours.

Thus, by operating a 24 hour system of temporary reservoir deficit followed by overnight recharge to achieve continuous maximum filtration through the day, an additional output of 246 m^3/day could be achieved and bring total Stanley supply up to 1,116 m^3/day. This would exceed any forecast demand from both Development usage and Stanley demand. It would not require additional capital investment or increased staffing, only the formalisation of using the DPR, which is a component of the Stanley two-day contingency supply, at a temporary deficit. However the role of the DPR as a component of the two-day contingency supply will be diminished with the programmed addition of additional high-level storage tanks on Sappers Hill, further increasing the viability of the cycling-drawdown method.

In addition to the above, with increased staffing levels and an extension of the processing day beyond 14.5 hours, even greater increases in capacity could be achievable. This optimum strategy would be to allow an 18.7 hour processing day with 5.3 hours of overnight recharge (totalling 24 hours) as with a longer processing day there would not be sufficient time for the DPR to replenish overnight. The total supply in this scenario could reach up to 1,440 m^3/day which is in excess of any forecast demands.

However, the above assumes that the filtration clarifiers can sustain the higher 77 m^3/hr peak rate when in fact, this rate may have to be reduced if the:

- Raw water quality is low such that the filters need to be taken off-line more frequently for cleaning. This can occur and is more common in winter when higher run-off in the catchments causes peat staining and sedimentation in the catchment rivers; or
- Pumping of the clarifier output is restricted to only one of the two Stanley header tanks, restricting output pipeline capacity to almost half.

If 77 m^3/hr cannot be sustained for any reason, then even at the supply rate of 60 m^3/hr capacity, increases in supply could still be achieved by extending the processing day beyond 14.5 hours, though to do so for extended periods would require a re-analysis of staffing needs.

These modified systems have already been used by the Water Section in the past to respond to periods of higher demand, most notably during the last exploration campaign. Supply was increased by using the reservoir deficit and / or staff working on temporary overtime.

Additional further actions have been proposed by the water section and are at varying stages of planning and budgetary consideration including (D. Roberts, *pers. comm*.);

- Additional clarifier in parallel would increase processing capacity beyond 77m^3/hour and provide increased redundancy,
- Increased high-level storage tanks on Sapper Hill to increase buffer capacity, to increase component of two-day contingency storage and increase duration of processing pumping of the clarifiers to storage thus maintaining 77m^3/hour process rates for longer.
- Upgraded pumping pressures and line improvements from Moody Brook to DPR. The current pump rates of 55-60m^3/day is the process limiting stage. Testing with higher pressures has been completed up to 90m^3/hour, a 50% improvement to current supply that would remove all potential supply conflicts however higher capacity pumps and an upgraded line would be required to maintain increased pressures in the long-term.

However, to utilise these ‘workarounds’ in the longer-term during the Development Stages would need the consent of FIG and is outwith the sole control of Premier. Premier will liaise closely with FIG to ensure that mutually acceptable systems are in place for oil readiness such that domestic supply is not jeopardised.

11.4.5 Industry-standard mitigation

Within larger economies there is generally a country-wide network with the capacity to absorb and respond to increased demand. This is especially true of water distribution that works within a national supply grid. As competition for resources is not generally significant, no industry-standard mitigations or Codes of Practice exist. Nonetheless, within the Falkland Islands, FIG operate systems to safeguard the water supply for domestic and commercial users in Stanley.

11.4.5.1 FIG water prioritisation

Regardless of trends in supply versus demand, the FIG Water Section is tasked with maintaining a two-day supply of stored potable water. To safeguard emergency services and domestic users in the event of a production failure, a system of user prioritisation would be applied.

Light-industrial use is prioritised at the lowest level and would be the first to have supply restricted. The likely order of restriction would be TDF, FIPASS, Public Works Department (Megabid).

As such security of water supply is a greater risk to development activity than to domestic users. If water usage was excessive at any time, the supply to the Development infrastructure would be cut before there was any impact to the domestic sector.

However, it should be noted that while this mitigation safeguards the human population, it may not be sustainable as a valid or reliable longterm 'mitigation' with regards to the Phase 1 Development if water demands cannot reliably be met and fall below requirements.

11.4.6 Impact assessment

Assessment of the impact of water use is challenging as it is understood that water availability can be managed in different ways by FIG, which could effectively alter the baseline against which this assessment is made. This is outwith Premier's control and the below assesses water use against the existing baseline. However, a separate assessment is also provided for Stage 1 (which requires the highest water use) assuming the use of the various FIG 'workarounds' to demonstrate the benefits (section 11.4.4.3).

The following section draws upon all the information provided above to assess the 'Sensitivity of the Receptor' and the 'Severity of Effect' in order to determine the overall 'Impact' of planned activities.

A summary of the impact assessment outcomes for this Development is tabulated in section 11.4.11 which shows the worst case impact for each activity and receptor and details are provided below.

11.4.6.1 Impact assessment assuming current Stanley operating system

11.4.6.1.1 Water use during Stage 1 and Stage 2

Stage 1 and Stage 2 are assessed together as both incorporate active drilling demands and increased personnel, and the forecasted average water demands are similar (section 11.4.4.2.3).

Without changes to work practices and hours of operation the Stanley water supply is already at near capacity and for short durations may operate at temporary deficit. The forecasted average water use by the Development during Stages 1 and 2 is 103 m^3/day and the peak daily use is 170 m^3/day (section 11.4.4.2.3.1). In 2014 prior to the last period of oil exploration the excess capacity in the Stanley water supply estimated at only 107 m^3/day (section 11.4.4.2.1.2), and thus even based upon these pre-exploration Stanley usage figures the Development demand is expected to exceed supply. This is supported by the fact that usage did indeed exceed supply in the 2015 exploration campaign (section 11.4.4.2.1.3) and required a responsive change in FIG working practices to meet the short-term increased demands. Adding to this the indirect and unallocated water use which was *c.* 81 m^3/day during the 2015 exploration (section 11.4.4.2.3.1), must also be considered and thus, with this additional indirect usage then even at average levels, the capacity of the system will be exceeded.

Furthermore, with the number of households in Stanley increasing (section 11.4.4.2.1.2) along with general diversification of the economy, there is a long-term trend of increasing annual water usage of 2-3% per annum. Recent usage figures from 2017 show that supply and demand is now in balance with little or no excess capacity (±10m3/day excess and deficit) under current working practices.

While the Stanley population and other water consumers will be prioritised by FIG in the event of water shortage or system malfunction (section 11.4.5.1) and the use of buffer tanks will reduce the risk of any demand spikes and associated drawdown in mains header tanks, there is still the potential for nuisance to other users (section 11.4.4.1.2). Further, the above shows that with the ever-increasing Stanley usage, the existing water supply may not sustain the Development in the long-term. Therefore, the **sensitivity of the receptors** (Human Population and Tangible property) is considered to be '**Very High'**.

Restriction in supply or reduction in water quality through tainting caused by tank drawdown (section 11.4.4.1.1) would be considered negatively. The consumers most likely to be impacted would currently be those on the low-level mains system predominantly in central Stanley, along the harbour front and FIPASS that share the same low-level supply tanks at Murray Heights as the TDF. However, since the whole of Stanley is reliant on a single filtration plant with potential single point failure, any significant issue could have wider knock-on effects. The effects would generally be short-term and reversible, however with supply / demand in equilibrium, any unplanned usage or human error could cause impacts and tank-draw down may take several days or weeks to be fully recharged to capacity. Anecdotally, during exploration the accidental drawdown of one header tank took over a month to refill due to the equilibrium between demand and supply and insufficient excess to refill the tank (S.Cockwell, *pers. comm.*). While development usage through Stages 1 & 2 is not significantly different from exploration usage (offshore demands decrease but onshore demands increase relative to exploration), the system is currently operating at near capacity and average daily demand exceeded supply during the previous exploration campaign (section 11.4.4.2.1.3). The ability to respond to increased demand or recover from tank drawdown is limited and the ability to maintain two full day's supply at all times may be restricted. Options to increase capacity (filtration), regulate demand (buffer storage) and reduce use have been identified, and the use of buffer storage has been committed to by Premier (section 11.4.4.2.2). However, as full analysis of required tank volumes has not been confirmed, and since tank storage does not change the overall used volume but only buffers against demand spikes, the inherent capacities of the production system remain valid. Since it is currently FIG operating policy to restrict water supply to light industrial uses before any effect is transferred to domestic users, there is a degree of insulation from impact. However, if sustained deficit occurs this restriction may not be sustainable for either the human population or the development needs beyond a short-term response to temporary shortage. Therefore, the **severity of effect** of water usage on the Human population and the effect on Tangible property is considered to be '**Serious'**.

The overall **significance of the impact** of water use on the Human population and the impact on Tangible property during Stages 1 and 2 is therefore considered to be '**High (20)'**, and consequently project-specific mitigation measures to reduce the significance will be developed and implemented.

11.4.6.1.2 Water use during Stage 3

The impact assessment of Stage 3 must look forward 20 years and with uncertain predictions for the future growth of Stanley any associated increased water usage all predictions become less certain with increasing length of forecast (section 11.4.4.2.1.2).

The sensitivity of the receptor is the same as described above. Water use by the Development will have decreased but Stanley usage may well have increased in line with ongoing trends (section 11.4.4.2.1.2) and therefore there is uncertainty in the level of buffering capacity. Therefore, the **sensitivity of the receptors** (Human population and Tangible property) is considered to be '**Very High**'.

At commencement of Stage 3, upon cessation of drilling operations and simultaneous operations, the offshore water requirements drop to only vessel top-up and the onshore personnel numbers also reduce. Whilst forecasted direct usage drops, it is likely that Stanley usage will continue to increase over the intervening years and hence, since supply and demand became matched in 2017 with only 10m^3/day disparity, the forecast direct and indirect total associated usage of 120 m^3/day will still exceed supply. (section 11.4.4.2.3.1). However it should be noted that even with the historical trend of 2-3% per annum increase in Stanley usage the current capacity of 870m3/day will have been surpassed with or without the additional of the development demand and hence it is very likely that FIG will have already changed work practises or invested in capital improvements as detailed within the "work arounds" and hence the supply will also have changed relative to the demand making any prediction uncertain. This is addressed within Cumulative Impacts (section 11.4.9)

Given the closer equilibrium between forecasted supply and the forecasted demand, any deficit is likely to be of short duration, most likely associated to crew change within a two day period thus allowing time to accumulate water in the storage tanks. This ensures there will be some buffer against nuisance to the human population (section 11.4.4.1.2). Therefore, the **severity of effect** of water usage on the Human population and the effect on Tangible property is considered to be '**Moderate**'.

The overall **significance of the impact** of water use on the Human Population and the impact upon Tangible Property during Stage 3 is therefore considered to be '**Upper Moderate (15)**' and consequently project-specific mitigation measures to reduce the significance will be developed and implemented.

11.4.6.2 Impact assessment assuming FIG 'workaround'

The following is an assessment of the impact of water use during the peak period of demand (Stages 1 and 2) assuming the application of FIG 'workarounds'.

The use of the base case mitigations (section 11.4.4.2.2) can reduce the Development's water demand but a significant reduction in both the sensitivity of the receptors and the severity of effect can only be achieved by increasing the capacity in the supply. This can only be achieved by FIG.

Utilisation of the higher filtration rates and / or the extension of working hours up to the theoretical maximum of 18.7 hours could increase capacity by up to 60 % above current levels which would be well in excess of any current forecast demands (section 11.4.4.2.3). The increased buffer would insulate domestic users from any potential nuisance (section 11.4.4.1.2) and increase the robustness of the supply system thus reducing the potential for water shortages (section 11.4.4.1.1) and raising the point at which any deleterious impacts would be noticed.

As water is essential to daily human life and all economic activity, the underlying inherent sensitivity of the Human population as a receptor cannot be fully reduced despite the fact that the above considerations will provide greater robustness. Further, with regard to Tangible Property, the above workarounds may lead to greater wear and tear on the system and higher maintenance requirements and therefore, on balance, the **sensitivity of the receptor** (Human population and Tangible property) can only be reduced to '**High**'

Increased supply in excess of the demand significantly reduces the likelihood that any negative impact will occur and should any impact occur, due to higher processing capacity, the system and storage volumes can be rapidly recovered. Therefore, the **severity of the effect** to the Human Population and Tangible Property can be reduced to '**Minor**'.

Thus, with base case and FIG measures in place **the significance of the impact** of water use on the human population and tangible property would be reduced to '**Moderate (8)**'.

11.4.7 Project-specific mitigation measures

Premier will work closely with FIG to ensure that water utilities are developed and water use is suitably controlled as part of 'oil-readiness' planning. As described in section 11.4.4.3, a number of 'workarounds' that could mitigate against impacts to the human population are identified.

These will require liaison and cooperation between the public utility sections of FIG and Premier in order to best meet increased demands without impacting domestic residential supplies or commercial sector usage.

Project-specific mitigation that is within Premier's control is primarily based around planning and logistics.

11.4.7.1 Offshore planning & supply logistics

All planning will remain cognisant of the need to minimise water requirements and will continue to identify where water efficiency can be improved and usage minimised. There are many actual and potential measures within Premier's control that can be instigated to balance or offset demand at peak times, including:

- Ensure reliability of water supplies is built into project design premise and operational processes/contingencies, to avoid environmental impacts from unnecessary shutdowns or slowdowns.
- Put in place and monitor offtake limits to the Supply Base and TDF (daily average volume and instantaneous rate, precise figures to be agreed with FIG);
- Communicate to FIG water department significant demand points within the overall schedule;
- Replacement of potable water with seawater where possible (e.g. tophole sweeps), this would significantly reduce drilling fresh water demands (section 5.11.4.2.7);
- Potential to have the MODU pre-supplied with full water on delivery and use of storage capacity onboard the MODU;
- Importation of water to the MODU using additional incoming vessels that arrive with full fresh water tankage onboard; and
- Specify that some items will come pre-filled with inhibited water during subsea installation to reduce additional flushing needs. In some applications sea-water can be used in replacement for fresh water.

11.4.8 Residual impacts and risks

11.4.8.1 Stage 1 and Stage 2 residual impacts

While the added project-specific mitigations may lessen reliance on the Stanley water system, additional mitigation focused on reduced use does not actually change the inherent sensitivity of the receptors (Human population and Tangible property) which remains '**Very High**'.

However, as regards the severity of effect, the further reductions that will be identified through the FEED process in offshore logistics will reduce reliance on shore supplies further. This will insulate current domestic usage from impact. Although not specifically a mitigation measure, monitoring of water use will highlight any issues early and allow water use to be restricted early prior to any widespread effect occurring. Furthermore, by reducing usage further, the duration of any effect will be less as the supply will be able to recover faster. Therefore, the **severity of effect** of competition for water usage will reduce to '**Moderate**'.

The overall **significance of the impact** of water competition on the human population is therefore reduced to '**Upper Moderate (15)**'.

11.4.8.2 Stage 3 residual impacts

All additional project-specific mitigation measures address planning and logistics to reduce water use during the drilling phases such that there is no change to the assessment within Stage 3 and the significance of the impact remains '**Upper Moderate**'.

11.4.8.3 FIG 'increased capacity scenario' residual impacts

All additional project-specific mitigation measures address planning and logistics to reduce water use during the drilling phases such that there is no change to the assessment that assumes increased FIG capacity and the significance of the impact remains '**Moderate**'.

11.4.9 Cumulative impact

Competition for water as a resource is not only incurred by O&G activities and there is the potential for cumulative impacts via increased 'concentration' (section 8.10.1). Indeed, even if oil development usage remains constant, competition may still increase if domestic or other economic sector usage increases. Between 1995 to 2017, Stanley usage has increased by 74% from 492 m^3/day to 860 m^3/day and continues to rise. Forecast growth in water usage is difficult to predict and will depend upon socio-economic factors, but longterm historic trends would suggest an annual increase in water demand of between 2 to 3 % per annum. Further, past exploration rounds have shown an approximate 6 – 8 % increase in water use above base levels that cannot be directly attributed to O&G infrastructure use, but may relate to associated services and increased economic activity.

It can be assumed that oil development will bring associated wider economic growth that will in turn result in greater water demands. With a finite cap on water volumes, competition is likely to increase over the duration of the project even if direct water use within the project remains constant. However, this will be buffered against as once steady state production is reached (Stage 3) water demands will drop as without drilling usage the offshore demand will almost cease with only contingency for support vessel top-up. The peak demand of the development is short-term at less than 5 years.

11.4.10 Confidence

There are a number of uncertainties within the above assessment. These are as follows:

- While the requirement for a buffer storage capacity has been included within the base case mitigations, the tank volumes have not yet been defined and although they will be based upon the forecasted, and conservative, daily averages their efficacy will depend upon the accuracy of the forecast;
- While the yard area and accommodation bed capacities have been determined, the final design and incorporation of sustainable technologies, which may lessen water demands, have not been finalised;

- The exact cause of unallocated water use increase and the proportional contribution that may be associated to the wider O&G stimulated activity is difficult to quantify with certainty; and
- The Stage 3 assessment is based on the assumption of continued growth in water usage of c. 2 % which may change.

Therefore, the level of confidence in the impact assessment and the efficacy of mitigation is therefore considered to be **'Uncertain'**.

11.4.10.1 Monitoring required

Use of onshore water supply will be monitored at all infrastructure locations and will be included within the EMMP for on-going assessment to identify any emerging issues at an early stage. Detailed monitoring requirements have been established during the Environmental Monitoring and Management Plan (EMMP) workshop. All monitoring requirements agreed by Premier and FIG will be recorded and managed via the project-specific Phase 1 EMMP (an outline EMMP is provided in Chapter 15).

Offsetting

For significant residual and impact and risks (Moderate or above), offsetting via an Environmental Fund is proposed, see section 8.9 for further details.

11.4.11 Findings summary

Table 11.25: Summary of the impact assessment for water use resource competition during the Sea Lion Phase 1 Development

Activity / Event	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance[a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Phase 1 impact assessment											
Water use for MODU drilling, vessel top-up, onshore yards and accommodation	Competition for water resources	Restriction of water supply and/or quality	Planned	1 & 2	Very High	Serious	n/a	**High (20)**	**Upper Moderate (15)**	**Uncertain**	**Industry-standard:** End user prioritisation; Buffer tank capacity and voluntary restrictions; Offshore desalination; **Project-specific:** Sustainable design; and Offshore planning.
Water use for offshore vessel top-up, onshore yards and accommodation			Planned	3	Very High	Moderate	n/a	**Upper Moderate (15)**	**Upper Moderate (15)**	**Uncertain**	

Activity / Event	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance[a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Supplementary impact assessment assuming use of FIG 'workarounds'											
Water use for MODU drilling, vessel top-up, onshore yards and accommodation	Competition for water resources	Restriction of water supply and/or quality	Planned	1 & 2	High	Minor	n/a	**Moderate (8)**	**Moderate (8)**	**Uncertain**	**Mitigations outwith Premier's control:** End user prioritisation; Capacity increase (FIG); and Mains upgrade (FIG/PMO).

[a] See Chapter 8 for definitions of sensitivity, severity, likelihood and significance.

PremierOil

11.5 Resource Competition – Electricity

Table of Contents

11.5.1 Introduction

Onshore and at-shore infrastructure in support of the Phase 1 Development will require connection to the existing electrical power grid of Stanley for energy requirements. Stanley power station (owned and managed by FIG) is the single energy utility supplier and has a fixed power capacity from a finite number of generators and a series of wind turbines. Energy can thus be considered a limited resource.

Both the carrying capacity of existing infrastructure and competition for resources were raised as a concern during the scoping consultations (Chapter 6).

This chapter investigates forecast energy use and compares it to the power capacity and current level of Stanley energy demand. The forecast difference between Phase 1 Development demand and the current excess power capacity is used to inform the assessment.

Note: impacts related to competition for other resources e.g. accommodation, water etc. are described elsewhere in this document as described in section 9.2.

11.5.1.1 Relevant legislation

Resource competition is not legislated for specifically within any Ordinance or Regulation and therefore no statutory limits are defined through legislation.

However, as was agreed during the consultee scoping workshop with FIG in 2015 (Chapter 6), the social impacts of competition for resources such as electricity was considered to be within the scope of the EIS as defined by the EIS guidance (EPD EIA Guidance Note (FIG, 2015m).

11.5.2 Sources of onshore energy use

Sources of energy use and thus resource competition during the Phase 1 Development include:

- Temporary Dock Facility (section 5.11.1.1.1);
- Potential shore-power hook-up for berthed vessels at night (only MRSVs will have this capability);
- Onshore laydown yards, storage bases and associated offices (section 5.11.1.2);
- Accommodation (section 5.11.4.1):
  - Transit accommodation: and
  - Rental accommodation.
- Heliport aviation (section 5.11.3.1.2); and

The majority of the above are the same in terms of the energy uses, e.g. lighting, heating etc. However, it is important to note at this point that the shore-power hook-up for berthed vessels (MRSVs) at night is new and is included as a mitigation against the potential impact of onshore noise (section 11.8). This impact is currently assessed as low and vessel noise is not predicted to cause a nuisance at the nearest residential properties, nevertheless the factors leading to a noise nuisance are complex and will be reviewed depending upon further monitoring and the balancing of impacts of noise versus energy use. However, in line with the EPD EIA Guidelines

(FIG, 2015m), it is included within this assessment to ensure that the worst case has been assessed with regard to energy use.

11.5.3 Potential receptors

The ENVironmental Impact IDentification (ENVIID) workshop was used to identify those receptors upon which the impacts of resource competition warranted further investigation (Chapter 9)

Receptors that may be directly and indirectly impacted by power usage associated with the Phase 1 Development include:

- Tangible Property (finite power supply) (section 7.7.4.5.5); and
- Human Population (in Stanley) (section 7.7.2).

A degree of interdependence exists between the receptors as any impact upon power utilities (Tangible Property) will also impact upon the Human Population that is reliant upon it.

The assessment is based upon the human population of Stanley and is confined to the area within the coverage of the Stanley Town Plan and Stanley power station supply. Onshore and at-shore logistical support services, and associated accommodation, are or are most likely to be, based within close proximity to Stanley.

11.5.4 Characterising and quantifying the impact of onshore energy use

11.5.4.1 Nature of potential Impact

Electrical energy is provided to Stanley through a single power and distribution network. No alternative supply is available. Installing a local (renewable) power supply at the onshore supply base was rejected by Premier as they will be buying electricity off the grid so have no incentive to install local power. Power and energy usage is therefore capped by the existing generator capacity and thus, in a practical sense, electricity can be considered as a finite resource (section 7.7.4.5.5).

The contribution of wind-power is discounted from this assessment as it is dependent upon meteorological conditions and cannot be fully relied upon. If there is no wind there is no power and needs must be able to be met by diesel generator capacity alone.

With a single point supply and finite capacity, energy provision to Stanley residents and other commercial users is vulnerable to increased or excessive demand. Unlike water where buffer storage capacity may insulate users from temporary supply issues, any interruption or over-load to the electrical system will cause immediate impact.

Increased demand may cause:

- Increased wear and tear of generation infrastructure operating at capacity for extended periods in an aging system which is vulnerable to single point failure;
- Operating at, or near, capacity removes spare stand-by generator capacity to buffer against generator drop-out or demand spikes, potentially causing temporary black-out or power surges;

- Spikes in power use within the distribution grid may cause over-load of distribution transformer boxes and / or generator surge causing black-out to users on a shared electrical main; and
- Power surge and drop out may damage modern electronics; computers, communications and even domestic appliances (such as kerosene heating and gas cooking) now largely rely upon an electric power source for operation.

All of the above may impact upon the availably of the finite resource (electricity) to the end users, thus impacting upon Tangible Property and the Human Population.

11.5.4.2 Quantification of energy use

In order to assess the sensitivity of the power grid to increased demands it is necessary to understand the baseline electrical capacity. To quantify the baseline it is necessary to consider both the overall amount of energy available (kWh), as well as the peak power (kW) available at any given time. Therefore, electrical capacity needs to be considered in terms of the:

- 'Overall energy use' - this is the total energy (power use over time) used over the course of the day and is measured in KiloWatt hours (kWh) or units (1 kWh = 1 unit); and
- 'Peak power demand' - this is the maximum amount of power required at any given moment in a day and is measured in KiloWatts (kW).

Overall energy use is the metric used to understand the difference between normal electrical usage and the increased overall use when oil and gas (O&G) operations are occurring. However, as a metric, 'overall energy use' cannot tell us the whole story as it is also necessary to understand how much electrical power may be available at any one moment in time. As electricity must be supplied instantaneously with no storage potential, and since energy use is not uniform through the day, it is the increase in peak power demand that is critical to assessing the ability of a system, and the available generators, to supply enough electricity.

The key question is: if all users 'switched the lights on at the same time', could the capacity of the existing Stanley power supply cope with the total demand?

Therefore, the following section describes:

- Current overall energy use (including exploratory campaigns);
- Forecast Phase 1 energy use relative to existing supply use; and
- Peak Phase 1 power demands and output.

11.5.4.2.1 Current energy use (including exploratory campaigns)

The average daily energy use taken over the last seven years (2013-2019) is 47,246 kWh/day.

Within the seven year data set, the lowest average daily energy use (averaged over the year) was 44,308 kWh/day in 2013-14, during which there was no oil exploration activity. The highest equivalent exploration use was 51,162 kWh/day in 2015-16 which saw eight months of exploration activity (Figure 11.9). This suggests past exploration campaigns have shown an increase of *c.* 16 % (rounded up) of the overall daily average Stanley energy usage from the immediately preceeding year without exploration (Table 11.26).

Some caution in attributing increased energy use and power demand to only oil exploration activities must be exercised as whilst there was a 16% increase in overall energy usage between 2013-14 (without exploration) and 2015-16 (with exploration), in subsequent years usage did not return to former levels prior to exploration activities and remained at +11% in 2016-17 and +6% in 2017-18 suggesting that a component of the increases is also due to increasing residential and economic diversification activities. However to provide a conservative and "worst case scenario" the current assessment assumes that the full increase was attributable to the direct and indirect effects of oil exploration activities. Therefore through-out the assessment the percentage energy use increases and the peak power demands between the immediately preceeding years and the 2015-16 Eirik Raude exploration campaign will continue to be used over recent data as it is believed to be a better direct comparison and the more conservative.

As would be expected, energy use varies by season. Table 11.26 shows the weekly units of energy used throughout the year, showing peaks in the austral winter months with higher peaks in the latter half of 2014-15 and through 2015-16 when the *Eirik Raude* exploration campaign was underway. Overall there was an 18 % increase in winter maximum energy use and a 19 % increase in summer minimum energy use during the year with active exploration (Table 11.26).

Table 11.26: Maximum and minimum weekly energy use in a year with, and a year without, oil exploration.

Year	Year 2013/14 (Without oil exploration)			Year 2015/16 (With oil exploration)			% increase in energy use
	Occurrence	kWh / week	Average kWh / day	Occurrence	kWh / week	Average kWh / day	
Average daily energy use	n/a	n/a	44,308	n/a	n/a	51,162	+16
Peak weekly usage	Week 41 6 Apr - 13 Apr	349,404	49,915	Week 12 6 Sep - 23 Sep	412,300	58,900	+18
Minimum weekly usage	Week 27 30 Dec - 6 Jan	249,380	35,626	Week 28 6 Jan - 13 Jan	297,410	42,487	+19

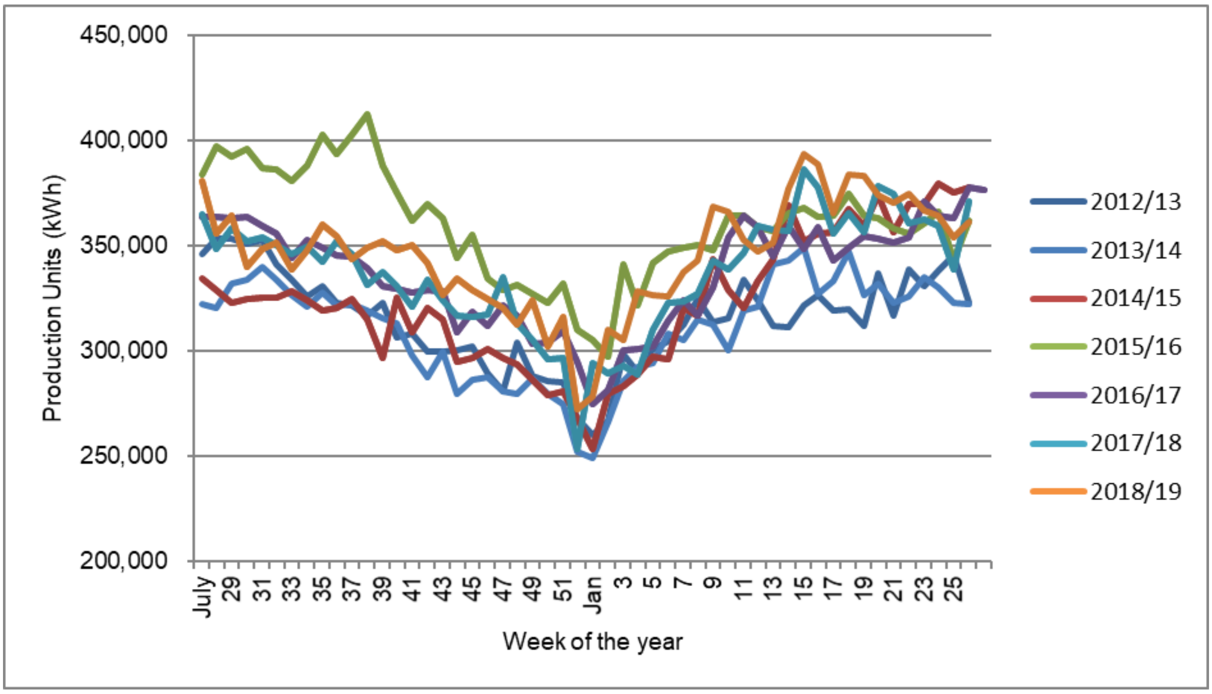


Figure 11.9: Weekly energy use (kWh/week) for period 2012 – 2019.

11.5.4.2.2 Forecast Phase 1 energy use relative to existing supply use

11.5.4.2.2.1 Data sources

The data used to forecast energy use during the Phase 1 Development are largely based upon recorded energy use during the 2015 *Eirik Raude* exploration drilling campaign. These data were extrapolated according to the expected changes in area or personnel numbers during the Development. Full detail on the forecast figures for energy use are presented in section 5.11.4.3 and summarised below (Table 11.27).

11.5.4.2.2.2 Energy use during exploration rounds

During exploration, direct usage by the four main exploration infrastructure centres (TDF, laydown yards, accommodation unit, and heliops hanger) had an average total daily usage of 3,025 kWh, representing a 7 % increase in pre-exploration Stanley usage (Table 11.27 below). However, as described above, overall Stanley usage increased by 16 % during the 2015 drilling campaign.

For the purposes of this assessment it is presumed that the remaining 9 % increase in usage can be attributed to contracted services (such as laundry, rental accommodation, offices) and associated increases in wider economic activity (hotels, restaurants, general services, water pumping, etc.), which may or may not have been fully associated with the exploration campaign. A proportion of the increase may have been down to an unrelated residential and economic activity such as fishing industry cold-storage and this alternative may be supported by the fact that post-exploration usage did not revert and decrease to former levels but remained at between +6 % to +11 % above the baseline levels in subsequent years, suggesting that there may be a general underlying increase in usage. Despite this unknown, it is prudent to consider a contingency for such usage within the impact assessment. An increase in utility use of c. 16 %

would appear consistent with other services such as water usage that increased by comparable amounts.

11.5.4.2.2.3 Forecasted Phase 1 Development energy usage

While the development infrastructure centres will essentially be the same as those used during exploration, there are three main differences:

- During Stages 1 and 2, the onshore supply base will be three times larger than that used during the exploration campaign, this will be in place for approximately four years;
- During Stage 3, steady state production, the onshore supply base will decrease in size to approximately 61 % of the area used during the exploration campaign; and
- Potential for shore-power connection for berthed vessels as a mitigation against at-shore noise from vessel generators (section 11.8) - included in this assessment to ensure worst case energy use assessed.

As shown in Table 11.27, the change in the size of the supply base throughout the Development has minimal effect. However, the potential addition of shore-power use by vessels, albeit at night and off-peak, is significant. Whilst the other infrastructure centres all require moderate usage, the use of shore-power by vessels could add an additional 7.6 % increase to Stanley usage (a conservative estimate based on continuous peak loads). Therefore, based upon the overall increases to the supply base, accommodation requirements and shore-base vessel hook-up, Phase 1 energy usage may total 21 % of current Stanley usage in Stages 1 and 2, and 14 % in Stage 3 (Table 11.27). It should be noted that as the population of Stanley grows, so will electricity demand, meaning the percentage overall spare capacity may be lower (assuming there is no increase to available electricity supplies, such as the new interim generators that should go on-line in 2020 or the planned for new power station, for the duration of the Sea Lion project).

As described above, and to take a precautionary approach, an additional 10 % has been added to the attributable total to account for the additional, but unattributed, power use in contracted services and wider economic activity that may result from O&G activity. It could be argued that these unassociated increases should be proportional to the Phase 1 Development increase, however, as the exact cause of the extra 9 % usage increase observed during exploration is not known, a nominal addition is made. Therefore, as shown in Table 11.27, the maximum (and very conservative) overall increase in energy usage is 31 % over and above the baseline Stanley usage during Stages 1 and 2 of the Development. Given the marginal difference between the increases during Stages 1 and 2, and Stage 3 (31 % and 24 % respectively), and the fact that the electrical system must be considered robust against peak energy use throughout the Stages, the Development Stages are not separated out hereafter.

Finally, with the exception of vessels using the shore-connection, Phase 1 daily usage is likely to follow the same annual energy use curve as overall Stanley usage with winter peaks occurring due to the usual increased demand for lighting and heating.

Table 11.27: Summary of exploration use and forecast Phase 1 energy use

Facility	Exploration usage (kWh / day)		Proportionate increase in development usage expected	Forecast Phase 1 usage	
	kWh / day	% Increase to Stanley usage [a]		kWh / day	% Increase to Stanley usage [a]
Stages 1 and 2					
TDF base load	125	0.3	None	125	0.3
Shore-power vessel connection (off-peak) [b]	n/a	n/a	Theoretical maximum based on 280 kW for 12 hours [c]	3,360	7.6
Laydown yards	358	0.8	Increase in area x 3	1,100	2.5
Accommodation facility	1,653	3.7	Increase in maximum personnel numbers x 2.2	3,668	8.3
Heliops base	889	2	None	890	2
Attributable total	**3,025**	**7 %**	**Attributable total**	**9,143**	**21 %**
Unattributable contribution [d]	**-**	**9 %**	**Unattributable contribution**	**-**	**10 %**
Total	**-**	**16 %**	**Precautionary total**	**-**	**31 %**
Stage 3					
TDF base load	125	0.3	None	125	0.3
Shore-power vessel connection (off-peak) [b]	n/a	n/a	Theoretical maximum based on a 280 kW equivalence [a]	3,360	7.6
Laydown yards	358	0.8	0.61 % of existing yard area	218	0.5
Accommodation facility	1,653	3.7	Personnel numbers comparable to exploration	1,653	3.7
Heliops base	889	2	None	890	2
Attributable total	**3,025**	**7 %**	**Attributable total**	**6,246**	**14 %**
Unattributable contribution [d]	**-**	**9 %**	**Unattributable contribution**	**-**	**10 %**
Total	**-**	**16 %**	**Precautionary total**	**-**	**24 %**

[a] Assuming Stanley usage in last year without O&G exploration: 44,308 kWh/day in 2013/14.

[b] This may not occur and given the location of the TDF, and the muffling of modern on-board generators, the level of noise nuisance is likely to be low (section 11.8). Noise monitoring will be conducted to inform the need for shore-power hook-up of vessels berthed at the TDF. As a heavy energy user, it is included within this assessment to ensure a worst case assessment is carried out.

[c] Vessel energy usage is weighted for time inshore based on an: MRSV of 200kW @ 50 % time inshore; Inshore Support Vessel of 100 kW & 80 % time inshore; drilling PSV of 200kW @ 50 % time inshore; and Dedicated Oil Spill Response Vessel / Workboats powered down. This gives an equivalence of 280 kW. However vessels are unlikely to draw their peak power load for a full 24 hour period and are also unlikely to be berthed and connected to shore-power for the entire time 'inshore'. This figure is therefore very precautionary.

[d] Unattributable usage may not be directly related to O&G activity, however as any wider increase in Stanley usage, even if unrelated, will also reduce any excess capacity a nominal additional increase is included to cover associated and unassociated increases.

11.5.4.2.3 Peak Phase 1 power demand and output

As described above, it is necessary to understand the peak power demands to determine whether or not the Stanley power station will be impacted by the O&G operation making power demands at the same time as other local users.

11.5.4.2.3.1 Stanley power generation capacity

Details on the current Stanley power generation are provided in the Baseline Description (section 7.7.4.5.5). In summary, the power station currently uses eight generators of differing capacity. However, very importantly, the amount of power available at any given time depends upon the combination of generators that are in use, on standby or under deep maintenance.

While varying combinations of generator status exist, the, maximum power capacity, under the current generator maintenance schedules and standby procedures, ranges from 3,600 – 5,100 kW (Table 11.28). Although a theoretical maximum of 6,600 kW may be possible if all generators were in use, this cannot be relied upon as one generator set is almost always undergoing scheduled maintenance and unavailable, while it is normally preferred that a second generator remains on stand-by to provide redundancy in the event that one of the generators malfunctions. Overall, the baseline power capacity is considered by FIG to be 3,600 kW (G. Ross, *pers. comm*). It is these working peak power limits that are considered within the assessment.

However, as part of the continuing FIG review of utilities, power provision and inherent system risks the expansion of the current power station with three additional interim generator sets is currently underway. An additional three units, each of 2,000 kW output, will provide a maximum additional output of 6,000 kW. Even assuming that one unit will always be undergoing scheduled rolling maintenance an additional output of c. 4000 kW will still almost double existing working peak loads. This should, in the very near future, remove any critical load calculations from the assessment. Whilst the three generator units are now mounted and should be commissioned in the first quarter of 2020 they have not been incorporated in the current assessment until it is definitively proven that they will correctly mesh with the existing analogue switching gears of the older generator-sets and whether they will run in isolation or parallel.

Furthermore , as these improvements are outwith Premier's control, the following assesses the impact of Phase 1 energy use against the current Stanley baseline.

11.5.4.2.3.2 Stanley power demand (including exploration campaigns)

Stanley power demand varies depending upon:

- The time of year (generally higher in winter);
- The time of day (peaks late-morning / midday with lesser peak in early evening and off-peak overnight);
- Whether it is a weekend or a week-day; and
- Whether oil and gas activity is on-going.

Table 11.28: Power station maximum capacity under various operating conditions of maintenance and stand-by

Stanley power station generator scenarios	Load (kW)
Full generator capacity (8 generators) Theoretical as 1 generator always under going deep maintenance	6,600
Peak Load Operation (7 generators) Usual capacity with largest 1,500 kW generator undergoing deep service	5,100
Standard Load Operation (6 generators) Capacity with further generator on standby, but ready to come on-line to respond to peak loads or if another unit drops out. As not all generators can replace all other generators due to differing sizes this is taken as the second of the two largest 1,500 kW generators. **Note**: If any incident to the second of the two largest generators occurs while the first is undergoing maintenance this becomes the peak working capacity and not the stand-by capacity, whilst unlikely this is a feasible and plausible worst case scenario	3,600

Typical diurnal demand curves for winter (which is the seasonal period of highest demand) are given in Figure 11.10 corresponding to the same day of the week for inter-annual consistency over six years. Figure 11.10 shows that energy use is higher during the day with lowest use (or off-peak use) falling between 2300-0600 hrs. The highest load curve (Thursday 30/07/2015) represents the only date coinciding with an oil exploration round.

Peak power demand was 3,320 kW during exploration while the average peak demand over the non-exploration days was 2,756 kW (Table 11.29). This amounts to an estimated increase of 564 kW power demand during the 2015 exploration campaign. Whilst the inter-annual comparison is limited to only four sampled days, and must therefore be treated with caution, it can be seen that peak power demand was 15 % – 30 % higher during oil exploration (Table 11.29). Supporting this, the FIG PWD power section estimated that, on average, the total impact on Stanley power load from oil exploration was *c.* 500 kW (i.e. *c.* 18 % above non-exploration) (G.Ross, *pers. comm*.).

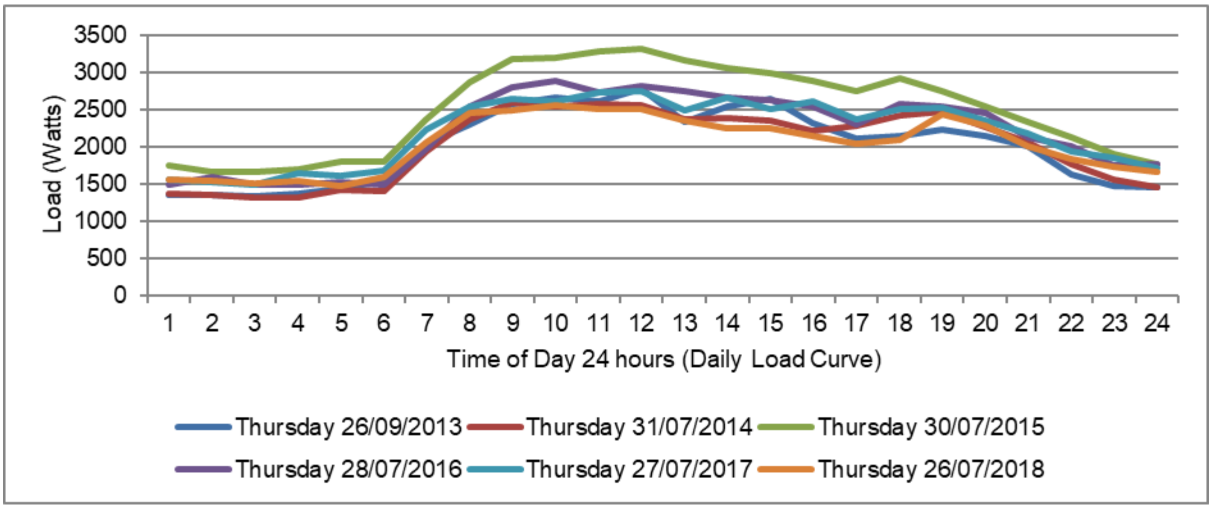


Figure 11.10: Diurnal power demand curve over 6 typical winter days, the higher curve relating to a period of oil exploration

Table 11.29: Peak power demand (kW) within 6 selected days over 6 years

Activity	Date	Maximum demand peak		Average maximum power (kW)	Difference in max. peak between non-exploration days and exploration day
		Time	Power (kW)		
Non-exploration year	2013 (Thurs 26/09)	12:00	2,791	2,716	19 %
	2014 (Thurs 31/07)	09:00	2,600		28 %
	2016 (Thurs 28/07)	10:00	2,878		15 %
	2017 (Thurs 27/07)	12:00	2,752		21 %
	2018 (Thurs 26/07)	10:00	2,562		30 %
Exploration year	2015 (Thurs 30/07)	12:00	3,320	3,320	n/a

11.5.4.2.3.3 *Phase 1 forecast power demand*

The individual contributions of exploration infrastructure centres, with additional Phase 1 uses, are given in Table 11.30 and approximately match expected estimates if the unattributable services (such as those described above) are also considered. However, it should be noted that it is extremely unlikely that each infrastructure facility would peak at the same time. For example, accommodation demand may be higher when yard or heliport demand was lower, and thus the likely contribution of unattributed sources is more significant than the data would initially suggest. Indeed, the unattributed sources increase the power demand to the equivalence of all facilities operating at peak.

If power demand during Phase 1 is assumed proportional to changes in yard area and personnel capacities, and with inclusion of vessel (MRSV) power hook-up to shore-power, it is estimated that, if all power was used at the same time, the total Phase 1 peak power usage may reach approximately 1,000 -1,100 kW (as opposed to the *c.* 500 kW used during exploration).

With an addition of *c.* 1,100 kW load to the system, the normal power station operating capacity of 3,600 kW would be surpassed by *c.* 300 kW (Table 11.31) and would thus require the stand-by generator to be deployed. The use of the standby generator means that the system could be vulnerable should a generator drop out, or a spike occur (section 11.5.4.1).

However, as is shown in Table 11.30, the shore-power hook-up alone adds 300 kW to the total Phase 1 demand and it is anticipated that this activity would only occur during the night in off-peak hours.

Owing to the decreased demand from the Stanley user-base at night, and even assuming that all daytime Phase 1 uses were still peaking, the use of vessel hook-up at night would still leave *c.*1000 kW ‘spare’ (Table 11.31). Therefore, there would be no need to operate any of the stand-by generators to accommodate the increased night-time demand. This is important as the power station can be heard by local residents and the use of an additional generator at night would somewhat negate the benefit of not using the vessel generators to mitigate against night-time noise.

However, even with vessel hook-up excluded during the day, which reduces the daytime demand to *c.* 800 kW, this would still take the day-time Phase 1 power demand very close to the baseline capacity with only c. 40 kW to 'spare' (Table 11.31). Therefore, in the event of any spike, the Stanley power station would still need to move to use of the stand-by generators, and could still therefore be vulnerable.

Furthermore, should the largest 1,500 kW generator be under-going scheduled routine maintenance when there is an incident with the second 1,500 kW generator, then the total capacity of the power station drops to an absolute maximum of 3,600 kW with no reserve capacity. Whilst this is unlikely, it is a plausible scenario in an aging system where the oldest generator dates to 1973.

Table 11.30: Contribution of exploration infrastructures to power demand

Facility	Peak Power (kW) use during exploration	Smoothed 24 hour average power equivalence (kW)	Estimated Phase 1 peak power (kW)
Heliops hanger	250 [a]	37 [b]	250
Accommodation facility	120 – 140 [a]	69 [b]	264 - 308
TDF (estimate)	25 [c]	5 [b]	25
Laydown yards (estimate)	75 [c]	15 [b]	225
TDF vessel shore-power connection	0	0	300 [d]
Total attributable load	470 - 490	126	1064 - 1108
Total attributable load minus shore-power connection	470 - 490	126	764 - 808

[a] PWD figures (*pers. comm.* G Ross).

[b] Figures derived from average kWh/day meter readings

[c] Estimate assuming that peak power use is 5-times averaged power use over 24-hours

[d] Assumed if 1 large and 2 smaller vessels are berthed at the same time, e.g. on the outer and inner faces of the TDF. Note also that this activity may be most likely to occur overnight (i.e. in off-peak periods) given that it is largely driven by the need to minimise noise disturbance from vessel generators at night.

Table 11.31: Current Stanley power demand with forecast development demand superimposed relative to current generator operating power outputs

Average Stanley power demand (non-exploration) (kW)		Peak potential Phase 1 demand (kW)	Potential overall demand (kW)	Current baseline capacity (kW) [a]	Excess Capacity (kW)
Total demand of all activities if operating at the same time					
Stanley typical maximum power demand	2,756	1,108	3,864	3,600	(-264)
Day-time (excluding shore-hook-up)					
Stanley typical maximum power demand	2,756	808	3,564	3,600	36
Night-time					
Stanley typical maximum power demand	1,500	1,108	2,608	3,600	992

[a] Baseline Stanley power station generator capacity (Table 11.28).

It should be noted, as stated before, that the current assessment takes a conservative worst case scenario with all facilities peaking at once and applies it to the current status quo of power generation, usage and working generator capacities. That this approach suggests a deficit of c. 300 kW may occur at critical times without mitigation should be considered alongside the new additional capacity of 6,000 kW from three new generators that will come on-line in the first quarter of 2020.

11.5.5 Industry-standard mitigation

Within larger economies there is generally a national network with the capacity to absorb and respond to increased demand and therefore, no industry-standard mitigation or Codes of Practice exist.

11.5.6 Impact assessment

The following section draws upon all the information provided above to assess the 'Sensitivity of the Receptor' and the 'Severity of Effect' in order to determine the overall 'Impact' of planned activities.

Assessment of the impact of energy use is challenging as it is understood that the Stanley baseline in terms of energy availability may change within the next few years. However, this is outwith Premier's control and, therefore, the following assessments are based on the current baseline and are split according to the use of power through the day, and that at night-time.

A summary of the impact assessment outcomes for this Development is tabulated in section 11.5.12 which shows the worst case impact for each activity and receptor, and details are provided below.

11.5.6.1 Impact of power use through the day

Electricity is an essential utility upon which almost all daily activity depends in an increasingly electronic age, from heating controllers, lighting, refrigeration, to computers and communications. Whilst emergency services are protected with auxiliary generators, any interruption in supply would be immediately noticed and cause high levels of inconvenience and nuisance within the Human Population. Unlike water, where a buffer storage capacity may insulate the population from immediate impacts, the effect of electrical supply issues would be immediate. Further, with regard to electricity as a Tangible Property, Stanley's current baseline capacity is such that it may be unable to sustain peak demand spikes in the short-term and therefore must be considered a finite resource which has the potential to be unsustainable in the immediate term (section 11.5.4.2.3.1). Notwithstanding the fact that any interruption would be restored, the **sensitivity of the receptor** (Tangible Property) is considered to be '**High**'.

Daytime energy demand from the Sea Lion development is limited to onshore assets and infrastructure. It is expected that the Phase 1 usage will be similar in nature to the exploration campaigns, with increases in power usage being proportional to the size of infrastructure and increases in personnel numbers. These increases may result in a worst case 31 % increase in Stanley electrical energy usage (section 11.5.4.2.3.3). Further, peak daytime power demands could reach the threshold where the standby generator capacity is required (section 11.5.4.2.3.3). Power demand would still be within *overall* capacity in such a case, however, the operation of the power grid system using stand-by generators increases the vulnerability of the system to generator drop out, power fluctuations or electrical fault without a reserve to come on-line. In a worst case scenario if both of the largest generator sets were off-line at the same time then the stand-by capacity would become the total capacity, and this could be reached with no reserve to come on-line. As the use of the finite resource has the potential to be extensive and will be daily, the worst case **severity of effect** (to Tangible Property) of daytime power use is considered to be '**Major**'.

The overall **significance of the impact** of competition for electrical energy during daytime hours is therefore assessed as **High (20)**. Consequently project-specific mitigation measures to monitor and where possible reduce the significance will be considered.

11.5.6.2 Impact of power use through the night

Night-time hours (between 2300-0600 hrs) are generally considered to be off-peak (section 11.5.4.2.3.2). The overall Stanley power demand nearly halves through the night such that at this time, the resource can be considered to be less finite, and more able to absorb other uses of power e.g. vessel connection to the shore-power. Further, during this time, the majority of the Stanley power user base will be asleep or not-operational such that any interruptions to the power supply would be less likely to cause disruption to residents or other businesses. However, given that night-time is often used by many for downloading of material from the internet etc. disruption may well cause annoyance and on balance, the **sensitivity of the receptor** (Tangible Property) during night-time hours is considered to be '**Moderate**'.

As shown in section 11.5.4.2.3.3 above, the use of power at night, including the hook-up of vessels (MRSVs) to shore-power, still leaves approximately 1,000 kW 'spare' capacity. In this case the system would still be operating well below its baseline capacity of 3,600 kW. Noting that electricity may be required through the night to heat houses etc., there is still plenty of capacity within the system to accommodate spikes without need to deploy the stand-by generators. Therefore, off-peak power use would result in moderate use of a resource that is not finite through the night such that, on balance, the **severity of effect** of power use (Tangible Property) at night is considered to be '**Minor**'.

The overall **significance of the impact** of competition for electrical energy between 2300-0600 hrs is therefore considered to be **'Moderate**' **(6)**.

11.5.7 Project-specific mitigation measures

Premier will liaise closely with FIG in preparation for 'oil readiness' to ensure that energy supply and demand are in balance. These discussions will include those based on future FIG development of power capacity (section 7.7.4.5.5.3), not least because minimising risks of loss in energy continuity is important to the Phase 1 Development as well as to the human population.

However, while future improvements to the FIG power station may alter the impact assessment by altering the baseline (e.g. by lessening the sensitivity of the receptor as a finite resource and the severity of effect by lowering the Phase 1 demand as a percentage of the available power), these changes are outwith Premier's control and cannot be used as a mitigation within this assessment.

Nonetheless, a number of mitigating and ameliorating strategies that are within Premier's control will be incorporated into the Phase 1 Development during the FEED process. These include:

- Sustainable and energy efficient design;
- Off-peak power utilisation; and
- Monitor and assess vessel shore-power needs.

11.5.7.1 Sustainable design

Where feasible, sustainable design and energy efficiency will be included in infrastructure and asset design, this may include where appropriate:

- Lighting set at minimum levels (which are still appropriate for safety);
- Low energy types and photosensitive light switching utilised where appropriate;
- Energy efficiency incorporated within buildings through insulation, heating systems, thermostats, timer switches, etc.; and
- Back-up emergency generators and switchgear will be provided for essential systems (allowing disconnection from grid in the event of an emergency).

Optimal energy use will be incorporated within all design considerations through the FEED process, as will lessons learned during the exploration campaigns. For example, the shorter-term exploration activities relied upon modular and / or temporary built assets. The modular buildings tended to rely to a greater extent on electrical heating and usage. It is assumed that permanent buildings will be more efficient in energy design and that kerosene, water and forced air heating may be feasible options to reduce *per capita* electrical energy use. Space heating through electrical forced air heaters was the greatest power demand at the heliops hanger accounting for 96 % of the peak 250 kW load.

11.5.7.2 Off-peak power utilisation

Diurnal power demand curves show significantly lower energy use overnight (section 11.5.4.2.3.3). Highest power demands occur between 08:00 – 18:00 hours with an approximate mid-day peak (Figure 11.10). Therefore, there is the potential to minimise impacts by taking advantage of off-peak periods for high power use activities and processes, where possible. Such use would average overall demand through the 24-hour period and reduce the likelihood of any capacity issues or impacts through the day when domestic demand is highest. Overall energy usage (section 11.5.4.2.1) may not drop but, as it would be utilised during a period when other demands are lower, the impacts on peak demand could be minimised.

11.5.7.3 Noise and electricity monitoring

As is described in Chapter 15, monitoring will be carried out to assess any impacts of noise and Premier will have a formal complaints process in place, with a member of staff assigned to respond. In the event that monitoring indicates noise *is* an issue for local residents *and* that monitoring of power use through the night indicates any problem with capacity, other solutions may be sought to mitigate against both power use and noise.

11.5.8 Residual impacts

11.5.8.1 Impact of power use through the day

The above project-specific mitigations (e.g. low energy buildings and the optimal use of off-peak periods) may lessen the sensitivity of the Stanley power supply (Tangible Property) as a finite resource and therefore would lessen the likelihood of the Human Population being subjected to downtime in power availability. Therefore, the **sensitivity of the receptor** (Tangible Property) can be reduced to ‘**Moderate**’.

The mitigations described above incorporate use of off-peak periods, energy optimisation and the monitoring of energy use to identify any emerging issues early. This provides for the ability to respond by modifying work practices or upgrading capacity. Energy efficiency in design will be promoted throughout the FEED stage of the project and it is expected that savings can be made relative to exploration usage upon which the Phase 1 estimates were based. It is believed that through close attention to energy use, power needs could be further reduced below the threshold level of 3,600 kW. However, because the energy savings cannot be quantified at this stage, and to take a precautionary approach given that there is currently only *c.* 40 kW ‘spare’ within the system once Phase 1 activities are added (and in a worst case scenario this might be the absolute capacity), the **severity of effect** can only be reduced by one level to be ‘**Serious**’.

The **overall significance** of the impact of competition for electrical energy on the human population of the Falkland Islands is therefore assessed as ‘**Upper Moderate (12)**’.

11.5.8.2 Impact of power use through the night

The mitigation measures are unlikely to change the **sensitivity of the receptor** which remains '**Moderate**'.

However, the use of the additional mitigation measures described above, in the event that monitoring of both noise levels and night-time power use indicate the need for an alternative solution are all such that the severity of effect can be reduced to '**Slight**'. The residual impact is thus reduced to '**Low (3)**'.

11.5.9 Cumulative impact

The current assessment deals specifically with the electricity usage of the Development assets and infrastructure centres. Cumulative socioeconomic impacts from wider economic activity will be further assessed within the separate Socio-economic Impact Assessment (section 2.4).

However, to be conservative a component of cumulative impact is already incorporated within the assessment. The disparity between direct O&G sector usage by infrastructure centre and the overall increase in Stanley usage exhibited during exploration illustrates the cumulative effect in energy use of the overall increase in economic activity. Unattributed cumulative usage contributed an additional 9 % in usage (section 11.5.4.2.2.2) that was considered and included in calculations. It should however be noted that as the population of Stanley grows, so will electricity demand. Consequently the excess capacity available for O&G activity will decrease unless additional infrastructure is developed to cover the additional usage.

11.5.10 Confidence

The scale of development activity is defined by area and personnel, both of which are known. A degree of uncertainty exists within some of the baseline figures and exploration figures have been used to provide the basis of the assessment. These actual-use figures have been scaled by any expected changes between the level of exploration activity and development activity. Energy use (kWh) is metered and recorded however instantaneous power use which is the most critical parameter in matching development peak demands to generator capacity is not recorded at infrastructure centres and is based upon estimates. There is thus a degree of uncertainty in figures and thus within the extrapolated estimates.

Overall, Stanley demand was estimated including uses directly attributable to the O&G operations, as well as noting that there were additional uses that could not be directly attributable. However exact quantification of how this is split between service sectors and how much is directly associated to oil and gas activity as opposed to a general increasing trend in Stanley usage remains unclear.

Full liaison between Premier and FIG, as the service utility provider, has still to be completed and thus planning is on-going. A number of utility infrastructure upgrades are already incorporated within FIG planning and are progressing, most notably the incorporation of new generator capacity within the interim power house upgrade. However, although this is progressing it is not within the control of Premier and thus no assumption based on these plans were included within the assessment.

Based on the above, on balance, the **level of confidence** in the impact assessment is considered to be '**Uncertain**'.

11.5.10.1 Monitoring required

Energy use will be monitored and reported to measure environmental and social impacts and to identify any emerging issues early. Detailed monitoring requirements have been established during the Environmental Monitoring and Management Plan (EMMP) workshop. All monitoring requirements agreed by Premier and FIG will be recorded and managed via the project-specific Phase 1 Socio-Economic Monitoring and Management Plan (SEMMP).

11.5.11 Offsetting

For significant residual and impact and risks (Moderate or above), offsetting via an Environmental Fund is proposed, see section 8.9 for further details.

11.5.12 Findings summary

Table 11.32: Summary of the impact assessment of energy use on the competition for resources

Activity / Event	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance[a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Daytime electrical energy use onshore by the TDF, laydown yards, accommodation facilities & heliops	Competition with domestic energy needs	Overloading of current capacity and potential need for use of stand-by generators at power station	Planned	1, 2 & 3	High	Major	n/a	**High (20)**	**Upper moderate (12)**	**Uncertain**	**Industry-standard:** None. **Project-specific:** Sustainable design; and Off-peak power utilisation.
Night-time use of all the above plus shore-power hook-up of vessels at TDF			Planned	1, 2 & 3	Moderate	Minor	n/a	**Moderate (6)**	**Low (3)**	**Uncertain**	**Industry-standard:** None. **Project-specific:** Monitoring of noise levels to determine need for shore-power hook-up by vessels.

[a] See Chapter 8 for definitions of sensitivity, severity, likelihood and significance.

11.6 Resource Competition – Air-links

Table of Contents

11.6.1 Introduction

In addition to the use of accommodation, freshwater and electricity, the Phase 1 Development will require the use of air-links to the Islands in order to transport personnel throughout Field Life. The Falkland Islands have limited international airlinks / flights and therefore, additional and regular requirements have the potential to impact upon the availability of seats for local residents and other visitors. The level of resource competition is determined by the forecast difference between Development demand and the current excess capacity in available seats.

Both the carrying capacity of existing infrastructure and competition for resources were raised as a concern during the scoping consultations (Chapter 6).

This chapter investigates air-link provision and specifically, the competition for seat availability on international flights.

Note: other impacts related to the competition for resource e.g. accommodation, water, electricity and roads, and those associated with the use of transportation e.g. emissions etc. are described elsewhere in this document, see section 9.2.

11.6.1.1 Relevant legislation

Resource competition is not legislated for within any specific Ordinance or Regulation and therefore, no statutory limits are defined through legislation. However, as was agreed during the consultee scoping workshop with FIG in 2015 (Chapter 6), the social impacts of competition for resources such as the use of air-links was considered to be within the scope of the EIS as defined by the EIS guidance (EPD EIA Guidance Note (FIG, 2015m).

11.6.2 Sources of air transportation competition

All expatriate (expat) personnel involved during the Phase 1 Development, both onshore or offshore, will require air transportation to the Falkland Islands at the beginning and end of their contract periods. A small number of technicians, managerial and administrative personnel may also be required to visit independently of offshore work programmes and crew exchanges. The sources of competition for seats on air-links are therefore the same as those for accommodation listed in section 11.3 above.

11.6.3 Potential receptors

The ENVironmental Impact IDentification (ENVIID) workshop was used to identify those receptors upon which the impacts of resource competition warranted further investigation (Chapter 9)

Receptors that may be impacted by air-link usage associated with the Phase 1 Development include:

- Human Population (section 7.7.2); and
- Tangible Property (section 7.7.4).

11.6.4 Characterising and quantifying the impact of service competition

When characterising and quantifying the impact of competition with regard to air-links to the Falkland Islands, it is necessary to consider the following:

- Availability of seats on standard air-links; and
- Premier personnel transportation requirements.

11.6.4.1 Seat availability on standard air-Links

As is detailed in the Environmental and Social Baseline (section 7.7.4.3), the standard air-links to the Falkland Islands are currently limited to a twice weekly Ministry of Defence flight from the UK (i.e. the air-bridge), and once weekly LATAM flights scheduled between the Islands and Chile.

On average, unallocated seat capacity is 91 seats / week (11 seats / flight on the air-bridge and 80 seats / flight on the LATAM flights) (section 7.7.4.3),

However, seat availability is highly seasonal and the unallocated seats may be used by:

- Students during school and college recesses;
- Summer tourism demand;
- Cruise vessel passenger exchanges;
- Medical flight requirements; and
- Occasional MoD operational and mobilisation requirements.

Taking the above into account, between 14 – 22 of all flights per annum may be full to capacity such that the availability of excess seats for additional needs, e.g. those of Premier, is expected to be limited and unreliable.

Furthermore, to manage personnel fatigue, Premier has a requirement for increased standards of seating-class options in certain situations. This would be problematic in the case of the MoD air-bridge which is provided with only economy class seating provision.

11.6.4.1.1 Premier transportation requirements and provision

The Phase 1 Development will require available and reliable fixed-wing flights to transport all expat personnel to and from the Falkland Islands for the entire duration of the Sea Lion Field life. The forecast requirement for exchange of personnel peaks at approximately 220 people during Stage 1, when simultaneous activities of FPSO commissioning and continued drilling run in parallel (Table 11.33).

The use of existing air-links by the Sea Lion Phase 1 development for personnel movements could significantly impact upon seat availability, thus limiting seat availability for:

- Resident travel and flexibility (including children in education);
- Commercial interests of other sectors such as:
  - Land-based tourism (land based and rural development);
  - Cruise ship tourism (passenger exchange); and

  - Fishing (crew exchange and business travel).
- Medical flight planning and capacity; and
- Veteran visits.

Recognising the limited capacity, variable seat availability and limited seating-class options within existing air-links, Premier has committed to a dedicated charter flight to meet personnel flight requirements. Dedicated charter flights assumes that there will not be increased air-links to the Falkland Islands with sufficient capacity within the initial timeframe of the Sea Lion Development peak loading. Should this change at a subsequent time needs may be reassessed with the same consideration of isolating existing links from undue competition.

During Stages 1 and 2 of the Development, dedicated charter flights will fly fortnightly or weekly from Europe, with a re-fuelling stop in the mid-Atlantic. At some point during Stage 2 the charter flight is anticipated to switch to a weekly transit, potentially with a smaller plane.

Following the completion of Sea Lion drilling activity and the entry of the project into steady state production operations, the number of personnel that need to be routinely moved to and from the Falklands reduces to a maximum of 82 per 28 days (Table 11.33). The need for the dedicated charter flight will be reviewed at this time to determine whether or not existing commercial flights could be used without detriment to the receptors listed above.

Additional air-link initiatives and potential transfer through South America will be continually monitored at all stages to determine whether this may supplement or provide an alternative to dedicated charter flights. A dedicated charter flight is the current base case given current available air links and seat capacity. If other routes open up in the future these will only reduce pressure on existing routes.

In addition to charter flights for routine personnel exchange, insurances will be in place for use of an air ambulance link to hospitals in South America or outside of the Falkland Islands to facilitate the evacuation of personnel with injuries which require treatment that is not available at the King Edwards Memorial Hospital.

Table 11.33: Air-link seat capacity requirements during the three stages of the Sea Lion Phase 1 Development

Development Stage	Offshore personnel (transiting through the Falklands at beginning or end of their rotations)	Onshore personnel rotation [a]	Total
Stage 1: Infrastructure Construction Pre-First Oil Drilling (Duration = *c*. 2 years)	64	73	137
Stage 2: Post First Oil Drilling, Installation and Production (Duration = *c*. 4 years)	103	23	126
Stage 3: Steady State Production (per annum) (Duration = *c*. 17.5 years)	61	15	76

[a] Based on a charter flight frequency of one flight per fortnight for stage one, and one flight per week for Stages 2 & 3, and a personnel rotation duration of 28 days, it is estimated that 50 % of the personnel will be changed out per flight

11.6.5 Industry-standard mitigation

No industry-standard mitigation, threshold levels, or codes of practice are applicable to air-link resource competition. No acceptable or permissible limits are set through industry codes of practice.

11.6.6 Impact assessment

The following section draws upon all the information provided above to assess the 'Sensitivity of the Receptor' and the 'Severity of Effect' in order to determine the overall 'Impact' of planned activities.

A summary of the impact assessment outcomes for this Development is tabulated in section 11.6.12 which shows the worst case impact for each activity and receptor and details are provided below.

11.6.6.1 Use of air-links

As described above, the Falkland Islands currently have limited air-link capacity and rely upon these links as the sole means of international travel into and out of the Islands. Whilst there is some excess capacity in the number of seats available, this is variable through the year and insufficient for the requirements of the project without restrictive block-booking agreements which could be to the detriment of the Human Population. Therefore, the **sensitivity of receptor** is considered to be '**High**'.

With the Phase 1 base case commitment to provide a dedicated charter flight to meet its transportation needs, the existing air-link capacities would only be used for a small number of *ad hoc* business unit, administrative or technician visits that may be necessary from time to time between fortnightly scheduled flights. Therefore, the **severity of effect** is considered to be '**Slight**'.

Therefore, the overall **significance of impact** upon air-link provision is '**Low (4)**'.

Consequently additional mitigation measures are not considered to be necessary.

11.6.6.2 Provision of air-links

No commitment as to whether any Sea Lion charter flights will be available for resident or third-party use has yet been made. During exploration dedicated charter flights provided an additional option for residents' travel and freight. Should such a provision be agreed, there is the potential for a '**Beneficial**' impact.

11.6.7 Project-specific mitigation measures

With the provision of a dedicated charter flight as the base case to meet Premier transportation needs during peak periods, no additional project-specific mitigation measures are proposed at this time. As described above, the need for a charter flight during steady state production will be reviewed during Stage 3.

11.6.8 Residual impacts and risks

With no project-specific mitigations in place, over and above those included in the base case, the residual assessment remains the same as the initial assessment.

11.6.9 Cumulative impact

No cumulative impacts within the scope of the assessment are identified as, for example, any increase in cruise vessel passenger exchange would utilise existing scheduled air-link capacity and remain separate from the provided charter flights.

It is assumed that additional and potentially concurrent future exploration or development is not included within the scope of the current assessment. Assessment and any mitigation of impact would lie within that future activity's environmental assessment, should sufficient spare capacity on existing links not be available. Any options would have to be assessed at such a time and no commitments can currently be made as to the most efficient solution. Premier will continue to review all available air-links, air-frame capacities and air-link charter partnerships if appropriate.

11.6.10 Confidence

Whilst exact air-frame capacities and fly-route have yet to be confirmed a similar service was operated during the various oil exploration phases without problem. Confidence in the assessment is therefore '**Certain**'. Confidence in the assessment of the beneficial impact is '**Uncertain**'.

11.6.10.1 Monitoring required

Any incidental usage of existing air-links will be recorded. All monitoring required will be recorded within the project-specific Phase 1 Socio-Economic Monitoring and Management Plan (SEMMP).

Whilst not specifically required for environmental monitoring, data on anticipated personnel movements and seat occupancy on all flights may prove beneficial to FIG and FIDC in demonstrating the business case for additional commercial airlinks scheduled flights and will be shared as necessary.

11.6.11 Offsetting

As no residual impacts or risks identified in this section are considered significant, i.e. Moderate or above, offsetting is not considered (see section 8.9).

PremierOil

11.6.12 Findings summary

Table 11.34: Summary of the impact assessment for air-link use by the Sea Lion Phase 1 development

Activity / Event	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance[a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
International movement of personnel to and from the Falkland Islands	Air-link resource competition for seat availability	Lack of seat availability for residents and third party economic sectors	Planned	1, 2 & 3 [b]	High	Slight	n/a	**Low (4)**	**n/a**	**Certain**	**Industry-standard:** A dedicated charter flight provisionally up to a weekly frequency, or as required depending upon personnel needs and on availability of other air links, will be provided to me*et al*l personnel travel requirements. **Project-specific:** None proposed, although Premier will continue to monitor and assess for use potential new air-link options and potential additional South American air-links as they may arise.
	Provision of additional air-link to the Falkland Islands	Potential for extra seat availability for third-party use	Planned [c]	1, 2 & 3	n/a			**Beneficial**	**n/a**	**Uncertain**	

[a] See Chapter 8 for definitions of sensitivity, severity, likelihood and significance.

[b] The ongoing need for a dedicated charter flight will be reviewed once into steady state production (Stage 3) to determine whether or not it is still required.

[c] Note that the availability of excess seating for use by third-parties will be reviewed and confirmed during the FEED process.

11.7 Resource Competition – Roads Network

Table of Contents

11.7.1 Introduction

All stages of the Sea Lion Phase 1 Development will require the use of the existing road network for the movement of personnel to and within Stanley, haulage of equipment, and transport of supplies and waste between a range of different locations.

The Falkland Islands Government (FIG) Public Works Department (PWD) Highways Section is responsible for the construction and maintenance of the road network and surfaces. Whilst road capacity cannot be accurately quantified, increased utilisation may be detrimental to the road surface and may result in increased necessity for remedial repairs. Therefore, increased road usage may impinge upon both the capacity of FIG to conduct repairs, and on other road users. Indeed, both the carrying capacity of existing infrastructure and competition for resources were raised as a concern during the scoping consultations (Chapter 6).

As described in section 2.4, socio-economic impacts are out of scope for this EIS. A separate Socio-economic Impact Assessment (SIA), building and updating the previous work undertaken for FIG and Rockhopper by Regeneris (2013 & 2015) and Plexus (2012), has been conducted by Premier Oil. This chapter focuses on the increase in road usage above the existing baseline to inform the impacts upon the road infrastructure and other road users. As wear and tear on the road network is proportional to vehicle passes and axle weight, it is considered that any impact will be proportional to the increase in traffic and haulage weights.

Note: noise and air quality are touched upon in this chapter but are not assessed in detail as they are considered elsewhere in this document, as described in sections 11.9 and 11.12.

Note: the assessment is based on an onshore supply base located near the TDF, helicopter flights operating from Stanley Airport and fixed-wing flights from Mount Pleasant Airport. Although it is not the base case, if an alternative supply base is chosen, such as Mare Harbour, it is expected that the impacts on roads in and near Stanley would, in general, be lower. In such a case, Premier would discuss with FIG the implications in terms of compliance with the onshore EIA legislation and other requirements.

11.7.1.1 Relevant legislation

- Relevant Falklands legislation:
  - The Offshore Minerals Ordinance 1994 Part VI;
  - The Road Traffic Ordinance; and
  - Highways (Weight Limits) Ordinance 2004.

Under the EIA Ordinance, the Hydrocarbons Environmental Impact Assessment Guidance Note 187/15 issued by EPD (FIG, 2015m) provides guidance on the content of an EIS. This includes section 3.7 that suggests infrastructure impacts, such as wear and tear on the road network, may be a relevant part of an EIA, guided by how they are described in the National Infrastructure Plan. This was agreed during the consultee scoping workshop with FIG in 2015 (Chapter 6).

All roads have designated speed limits and maximum axle and gross load capacities, with exemptions required for any heavier loads. An annual vehicle tax is levied on all road-going vehicles.

Premier operates a strict Health and Safety Transportation Policy. Travel on company business is mostly limited to capped (sealed) roads within Stanley and requires a driving safety induction to have been completed.

- Key UK Legislation:
  - The Road Vehicles (Construction and Use) Regulations 1986 (as amended);
  - Code of Practice Lighting and Marking for Abnormal Load Self escorting vehicles incorporating Operating guidance.

11.7.2 Sources of road and transport use

The activities that will result in the use of vehicles are:

- Weekly crew rotation transportation to Mount Pleasant Complex (MPC) charter flight;
- Daily commute from accommodation to the supply base, TDF and Stanley Airport heliops by minibus / coach;
- Haulage of freight;
  - Between TDF and laydown yards;
  - Air-freight from fortnightly/weekly charter aircraft;
  - Occasional sea-freight if ports or shipping services other than TDF are used;
- Waste haulage to waste disposal site;
- On-call technician and management vehicles; and
- Domestic supply deliveries.

It is likely that the majority of the project accommodation will be centralised, and transportation from this accommodation to the place of work will be by shared communal transport such as a minibus.

Vehicle use outside of Stanley on uncapped (unsealed) will comprise transport to the fortnightly/weekly charter flight at MPC and the short section of uncapped Coastel Road between the Airport Road, Lay-down yards and the TDF. Other travel on unsealed roads will require strong justification, will be subject to journey management plans and will therefore be very limited.

11.7.2.1 Crew rotations, freight haulage and use of the MPC road

The MPC road will be utilised for transfer of rotational personnel to the fortnightly air-link charter for crew exchanges. It is anticipated that transportation will be via minibus or coach.

11.7.2.2 Commute from accommodation to supply base, TDF and heliops airport

The Airport Road and Bypass in Stanley is the primary route that will be used to transport onshore personnel from accommodation to the supply base and TDF for shift pattern work, and is the primary road giving access to Stanley Airport. It is anticipated that the selected location for the accommodation facility will have easy access to the Airport and Bypass Roads. This will eliminate transit and through traffic within Stanley.

11.7.2.3 Haulage of freight

11.7.2.3.1 Between TDF and laydown yards

The majority of all consumables and equipment will arrive at the TDF by chartered coaster supply vessel and will require initial movement to the lay-down yards for storage, and then redelivery to the TDF for loading to the support vessels. The majority of all port transfer and HGV usage will be limited to the short interconnecting road between the TDF and lay-down yards, locally known as Boxer Bridge Road and Coastel Road. Dependent upon the final location and layout of yards and yard access points, this will vary up to approximately 1 km transit along public roads.

During Stages 1 and 2 of the Development, transfer of drilling materials will entail HGV use with high axle loads throughout the year for up to 9 years. In Stage 3 during steady state production, bulk process chemicals e.g. methanol and pour point depressants (section 5.9.1) may increase in volume but drilling consumables and bulks will no longer be required and overall materials will decrease. Although it may be possible to store some bulk drilling materials (dry or liquid) adjacent to the TDF access causeway, the majority are expected to be stored in the yard and will require road transportation for the short distance to and from the TDF. While logistics vessels located in Berkeley Sound will handle a large amount of heavy equipment for subsea installation, heavy lift objects such as X-mas trees are expected to be landed at the TDF and be moved to storage in the yards, for return to the TDF when required for well completion. The movement of abnormal loads, where the laden vehicle is above 38.5 tonnes, is expected to require special authorisation from the FIG Highways Section and would be subject to restrictions on overall dimensions and individual axle weights, which would be discussed in detail relevant to each circumstance with a view to ensuring that stresses on roads and road structures are within acceptable limits.

Operation of the supply base is continuous. Staffing is expected to reduce at night during steady state production but during Stages 1 and 2 activity levels will require day and night operations and vessel availability may also dictate night-time operations with some consequent vehicle movements. The main scenarios for night-time activities are drilling and installation support whereby vehicle movements would be between the supply base and TDF i.e. relatively short distances and avoiding residential areas. All non-critical activities will be efficiently coordinated with the aim that associated traffic movement will most likely occur between 7am to 7pm Monday to Friday and 7am to 4pm on Saturday.

11.7.2.3.2 Air-freight haulage from MPC

It is likely that the fortnightly/weekly charter flights will carry a small quantity of air-freight (section 5.11) that would likely be transported at the same time as exchanging crew within a Light Goods Vehicle (LGV) and would not add significantly to vehicle transits.

Further, whilst the base case assumes that sea-freight will be supplied through oil coaster supply vessels to the TDF, there may be the possibility that small levels of freight may be received on an occasional basis at Mare Harbour on the MoD charter service or via the regular SAAS vessel. If this were to occur this would also require transfer to Stanley supply bases. At present this is not considered to be in significant quantity or frequency and is not considered further as the current base case or within the assessment. If at some point greater cargos were to be transported by this route and / or reception facilities required at Mare Harbour, the implications with respect to planning consents and environmental assessment including transport impacts would be discussed with FIG.

11.7.2.4 Waste haulage

Most of the project's waste will be incinerated either in new FIG provided facilities or at the base but some waste will be shipped out from the TDF to the UK (section 10.10) and therefore it would not significantly contribute to on-island transportation except for the short distance from the yard to the TDF. In the long term, small amounts of recyclables and / or speciality wastes may find a disposal or treatment opportunity in the Islands, and would therefore require transport from the TDF to the disposal / treatment site. These opportunities are not assessed in this EIS as they are not currently part of the project, and are not considered further.

As described in section 10.10, the Falkland Island municipal waste facilities will become available in time for the project (currently anticipated to be constructed in 2020), meaning that haulage of waste would be required from the TDF / laydown yards to the location of the new waste facilities. This is likely to require transit along the Airport and / or Bypass Roads (the current proposed site for the FIG Waste Reception facility is at Megabid on the Airport/Bypass Road).

An assessment of waste arisings (section 10.10) undertaken for this Project predicts that onshore wastes being handled will peak at 324 tonnes per month during Stage 2 of the project, dropping to 54 tonnes per month in Stage 3 during steady state production. Assuming that the largest allowable heavy goods vehicles (38.5 tonnes gross vehicle weight) would be used that could each carry a payload of 28 tonnes, and that waste can be stored and manipulated to minimise the number of trips, this would give potentially 12 vehicle movements per month at peak falling to 2.5 movements per month during production. However, since their destination is uncertain and there may be multiple endpoints if waste outlets are located in different sites (e.g. landfill, incineration, waste to energy and water treatment), an overall estimate would be of one movement every working day at peak falling to one movement every week during steady production.

11.7.2.5 On-call personnel and domestic supplies

On-call technicians and operatives; senior management; and permanent personnel based in rental accommodation, will require access to self-drive vehicles for flexibility for out-of-hour call outs and requirements outside the shuttle-bus transit routes or scheduled times. An allowance for 35 vehicles making four daily return journeys along the Airport Road is included within the assessment. It is expected that some level of car-pooling between staff and rotation of vehicles between on-call staff will be possible, which may reduce overall vehicle number requirements. This component of transport will also have impacts within Stanley for meetings, office logistics, shopping and access to rental accommodation (depending upon where this located).

The degree of local supply of goods and services will depend upon the level of success of the local businesses in the competitive procurement process balanced against security of supplies for the local resident community. It is not possible to determine at this stage the degree of supply that will be sourced locally and the level which will be out sourced externally and arrive in conjunction with Premier Oil freight supply to the TDF. Undoubtedly there will be a level of increase in local supply and economic activity serving the O&G sector including, but not limited to, supply to;

- General retail sales serving personnel in rental accommodation;
- Food and consumables to transit accommodation; and
- Fuel and consumable deliveries to heliops, yards, etc.

This will cause a resultant increase in deliveries, retail stocking and thus vehicle movements in general retail, supply and service sectors. This would predominantly be within the vicinity of Stanley but may also impact the MPC road if importation of third-party private sector goods were imported through Mare Harbour shipping links.

11.7.3 Potential receptors

The ENvironmental Impact IDentification (ENVIID) workshop was used to identify those receptors upon which the impacts of road use warranted further investigation (Chapter 9)

Receptors that may be impacted by increased road use during the Phase 1 Development include:

- Human Population (section 7.7.2):
- Tangible Property - road networks (section 7.7.4):
- Air quality if emissions and increased dust are close to residential areas.

Note: impacts on regional and local air quality from particulate matter suspended by the use of uncapped roads is assessed in section 11.12.

11.7.4 Characterising and quantifying the level of resource competition in road transits

When characterising and quantifying the impact of road use on road infrastructure and other users, it is necessary to identify the key roads likely to be used and to consider the expected usage rates in comparison to the existing baseline usage.

Therefore, the following section describes:

- Location and types of road;
- Existing road usage;
- Nature of the impact in relation to the human population and tangible property;
- Base-case mitigations; and
- Estimation of road usage during the Phase 1 Development.

11.7.4.1 Location and types of road

The main roads used during the proposed Phase 1 development will be:

- The partially uncapped MPC Road for:
  - Fortnightly/weekly crew exchange;

  - Miscellaneous passenger exchange outside of crew rotations;
  - Air-freight fortnightly; and
  - Occasional sea-freight if alternative freight or coaster is utilised (not current base case).
- The capped Airport Road & Bypass Road in Stanley for:
  - Crew exchange fortnightly/weekly;
  - Shuttle-bus for rotational onshore personnel and heliport;
  - Miscellaneous local supply deliveries; and
  - Waste disposal to municipal waste processing facility (medium / long term if available).
- The uncapped Boxer Bridge Road and Coastel Road for:
  - Access to laydown yards and TDF;
  - Transit loads between laydown yards and TDF; and
  - Internal movements within yards (excluded as they do not utilise public roads).
- The capped Stanley roads for:
  - Potential shuttle bus from accommodation to central Stanley; and
  - Limited number of self-drive vehicles for technicians, managers and office support.

Note: no routine use of Camp roads beyond the MPC artery is envisaged.

The main arterial road network of the Falkland Islands extends to approximately 862 km in total, with 489 km on East Falkland and 373 km on West Falkland. Roads outside of Stanley, and those around the MPC, are predominantly uncapped and of variable surface quality.

In 2012 the FIG introduced a Highways Asset Management Plan which categorises the Islands' road network on the basis of each roads' strategic importance and prioritises maintenance in respect of this (Table 11.35).

At present the development expectation is that all activity related to the Phase 1 Development will occur within the vicinity of Stanley and between the infrastructure centres of Stanley and MPC. As such, almost all transit and transportation will occur on Class A roads which are prioritised for maintenance as a primary national asset. Use of the road network is therefore limited to roads that are already subject to on-going routine maintenance and prioritised work schedules such that duration of any degradation that may cause nuisance is minimised through remedial works as soon as weather and plant permit.

Main road elements are shown diagrammatically in Figure 11.11.

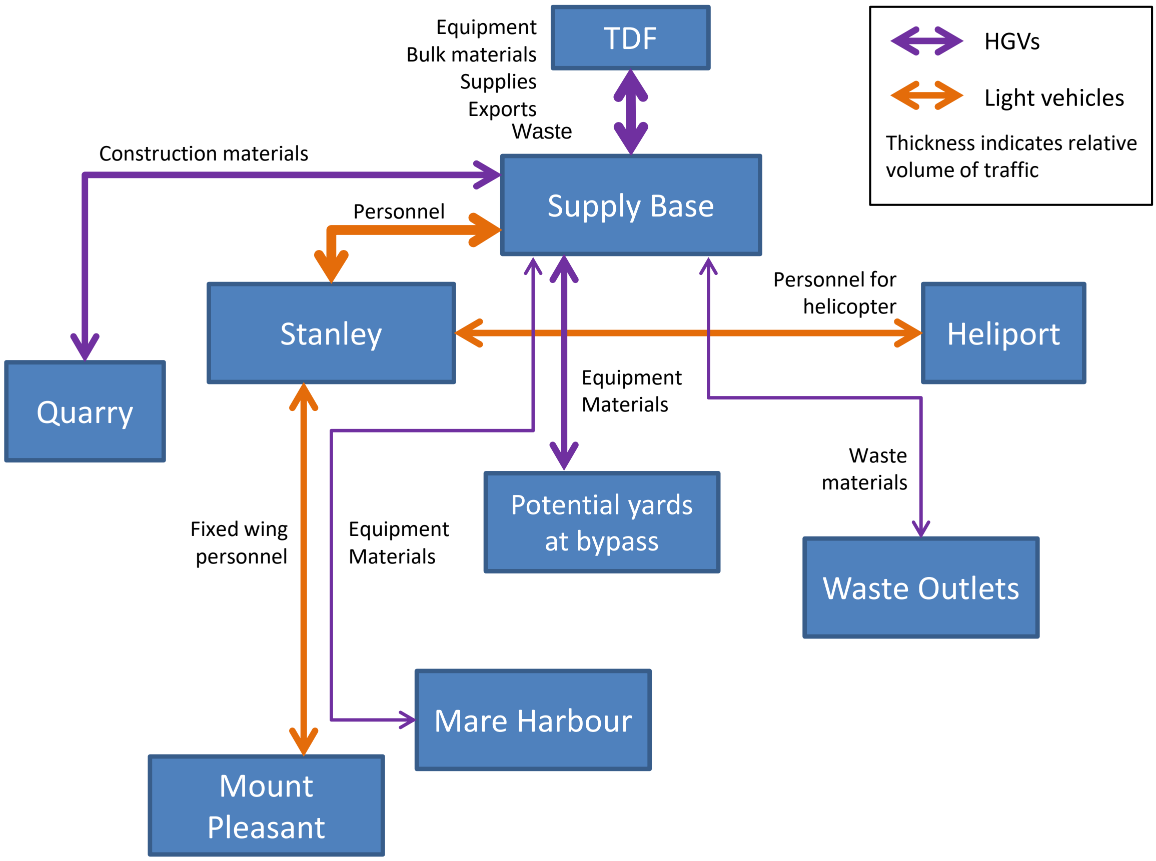


Figure 11.11: Key elements of road transport required

Table 11.35: Highways Asset Management Plan Road Classification (FIG, 2012; Executive Council Paper 39/12)

Road Classification	Description	Example
Class A Road	Primary link road between major national assets. Greatest traffic use by volume and weight.	Stanley to MPC MPC to New Haven ferry terminal Port Howard ferry terminal to Fox Bay
Class B Road	Link road between all Class A and Class C roads Major tourist destinations Major supply route to abattoir	North Camp road Goose green to North Arm
Class C Road	All other roads	Link roads to individual farms or a series of 2 – 3 farms on a single branch road

11.7.4.2 Existing road usage

The FIG PWD Highways Section have previously deployed pressure activated vehicle loggers at a number of sites to determine the number of vehicle passes, class of vehicle, weight of vehicle and the speed of vehicles.

Average daily usage on the MPC road over the three sampled periods (two locations) averaged 483 vehicle passes / day (Table 11.36). As shown in Table 11.37, the majority of these vehicles were cars, 4x4, minibuses or Light Goods Vehicles (LGV) with these groups accounting for 87.2 % of transit in 2015.

Daily usage on the Airport Road (measured between the Chandlery and Stanley Growers Market Garden), over a single sampled period, averaged at 1,755 vehicle passes / day (Table 11.36). Again, the majority of vehicles were cars, 4x4s, minibuses or LGVs with these groups accounting for 92.2 % of transit in 2015 (Table 11.37).

MPC Road usage has generally increased significantly year on year, however exact recent trends are not certain and road usage may have stabilised (Table 11.38).

Table 11.36: Vehicle passes recorded by vehicle loggers

Sample Location	Providing access to	Sampling Start Date	Sampling End Date	Sampling Period (Days)	Total Vehicle Passes	Daily Average
MPC Road Sapper Hill [a]	Quarry, abattoir, wind farm, Camp Road network (north and south) and onwards to MPC and New Haven ferry terminal	19/12/2011	05/02/2012	48	30,799	642
MPC Road Sapper Hill [b]	Quarry, abattoir, wind farm, Camp Road network (north and south) and onwards to MPC and New Haven ferry terminal	29/10/2014	21/01/2015	84	32,414	386
MPC Road by Mt Kent Fuel Tanks [b]	On the MPC Road at the junction with the East Falkland North Camp road network	02/03/2015	05/04/2015	34	14,317	421
Airport Road (Chandlery / Market Garden) [b]	Access between Stanley and FIPASS, Boxer Bridge Road, TDF, laydown yards, PWD Megabid municipal supplies, Stanley Airport and heliops and recreational access to Cape Pembroke and Surf Bay.	02/03/2015	08/04/2015	37	64,938	1,755

[a] Invenio (2013) Safety Review & Statistical Analysis Stanley-Darwin (MPC) Road. Data derived from FIG.

[b] FIG (2016) Supplied by C.Summers October 2016.

Table 11.37: Vehicle categories logged

2011/12		2015/16		
Vehicle category	MPC Road Sappers Hill (2011/12) [a] (% passes)	Vehicle category	MPC Road Sappers Hill (2014/15) [b] (% passes)	Airport Road (2015) [b] (% passes)
1. Very Short Bicycle or Motorcycle	0.8	1 (C)	0.1	0.1
2. Short Sedan, 4WD, Light Van	83.2	2 (O)	0.2	0.3
3. Short 4x4 Towing Trailer	1.8	3 (Car)	19.2	21.6
4. Two Axle Truck or Bus	8.8	4 (LGV)	68.0	70.6
5. Three Axle Truck or Bus	2.8	5 (R2)	4.3	4.0
6. Four Axle Truck	1.1	6 (R3)	3.5	1.0
7. Three Axle Articulated Vehicle	0.1	7 (R4)	0.7	0.1
8. Four Axle Articulated Vehicle	0.5	8 (A3)	2.4	0.7
9. Five Axle Articulated Vehicle or Rigid and Trailer	0.5	9 (A4)	0	0
10. Six Axle Articulated Vehicle	0.3	10 (A5+)	1.2	0.4
11. B Double or Heavy Truck and Trailer	0.0	11 (Bus)	0.4	0.2
12. Double or Triple Road Train	0.0	12	n/a	1.0

[a] Invenio (2013) Safety Review & Statistical Analysis Stanley-Darwin (MPC) Road. Data derived from FIG

[b] FIG (2016) Supplied by C.Summers October 2016

Table 11.38: MPC Road known historical road use (Invenio, 2013)

Year	Average daily number of journeys	Increase since previous measure	% increase since previous measure	Average rise year on year
1988 [a]	90	n/a	n/a	n/a
1998 [a]	125	35	39	3.8
2010 [a]	289	164	131	10.9
2013 [a]	550	261	91	30.2
2015 [b]	*c.* 386 - 421	not calculated	not calculated	not calculated

[a] Invenio (2013) Safety Review & Statistical Analysis Stanley-Darwin (MPC) Road. Data derived from FIG

[b] FIG (2016) Supplied by C.Summers October 2016

Note: FIG considers that road usage is similar to when this data was acquired. (C Summers *pers. comm.* October 2019)

11.7.4.3 Nature of the impacts to human population and tangible property

The nature of the potential impacts is as follows:

- Potential nuisance impacts to the human population:

  - Nuisance to other road users from increased 'congestion', reduced ease of use if surface degraded or more time is spent on maintaining the roads, etc.;
  - Disturbance caused by noise if there is increased use of Heavy Goods Vehicles (HGVs) close to residential areas;
- Potential impacts to the Tangible property:
  - Degradation of cappings / road surface of road networks;
  - Wear and tear on other users' vehicles if road surfaces are degraded; and
- Increased suspension of particulate matter from road uncapped road usage and impacts on local air quality (section 11.12).

The extent of the above impacts will vary according to the location and type of road.

In general, axle weight and frequency of loading are the most important considerations in determining the stress and degradation placed on roads from vehicle traffic. Axle weights can be expressed as a load equivalency factor to determine pavement wear which typically increases exponentially with axle weight. Other factors such as the quality of suspension are also important, and many such parameters are governed by controls on permissible vehicle types (e.g. following Highways (Weight Limits) Ordinance 2004 and the UK 'Construction and Use' Regulations) and mandatory inspections and testing. Research typically finds a 'fourth power law' relationship between axle load and pavement wear (e.g. NVF committee Vehicles and Transports, 2008), which translates, for example into pavement wear being around three times worse for a 38 tonne HGV compared with an 18 tonne two-axle truck or an 18 tonne large bus, with cars being negligible. Pavement wear is therefore significantly driven by movements of HGVs with axle loads up to around 10 tonnes; to a lesser extent by medium sized vehicles such as buses or smaller lorries; and virtually no impact from cars or minibuses.

11.7.4.3.1 MPC and camp roads

With regard to nuisance impacts on the human population, dust, noise and nuisance are not considered significant due to the remoteness of the road from any significant concentration of human habitation / residential area. The length of the road in comparison to the number of daily vehicle transits also signifies that vehicle density is low and that congestion, such as to increase journey time, should not be an issue.

With regard to impacts on the road as tangible property, the MPC and wider camp road network was initially designed as 'all-weather track' for predominantly low axle weight 4x4 light passenger vehicles. Degradation of the road surface (both capped and uncapped sections) may occur, especially in winter when weather conditions and the inability to conduct routine maintenance programmes combine to reduce surface quality. The existing use of HGV's, for example to transport civilian freight from Mare Harbour to Stanley, livestock to the abattoir and camp fuel supplies, has been noted as contributing to deterioration of road condition. This is a recognised as an on-going issue (FIG, 2012) even in the absence of oil development. The MPC road is ranked as a Category A road with the highest priority for on-going maintenance (FIG, 2012).

11.7.4.3.2 Airport Road and Bypass

With regard to nuisance impacts, the proximity to residential areas is such that there may be some concern over noise, especially from HGVs, affecting neighbouring residents, although the road is to a large extent bunded where residential properties are adjacent. Bunding assists in reducing visual and noise intrusion. The impact of noise from the Phase 1 Development on residents is more specifically assessed in section 11.9. The Airport Road and Bypass Roads are generally free-flowing in traffic and would accommodate increased traffic levels without detrimental levels of congestion being noticeable.

With regard to impacts on tangible property, the Airport Road and Bypass is fully capped and is thus more resistant to degradation. As detailed previously the significance of wear and tear to the surface will be proportional to the forecast increased usage in relation to current baseline usage. Capping also removes any consideration of dust impacts from passing vehicles to air-quality.

11.7.4.3.3 Coastel Road and Boxer Bridge Road

With regard to nuisances for the human population, these roads are located in a light industrial area, without residential development and prevailing westerly winds are such that dust, suspension of particulate matter and noise from transportation are not likely to be significant.

In general, the Coastel Road and Boxer Bridge Road in the vicinity of the Gordon Lines area are not used as primary through-transit routes to other areas. Vehicles would generally bypass the area along the Airport Road. Alternative diversion is possible via the Airport road on capped surfaces around the whole site and the Coastel Road and Boxer Bridge Road need only be used if accessing the TDF. As such it is not a transit route that by necessity need impinge on other domestic users if congestion or degradation were to occur.

The TDF is located at the approximate mid-point of the Coastel Road. Light industrial and warehouse sites to the west of the TDF (including Morrison’s Construction supply base, various fishing companies and agencies linked to FIPASS and general light industry / storage) would generally access third-party sites from the west (FIPASS Road) and depart to the west, thus transport servicing these areas would not reach or transit past the TDF shore frontage. There are third-party sites towards the east corner of Boxer Bridge Road and Coastel Road, including RBC, Ian Stewart Construction and Fortuna.

Sites to the east of the TDF or for access to the Canache, Boxer Bridge and Cape Pembroke would generally enter from the Airport Road to the east. Therefore, the middle section of the Coastel Road at the TDF access point is only relatively lightly used.

With regard to impacts on tangible property, these roads are uncapped and there are currently no plans for the surfaces to be capped. Currently no special authorisation is needed for vehicles of up to 38.5 mt gross load to use these roads. Individual axle weight is also an important consideration, and in the UK for example special authorisation is needed for axle loads greater than 10 tonnes for a non-driving axle, and 11.5 tonnes for a driving axle. Some upgrade of the road was conducted prior to the 2015 exploration drilling campaign to ensure the load capacity of the central section and to minimise spreading of road material which can create ‘soft’ edges. Degradation of the road surface did occur during the exploration activity and it is likely that Oil and Gas (O&G) movements comprised the majority of heavy transits and increased the rate of degradation. Salting of the clay road surfaces to maintain safety of work in winter may also have contributed to some breakdown of surface.

During Stages 1 and 2 of the proposed Phase 1 Development, when transfer of drilling materials in particular will entail HGV use, it is anticipated that movements may have a detrimental impact upon the road surface above the wear and tear of existing users. However, the overall impact is likely to be low due to the:

- Relatively low existing use of this section by other road users and public;
- Location of the road within a generally light industrial area;
- Lack of necessity for other adjacent users to transit the area to the east of the warehousing sites which supply FIPASS;
- Presence of alternative routes to by-pass the area via Airport Road for other users; and
- Relatively short road length and its proximity to PWD plant storage and quarry aggregates making it easily accessible which minimises logistics if routine repair is required.

11.7.4.3.4 Stanley roads

As described in section 11.7.2, general personnel working on a rotation basis will not normally have access to individual vehicles for personal use. The use of Stanley roads will therefore be limited to on-call technicians, managers and permanent onshore personnel. Transport from personnel accommodation and to central sites in Stanley will be conducted by shuttle bus or taxi services and are not expected to significantly increase congestion.

Whilst no site has yet been determined for the accommodation unit, it is expected that it will be built in a location with easy access to the Airport or Bypass Roads. Therefore, daily traffic can be diverted around Stanley and should not cause additional through-traffic along the East-West routes within Stanley that may be congested at peak times relating to the start and end of the working day and at lunchtime. However, it is believed that parking, with the resultant impact on traffic flow, is perhaps a greater issue in Stanley than the actual increase in vehicular traffic. As is detailed within the accommodation chapter (section 11.3) some or all accommodation for the additional 35 permanent staff who will live in Stanley may be achieved by new build, and any new build will come with the provision of off-street parking in line with planning regulations. The aim of this section is to consider tangible property i.e. wear and tear on roads, and parking is considered a socio-economic impact and so is not considered further here.

11.7.4.4 Base-case mitigations

In addition to adherence to legal speed and vehicle weight limits (section 11.7.1.1), a number of mitigations will be put in place to minimise impacts to the road surface from the Phase 1 Development. These are listed in Table 11.39.

Table 11.39: Base-case mitigations which will serve to minimise impacts from road use

Item / Vehicle	Location	Background and description
Crew and personnel transfers		
Minibus / coach	MPC Road and Airport Road	The most efficient transport system will be assessed through tender and subject to a risk assessment; and The transport system that achieves the best compromise between number of transit (seating capacity), axle weight (wear and tear) and safety will be selected. This is currently thought to be a mid-sized minibus or coach that would maintain axle weight within an LGV category.
Onshore rotation personnel		
Shuttlebus	Bypass & Airport Roads	No sole-use vehicles provided except in case of on-call workers or senior employees; Transfers made by scheduled shuttle-bus service to increase efficiency and minimise transits; and Accommodation is expected to be located with easy access to Bypass and Airport Roads to remove any through traffic and transit from central Stanley.
Permanent onshore personnel		
Individual Vehicles	Bypass and Airport Roads Central Stanley	Strict HSE driving policy and risk assessment that limits vehicle trips, especially out of town and on gravel surfaces, to absolute minimum; All drivers will undergo local training on driving techniques and driving etiquette to minimise impacts; Vehicles proportional to need, car-pooling will be applied where appropriate; and Location of private rental accommodation is not yet confirmed but off-street parking will be a preference.
TDF and lay-down yards haulage		
HGV, Haulage and transfer of materials	Boxer Bridge Road & Coastel Road	The use of logistics vessels in Berkeley Sound will minimise heavy load items being brought ashore; Appropriate de-icing chemicals or grit administered by FIG – Premier will work in liaison with FIG in respect of routes and timing of vehicle movements; Driver training and vehicle maintenance (minimise breaking, wash-boarding, etc.); and Escort vehicle or road side safety flashing lights when appropriate to warn of abnormal load movements.

11.7.4.5 Estimated Phase 1 Development road usage

11.7.4.5.1 MPC Road and air-link personnel movements

Crew transfer logistics will be finalised through tender processes accompanied by a risk assessment of options and therefore, the exact specification of vehicles and seat capacities cannot be confirmed at this time. The assessment is based on minibuses of 15 seat capacity that were used during the 2015 exploration campaign. However, with differing personnel numbers it may be that larger capacity options may be utilised and be more efficient in both fuel and vehicle passes for people moved. This would likely reduce impact.

While the larger buses would be heavier and have a greater impact on road surfaces they would require fewer trips and perhaps be most appropriate to passenger exchange when larger numbers must be moved to meet a single fixed check-in time. In contrast, a minibus would require a greater number of repeat trips contributing to congestion. Therefore, to assess the worst case, use of a 15 seat minibus has been assumed in this EIA. Further, rotation crew moving offshore are restricted to 15 kg baggage allowance and therefore additional luggage capacity is not a significant concern, however an additional allowance of one luggage van per 45 personnel has been allowed for.

As is shown in Table 11.40, a maximum 0.8 % increase in daily MPC road usage would occur during the Phase 1 Development. In Stage 3, once personnel requirements decline, passenger movements would account for only 0.48 % of MPC road usage.

Even taking into account the inevitable uncertainties in estimates and timings of trips, these levels are not considered significant to road maintenance schedules or wear and tear of road surfaces and are significantly below past historical year on year increases in road usage observed in the Falkland Islands (section 11.7.4.2, Table 11.38). Even recognising that use is a fortnightly/weekly pulse of vehicles to meet the air-charter it is unlikely that congestion would occur given that the legal speed limit is set at 40 mph and that minibuses would not be impeding other road users who should also be travelling at below that speed.

Even with nominal additional allowance for air-freight or sea-freight transfer the usage of the MPC road is not considered significant.

Table 11.40: Vehicle transit requirements based upon air-link capacity requirements during the three stages of the Phase 1 Development

Statistic	Stage 1	Stage 2	Stage 3 (per annum)
Maximum air-link capacity requirement for crew exchange	137	126	76
Minibus requirement based on 15 seat capacity	10	9	6
Luggage van requirement based on 45 personnel	4	3	2
Total number of vehicles	14	12	8
Number of bus trips (based on two return trips (four passes) required per exchange for arrival and departure)	56	48	32
Number of days between air-links (fortnightly)	14	7	7
Equivalent average daily usage transits	4	7	4.6
Increase in MPC road usage based on current average usage of *c.* 483 vehicles/day	0.8 %	1.3 %	0.89 %

11.7.4.5.2 Airport Road usage for transport between accommodation, TDF and supply base

Transportation needs are assumed based on a 12-hour shift pattern and 12-hour working day. This would necessitate all personnel being transported to work at the commencement of the day and returning at the end. At start and termination all movement would be in one direction with minibuses at capacity delivering personnel and returning empty for the next load.

A 24/7 working programme is planned. On the basis of a 12-hour dual-shift pattern, within a given maximum personnel, this would actually decrease (by approximately half) the transportation needs at commencement and end of shifts. In this scenario, half the personnel would be commencing as half the personnel were finishing and minibuses would be full in both directions.

Transport provision will be tendered and exact vehicle capacities and schedules are currently unknown. Based on the transportation used during the 2015 exploration drilling campaign, a worst and extremely precautionary case can be assumed as:

- Move all personnel at 06:00 to start shift
- Schedule of circular shuttle-bus at 30 minute departures 06:30 – 11:30 for any personnel needing to return to accommodation / Stanley
- Move all personnel to messing facility at 12:00 (start lunch)
- Move all personnel to site at 13:00 (end lunch)
- Schedule of circular shuttle-bus at 30 minute departures 13:30 – 17:30 for any personnel needing to return to accommodation / Stanley
- Move all personnel at 18:00 (end shift)
- All long-term onshore personnel have individual vehicles undertaking 4 return trips / day

Second 12 hour shift vehicle movements on the same basis.

Using these assumptions transportation needs are detailed in Table 11.41.

Requirements would be highest during Stage 1 and Stage 2 with a potential for a 22% increase in vehicle transit by car and LGV minibus. The main increase results from car transit by permanent personnel positions rather than the shuttlebus service. In Stage 3, use would decline as the shuttle service would largely cease and the increased usage of 14 % would be almost wholly due to permanent staff vehicles.

Although the vehicle use would incorporate only car and LGV usage of low axle weight, such increases may have long-term un-quantifiable significance to road capping wear and tear. However, this wear and tear is not considered to be significant to maintenance schedules. Impact upon other road users is thought to be low.

In reality needs would likely be less. Not all permanent personnel are likely to have permanent access to a vehicle of single person use.

Table 11.41: Transportation requirements during the Phase 1 Development

Description		Stage 1	Stage 2	Stage 3
Permanent / management personnel with access to self-drive vehicles				
Number of personnel	It is unlikely that all would have access to vehicles and car-pooling and vehicle rotation to the on-call person would occur. The estimate of 35 associated vehicles is conservative	35	35	30
Daily return trips	One return trip is equivalent to two vehicle passes per trip	4	4	4
Number of vehicle passes per day		*280*	*280*	*240*
Rotational onshore personnel shuttle bus requirements				
Maximum number of personnel	The maximum number of personnel would be split between 2 shifts for 24 hour working	125 (85 day & 40 night)	112 (76 day & 36 night)	18 (11 day & 7 night shifts)
06:00 return trips	Shift change over. One shift arriving and one shift returning on same return trip. Based on 15 seat minibus to move all personnel.	6	6	1
06:30 – 11:30 shuttle bus departures at 30-minute intervals	30-minute one-way departures 06:30: Accom. – Yards 07:00: Yards – Accom. 07:30: Accom. – Yards 08:00: Yards – Accom., etc.	5.5	5.5	Not required as capacity within self-drive vehicles
12:00 return trips	Based on 15 seat minibus to move all on shift day personnel for mid-shift meal.	6	6	1
13:00 return trips	Based on 15 seat minibus to move all on shift day personnel for mid-shift meal.	6	6	1
13:30 – 17:30 shuttle bus departures at 30-minute intervals	30-minute one-way departures 13:30: Yards – Accom. 14:00: Accom. – Yards 14:30: Yards – Accom. 15:00: Accom. – Yards, etc.	4.5	4.5	Not required as capacity within self-drive vehicles
18:00 return trips	Shift change over. One shift arriving and one shift returning on same return trip. Based on 15 seat minibus to move all personnel.	6	6	1
18:30 – 23:30 shuttle bus	One-way shuttle bus departures at 30-minute intervals as before	5.5	5.5	Not required
00:00 return trips	Based on 15 seat minibus to move all on shift night personnel for mid-shift meal.	3	3	1
01:00 return trips	Based on 15 seat minibus to move all on shift night personnel for mid-shift meal	3	3	1
01:30 – 05:30	One-way shuttle bus departures at 30-minute intervals as before	4.5	4.5	Not required
Total return trips per day		*50*	*50*	*6*
No vehicle passes per day		*100*	*100*	*12*
Total figures				
Total daily vehicle passes	Individual vehicles and shuttle buses	380	380	252
Increase to current baseline vehicle passes	Based upon current baseline level of 1,755 vehicle passes	22 %	22 %	14 %

11.7.4.5.3 Coastel Road and Boxer Bridge Road

The main bulk of all materials movement and HGV usage will be confined to the short 160 – 870 m transit between TDF access and the potential location of entrances to the lay-down yards.

The main movements of bulk materials and equipment occurs during drilling, i.e. Stages 1 and 2 and is a relatively steady level of activity. The majority of HGV traffic is between the TDF and the supply base, and peak levels are related to the capacity of incoming vessels and rate of offloading. It is anticipated that these parameters will be similar to those experienced in the drilling campaign for exploration wells. Basing traffic numbers on those levels, it is anticipated that 20 two-way HGV movements could be expected over a four to six hour period related to a single vessel, before the next spell of activity. This equates to a maximum rate of 5 two-way movements per hour.

11.7.4.5.4 Central Stanley

As stated above, it is expected that the location of the accommodation for rotational onshore personnel during Stages 1 and 2 of the Development will be located with easy access to the Bypass and Airport Roads. This will remove transit and through traffic from central Stanley and prevent any increase in congestion at peak times of 08:00, lunchtime and 16:30 relating to the domestic working day.

During the 2015 exploration campaign, four return shuttle buses took personnel to Stanley during the lunchtime period. In addition, there was an additional allowance for minibus runs to central Stanley and the leisure centre in the early evening (*c*. 18:00 hrs) after the end of the working day, although the utilisation of this on-call service in comparisons to taxi use is not available.

The greatest influence on traffic within central Stanley will be the location of the rental accommodation used for the 35 permanent staff, which may increase through-traffic within central Stanley or further limit parking provision. However, any newer accommodation, or new-build accommodation is likely to have two off-street parking spaces (as required by planning guidelines), so that Sea Lion project use of such properties would not additionally limit available parking provision. At the time of writing, the location of such accommodation is unknown, such that it is not possible to quantify the impacts of associated vehicle use.

11.7.5 Industry-standard mitigation

Vehicles used will conform to vehicle design regulations including the UK Road Vehicles (Construction and Use) Regulations 1986, with the exception of abnormal load trailers, which will be specifically designed for the load and road structures.

The movement of abnormal loads will comply with the Code of Practice Lighting and Marking for Abnormal Load Self escorting vehicles incorporating Operating guidance (Highways England, 2016) or similar requirements agreed with the FIG PWD Highways Section.

As per during the exploration campaign, Premier will implement the following industry standard mitigation measures:

- Specific applications for abnormal road movements; and
- Strict HSE driving policy, risk assessment and local training.

11.7.6 Impact assessment

The following section draws upon all the information provided above to assess the 'Sensitivity of the Receptor' and the 'Severity of Effect' in order to determine the overall 'Impact' of planned activities.

A summary of the impact and risk assessment outcomes for this Development is tabulated in section 11.7.11 which shows the worst case impact / risk for each activity and receptor and details are provided below.

11.7.6.1 Congestion from road use

As stated above, the impacts of noise on the human population are assessed in section 11.9 and therefore this section assesses the impacts of congestion and associated nuisance.

Most Project HGV traffic will be concentrated between the TDF and onshore supply base and while this will be frequent at times, it has relatively low public use and such use is consistent with the designation of the area and the design of road junctions.

According to the data gathered by the FIG PWD Highways Section, the most frequently used road in and around Stanley is the Airport Road. This road is used by residents for access to the airport and areas to the east of Stanley (section 7.7.4.2) and is in close proximity to residential areas (section 7.7.2). Further, the carrying capacity of existing infrastructure was raised as a concern by stakeholders on numerous occasions. While roads were not raised specifically, it can be assumed that congestion on the Airport Road and / or vehicles parked in Stanley may be unacceptable to the majority of stakeholders such that, to take a precautionary approach, the **sensitivity of the receptors** (Human Population) is considered to be '**Moderate**'.

During the Phase 1 Development, the Airport Road will be used for the transportation of onshore personnel from accommodation to the supply base, TDF and the heliops at Stanley airport. As shown in section 11.7.4.5.2, this use could result in an increase in traffic of up to 21 % in Stage 1 and 2, and 14 % in Stage 3. This could result in some degree of congestion at peak times which may cause some inconvenience. Therefore, the **severity of effect** of congestion to the Human Population is considered to be '**Minor**'.

The overall **significance of the impact** of road use on the human population is therefore assessed as '**Moderate (6)**'**,** and consequently further additional mitigations are not considered necessary.

11.7.6.2 Road degradation from increased vehicle use

As stated above, the impacts of particulate matter from uncapped road use on air quality and the human population are assessed in section 11.2 and therefore this section assesses the impacts of degradation of road surfaces i.e. on the tangible property itself.

With regard to surface degradation, the most sensitive roads are those which are uncapped (section 7.7.4.2). Both parts of the MPC road and the Coastel and Boxer Bridge Roads are uncapped and will be used during the Phase 1 Development. As is shown in section 11.7.4.5 however, the Phase 1 Development is anticipated to result in a maximum 1.3 % increase in use. Therefore, the greatest impact on road usage and road surfaces is considered to be in the vicinity of the TDF and laydown yards located in the Boxer Bridge and Coastel Road area. The largest proportion of all supply materials, chemicals and bulks will be handled and / or transferred between these two sites. Nonetheless, given that use of the roads is sustainable and the stretch of road is short and not used by many others, the **sensitivity of the receptors** (Tangible Property) is considered to be '**Low**'.

Whilst impacts will occur to the road surface in this area, the length of roadway that will be impacted is short at less than a kilometre in total length from Airport Road to the TDF. Given expected use during the Phase 1 Development, this length of road may require more frequent maintenance than at present. However due to the short length and accessible location it is not considered that this would place critical restrictions on road maintenance schedules. The area is not a major transit road required for access to onward sites and thus knock-on impacts and inconvenience to other users should not be restrictive. Therefore, the **severity of effect** of road use to the Tangible Property is considered to be '**Minor**'.

The overall **significance of the impact** of road use on Tangible Property is therefore considered to be '**Low (4)**'**,** and consequently further additional mitigations are not considered necessary.

11.7.7 Project-specific mitigation measures

A TDF / supply base traffic management plan will be put in place for operations, as has been done for exploration well activities, to minimise the impacts and risks from operational road use in this area. This will highlight operating hours, signage, allowable routes, warning devices, clothing and pedestrian precautions.

Accommodation for permanent onshore personnel within Stanley with off-street parking will be a preference.

Mitigation measures are considered sufficient to reduce impacts to levels that should not cause significant impact and additional mitigation measures are not considered at this point.

11.7.8 Residual impacts and risks

Residual impacts remain the same as considered for the initial assessment such the **significance of the residual impacts** of road use is considered to be **Moderate (6)** for nuisance and **Low (4)** for degradation of the road surface.

11.7.9 Cumulative impact

Cumulative impacts of increased traffic, or 'increased concentration' (section 8.10.1) is most likely to occur within Stanley. Central Stanley is limited in available parking and this can, at times, cause limitations on cars travelling through Stanley. However, as described above, any new developments built for rental to permanent personnel must follow planning regulations and provide off-street parking which will mitigate against cumulative impacts.

11.7.10 Confidence

The transport and laydown yard tenders have yet to be defined and released. Alternative transport and haulage tenders will be assessed against the Statement of Needs and will require demonstration of safety risk assessment. The exact specification and capacities of vehicles is therefore not defined at this stage. However similar systems were in place during exploration activity without major incident and can be used as a template on which to base the assessment.

The level of confidence in the impact and risk predictions and efficacy of mitigation is therefore **Probable**.

11.7.10.1 Monitoring required

Use of roads will be monitored and will be included within the EMMP for on-going assessment to identify any emerging issues at an early stage.

11.7.11 Offsetting

For significant residual and impact and risks (Moderate or above), offsetting via an Environmental Fund is proposed, see section 8.9 for further details.

11.7.12 Findings summary

Table 11.42: Summary of the impact assessment for use of road network during the Sea Lion Phase 1 Development

Activity / Event	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity[a]	Severity[a]	Likelihood[a]	Impact / Risk Significance1		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Phase 1 impact assessment											
Use of existing road network	Increased number of vehicles and use of infrastructure	Potential for nuisance to human population e.g. congestion	Planned	1, 2 & 3	Moderate	Minor	n/a	**Moderate (6)**	**Moderate (6)**	**Probable**	**Industry-standard:** Adherence to vehicle and road statutory requirements. Specific applications for abnormal road movements including signage and warning devices. Strict HSE driving policy, risk assessment and local training. All non-critical activities coordinated to avoid peak periods. **Project-specific:** Traffic Management Plan. Accommodation with off-street parking will be a preference.
		Degradation of road surfaces			Low	Minor	n/a	**Low (4)**	**Low (4)**		

[a] See Chapter 8 for definitions of sensitivity, severity, likelihood and significance.

11.8 Disturbance to the human population from light

Table of Contents

11.8.1 Introduction

The Phase 1 Development will use the supply base and Temporary Dock Facility (TDF) in Stanley. Additionally, Berkeley Sound will be used to host up to three Large Transport Vessels (LTV's) as storage and supply vessels for 12 months during the installation phase. All of these inshore, onshore and at-shore activities have the potential to create light pollution and a nuisance for the local residents. As shown in Chapter 6, lighting levels during operations were raised by stakeholders during informal scoping consultations.

This chapter specifically assesses the potential for artificial light to disturb the residents of Stanley and Berkeley Sound.

Note: other impacts associated with the LTV storage and supply vessels, activities at the supply base and TDF are described elsewhere in this document, as described in section 9.2.

11.8.1.1 Relevant legislation

There is currently no legislation in the Falklands relevant to light as a nuisance or disturbance.

The main piece of legislation concerning light pollution in the UK is:

- The Nuisance Provisions, under part III of the Environmental Protection Act 1990 (EPA '90).

Also, while not directly related to the impact of artificial light, it is important to understand during this assessment that mitigation measures will be limited by the need to ensure the use of sufficient lighting for safety reasons. Specifically, offshore installations are required to be lit in line with the:

- International Regulations for the Prevention of Collisions at Sea (ColRegs) (Rule 22 and Annex 1).

11.8.1.1.1 Disturbance from light

Under the Environmental Protection Act 1990 (EPA '90), a 'statutory nuisance' is defined based on its ability to cause disturbance. In order for an activity to cause disturbance, it must do one of the following:

- Unreasonably and substantially interfere with the use or enjoyment of a home or other premises;
- Present a long-term and sustained impact to local residents' quality of life; and / or
- Injure health or be likely to injure health.

With regard to light from the Sea Lion Development activities it is recognised that only the first two definitions above may apply.

11.8.2 Sources of light disturbance to Falkland Island residents

The following Phase 1 activities have the potential to cause disturbance to local residents:

- Use of the onshore supply base in Stanley;
- Use of the Temporary Dock Facility (TDF) in Stanley; and

- Mooring of up to two Large Transport Vessels (LTV's) in Berkeley Sound to support the installation operation.

The sources of light disturbance at various stages of the Development are presented in Table 11.43 below.

Table 11.43: Sources of light disturbance from operations in Stanley and Berkeley Sound during the three stages of the Development

Location of disturbance	Source of noise	Stage 1	Stage 2	Stage 3
Stanley	• Vessel deck lighting and navigation lights, both on vessels and on the TDF; • Deck and office lighting on the TDF; and • Yard and office lighting at the supply base.	✓	✓	✓
Berkeley Sound	• Deck lights on the Large Transport Vessels (LTV's) used as floating logistics vessels anchored in inshore waters in Berkeley Sound.	✓	✓	

11.8.3 Potential receptors

The ENVironmental Impact IDentification (ENVIID) workshop was used to identify the specific receptors upon which the impacts and / or risks of light disturbance warranted further investigation (Chapter 9). This chapter, focusing on the human population, identified the following receptors that may be impacted during the Phase 1 Development:

- Human population (section 7.7.2):
  - Residents living in the vicinity of the TDF and supply base (Stanley):
    - The east end of Stanley (Gordon Lines area), where the TDF and supply base are located is generally an industrial area although there are a number of houses in the vicinity (approx. 1km to the west).
  - Residents living in the vicinity of the proposed LTV site (Berkeley Sound) (section 7.7.2.3):
    - There are four settlements / farmsteads around the Sound (approx. 9 km from the proposed LTV location), with residents living and working in the area, as well as visitors and tourists.

11.8.4 Characterising and quantifying the impact of light disturbance

When characterising and quantifying the impact of light disturbance it is necessary to consider the:

- Nature of the impacts upon the human population;
  - Opinion of stakeholders;
- Quantification of the disturbance in both Stanley and in Berkeley Sound e.g.:
  - The number of sources of disturbance (e.g. sites) and duration of exposure;
  - The location of sources of disturbance (e.g site);

– The number of lights at each site; and
– Orientation of lights at each site.

11.8.4.1 Nature of the impact

Light pollution is the alteration of natural light levels in the night environment produced by the introduction of artificial light. Exposure to light at night has been shown to disrupt melatonin levels, which can impact on sleep and blood pressure, along with a number of other health issues (Falchi *et al.,* 2011). There are no set thresholds above which light can be considered a statutory nuisance in the UK (section 11.8.1.1.1). However, guidelines (section 11.8.5) suggest that acceptable levels of artificial light are dependent on the level of light found at the location prior to the artificial lights being introduced (Defra, 2015b). For example, in areas that are 'intrinsically dark', people are less tolerant of artificial light being introduced, compared to large towns or city centres with high levels of night time activity (Scottish Executive, 2007).

Light pollution can also affect our enjoyment of the night sky when observing the stars, planets and galaxies (CIRES, 2016). The New World Atlas of Artificial Brightness shows that the Falklands are a relatively dark sky area, with the majority of the population living with very little light pollution (CIRES, 2016).

Regardless of the above however, the impact of light is largely subjective and it is therefore useful to consider the input of local residents and stakeholders (i.e. those that may be affected).

11.8.4.1.1 Opinion of stakeholders

Light pollution in Stanley did not come up as a specific issue during scoping for the Sea Lion development in August 2016 (Chapter 6) but it was noted during previous scoping consultations that light from the TDF, vessels and yard is noticeable to Stanley residents. A community complaint was also made to Premier during the 2015 exploration drilling campaign regarding the lighting from vessels moored up at the TDF at night.

The issue of light, particularly in Berkeley Sound, was discussed during the scoping consultations held by Premier in 2016 (Chapter 6). The majority of stakeholders noted that the current levels of light in Berkeley Sound are quite high in jigger season (section 7.7.3.2.1.2) and complaints about light from jiggers have been noted.

11.8.4.2 Quantification of the disturbance

11.8.4.2.1 Light in Stanley

11.8.4.2.1.1 Source and duration of light exposure

Premier made a successful application in January 2018 to the Falkland Islands Government (FIG) to vary the planning consent for the TDF to cover the duration of expected Phase 1 activities. Premier may propose future modifications to improve the Dock's functionality in the future (section 5.11.1.1.1). As described in section 5.11.1.1.1, proposals to upgrade TDF facilities will have to go through the process of planning consent, which may, at the planning officer's discretion, be accompanied by a full EIA. At this time however, it is assumed that the TDF operations will be the same as they were during the 2015 exploration campaign.

Therefore, it is estimated that light sources at the TDF and supply base will include:

- Deck and navigation lights from vessels at the TDF;
- Deck and navigation light from the TDF;
- Office lighting on the TDF;
- Floodlights at the supply base; and
- Office lighting at the supply base.

All of these light sources will be required throughout the Phase 1 Development.

Both the TDF and supply bases may be operational 24 / 7 and will be illuminated during the hours of darkness.

11.8.4.2.1.2 Location of light sources

The TDF is located east of FIPASS, over one km from the nearest residences (see section 5.11.1.1.1). Vessel activity at the TDF will be limited to a maximum of two vessels berthing at any one time, due to space constraints.

The supply base is likely to be based in close proximity to the TDF, although the specific area has not yet been defined.

11.8.4.2.1.3 Number of lights

At the time of writing the specific lighting arrangements are not known for the supply base but are likely to be very similar to the lighting arrangements at the yards used during the exploration drilling campaign. Lighting arrangements at the TDF are already in place.

The base will be larger in Stages 1 & 2 than the yard that was used during the 2015 exploration drilling campaign (section 5.11.1.2). However, in Stage 3, steady state production, the overall yard space used will be smaller than that used during the 2015 exploration campaign. For the purposes of this EIS, it has been assumed that the number of lights will be proportional to the area of the yard. The yard will be similarly lit to the 2015 exploration campaign yard and it has been assumed that lights will be evenly spaced throughout. The area used for the exploration yard covered an area of 51,000 m^2 and the increase in area of the yards during each Stage of the Phase 1 Development is shown below in Table 11.44.

Table 11.44: Proposed area of yard space required for the Phase 1 Development in comparison to 2015 exploration drilling campaign yard space

Stage (and duration)	Area required (m^2) [a]	Difference in area to exploration yard area (51,000 m^2)	Comparison to exploration yard area
1 and 2 (*c.* 6 years)	157,500	106,500 m^2 more	Approx. 3 times greater
3 (*c.* 17.5 years)	30,000	21,000 m^2 less	Approx. 2/3rd of the area

[a] Note that the area required for the specialised storage of explosives, NORM and radioactive sources (required throughout field life), and the onshore storage and testing area for subsea X-mas trees (required for 2 years in Stage 1) is as yet unknown.

Owing to the differences in the areas of yard space required during the different stages, it is estimated that during Stage 1 and 2, the number of lights will be greater than residents have been used to during drilling and that during Stage 3, the lit areas will reduce in proportion. It should also be noted that much of the yard space, as with the yards used during the 2015 exploration campaign, will be covered sheds. As such the whole area will not be floodlit, only those areas outside.

The lighting on the TDF will remain the same throughout the Phase 1 development, with a maximum of two vessels (e.g. two supply vessels) berthing at the TDF at any one time due to berthing space.

11.8.4.2.1.4 Orientation of lights

Some lights, such as office lighting, are not likely to be intrusive as the lights will be of a low level and inside buildings. These will be comparable to other residences and offices in Stanley.

The highest intensity lights will be the TDF deck and yard floodlights, which are generally orientated to illuminate any operational activity being undertaken on the deck of the TDF or in the yard.

11.8.4.2.2 Light in Berkeley Sound

11.8.4.2.2.1 Sources and duration of light exposure

The sources of light that will be present in Berkeley Sound over the various stages of the Phase 1 Development are shown below in Table 11.45.

Table 11.45: Source and duration of lights in Berkeley Sound during the Phase 1 Development

Phase 1 Development Stage	Activity in Berkeley Sound	Duration of Presence in Berkeley Sound	Approximate number of light sources in Berkeley Sound
Stage 1: Mobilisation and installation of materials and equipment, pre-first oil drilling by MODU, installation, HUC [a] of the FPSO and 'first oil'	Up to 3 Large Transport Vessels (LTV's) anchored in Berkeley Sound (maximum two present at any one time) 2 x installation vessel transiting between the LTVs in Berkeley Sound and the field location.	12 months and a 24hr operation	4 vessels (deck lighting and navigation lights from installation vessel and LTV's)
Stage 2: Post first-oil drilling by the MODU, and concurrent production operations by the FPSO and oil export	1 x Large Transport Vessel (LTV) anchored in Berkeley Sound 1 x installation vessel transiting between the LTV in Berkeley Sound and the field location.	6 months and a 24hr operation	2 vessels (deck lighting and navigation lights from installation vessel and LTV)

[a] Hook up and commissioning

11.8.4.2.2.2 Location of light sources

Most of the installation vessel activity that requires deck lighting will be based around the Large Transport Vessels (LTVs) in Berkeley Sound; each vessel will have its own individual 500m exclusion zone and Premier will work with FIG / Fisheries to identify optimum locations within Berkeley Sound that will cause the least disruption to other users by striving to avoid periods of high marine traffic in the Sound. The installation vessel will spend minimal amounts of time in the Sound while it collects equipment from the LTVs. While on-station, deck lighting will have to be maintained by all vessels throughout the 24hr operation to provide a safe working environment.

11.8.4.2.2.3 Number of lights

The intensity of light emitted by each vessel will vary depending on activity. At the time of writing, the identity of the specific vessels involved is unknown; however, some comparisons can be made with other vessels operating in Berkeley Sound.

The lighting arrangements of the LTVs will be similar to the supply vessels utilised during the exploration drilling campaign.

11.8.4.2.2.4 Orientation of lights

Some lights, such as navigation lights, are designed to be seen by other vessels and therefore are orientated to face out-board. However, these are usually low intensity lights.

The highest intensity lights are the deck floodlights, which are generally orientated to illuminate:

- any operational activity being undertaken on the deck of the vessel;
- to assist safe access and egress; and
- the surrounding water.

11.8.5 Industry-standard mitigation

Various guidance is available on minimizing light pollution:

- Scottish Executive 'Controlling Light Pollution and Reducing Lighting Energy Consumption' (2007);
- The Institute of Lighting Professionals Guidance Notes (2012); and
- International Commission on Illumination (CIE) Report 150: Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations (2003).
- Department for Environment, Food and Rural Affairs (DEFRA) Guidance: Artificial Light Nuisances, How Councils Deal with Complaints (DEFRA, 2015b).

Good working practice and design will help to limit the amount of light the vessels operating in Berkeley Sound emit, particularly the design of vessels' lighting arrangements and use of black out blinds. The vast majority of light emitted will be focused on the vessel decks and immediate area surrounding the vessels.

In Stanley at the TDF and supply bases, light will be minimized where possible by design, through good working practice and the use of black out blinds, which aim to reduce potential nuisance to local residents.

11.8.6 Impact assessment

The following section draws upon all the information provided above to assess the 'Sensitivity of the Receptor' and the 'Severity of Effect' in order to determine the overall 'Impact' of planned activities.

A summary of the impact assessment outcomes for this Development is tabulated in section 11.8.12 which shows the worst case impact for each activity and receptor and details are provided below.

11.8.6.1 Impact assessment of light in Stanley

Light was raised as an issue during the scoping consultations and a single complaint has been received before relating to lighting of vessels at the TDF. There are already lights in the Gordon Lines industrial area at the east end of Stanley. Therefore, **sensitivity of receptor** is considered to be '**Moderate**'.

Lighting used at the TDF will result in very similar levels of light experienced during the exploration campaign. However, the yard space will triple, albeit for a short time, before reducing to an area approximately 60% of that used for the exploration campaign. As such, lighting is expected to increase initially for a short period before decreasing during steady state operations. Therefore, on balance, the **severity of effect** is considered to be '**Minor**'.

Therefore, the overall **significance of impact** is '**Moderate (6)**, and mitigation measures to reduce the significance will be developed and implemented.

11.8.6.2 Impact assessment of light in Berkeley Sound

There are a number of light sources in Berkeley Sound from both fishing vessels and permanent navigation lights. The fishing vessels are seasonal and complaints have been noted about the light pollution. The issue of light was raised by stakeholders during the scoping consultations and therefore **sensitivity of receptor** is considered to be '**Moderate**'.

The relatively short-term nature of the light impact from the LTV operation combined with the distance of residences to the light source (greater than 10 km) indicate the **severity of effect** is considered to be '**Minor**'.

Therefore, the overall **significance of impact** of light disturbance in Berkeley Sound from the LTV operation is assessed as '**Moderate (6)**'.

11.8.7 Project-specific mitigation measures

11.8.7.1 Light impact in Stanley

Minimum levels of lighting are required on the TDF and at the supply base to ensure a safe operation. However, the following measures will be taken, where possible, to reduce the light impacts from the supply base, TDF and vessels alongside the TDF:

- Deck lights and yard lights will face inwards; and
- Vessel lights to be turned off when not required, particularly deck lighting.

11.8.7.2 Light impact in Berkeley Sound

Minimum levels of lighting are required on the Large Transport Vessels (LTVs) to ensure a safe operation and in line with legislation (section 11.8.1.1). However, the following measures will be taken, where possible, to reduce the light impacts from the LTV's:

- Deck lights and yard lights will face inwards; and
- Vessel lights to be turned off when not required, particularly deck lighting.

11.8.8 Residual impacts and risks

11.8.8.1 Light impact in Stanley

Implementing the proposed mitigations to reduce the impact of light nuisance from the supply base, TDF and vessels moored at the TDF have the potential to lessen the severity of effect. However, these mitigations were implemented during the 2015 exploration drilling campaign and a complaint was still received.

As such, even with project-specific mitigation measures in place, the **significance of the residual impact** of light in Stanley remains '**Moderate (6)**'.

11.8.8.2 Light impact in Berkeley Sound

Implementing the proposed mitigations to reduce the impact of light nuisance from the LTVs anchored in Berkeley Sound has the potential to lessen the severity of effect.

As such, with the proposed project-specific mitigation measures in place, the **significance of the residual impact** of light in Berkeley Sound remains '**Moderate (6)**'.

11.8.9 Cumulative impact

Places of human settlement and industry ashore represent permanent, or at least regular, sources of light. In the Falklands, these are primarily associated with the two major population centres, Stanley and Mount Pleasant (MPC). Additionally, Berkeley Sound (the LTV site) is used as an anchorage for the trans-shipment of fish and so is also a significant seasonal source of light pollution.

11.8.9.1 Stanley

Sources of existing anthropogenic light in Stanley include all housing, industry and human activity in the town. At the east end of Stanley, where the TDF and supply base will be operating, the area is already designated for 'a mixture of heavy and light industrial, warehousing and storage' within the Stanley Town Plan (FIG, 2015u). The area is currently used as yard space and the TDF is already in place, although, at the time of writing, not in operation.

The peak of activity in Stages 1 and 2, will add in 'concentration' (section 8.10.1) to the light in the area, particularly from vessels visiting the TDF. This period will last approximately six years.

Once into steady state operations the activity, and hence light, will reduce to below levels experienced during the exploration drilling campaign, though these are above the baseline levels experienced in Stanley on a day-to-day basis.

11.8.9.2 Berkeley Sound

Sources of existing anthropogenic light within Berkeley Sound are summarised in the Chapter on the environmental (as opposed to social) impacts of artificial light (section 10.1.9.2). Notably, the jiggers utilise Berkeley Sound to trans-ship their catches to reefer vessels and to refuel. Although the full rig of jigging lights are not deployed in Berkeley Sound, there is a considerable amount of light emitted from these vessels, the glow from which can be seen from Stanley (A. Black *pers. obs.).* In addition to the jiggers, other vessels use Berkeley Sound as an anchorage, primarily for the transhipment fish catches.

Although vessels can be present in all months of the year, activity peaks between March and June, when tens of vessels can be present, but this varies considerably from year-to-year. Combined, these vessels represent a large source of anthropogenic light. Premier plan to avoid peak fishing season as much as practicable, to avoid competition for sea room. At peak times, the LTVs and installation vessels will have less of a cumulative impact as they will be one of many vessels in the Sound (adding to the concentration). At other times of the year, there may be very few vessels using Berkeley Sound and therefore the LTVs and installation vessels will add considerably to the ambient level of light pollution (increasing the duration of the impact) albeit that the level of light will be far less than residents are accustomed to when jiggers are present.

11.8.10 Confidence

While the approximate timing of activities and type of vessels used during the Phase 1 Development of the Sea Lion Field is known, the intensity and orientation of lights on the vessels and supply base are not quantified, and analogous examples have been used in this assessment.

The nature of the impact on the receptor (people) is understood, however, it is very subjective and so it is difficult to predict the impact. Scoping consultations highlighted that light may be considered an issue by some and a complaint was received during the previous exploration drilling campaign.

With the available data, the level of confidence in the impact predictions (in terms of the nature of the impact and its level of significance) is considered to be '**Probable**'. Additionally, the data gaps are not considered to have the potential to significantly change the outcome of the assessment.

11.8.10.1 Monitoring required

The two key areas where monitoring will be focused is

- Understanding the baseline; and
- Understanding tolerance of the local residents.

11.8.10.1.1 Understanding the baseline

Further monitoring of light will be conducted to establish baseline levels.

During operations, periodic site environmental monitoring will include community and site surveys.

11.8.10.1.2 Understanding tolerance of local residents

Performance of key activities that have the potential to lead to disturbance will be monitored and managed through periodic monitoring at relevant sites.

Further, during Phase 1, Premier will develop and implement a complaints mechanism, whereby members of the public can make a complaint, comment or observation directly. A point of contact will be identified in the Islands to receive any complaints and act as community liaison.

Complaints will be monitored and reported to FIG on a monthly basis (at a minimum). If it is determined that any complaints have similar contributing factors, or a trend is identified, the most appropriate mitigation measure will be identified and implemented using the Premier HSE-MS Management of Change process (section 3.2.17).

All monitoring requirements agreed by Premier and FIG will be recorded and managed via the project-specific Phase 1 SEMMP.

11.8.11 Offsetting

For significant residual and impact and risks (Moderate or above), offsetting via an Environmental Fund is proposed, see section 8.9 for further details.

11.8.12 Findings summary

Table 11.46: Summary of the social impact assessment for light disturbance

Activity / Event	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Operations at the TDF and supply base	Vessel, TDF and yard lighting	Annoyance, sleep disturbance to Stanley residents	Planned	1, 2 & 3	Moderate	Minor	n/a	**Moderate (6)**	**Moderate (6)**	**Probable**	**Industry-standard:** Good working practice and design; and Black-out blinds will be used on the vessels, TDF offices and yard offices. **Project-specific:** Deck lights and yard lights will face inwards; and Vessel lights to be turned off when not required, particularly deck lighting;
LTV operations	Deck and accommodation lights	Annoyance, sleep disturbance, impairment of dark skies	Planned	1 & 2	Moderate	Minor	n/a	**Moderate (6)**	**Moderate (6)**	**Probable**	**Industry-standard:** Good working practice and design e.g., focussing deck lighting; and Black-out blinds will be used on the vessels. **Project-specific:** Deck lights will face inwards; and Vessel lights to be turned off when not required, particularly deck lighting.

[a] See Chapter 8 for definitions of sensitivity, severity, likelihood and significance.

11.9 Disturbance to the human population from helicopters and noise

Table of Contents

11.9.1 Introduction

Throughout the Phase 1 Development it will be necessary to use helicopters, the supply base and port facilities in Stanley, and Berkeley Sound for the LTVs and subsea installation vessels. All of these activities have the potential to create a noise nuisance. As shown in Chapter 6, noise from operations and helicopter overflights were raised by stakeholders during the informal scoping consultations.

This chapter assesses the potential for noise to impact upon local residents and livestock specifically. The impacts of helicopter noise on wildlife are assessed in section 10.2.

11.9.1.1 Relevant legislation

11.9.1.1.1 Helicopter use

There are numerous pieces of International and Overseas Territory legislation in place to govern air safety, which are outwith the scope of this EIA.

As is also described in section 10.2, aviation activities within the Falklands are overseen by Falkland Islands Civil Aviation Department (FICAD). Their work is principally governed by the following:

- Air Navigation (Overseas Territories) Order (AN(OT)O) (2013); and
- International Conventions and Standards ('Rules of the Air')

While no legislation is in place specifically with regards to the social impacts of noise disturbance, due to concern over disturbance to wildlife and livestock from low flying aircraft, guidelines have been developed in the Falklands, and elsewhere, to minimise the impact. These are described in section 11.9.5.1 below as Industry-Standard mitigations.

11.9.1.1.2 Noise legislation

The main pieces of legislation governing noise pollution in the UK are:

- The Nuisance Provisions, under part III of the Environmental Protection Act 1990 (EPA 1990).
- The Environmental Noise (England) Regulations (2006).
- The Noise Abatement Act (1960).
- MARPOL Convention on the International Regulations for Preventing Collisions at Sea, (ColRegs) (1972).

11.9.1.1.2.1 Disturbance from noise

Disturbance in general is based on the definition of a 'statutory nuisance' in the EPA 1990. For an activity to qualify as a source of disturbance it must do one of the following:

- Unreasonably and substantially interfere with the use or enjoyment of a home or other premises;
- Present a long-term and sustained impact to local residents' quality of life by an otherwise unwanted aspect; and / or
- Injure health or be likely to injure health.

With regard to the type of noise exposure anticipated in the Phase 1 Development, it is recognised that only the first two definitions above may apply.

11.9.2 Sources of noise disturbance

The following activities have the potential to cause disturbance to local residents:

- Use of helicopters:
  - To carry personnel and / or equipment to and from the Mobile Offshore Drilling Unit (MODU) and the Floating Production, Storage and Offloading (FPSO) vessel;
  - To carry a Falkland's marine Pilot to and from the purchaser's Conventional Trading Tanker (CTT) prior to approaching the FPSO; and
  - For Search and Rescue (SAR) exercises, test flights and any SAR response required.
- Use of the onshore supply bases and accommodation in Stanley;
- Use of the Temporary Dock Facility (TDF) in Stanley; and
- Anchoring of up to three Large Transport Vessels (LTVs) in Berkeley Sound to support the installation operation.

The specific sources of noise disturbance as they apply during the various stages of the Development are presented in Table 11.47 below.

If, in discussion with FIG / MoD, a logistics solution is developed at Mare Harbour instead of at the TDF / Gordon Lines, disturbance to humans will be greatly reduced, but this assessment assumes development at the TDF and onshore supply base as described in order to consider the worst case.

Table 11.47: Sources of noise disturbance from helicopter operations, operations in Stanley and operations in Berkeley Sound during the three stages of the Development

Location of disturbance	Source of noise	Stage 1	Stage 2	Stage 3
Under flight paths	Helicopter engine noise.	✓	✓	✓
Stanley	Operation of the TDF: engine noise from vessels, vehicles, cranes, generators, lifting and loading of cargo from the TDF onto vessels and vice versa.	✓	✓	✓
	Operation of the supply bases: engine noise from vehicles, generators, forklifts, reversing alarms on vehicles.	✓	✓	✓
Berkeley Sound	Engine noise from the Large Transport Vessels (LTVs) during anchoring.	✓	✓	
	Noise from the LTVs during crane-lifting of infrastructure onto the associated installation vessels.	✓	✓	
	Engine and pump noise from Large Transport Vessels (LTVs) and offshore installation vessels.	✓	✓	

11.9.3 Potential receptors

The ENVironmental Impact IDentification (ENVIID) workshop was used to identify the specific receptors upon which the impacts of noise disturbance warranted further investigation (Chapter 9). This chapter, focusing on the human population, identified the following receptors that may be impacted during the Phase 1 Development:

- Human population:
  - Residents living in the vicinity of the TDF and supply base (Stanley) (section 7.7.2):
    - The population of the Falklands is concentrated within Stanley with the heliport located within Stanley Airport, approximately 3.5 km from the nearest housing;
    - The Gordon Lines area to the east end of Stanley, where the TDF and supply base are located, is generally an industrial area although there are a number of houses in the vicinity, albeit >1 km away; and
    - The north of East Falkland is dotted with small settlements and farms on potential flight routes.
  - Residents living in the vicinity of the proposed installation vessels LTV site in Berkeley Sound (section 7.7.2.3):
    - There are four settlements / farmsteads around the Sound, with residents living and working in the area, as well as visitors and tourists.
- Aggregations of livestock (section 7.7.4.7):
  - Following the austral winter, local farmers are concerned about the condition of their livestock and the likelihood of a poor lambing season (mid-September to end October). Further, livestock is corralled during the shearing season that runs from November to February, potentially making it more vulnerable to disturbance (FILFH, 2015).

11.9.4 Characterising and quantifying the impact of noise disturbance

When characterising and quantifying the impact of noise disturbance on the local population and livestock, it is necessary to consider the:

- Nature of the impact upon the human population and livestock;
- Baseline noise levels in Stanley and Berkeley Sound;
- Quantification of disturbance from helicopters during Phase 1;
- Quantification of disturbance from other Phase 1 noise sources in Stanley; and
- Quantification of disturbance from other Phase 1 noise sources in Berkeley Sound.

11.9.4.1 Nature of the impacts

Noise disturbance may affect the human population by directly impacting upon residents or by impacting upon livestock.

11.9.4.1.1 Human population

The most commonly reported effects of noise exposure are annoyance and sleep disturbance, both of which can impact on quality of life (WHO, 1999). Unlike many other pollutants, noise pollution depends not just on the physical impact of the sound itself, but also the human reaction to it (Defra, 2010b).

Annoyance is defined by WHO (1999) as:

"a feeling of displeasure, associated with any agent or condition, known or believed by an individual or group to adversely affect them".

Factors determining how 'annoying' the noise is to humans include:

- The individual's attitude to the noise source;
- The tonality, impulsivity, and intermittency of a noise;
- When the noise is occurring; and
- A feeling that the noise could be avoided.

Different levels and types of noise can cause different magnitudes of annoyance in different individuals depending upon their hearing and tolerance. To account for this, British Standard 4142 and the WHO add 'penalty' decibels (dBs) to measurements to account for those noises that are particularly annoying. For example, an intermittent sound that is clearly perceptible is considered in BS 4142 to be more annoying than a continuous noise at the same level and thus incurs a penalty of +3 dB (BS4142, 2014).

Additionally, studies have shown that much greater annoyance results when sleep is disturbed compared with daytime activities (Passchier and Passchier, 2000; NoMEPorts, 2008). As such, there are different exposure thresholds for noise to reflect the varying sensitivity to noise during the day and at night. To ensure a 'good night's sleep' the WHO (1999) recommend that continuous background noise levels should not exceed 40 dB(A). The '(A)' refers to an 'A-weighting' which is applied to sounds that have been measured by instruments in an effort to account for the loudness, as perceived by the human ear. Essentially, between 500 Hz and 6 kHz, the human ear is much more sensitive, but above and below these frequencies, the human ear is not particularly sensitive and the 'A-weighting' takes these sensitivities into account.

The WHO recommend that sound levels during the evening and night should be 5-10 dB(A) lower than during the day (WHO, 1999) (Table 11.48). As sound levels vary over the course of a day, an average ambient sound level is normally used for determining acceptable thresholds; this is referred to as the Equivalent Continuous Level. Most commonly this is 'A-weighted' (to account for human perception) and is expressed as the 'LAeq' (NoiseNet, 2008).

The WHO Guidelines for Community Noise (1999) state that during the day:

"'few people are highly annoyed' at LAeq levels below 55 dB(A), and 'few are moderately annoyed' at LAeq levels below 50 dB(A)"

These WHO thresholds are used to determine the noise levels that should not be exceeded in various settings (Table 11.48).

To summarize the above:

- A penalty (in dB) is added to account for the particular annoyance of different types of sound e.g. tonality, intermittent vs. continuous;

- An A-weighting (e.g. dB(A)) accounts for the sensitivity of human hearing; and
- The LAeq refers to the average ambient noise level over the course of a day to enable comparisons between the dB(A) of noise during the night-time, when people are less tolerant, with that of the day-time.

Table 11.48: WHO guideline thresholds for noise in specific environments [a]

Specific environment	Critical nuisance effects	LAeq dB(A)
Outdoor living area	Serious annoyance daytime and evening	55
Outdoor living area	Moderate annoyance daytime and evening	50
Outside bedrooms	Sleep disturbance, window open (outside value)	40

[a] Note: WHO (1999 & 2009) do not give guideline thresholds for 'no annoyance'.

11.9.4.1.2 Livestock

Generally, in the Falkland Islands, livestock is widely spread at low densities and therefore a small proportion of animals would be subject to disturbance from helicopters at any one time. However, when animals are corralled, the reaction by livestock that have been startled by aircraft is similar in nature to that of wildlife and is one of mass panic, which can lead to animals being trampled or to reduced lambing success (FILFH, 2015). Further, corralling of livestock is usually associated with times when animals may already be experiencing stress, such as during lambing or shearing. Given that the same animals are unlikely to be exposed to repeated overflights and may only experience helicopters when corralled in certain locations, it is unlikely that animals exposed to such disturbance events will become habituated and thus de-sensitised.

11.9.4.1.3 Opinion of stakeholders

Noise was noted during the scoping consultations as a potential issue in Berkeley Sound. Concerns were particularly raised about foggy weather where noise carries further and during which the foghorn, associated with earlier Inshore Transfer proposals, may sound. Premier have since eliminated Inshore Transfer oil export option, and the associated mooring buoy foghorn, so this aspect has been removed from further consideration in this chapter. However, stakeholders also mentioned that activities in Berkeley Sound can already be heard by local residents and complaints are made about noise when incumbent boats are loading and offloading.

Noise as a potential disturbance from the TDF and supply base in Stanley was noted during the 2015 exploration drilling scoping consultations, though not during those for the Sea Lion Phase 1 Development in 2014 or 2016 (Chapter 6).

During the scoping consultations it was noted that livestock are disturbed by helicopters but also that they may become habituated to the sound. There was also concern raised as to whether the guidelines in the Falkland Islands Low Flying Handbook are followed by all pilots.

11.9.4.2 Baseline levels of noise in Stanley and Berkeley Sound

As detailed in the Environmental and Social Baseline Chapter (section 7.7.5.1.1) noise measurements were previously conducted on behalf of:

- Noble Energy Falklands Ltd. in March 2014; and
- Workboat Services Ltd. in March 2013.

Premier also conducted a short noise survey in August 2016 for a period of 48 hours and some additional spot measurement in February 2017. Locations of the Noble Energy, Workboat and Premier 2016 surveys are shown in Figure 11.12.

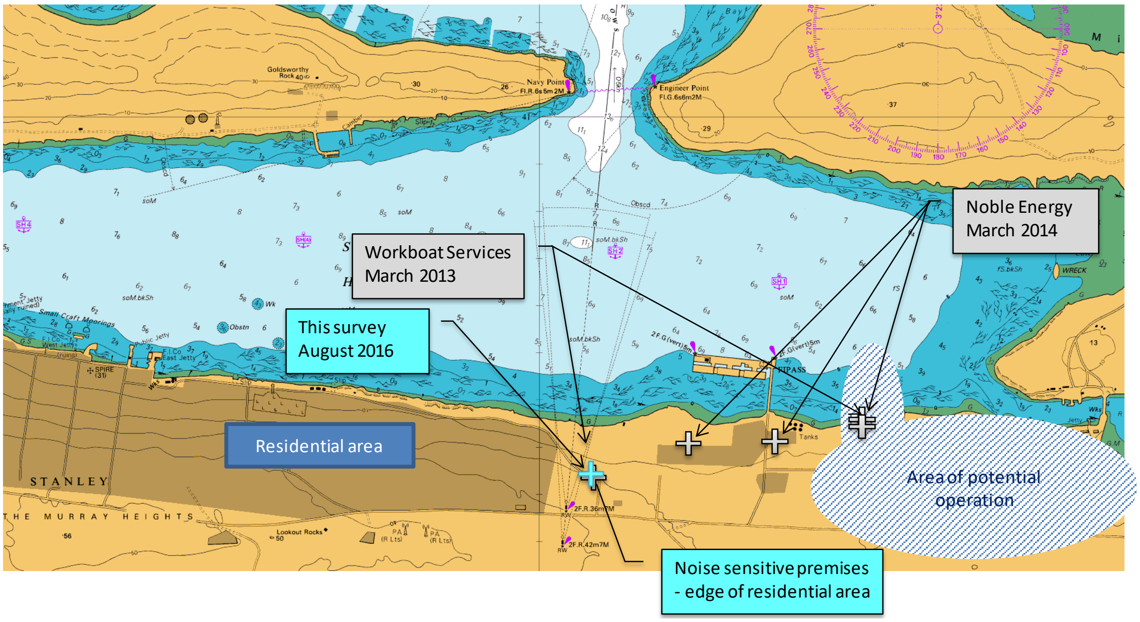


Figure 11.12: Location of noise monitoring points in Stanley. **Note:** 'This Survey' refers to the 2016 survey carried out by Premier (section 7.7.5.1.2.1).

11.9.4.2.1 Baseline noise in Stanley

In summary, wind and traffic play key roles in the noise profile in Stanley. Sound levels rarely dip below 40 dB(A) either during the day or at night, with an average noise level over the 2016 measurement period of 41.7 dB. The quietest period is between 11pm and 6am. Peaks in noise level reflect daily activities, with increases in noise levels between 6am and 9am and again between 3pm and 5:30pm. The minimum noise level recorded was 31.9 dB(A) and the highest was 106.3 dB(A), during a military overflight. The highest noise level spot measurements were recorded outside the power station (72.5 dB).

More detail on noise baseline monitoring in Stanley is available in the Environmental Baseline Description (section 7.7.5.1.1).

11.9.4.2.2 Baseline noise in Berkeley Sound

Noise measurements were taken in Berkeley Sound near Long Island Farm, facing the Sound, over a period of 30 hours. Unfortunately, the initial recording was affected by wind. By convention, noise measurements taken above wind speeds of 5 m/s are not deemed reliable for noise assessments due to the effect of wind on ambient noise levels and, more specifically, the effect of buffeting on the microphone.

A second monitoring period at Long Island Farm was conducted in February 2017 which measured baseline noise levels in the absence of strong winds. Although winds were not monitored continuously, they were subjectively very low at the start and end of the measurement and no significant changes in weather were noted at the time. This reflects conditions when added noise from proposed Project activities may cause the most annoyance. In this area, wind noise is a common and very apparent feature most of the time, and it was difficult to identify a period of more than a few hours when winds were low. The results should be read in this context, that they represent unusually 'quiet' conditions and do not reflect long term averages.

Daytime noise levels average around 40 dB(A), and night-time background levels average around 30 dB(A) for significant periods were recorded. Periodic loud noise events are observed lasting 1-2 minutes; these are unidentified, but are unlikely to be passing local vehicles given the location of the meter and would be consistent with passing aircraft.

11.9.4.3 Quantification of disturbance from helicopter use

When quantifying the potential impacts of helicopter noise, it is necessary to consider the following:

- The proposed helicopter activity during the Development;
- Helicopter noise levels;
- The distribution of the susceptible residents and livestock; and
- The overlap between helicopter flight paths and residential and livestock areas.

11.9.4.3.1 Proposed helicopter activity during the Phase 1 Sea Lion Development

The level of helicopter activity throughout the Development is described in detail in section 10.2.4.2.1. However, Table 11.49 is repeated below as a summary. The distribution of human and livestock receptors and the overlap between these and flightpaths are described below in section 11.9.4.3.4.

Table 11.49: Number of helicopter flights during the Phase 1 Development

Helicopter activity	Stage 1 (169 weeks)		Stage 2 (130 weeks)		Stage 3 (910 weeks)	
	Frequency of flights	Number of flights	Frequency of flights	Number of flights	Frequency of flights	Number of flights
Crew change to MODU / FPSO	8 / fortnight	456	8 / fortnight	592	5 / fortnight	2,600
Berthing Master / Pilot and assistant transfer to CTT	n/a	n/a	1 / fortnight	74	15 per year	300
Routine flights	2 / week	226	3 / week	444	n/a	n/a
SAR training	17 / month	442	17 / month	578	17 / month	4,080
Total number of flights per Stage	**-**	**1,124**	**-**	**1,762**	**-**	**7,500**
Total	**10,386**					

11.9.4.3.2 Helicopter noise levels

Detail on the sound levels generated are described in section 10.2.4.2.2. However, a summary of the sound levels, as well as noise levels of day-to-day activities for comparison, are repeated below in Table 11.50.

Table 11.50: Sound level from helicopter activity experienced at ground level (adapted from Norske Olje & Gass, 2014 and BMT, 2005)

Activity	Maximum sound level at distance from sound source (dB(A))[b]			
	Equivalent at 1 m	Approx. 100 m	600 m	3,500 m
Super Puma EC225 (idling)	>114	-	*c.* 68	*c.* 43
Sikorsky S92 (idling)	>110	-	*c.* 54	*c.* 39
EC155 (overflight)	133	-	77	48
Sikorsky S61 taking off (recorded at MPN)	-	145	-	-
FIGAS Britten-Norman Islander (recorded at Stanley Airport)	-	148	-	-
Comparison with typical noise levels experienced by the public[a]	Chainsaw (120 dB)	-	Conversation (60 dB) Small penguin colony (65 – 69 dB)	Street in the evening (41 dB)

[a] After NoMEPorts, 2008.

[b] An 'A-weighting' is normally applied to sounds measured by instruments in an effort to account for the 'loudness' as it is perceived by the human ear. Essentially, between 500 Hz and 6 kHz the human ear is much more sensitive, but below and above these frequencies the human ear is not particularly sensitive and the 'A-weighting' takes these sensitivities into account.

11.9.4.3.3 The distribution of the potentially affected residents and livestock

The only notable areas of dense human habitation in the Falkland Islands are found in Stanley and Mount Pleasant Complex (MPC). Heliports are also located close to these communities and therefore air traffic and the human population converge here.

The distribution of Camp settlements and farms on north East Falkland is shown in Figure 11.13. Although livestock is widely spread at low density throughout much of the year, livestock corrals are generally associated with the settlements.

11.9.4.3.4 Overlap between helicopter flight paths and residential and livestock areas

Figure 11.13 highlights the distribution of sensitive environmental receptors and community settlements in the north of East Falkland.

11.9.4.3.4.1 Flights to the Sea Lion Field

Direct flightpaths between the two main heliports and the Sea Lion Field are indicated by the arrows. The flightpath from Stanley to the Sea Lion Field is on a bearing of 340° (Ian Ewen *pers. comm.*).

Direct routes to the Sea Lion Field from both Stanley and MPN, and between the two, will pass over three farms and settlements (Figure 11.13).

11.9.4.3.4.2 Flights to the CTT

A Berthing crew will be transported from Stanley Airport by helicopter to the CTT at a safe distance from the FPSO and at least 12 nm from the Falkland Islands, using a similar approach route to that anticipated for normal FPSO crew change flights.

11.9.4.3.4.3 SAR Test Flights

SAR test flights may occur from MPN or from Stanley Airport, as occurred during the 2015 exploration campaign.

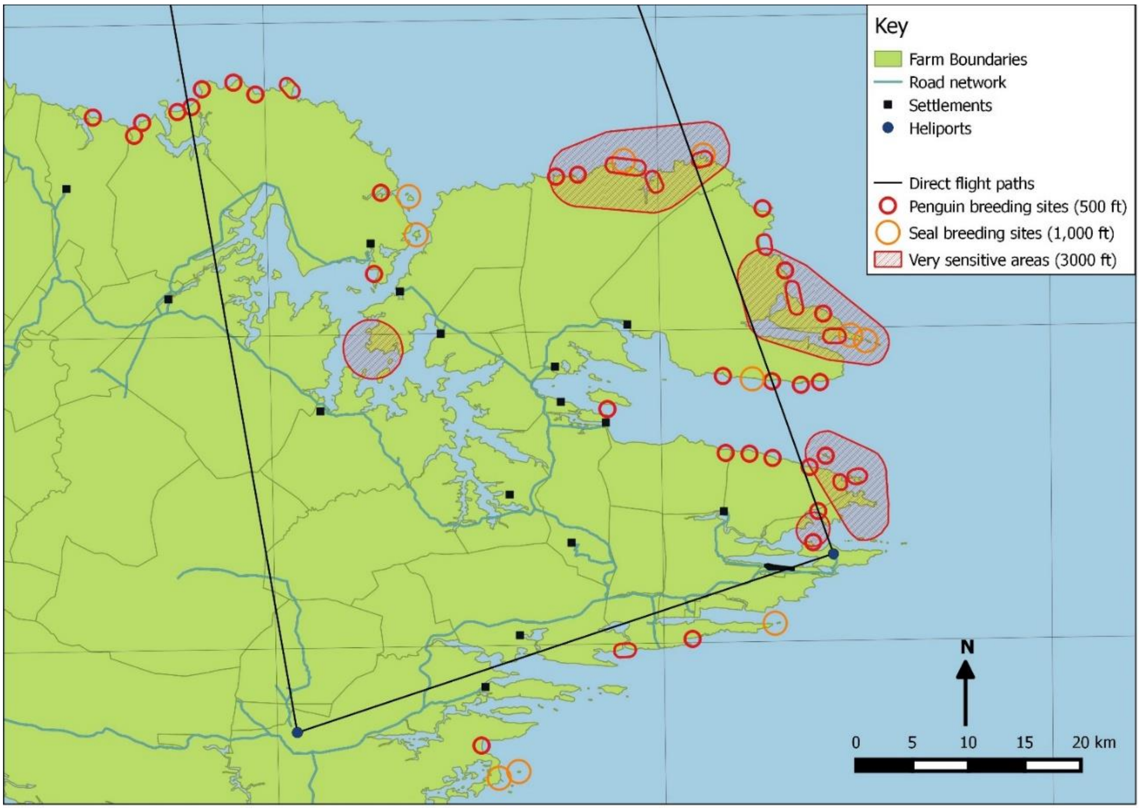


Figure 11.13: The distribution of sensitive wildlife receptors (see section 10.2) and settlements in relation to the most direct helicopter flightpaths. **Note**: the arrows heading out to sea ultimately converge at the Sea Lion Field 200 km offshore.

11.9.4.4 Quantification of disturbance from other Phase 1 noise sources in Stanley

When characterising and quantifying the impact of noise in Stanley it is necessary to consider the:

- Type, location and timing of the Phase 1 noise sources near Stanley;
- Comparison of Phase 1 noise sources and duration with 2015 exploration campaign; and
- Estimation of Phase 1 noise levels near Stanley.

11.9.4.4.1 Type, location and timing of Phase 1 noise sources near Stanley

Noise types at the TDF and supply base during Phase 1 might include:

- Vessel engine noise;
- Lifting and loading at the TDF;

- Operation of the mud mixing plant;
- Vehicles in the yard, including reversing alarms; and
- Lifting and moving equipment in the yard.

Premier made a successful application in January 2018 to the Falkland Islands Government (FIG) to vary the planning consent for the TDF to cover the duration of expected Phase 1 activities. Premier may propose future modifications to improve the Dock's functionality in the future (section 5.11.1.1.1). As described in (section 5.11.1.1.1), proposals to upgrade the TDF facilities will have to go through the planning consent process. At the Planning Officer's discretion such applications may be accompanied by a full EIA. For the purposes of this EIS however, it is assumed that the TDF operations will be the same as they were during the 2015 exploration campaign.

The supply base is likely to be based in close proximity to the TDF, although the specific location has not yet been defined as described in section 5.11.1.2.

Both the TDF and supply bases may be operational 24 / 7 and thus may generate noise during the night.

A summary of the location and timing of Phase 1 noise sources, as compared to the 2015 exploration campaign is provided in Table 11.51 below.

11.9.4.4.2 Comparison of noise sources and duration of exposure with 2015 exploration campaign

Specific data on anticipated Phase 1 noise levels from the varying sources are not available. Therefore, a comparison with the number and duration of noise sources during the 2015 exploration drilling campaign was made as it is assumed that the types of activity carried out during the Phase 1 Development activities at the TDF and the supply bases would be similar. Table 11.51 below summarises the number of sources and duration of noise at the TDF and at the supply base during the Phase 1 Development as they compare to the exploration campaign.

Following extrapolation of the number of vessels required and the area of yard space used during the 2015 exploration campaign, it is anticipated that during Stages 1 and 2 of the Phase 1 Development, the sources of noise from the yards could be greater, albeit not proportionally (Table 11.51). This will be for a period of approximately five years. When the project progresses into steady state production (Stage 3), noise is likely to be less than that experienced during the exploration campaign.

A summary of the sources and duration of Phase 1 noise sources, as compared to the 2015 exploration campaign is provided in Table 11.51.

Table 11.51: Source and duration of noise at the TDF and in the supply base during the Phase 1 Development as compared to the 2015 exploration campaign

Operation	Duration	Location	Activity at TDF and supply base	Comparison with 2015 exploration campaign	Potential implications for noise levels
Exploration drilling campaign					
2015	12 months	Current TDF location	2 supply vessels, 1 tug and 10 coasters (6 one way, 4 also counted on the return)	n/a	n/a
		Exploration drilling yard	51,000 m² of yard space		
Phase 1 Development					
Stage 1: Mobilisation and installation of materials and equipment, pre-first oil drilling by MODU (13 wells), installation, HUC of the FPSO and 'first oil'	*c.a.* 3 years	Current TDF location	29 vessels transiting to and from TDF	3.2 times more vessels (including engine noise and loading and unloading from the TDF) [a]	Vessel activity at the TDF is limited to 2 vessels due such that the noise level at any given time is unlikely to differ
		Yard location unknown	157,500 m² of yard space	c.a. 3 times more yard space (including noise from vehicles, cranes, reversing alarms)	Potential for noise levels to be higher than during the 2015 campaign
Stage 2: Post first-oil drilling by the MODU (up to 17 wells), and concurrent production operations by the FPSO and oil export	*c.a.* 2.5 years	Current TDF location	21 vessels transiting to and from TDF	2.3 times more vessels (including engine noise and loading and unloading from the TDF) [a]	Vessel activity at the TDF is limited to 2 vessels due such that the noise level at any given time is unlikely to differ
		Yard location unknown	157,500 m² of yard space	*c.a.* 3 times more yard space (including noise from vehicles, cranes, reversing alarms)	Potential for noise levels to be higher than during the 2015 campaign
Stage 3: Steady phase production	*c.a.* 17.5 years	Current TDF location	9 vessels transiting to and from the TDF per annum	The same amount of vessels (including engine noise and loading and unloading from the TDF)	No change compared to the 2015 campaign

11.9.4.4.3 Estimation of Phase 1 noise levels near Stanley

In order to predict whether noise levels at the TDF and supply base might be acceptable based on commonly accepted standards (BS4142) (section 11.9.4.1.1), noise attenuation calculations were undertaken. These were used to predict the attenuation that would be expected over a ~1 km distance from the nearest residential location to the supply base / TDF, using appropriate assumptions for sound and environmental properties (Table 11.52).

These calculations show, for example, that a noise source with a sound power level of 110 dB(A), such as a diesel generator at the supply base, would result in a received noise level at the residential properties of 36.6 dB(A). A 6 dB(A) penalty for any potentially annoying characteristics of the sound tonality is added, giving a total received noise level at the residential properties of 42.6 dB(A). This is 0.9 dB above the average noise level during night and day (41.7 dB) measured by Premier at Liberty Lodge (section 11.9.4.2).

The British Standard 4142 states that if the commercial / industrial noise is around 5 dB higher than the background noise level, then this activity should be avoided (remembering that decibels are on a logarithmic scale such that an increase in sound level of 10 dB is equivalent to a doubling in the sound level). It also notes that if the noise is lower than the background, this is normally acceptable. An increase in background levels of around 0.9 dB therefore, may be acceptable to some but may disturb others (BS 4142). It is acknowledged that this is a guide only as, due to the subjective nature of disturbance from noise, some noises may still give rise to disturbance, despite being below the threshold.

Although all the received sound levels are below the WHO LAeq threshold of 50 dB(A), and as such are below the level likely to cause 'moderate annoyance in daytime and evening' (section 11.9.4.1.1), the results in Table 11.52 indicate that unmitigated noise levels from certain activities could be near to 50 dB(A) and therefore could give rise to nuisance. Similarly, those that exceed the WHO night-time LAeq of 40 dB(A) could be more inclined to cause disturbance (Table 11.52).

Table 11.52: Potential noise sources from the supply base and TDF and the calculated received sound at nearest residences

Source example	Main frequency (Hz)	Sound power level (dB(A))	Received sound pressure level at nearby residences (dB(A))[a]	Received sound pressure level at nearby residences (dB(A)) + 6dB(A) penalty[b]	Difference to measured average background noise level (dB(A))	Potential outcome
75 kVA Diesel generator (BS5228-1:2009)	100	110	36.6	42.6	+2.1	Low to adverse impact
Inshore support vessels (as above)	63-100	96.8	23.4	29.4	-11.1	Low impact, normally acceptable
7.5 kW water pump (BS5228-1:2009)	125	106	32.5	38.5	-2	Low impact, normally acceptable
Reversing alarm (medium duty, manufacturer data)	1,000	114	40.2	46.2	+5.7	Adverse impact, should be avoided, if possible

[a] Results calculated for 20°C, 70% humidity, mixed ground cover, no elevation difference.

[b] Although a 6 dB(A) penalty has been assumed, the penalty can be higher or lower depending on any specific unpleasant characteristics.

11.9.4.5 Quantification of disturbance from other Phase 1 noise sources in Berkeley Sound

When characterising and quantifying the impact of noise in Berkeley Sound it is necessary to consider the:

- Location and timing of the noise sources in Berkeley Sound;
- Number of noise sources and duration of exposure in Berkeley Sound; and
- Airborne noise modelling.

11.9.4.5.1 Location and timing of noise sources in Berkeley Sound

Most of the installation vessel activity will be based around the LTVs in Berkeley Sound; each vessel will have its own individual 500m exclusion zone. Premier will work with FIG / Fisheries to identify optimum locations within Berkeley Sound that will cause the least disruption to other users and will strive to avoid periods of high marine traffic in the Sound. The installation vessels will spend minimal amounts of time in the Sound while they collect equipment from the LTVs.

11.9.4.5.2 Number of noise sources and duration of exposure in Berkeley Sound

The expected sources and duration of noise in Berkeley Sound during the Phase 1 Development are shown below in Table 11.53,

Table 11.53: Number, source and duration of noise in Berkeley Sound during the Phase 1 Development

Phase 1 Development Stage	Activity in Berkeley Sound	Duration of Presence in Berkeley Sound	Approximate number of noise sources in Berkeley Sound
Stage 1: Mobilisation and installation of materials and equipment, pre-first oil drilling by MODU, installation, HUC of the FPSO and 'first oil'	Up to 2 x Large Transport Vessels (i.e.LTVs) anchored in Berkeley Sound 2 x installation vessel transiting to and from the LTVs in Berkeley Sound	12 months	4 vessels (engine noise and lifting and loading noise from installation vessel and floating logistics vessels)
Stage 2: Post first-oil drilling by the MODU, and concurrent production operations by the FPSO and oil export	1 x Large Transport Vessels (i.e.LTVs) anchored in Berkeley Sound 1 x installation vessel transiting to and from the LTVs in Berkeley Sound	6 months	2 vessels (engine noise and lifting and loading noise from installation vessel and floating logistics vessels)

11.9.4.5.3 Airborne noise modelling

The activities planned for Berkeley Sound that may create additional noise are associated with the LTVs that will be anchored there and the associated visits of the Offshore Construction Vessels (OCVs).

To enable brevity, the following sections provide only the information required to ensure appreciation and understanding of the modelling results and the impact assessment. Additional detail on the modelling methodology and results are provided in Premier's Inshore Environmental Modelling Report (FK-SL-PMO-EV-REP-0010).

The following sections describe the:

- Modelling assumptions;
- Modelling of vessel noise around the proposed LTV anchorage location; and
- Summary of results.

11.9.4.5.3.1 Modelling assumptions

Given the standardisation of many vessel types according to their function and class requirements, it is possible to achieve reasonable correlations for noise output by different vessel classes. Therefore, a corresponding frequency profile was drawn from the Danish Ministry of the Environment (2010) which gives a noise profile from a Wartsila W6L32 engine exhaust stack. This type of engine is considered representative of the types of the vessels likely to be used. Table 11.54 provides a summary of the assumptions used in the model and the levels of noise modelled for each vessel.

Table 11.54: Main source assumptions used for modelling

Description	OCV[b]	LTV [b]
X coordinate (km) relative to the LTV anchorage	0.000	0.000
Y coordinate (km) relative to the LTV anchorage	0.000	-0.050
Elevation (m)	30	30
Source Noise Level, broadband sound power level dB(A) [a]	112.7	112.7

[a] Source levels are calculated from correlations in Danish Ministry of the Environment (2010).
[b] OCV = Offshore Construction Vessel, LTV = Large Transport Vessel,

11.9.4.5.3.2 Modelling of vessels around the previously proposed Mooring Buoy location

Figure 11.14 plots the predicted noise levels (in dB(A)) from all vessels over an area 12 km by 24 km wide including the north and south shorelines of Berkeley Sound and receptors in line-of-sight to the west (Long Island Farm). Modelling shows that received levels from vessel noise are predicted to be up to 38 dB(A) at either shoreline and, since this is similar to existing vessel noise, and is below the WHO LAeq of 50 dB(A), it has been assumed that there would be no specifically annoying characteristics. The noise levels for assessment are 12 dB(A) lower than the level at which people experience 'moderate annoyance during the day', and 2 dB(A) lower than the WHO night-time level for sleep disturbance (Table 11.48 above). At the closest residence in this area (Long Island Farm), received noise levels from vessels are predicted to be around 24 dB(A).

Further, it should be noted that the noise modelling uses an attenuation method (ISO9613-2) that is widely used over open ground but which does *not* take account of topographical barriers. Relatively steep hills of around 100 m elevation or more exist to the north and south of Berkeley Sound which would dramatically attenuate (lessen) the noise heard in those directions e.g.

towards Murrell Farm and Stanley. As such, noise levels in those directions are considered to be substantially less than those modelled at Long Island Farm.

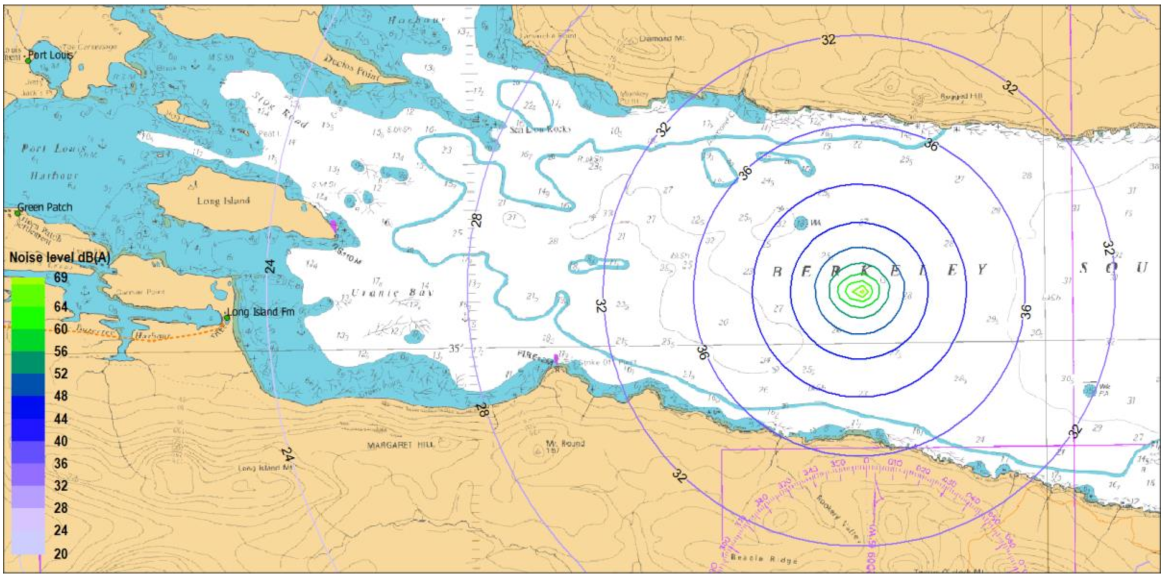


Figure 11.14: Received noise levels at a height of 1.5 m above ground from vessels operating around the proposed LTV Anchorage

11.9.4.5.3.3 Summary of modelling results

Table 11.55 compares the noise of the vessels operating, to the WHO Guidelines for Community Noise (1999) and the WHO Night Noise Guidelines for Europe (2009) (section 11.9.5).

The noise levels received from the vessels at the Berkeley Sound shoreline and at Long Island Farm do not exceed the day or night-time thresholds. It is therefore considered unlikely that the current proposed operation will cause disturbance.

To further confirm whether noise sources in Berkeley Sound are acceptable or otherwise based on the WHO standards, further noise monitoring of the baseline in Berkeley Sound will be conducted throughout the Development and the results compared again to the WHO standards as per Table 11.55. For further detail on this monitoring, see section 11.9.10.3.

Table 11.55: Berkeley Sound noise modelling results in comparison to WHO recommended levels

Noise Source	Modelled noise level received at Berkeley Sound shoreline	Modelled noise level received at Long Farm	WHO recommended level for day time (WHO, 1999)	WHO recommended level for night time (WHO, 1999 and WHO, 2009)
Vessels at the LTV Anchorage	38 dB(A)	24 dB(A)	50-55 dB(A)	40 dB(A)

11.9.5 Industry-standard mitigation

Relevant guidance on noise pollution includes:

- The International Finance Corporation (IFC) Environmental, Health and Safety (EHS) Guidelines: Noise Management (2007);

- Noise Management in European Ports (NoMEPorts): Good Practice Guide on Port Area Noise Mapping and Management (2008);
- World Health Organisation (WHO) Guidelines for Community Noise (1999);
- WHO Night Noise Guidelines for Europe (2009);
- British Standard 4142:2014: Methods for rating and assessing industrial and commercial sound (2014);
- British Standard 5228:2009: Noise and Vibration Control on Construction and Open Sites (2009);
- Falkland Islands Low Flying Handbook Guidance (2015); and
- The Ministry of Defence's (MoD's) Falkland Islands Range and Avoidance Areas (5-GSGS) map (2014).

Good working practice, in accordance with the above, will help to limit the amount of noise from the LTV operation as well as operations at the supply base e.g. maintaining vessel engines, design and layout of the base. Similarly, the design and working practices of the LTVs anchored in Berkeley Sound for the installation phase will aim to reduce potential nuisance to local residents.

11.9.5.1 Mitigating the impact of helicopter use on livestock

While no industry-standard mitigations exist with regard to helicopter use in the O&G industry specifically, the guidelines listed above which are specific to overflights have been developed in the Falklands to minimise the environmental impacts of disturbance from helicopters.

As described in section 10.2, the simplest and most effective way to mitigate the effects of noise from helicopter overflights is to route helicopters away from aggregations of livestock. Following the example set by the MoD (MoD, 2014), and on other islands such as South Georgia, impact reduction methods (e.g. flight avoidance maps) can be used, which generally have a history of successful use and acceptance.

The key livestock avoidance areas are marked on the FIFLH avoidance maps and the FILFH (2017) lists the following guidance:

- Sheep and Livestock Avoids - all aircrew, and particularly helicopter aircrew, are to be aware of the locals' concerns and are to avoid unnecessary over flight of livestock or known livestock grazing areas.

It is understood that during shearing season large flocks of sheep are gathered in preparation for shearing. The Military will invite landowners to notify HQ BFSAI (Mount Pleasant) of these areas of sheep concentrations and then promulgate them as temporary Notice To Airmen (NOTAMs), which will be followed by Premier's helicopters. Further, as the above is considered standard within the Falklands, Premier will develop an approved project-specific flight plan which should be sufficient to mitigate the impact of helicopter disturbance to livestock (section 11.9.4.1.2). Premier will use the flight avoidance map as the basis for flight planning, following the Falkland Islands Low Flying Handbook Guidance (FILFH, 2015). All helicopter pilots will:

- Be briefed on flight avoidance protocols for sensitive areas prior to flying;

- Sign a document indicting that that the FILFH (2017) has been read and understood;
- Be accompanied by a pilot experienced in the area on their first flight; and
- Be issued with an approved flight path.

The above mitigation measures are taken into account during the initial impact assessment of helicopter noise described below (section 11.9.6.1.2).

11.9.6 Impact assessment

The following section draws upon all the information provided above to assess the 'Sensitivity of the Receptor' and the 'Severity of Effect' in order to determine the overall 'Impact' of planned activities.

A summary of the impact assessment outcomes for this Development is tabulated in section 11.9.12 which shows the worst case impact for each activity and receptor and details are provided below.

11.9.6.1 Impacts of helicopter use

11.9.6.1.1 Disturbance to human population

Direct flight lines between the Mount Pleasant Airport (MPN) and the Sea Lion location, and those between MPN and Stanley Airport will pass over three settlements. However, the use of aircraft to transport passengers is an everyday occurrence in the Falklands so there is already a high degree of tolerance from people subjected to mild noise disturbance. Based upon the level of exposure, the **sensitivity of the local population as a receptor** to helicopter disturbance is therefore considered to be '**Low**'.

Stanley airport is sufficiently far from the nearest housing to negate the effect of helicopter noise. At times, it may be possible to hear the helicopters but the sound level experienced will be comparable with background noise. Equally, the SAR test flights may be carried out around MPN or around Stanley. Therefore, there should be no need for helicopters to overfly Stanley during normal operations, although this may happen in the case of a medivac situation when delivering patients to the King Edward VII Memorial Hospital (KEMH).

While every effort will be made to ensure that helicopters do not fly unnecessarily close to settlements, the impact of helicopter noise will be localised and short-term resulting in a barely detectable impact on the local population. Therefore, the **severity of effect** on Falklands' residents is considered to be **'Minor'**.

The overall **significance of the impact** of helicopter noise on Falklands' residents is therefore assessed as '**Low (4)**'.

11.9.6.1.2 Disturbance to livestock

Where animals are gathered e.g. for shearing or lambing, there is the potential to impact a high proportion of any one farms' livestock (section 11.9.4.1.2). Direct flight lines from MPN to the Sea Lion Field and between MPN and Stanley Airport would also pass directly over, or close to, three settlements at which livestock may be corralled (Figure 11.13). Therefore, the sensitivity of receptor could be considered to be 'Very High'. However, as a flight plan, in line with the

FILFH (section 11.9.5.1), will be in place to ensure the avoidance of areas containing corralled livestock, the animals will not actually be exposed to the helicopter noise. Therefore, the **sensitivity of the receptor** to the impact of helicopter noise can be considered to be '**Low**'.

As the FILFH compliant flight plan will prevent one-off or chronic exposure of corralled livestock to helicopter noise, the **severity of effect** of helicopter disturbance on livestock is considered to be '**Minor**'.

The overall **significance of the impact** of helicopter noise on livestock is therefore assessed as '**Low (4)**'.

11.9.6.2 Impact of noise disturbance in Stanley

While there is already a certain level of noise in the Gordon Lines area of Stanley (section 11.9.4.1.1), noise was raised as an issue during the scoping consultations and it was noted that there have been complaints when boats are loading and unloading at FIPASS. Therefore, the **sensitivity of receptor** is considered to be '**Moderate**'.

Noise levels during the Sea Lion Phase 1 will be highest during the drilling and installation periods (Stages 1 and 2) when there will be the highest levels of vessel traffic in Stanley Harbour and most activity at the supply base (section 11.9.4.1). Stages 1 and 2 will last for *c.a.* six years. Once into steady state production (Stage 3) which is the longest Stage of the operation, noise levels will decrease and level out. Therefore, on balance, the **severity of effect** is considered to be '**Minor**'.

Therefore, the overall **significance of impact** is '**Moderate (6)**, and project-specific mitigation measures to reduce the significance will be developed and implemented.

11.9.6.3 Impact of noise disturbance in Berkeley Sound

There are currently a variety of noise sources in Berkeley Sound from the fishing vessels and other vessels that use the Sound. However, noise was raised during the scoping consultations as a potential issue and it was noted that there have been complaints about noise in the past. Therefore, the **sensitivity of receptor** is considered to be '**Moderate**'.

Noise modelling shows that the noise from the vessels involved is unlikely to pose a disturbance to the local residents as the sound of the vessels at the shoreline is lower than the WHO daytime and night-time thresholds (section 11.9.4.5.3.3). The noise from the LTV's and associated operations will be short term and intermittent however, the exact location of the LTV's is, as yet, undecided and therefore, to utilise a precautionary approach the **Severity of Effect** is considered to be '**Minor**'.

Therefore, the overall **significance of impact** is '**Moderate (6)**', and project-specific mitigation measures to reduce the significance will be developed and implemented.

11.9.7 Project-specific mitigation measures

11.9.7.1 Impact of helicopter use

As the impact of helicopter noise on humans and livestock is considered to be '**Low (4)**', there is no need to consider any additional project-specific mitigation measures.

11.9.7.2 Noise impact in Stanley

The introduction of operations at the TDF and the supply bases in east Stanley will increase noise levels in the area, particularly during the early stages of the development. The following measures will be taken, where possible, to reduce noise impacts from the supply base, TDF and vessels alongside the TDF:

- Optimising the layout of the supply base to minimise sound propagation towards Stanley;
- Designing and managing construction and operations to minimise noise sources e.g. choice of site layout to minimise the travel of reversing alarm sounds or the use of white-noise reversing alarms;
- Application of specific mitigations for site equipment, based on noise calculations e.g. engine specification, enclosure and shielding of engines, auto-adjusting reversing alarms which alter output to suit the ambient noise level, or 'night-shift' alarms with lower output;
- Restrictions on the types of operations that can be undertaken at night to minimise night time disturbance;
- Loading of cargoes at the TDF will not routinely be done at night; and
- Vessels at the TDF may be hooked up to the shore power at night to prevent having to use their generators, thus minimising noise. Note however that whilst this minimises noise levels, the use of shore-based power may have other social impacts with regard to the use of onshore energy resources (see also section 11.5).

11.9.7.3 Noise impact in Berkeley Sound

It is likely that the noise impact of the LTVs and associated operations will be minimal. However, the initial impact assessment retains a conclusion of '**Moderate (6)**' as a precautionary approach given that the final location of the LTV's is currently undecided. Therefore, noise impact from these operations shall be mitigated using the following methods:

- LTV engines use will be minimised;
- Installation vessels will, by preference, moor to the LTVs for cargo transfer, and avoid the use of dynamic positioning; and
- Cargo transfer operations will avoid, where practicable, the hours of 11pm to 6am.

11.9.8 Residual impacts

11.9.8.1 Impact of helicopter use on livestock

No residual assessment was carried out for impacts to the human population or livestock for which the impacts assessments were considered to be '**Low (4)**'.

11.9.8.2 Noise impact in Stanley

The minimisation of noise where possible at the TDF and supply bases will reduce the severity of the impact to '**Slight**'.

With project-specific mitigation measures in place therefore, the **significance of the residual impacts** of noise disturbance in Stanley is reduced to '**Very Low (3)**'.

11.9.8.3 Noise impact in Berkeley Sound

The minimisation of noise where possible within Berkeley Sound will reduce the severity of the impact to '**Slight**'.

With project-specific mitigation measures in place therefore, the **significance of the residual impacts** of noise disturbance in Stanley is reduced to '**Very Low (3)**'.

11.9.9 Cumulative impact

Human settlements and industry onshore will always be sources of noise pollution. In the Falklands, these are primarily associated with the two major population centres, Stanley and MPC. Additionally, Berkeley Sound (the proposed LTV site) is used as an anchorage for the trans-shipment of fish and is also a seasonal source of noise. The following sections assess the potential for cumulative impacts at these two sites.

11.9.9.1 Stanley

Sources of existing anthropogenic noise Stanley include all housing, industry and human activity in the town. At the east end of Stanley, where the TDF and supply base will be operating, the area is already designated for 'a mixture of heavy and light Industrial, warehousing and storage' within the Stanley Town Plan (FIG, 2015u). The area is currently used as yard space and the TDF is already in place, although, at the time of writing, they are not in operation.

The peak of activity in Stages 1 and 2, will add in 'concentration' (section 8.10.1) to the noise in the area. This period will last approximately six years.

Once into steady state operations (Stage 3) the activity, and hence noise, will reduce to below levels experienced during the exploration drilling campaign.

11.9.9.2 Berkeley Sound

Sources of existing anthropogenic noise within Berkeley Sound are summarised in section 11.9.4.2.2. It was noted during the scoping consultations that the jiggers can be heard from local settlements around Berkeley Sound. In addition to the jiggers, other vessels use Berkeley Sound as an anchorage, primarily for the trans-shipment of fish catches.

Although vessels can be present in all months of the year, activity peaks between March and June, when tens of vessels can be present, but this varies considerably from year-to-year (section 7.7.3.2). The LTVs and installation vessels will, where practicable, avoid this period and so not add to this in terms of 'increased concentration' and 'increased extent and proportion' (section 8.10.1). At peak times, Premier's activities will have less of an impact over and above the existing baseline as they will be one of many vessels in the Sound. At other times of the year, there may be very few vessels using Berkeley Sound and therefore Premier's activities will add incrementally to the current baseline noise level and thus may have a more discernible impact.

11.9.10 Confidence

11.9.10.1 Helicopter use

The project activities are clearly defined in terms of the:

- Start and end points of flights;
- Frequency of flights; and
- Adherence to project-specific flight plans.

Equally, the locations of receptors (e.g. human populations and corralled livestock) are known.

Nonetheless the impact of noise on the human population is highly subjective such that the confidence in the assessment of impacts to humans is considered to be '**Probable**'.

While the long-term consequences of the impact of noise on livestock are not fully understood, the use of the flight plan will take account of tried and tested mitigation measures such that the confidence in the assessment of impacts to livestock is considered to be '**Certain**'.

11.9.10.2 Noise in Stanley and Berkeley Sound

The approximate timing of activities and type of vessels anticipated for use during the different options for the Phase 1 Development of the Sea Lion Field are well understood whilst the noise that may be emitted from the LTV's, supply base and TDF is not.

The nature of the potential impact on the receptor (people) is understood but it is a very subjective issue and is therefore difficult to predict. Scoping consultations highlighted that noise may be considered an issue by some. Further consultations may be required to better understand the sensitivity of local residents to noise and, once operations start, a clear complaints procedure will be in place, as well as a monitoring programme to record baseline noise levels (section 11.9.10.3 below).

There is some uncertainty in the modelling conducted in that there are certain rare weather conditions, i.e. temperature inversions over water, in which sound levels may be higher than predicted by the model and it is not known how often these weather conditions may occur.

With the available data, the level of confidence in the impact predictions (in terms of the nature of the impact and its level of significance) is considered to be '**Probable**'.

11.9.10.3 Monitoring required

In order to confirm whether noise sources at the TDF, supply base and Berkeley Sound might be acceptable based on commonly accepted standards (BS:4142), further noise monitoring of baselines and typical noise levels created by normal activities at the TDF and supply base will be conducted. Further baseline monitoring will be undertaken to strengthen the basis of the assessment and to inform operations and monitoring programmes.

Performance of key activities that have the potential to lead to disturbance will be monitored and managed through periodic monitoring at relevant sites as is described in the Disturbance from Light Chapter (section 11.8).

Detailed monitoring requirements have been established during the Environmental Monitoring and Management Plan (EMMP) workshop. All monitoring requirements agreed by Premier and FIG will be recorded and managed via the project-specific Phase 1 EMMP (an outline EMMP is provided in Chapter 15).

11.9.11 Offsetting

As no residual impacts or risks identified in this section are considered significant, i.e. Moderate or above, offsetting is not considered (see section 8.9).

11.9.12 Findings summary

Table 11.56: Summary of the impact assessment of noise from helicopter use, and operations in Stanley and in Berkeley Sound

Activity / Event	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance[a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Helicopter use for crew changes, marine pilot transfer and SAR test flights	Noise disturbance to human population	Annoyance, sleep disturbance	Planned	1, 2 & 3	Low	Minor	n/a	**Low (4)**	**n/a**	**Probable**	**Industry-standard:** Use of specific flight plan in line with the flight avoidance map as the basis for flight planning, following the Falkland Islands Low Flying Handbook Guidance (FILFH, 2015). **Project-specific:** None proposed
	Noise disturbance to livestock	Stress, reduced lambing success	Planned	1, 2 & 3	Low	Minor	n/a	**Low (4)**	**n/a**	**Certain**	
Operations at the TDF and supply base near Stanley	Noise from loading and unloading at the TDF, and supply base activities	Annoyance, sleep disturbance to Stanley residents	Planned	1, 2 & 3	Moderate	Minor	n/a	**Moderate (6)**	Very Low (3)	**Probable**	**Industry-standard:** Adherence to guidance. **Project-specific:** Optimising design and management to minimise noise; Equipment specific noise mitigations; Activity restrictions; and, Potential vessels hook-up to TDF at night.
LTV operations and installation vessels in Berkeley Sound	Noise from pumps, vessel engines and vessel loading	Annoyance, sleep disturbance to residents around Berkeley Sound	Planned	1 & 2	Moderate	Minor	n/a	**Moderate (6)**	Very Low (3)	**Probable**	

[a] See Chapter 8 for definitions of sensitivity, severity, likelihood and significance.

11.10 Disturbance to the human population from odour

11.10.1 Introduction

The only significant aspect in terms of potential odour nuisance, associated with the Sea Lion Phase 1 project, was vapour emissions from Inshore Transfer. As Inshore Transfer is no longer being considered for the project the sources of odour in Berkeley Sound have been eliminated and odour is not considered further herein.

As shown in Chapter 6, odour was not raised by stakeholders during the informal scoping consultations.

11.11 Disturbance to the human population from visual impact

11.11.1 Introduction

Berkeley Sound will still be used as an operations base for the subsea installation work. This will involve up to three Large Transport Vessels (LTVs) being anchored in Berkeley Sound, supporting up to two subsea installation vessels. However, the LTVs and the installation vessels transiting between the Sea Lion Field and Berkeley Sound (section 5.11.2) do not warrant a visual impact assessment due to their relatively temporary nature (in place for up to twelve months).

Visual impact has also been screened out for the operation of the TDF and supply bases in Stanley as the TDF is already *in situ* and underwent assessment as part of the planning application. Also, the supply bases will be within an area designated in the Stanley Town Plan for "*the continued development of heavy and light industrial, warehousing and storage*" (the area in east Stanley known as Gordon Lines). The mud plant within the supply base may require buildings / silos up to 11m high to accommodate bulk materials and mixing equipment but this is considered to be in keeping with the current use of the area and the activities therein (FIG, 2015u).

It is acknowledged that long term visual impact was raised by stakeholders during the informal scoping consultations (Chapter 6), but, given the changes to the activities in Berkeley Sound, visual impact is no longer considered within this assessment.

11.12 Regional and local air quality

Table of Contents

11.12.1 Introduction

Numerous activities associated with the Phase 1 Development will generate atmospheric emissions and this was raised as a concern by stakeholders during scoping consultations (Chapter 6). The emissions of oxides of nitrogen (NOx), oxides of sulphur (SOx), carbon monoxide (CO) and Particulate Matter (PM) have the potential to impact upon regional and local air quality and therefore to human health.

This chapter assesses the impact of combustion emissions on air quality and human receptors based on the known nature of the impacts, the estimated quantities of emissions generated during the Phase 1 Development and, where appropriate, dispersion modelling, to enable comparison of emissions with published air quality standards.

Note: the impacts of emissions on air quality and ecological receptors are assessed in section 10.9. Other impacts associated with vessel use are described elsewhere in this document, as described in section 9.2.

11.12.1.1 Relevant legislation

There is currently no legislation in the Falklands relevant to air quality. However, conventions and legislation relevant to air quality include:

- International protocols and conventions:
  - International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78 Annex VI on the Prevention of Air Pollution from Ships.
- UK legislation applicable to the Falkland Islands:
  - The Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2008.

Under the above, there are numerous compliance requirements with regard to air pollution as described below.

Further, key legislation and guidance which informs the design and management of an onshore waste incinerator includes:

- Environmental Permitting (England and Wales) (Amendment) Regulations 2013 (SI 2013 No, 390);
- European Directive on Ambient Air and Cleaner Air for Europe EC 2008/50/EC;
- Air Quality Strategy (AQS) for England, Scotland, Wales and Northern Ireland (2007);
- Air Quality Standards Regulations (2010);
- Department for Environment, Food and Rural Affairs (DEFRA) (2016): Part IV The Environment Act 1995 Local Air Quality Management Review and Assessment Technical Guidance; and
- Environment Agency (2016) Air emissions risk assessment for your environmental permit.

11.12.1.1.1 MARPOL Annex VI on air pollution

In 1973, the International Maritime Organisation (IMO) adopted the International Convention for the Prevention of Pollution from Ships, now known universally as MARPOL. The convention has been repeatedly amended and updated by the Marine Environmental Protection Committee

(MEPC). Annex VI entered into force in 2005 and is concerned with the prevention of air pollution by shipping. The aim of Annex VI is the progressive reduction in global emissions of SOx, NOx and PM by shipping and the introduction of Emission Control Areas (ECAs) to further reduce emissions of the above in designated sea areas.

The details below are of primary relevance to Premier when conducting audits during the vessel selection processes for those vessels contracted directly to Premier and during the nomination of the crude purchaser's tanker (section 5.10). They are included here to provide a context for understanding.

Of relevance to the Phase 1 Development, Annex VI covers:

- Regulation 13 - Nitrogen Oxide (NOx) emissions from diesel engines;
- Regulation 14 - Sulphur Oxide (SOx) emissions from ships;
- Regulation 15 - Volatile Organic Compounds (VOCs) emissions from cargo oil tanks of oil tankers; and
- Regulation 18 - Fuel Oil quality.

All ships of >400 gross tons, or registered to carry > 15 persons are required to carry an International Air Pollution Prevention Certificate (IAPP Certificate).

11.12.1.1.1.1 Nitrogen oxides (NOx) emissions

Regulation 13 in Annex VI specifies limits on NOx emissions that must be managed using NOx reducing technologies and / or fuel treatment. The Falkland Islands are not covered by a NOx ECA and Table 11.57 shows the NOx emission limits based on ship construction dates as they apply in the Falkland Islands.

Table 11.57: NOx emissions limits outwith NOx Emission Control Areas [a]

Tier	Ship construction date (on or after)	Total weighted cycle emission limit per engine (g/kWh)		
		< 130 rpm (*n*) [b]	130 - 1999 rpm (*n*) [b]	> 2000 rpm (*n*) [b]
I	January 2000	17.0	$45*(1/n^{0.2})$ (e.g. *n* = 720 rpm = 12.1)	9.8
II	January 2011	14.4	$44*(1/n^{0.23})$	7.7

[a] As amended from http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Nitrogen-oxides-(NOx)-–-Regulation-13.aspx

[b] n = engine's rated speed (rpm)

11.12.1.1.1.2 Sulphur oxide (SOx) and particulate matter emissions

Regulation 14 in Annex VI places controls on the sulphur content of marine fuel oils to reduce sulphur oxide (SOx) emissions. Within the regulation, certain areas have been identified as SOx ECAs in which the sulphur content in fuels is limited more stringently. The Falkland Islands are not covered by a SOx ECA and Table 11.58 shows the fuel sulphur limits as they apply in the Falkland Islands.

To meet the SOx limits, ships must use low-sulphur compliant fuels and must obtain a bunker delivery note which states the sulphur content of the fuel oil supplied. However, ships may also use gas as a fuel as when ignited it leads to negligible SOx emissions. This has been recognised in the development by IMO of the International Code for Ships using Gases and other Low Flashpoint Fuels (the IGF Code), which was adopted in 2015. Alternatively, ships may also meet the SOx emission requirements by using approved equivalent methods, such as exhaust gas cleaning systems or 'scrubbers', which 'clean' the emissions before they are released into the atmosphere. In this case, the equivalent arrangement must be approved by the ship's Administration (the flag State).

Table 11.58: Limits placed on sulphur contents of fuel oils outwith SOx Emission Control Areas

Dates	Sulphur content of fuel
1st January 2012 to 31st December 2019	3.5 %
From the 1st January 2020	0.5 %

11.12.1.1.1.3 Volatile Organic Compounds (VOCs)

Regulation 15 requires that all tankers carrying crude oil must carry a VOC Management Plan to prevent or minimise the emission of VOCs by:

- Optimising operational procedures; and / or
- Using devices, equipment or design changes, where safe and possible, to prevent or minimise emissions.

Details on the recommended best management practices are provided in the MEPC Guidelines for the development of a VOC management plan (resolution 185(59) (MEPC, 2009). See also section 10.9, which assesses the emission of VOCs in greater detail.

11.12.2 Sources of air pollutants

The main sources of air pollutants from the Phase 1 Development which may impact upon local air quality include:

- Combustion activities onshore and inshore:
  - Use of diesel generators at the onshore supply base;
  - Incineration of combustible wastes at the municipal waste facility; and
  - Fuel combustion by installation and support vessels.
- Particulate matter
  - Particulate matter from combustion activities; and
  - Use of the unpaved Mount Pleasant road.

Note: the potential impact on air quality associated with inshore oil spills is assessed in section 12.2.

Note: modelling of the emissions from the FPSO offshore was carried out and the results indicated that all emissions dispersed within 10 km such that these emissions are not listed as a source which could impact upon local air quality or human health.

11.12.2.1 Onshore emissions

Emissions onshore will result from the use of the standby diesel generators and incineration of combustible wastes at the municipal waste facility, or, in the event that this is not available, a project-dedicated waste incinerator at the supply base :

- Emissions from the combustion of diesel will consist of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), NOx, SOx, CO and PM.
- Waste incinerators produce emissions in the form of flue gases, which largely comprise CO_2, oxygen (O_2), nitrogen (N_2), water (H2O) and PM in the form of dust and potential dioxins and furans. However, the exact composition of emissions will be dependent on the mixture of waste being incinerated.

The location of the standby generators or contingent project specific incinerator is not yet determined but, for the purposes of assessment they are assumed to be within the area covered by the 2015 exploration campaign base (section 5.11.1.2.2), or in very close proximity (Figure 11.15). As such, they will be situated just over 1 km east of the nearest residential site. Assuming this location, it can be noted that the predominant winds in Stanley are from the West (section 7.3.2.1.1) such that the plume from the generator or incinerator is likely to be over the industrial area (known as Gordon Lines) rather than residential areas for the majority of the time. The final location of the incinerator and generators will be developed in discussion with FIG and with stakeholder input through the planning process.

Potential incinerator/generator location ★ Nearest residential area, East Stanley ⏢

Figure 11.15: Potential location of incinerator in relation to closest residential area in East Stanley

11.12.2.2 Inshore emissions

As with the diesel generators, the LTVs and installation vessels will produce emissions comprising of CO_2, CH_4, N_2O, NOx, SOx, CO and PM.

11.12.3 Potential receptors

Receptors that may be impacted by emissions associated with the Phase 1 Development include:

- The human population in the Falkland Islands (section 7.7.2).

11.12.4 Characterising and quantifying the impact and risk of emissions on air quality

When characterising and quantifying the impact of emissions on regional and local air quality, it is necessary to consider the following:

- Characteristics, sources and behaviour of NOx, SOx, CO and PM in the atmosphere;
- The nature of the impacts to human health;
- Quantification of onshore emissions; and
- Quantification of inshore emissions:

11.12.4.1 Characteristics, sources and behaviour of air pollutants in the atmosphere

Air pollutants, such as CO, SO_2, NOx, VOCs, Ozone (O_3) and respirable PM (PM2.5 and PM10) can all impact upon human health. Each of these components differs in their chemical composition, reaction properties, time of disintegration and their ability to diffuse over long or short distances. Therefore, levels of these pollutants in the atmosphere vary widely and are dependent upon the number of sources producing emissions at any given time as well as the prevailing weather conditions. For example, in congested built up areas, pollutant levels peak during the morning and afternoon rush hours.

11.12.4.1.1 Oxides of nitrogen (NOx)

When nitrogen is released during fuel combustion it combines with oxygen atoms to create nitrogen monoxide (NO, also known as nitric oxide). Nitrogen monoxide is readily converted into the much more harmful nitrogen dioxide (NO_2) by chemical reaction with ozone present in the atmosphere. In urbanised regions, these two forms of gaseous nitrogen oxides can be significant pollutants in the lower atmosphere (WBG, 1998a). Notably however, NOx emissions are often higher indoors than they are outdoors owing to, for example, the presence of gas-fired appliances and / or space heaters (WBG, 1998a). While nitrogen monoxide is not considered to be hazardous to health at typical ambient concentrations, NO_2 can be.

When in the atmosphere, NOx gases react to form smog and acid rain (section 10.9) as well as being central to the formation of fine PM and ground level ozone, both of which can be associated with adverse health effects.

11.12.4.1.2 Oxides of Sulphur (SOx)

Sulphur oxides (SOx) are compounds of sulphur and oxygen molecules. Sulphur dioxide (SO_2) is the predominant form found in the lower atmosphere (WBG, 1998). It is a colourless gas that can be detected by taste and smell in the range of 1,000 - 3,000 $\mu g/m^3$ and at concentrations of 10,000 $\mu g/m^3$, it has a pungent, unpleasant odour (WBG, 1998b). Further, SO_2 reacts with other substances in the atmosphere to form sulphate aerosols which are part of PM2.5 (see below).

Periodic episodes of very high concentrations of SO_2 are believed to cause health issues although, as stated above, such peaks are dependent upon the number of sources and on wind, temperature, humidity, and topography (WBG, 1998b).

11.12.4.1.3 Carbon monoxide (CO)

Carbon monoxide is a colorless, odourless, and tasteless gas that is slightly less dense than air and is formed through the incomplete burning of fossil fuels. CO can be harmful to health by preventing the uptake of oxygen by the blood.

11.12.4.1.4 Dioxins and furans

Dioxin is a general term that describes a group of hundreds of chemicals that are highly persistent in the environment and are very toxic. All dioxins have the same basic chemical 'skeleton', and they all have chlorine atoms as part of their make-up. Furans are similar, but have a different 'skeleton'. Dioxin is formed by burning chlorine-based chemical compounds with hydrocarbons. A major source of dioxin in the environment comes from waste-burning incinerators of various sorts and also from back garden burn-barrels.

There is evidence of dioxins and furans exchanging between the water/air phases (Lohmann and Jones, 1998) and, exposure to dioxins and furans occurs primarily via the diet as the chemicals accumulate in the food chain. However, in general, dioxins and furans have long atmospheric residence times, rendering them subject to long-range atmospheric transport and highest concentrations occur in urbanised / industrial sites (Lohmann and Jones, 1998).

11.12.4.1.5 Particulate matter characteristics, sources and composition

Particulate matter (PM) comprises of:

- Primary PM (EEA, 2012) which arises from direct sources such as combustion (see above) and generation of dust; and
- Secondary PM which is not emitted directly but results from other emissions e.g. the emission of ozone precursors leading to the formation of tropospheric ozone.

Primary PM comprises of particles suspended in the atmosphere that are small enough to be inhaled. Some particles, such as dust, dirt, soot, or smoke are large, or dark, enough to be seen with the naked eye while others are microscopic (Figure 11.16). Primary PM includes:

- PM10 which comprises inhalable coarse particles that are 2.5 - 10 µm in diameter;
- PM2.5 which comprises fine particles that are 0.1 - 2.5 µm in diameter e.g. sulphate aerosols which result from SOx emissions; and
- PM0.1 which comprises ultrafine particles that are <0.1 µm in diameter.

Secondary PM includes tropospheric ozone which is formed by chemical reactions in the atmosphere when SO_2, NOx and CO that are emitted during fuel combustion react with sunlight. Tropospheric ozone can cause adverse effects to humans and other fauna.

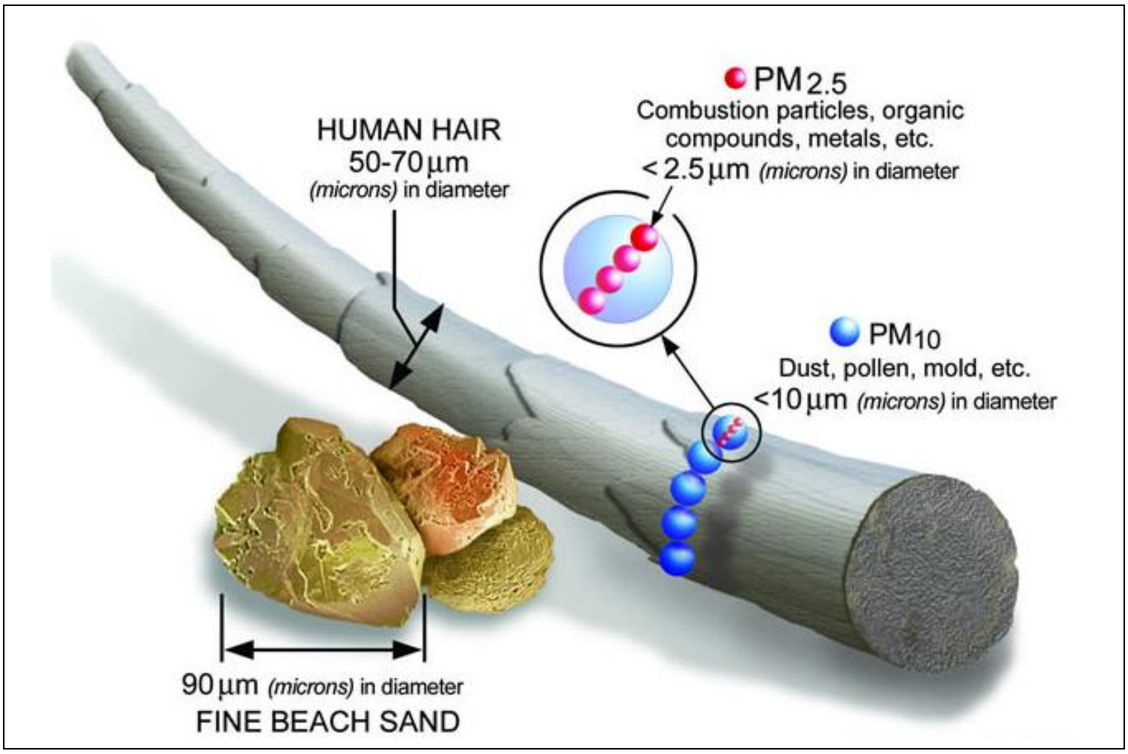


Figure 11.16: Relative sizes of PM (*Source: US Environmental Protection Agency*)

11.12.4.2 Nature of the impact on human health

In assessing the impact of air emissions on the human population, DEFRA guidance (2016) suggests it is important to consider all locations 'where member of the public are regularly present'. In industrialised regions, air pollution can have both acute and chronic effects on human health, affecting a number of different systems and organs. Generally, it is understood that moderate air pollution levels are unlikely to have any serious effects on people who are in good health. However, elevated concentration levels and / or long-term exposure to air pollution can lead to more serious symptoms and conditions (DEFRA, 2013). The effects range from minor upper respiratory irritation to chronic respiratory and heart disease, lung cancer, acute respiratory infections in children and chronic bronchitis in adults, aggravating pre-existing heart and lung disease, or asthmatic attacks (Kampa and Castanas, 2008; DEFRA, 2013; EMSA, 2016).

Details on the most common health effects resulting from NOx, SOx and CO are provided in Table 11.59. Owing to the potential impacts of these pollutants, air quality standards are in place, which indicate the maximum concentrations at different exposure times that people can be subjected to without impact. These standards are used in the air quality modelling report described below, which is designed to estimate the concentrations and dispersion of pollutants over different timescales to assess the impact of Phase 1 Development emissions (section 11.12.4.4).

Table 11.59: Potential health effects experienced from repeated exposure to the most common pollutants at elevated levels [a]

Pollutant	Health effects at elevated concentrations
NOx	These gases irritate the airways of the lungs, increasing the symptoms of those suffering from lung diseases.
SOx	
CO	This gas prevents the uptake of oxygen by the blood which can lead to a significant reduction in the supply of oxygen to the heart, particularly in people suffering from heart disease.
PM	While all PM can be inhaled and is of concern, fine particulate matter (PM2.5) is of the greatest concern in the context of this EIA as fine particles can be carried into the lungs where they can cause inflammation, damage to lung tissue and a worsening of heart and lung diseases (Pope *et al.,* 1995; DEFRA, 2013). Such effects are mostly observed in susceptible groups e.g. children, elderly, asthmatics (Pope *et al.,* 1995).

[a] As amended from DEFRA (2013).

11.12.4.3 Quantification of onshore emissions

It is anticipated that compliance standards for the operation of the generators, and for their emissions, will be based on the 2013 UK Environmental Permitting Regulations (section 10.10.1.1), which targets the following pollutants:

- Nitrogen oxides;
- Carbon monoxide;
- Total dust (as PM_{10} and $PM_{2.5}$);
- Gaseous and vaporous organic substances, expressed as total organic carbon;
- Sulphur dioxide;
- Hydrogen chloride;
- Hydrogen fluoride;
- Twelve trace metals; and
- Dioxins and furans.

With regard to the incinerator emissions, from the municipal waste facility, the exact composition and volume of emissions will be dependent on the mixture and quantity of waste being incinerated. Appropriate technologies, operating parameters and monitoring requirements will be employed by FIG and the method will be dependent on the exact model of incinerator used. The stack gas composition of a typical diesel incinerator of the type anticipated is given below in Table 11.60.

Based on previously measured concentrations for similar incinerators, dust generated via the emissions stack are expected to be in the region of 12 mg / m^3 (half hour average) (Inciner8, 2017).

Table 11.60: Example of typical stack gas composition from containerised waste incinerator

Component	Concentration (dry) % v / v	Concentration (wet) % v / v
CO_2	10.00	9.23

Component	Concentration (dry) % v / v	Concentration (wet) % v / v
O_2	11.93	11.02
N_2	78.07	72.08
H_2O	-	7.67

Source: Exova Catalyst, 2017

11.12.4.3.1 Onshore combustion emissions modelling

As the exact model and location of the municipal or contingency project-specific supply base incinerator is not yet known, an assessment for an incinerator in the UK with a 17.5 m stack, using diesel fuel and with a similar throughput to the incinerator proposed at the supply base has been referenced (see Sol Environmental, 2016). This existing assessment concludes that maximum off-site concentrations of all pollutants at around 100 m from the incinerator are within the relevant air quality standards for habitats and human receptors (Sol Environmental, 2016).

11.12.4.4 Quantification and modelling of inshore emissions

11.12.4.4.1 Inshore combustion emissions modelling

The previous base case oil export option was Inshore Transfer between an Offshore Loading Shuttle Tanker and a Conventional Trading Tanker. To support the EIA for that operation, dispersion modelling was carried out to assess the impacts of the tanker and vessel fuel combustion.The modelling carried out was:

- Cambridge Environmental Research Consultants' (CERC) Atmospheric Dispersion Modelling System (ADMS) version 5 (CERC, 2012a), to model the air quality impact of the proposed development (Genesis, 2015f).

The above modelled the emissions from tankers operating inshore over the 20 year life of field and included significantly more emissions than the LTVs and subsea installation vessels. However, the model demonstrated that the overall significance of this aspect was '**Very Low'**. Therefore the emissions modelling has *not* been adjusted to remove the Inshore Transfer components and retain only the LTV and installation vessel operations and the work has been retained herein to represent a worst case. Therefore, while there is reference to the Inshore Transfer operation in the modelling sections below, note that there is no plan to reinstate any elements of Inshore Transfer to the project and the modelling is retained for illustrative purposes only.

The ADMS modelling was carried out to predict the NO_2,SO_2, CO and PM emissions resulting from fuel combustion by the inshore activities associated with the Phase 1 Development. The modelling below is representative of tankers operating within Berkeley Sound, which is a significantly worse case than the LTVs and subsea installation vessels that will use the Sound.

Note: Modelling of the emissions from the FPSO offshore was carried out which indicated that all emissions dispersed within 10 km. These emissions were considered to be less relevant than the emissions associated with the inshore operations. Therefore, the results of the FPSO air quality modelling are provided in Genesis (2015e) only, while the below details the results of the modelling for the inshore tankers only.

11.12.4.4.1.1 The ADMS modelling approach

The ADMS model calculates long-term and short-term deposition fluxes from pollutant sources. It uses 'real-world' hourly meteorological data allowing a realistic output to be generated for particular locations. ADMS 5 is a 'new generation' dispersion model and this modelling approach is accepted for use in the UK for assessment of air quality impacts by the Environment Agency (EA) and BEIS (formerly DECC).

ADMS is a Gaussian plume modelling program that predicts dispersion of point source plumes, puffs or area emissions over varying meteorological conditions using hourly-sequential meteorological data including wind speed and direction, humidity, cloud cover (for solar forcing) and other parameters. It also includes the ability to model over terrain.

The following describes only the information required to ensure appreciation and understanding of the modelling results. Full detail with regard to the modelling methodology is provided in Premier's Inshore Environmental Modelling Report (FK-SL-PMO-EV-REP-0010).

11.12.4.4.1.2 Assumptions and input data used in ADMS

Emission flow rates

When estimating the power use and therefore the fuel consumption and associated emission release rates it is necessary to consider the following:

- Tankers are considerably higher-powered than the support vessels and at certain times will utilise much of the installed power while moving under load; and
- At any time, one of the vessels (the one carrying the crude) will also be operating boilers to keep the crude in a liquid form.

With regard to power use the United States Environmental Protection Agency (USEPA, 2000) recommends assuming 80 % of Maximum Continuous Rating (MCR) when the vessels are cruising to estimate emissions (i.e. nearly at maximum power use). However, this is a very conservative estimate as cruising speeds by vessels will be limited to eight knots while approaching and then operating inside Berkeley Sound. When vessels are manoeuvring into position it is estimated that they will use 20 % of their MCR.

Given that the details on the specific vessels are not yet known, the emission flow rates entered into the model were estimated using:

- The United States Environmental Protection Agency (USEPA) dataset which provides representative emissions levels for different vessels (USEPA, 2000); and
- Load factors based on the percentage use of maximum power (i.e. 80 % of MCR when cruising, 20 % when manoeuvring) (USEPA, 2000).

Sulphur dioxide emissions have been estimated separately since they are essentially independent of the combustion system as they follow a mass balance of sulphur from the fuel source. Marine fuels available to the Falklands region can range in sulphur content from 0.008 % - 0.20 % (Stanley Services *pers. com.*), which is within the current, and future, MARPOL limits for sulphur outwith ECAs (section 11.12.1.1.1.2). Reflecting this, a sulphur content of 0.2 % has been assumed in the model, which also corresponds to the value adopted in the UK EEMS Atmospheric Emissions Guidelines (OGUK/DECC, 2008).

Note that the USEPA (2000) does not distinguish between different classifications of particulate matter. Standards in the UK and elsewhere usually relate to PM10 and PM2.5 (section 11.12.4.1.5), the latter of which has the greater potential to impact upon health (section 11.12.4.2). As a conservative approach, the PM emission calculated by the USEPA (2000) approach is assessed against both PM10 and PM2.5 standards.

The release rates estimated for the model for the different pollutants are as defined in Table 11.61. Importantly, it is expected that actual future emissions will, in general, be better quality than those recorded due to ongoing advances in vessel and engine design.

Full detail on the assumptions made with regard to estimating the different emission release rates are provided in Premier (2016f).

Table 11.61: Estimated pollutant release rates used in the model

Pollutant release rates (g/s)				
PM	NO_2	SO_2 [a]	CO	NOx
1.16	42.5	3.61	5.28	111.9

[a] Mass balance for sulphur is set at 0.2 % w/w.

Additive effects

For some parts of the operation, the vessels will be adjacent to eachother such that the plumes from the exhausts may mix and give rise to additive effects.

The worst case for atmospheric dispersion modelling of combustion emissions is considered to be when the vessels are operating within Berkeley Sound as it is possible that the plumes may combine for a period of time.

11.12.4.4.1.3 Modelling parameters and input data

The modelling of pollutant concentrations was performed within a 27 km x 27 km grid centred on a potential location for the LTVs (i.e. 16 km north, south, east and west of the potential anchorage) (Figure 11.17). The actual release location will differ slightly to this depending on the final position of the LTVs, but this is considered representative. Residential receptors within this grid and are located at Long Island Farm, Johnson's Harbour, Murrell Farm and at Stanley, which are 9 -16 km from the Mooring Buoy. Green Patch and Port Louis are approximately 18 km away and are outwith the grid.

Terrain data was imported from the GTOPO30 database from the United States Geological Survey with a resolution of 30 arc-seconds, which is considered adequate to represent terrain effects within the accuracy of the model. Terrain is incorporated into the predictions using the complex terrain module in the model. Surface roughness was based on recommendations within the model literature (CERC, 2001) as valid for 'open grassland'.

The modelling was conducted to investigate the effect of over three years of continuous emissions. Meteorological data was obtained from Mount Pleasant airport (section 7.3.2) and has been through quality assurance processes via consultants ADM Ltd. so that it was ready for use in the model. This, and other assumptions described below, result in a highly precautionary approach to calculating air quality metrics given that the LTV operation will occur for 365 days as a worst case during the first subsea installation campaign.

The combustion emissions will be released through a set of exhaust stacks. The detail of these will vary between vessels so an overall assumption has been made to model the releases using stack details given in BMT (2000). In terms of the operation of the model, the key inputs are the mass flux in grams per second (Table 11.61 above) and the release velocity, which have been specified. The diameter, or the effective diameter, represented by multiple exhausts, is less important. A summary of the key data used in the model is provided in Table 11.62.

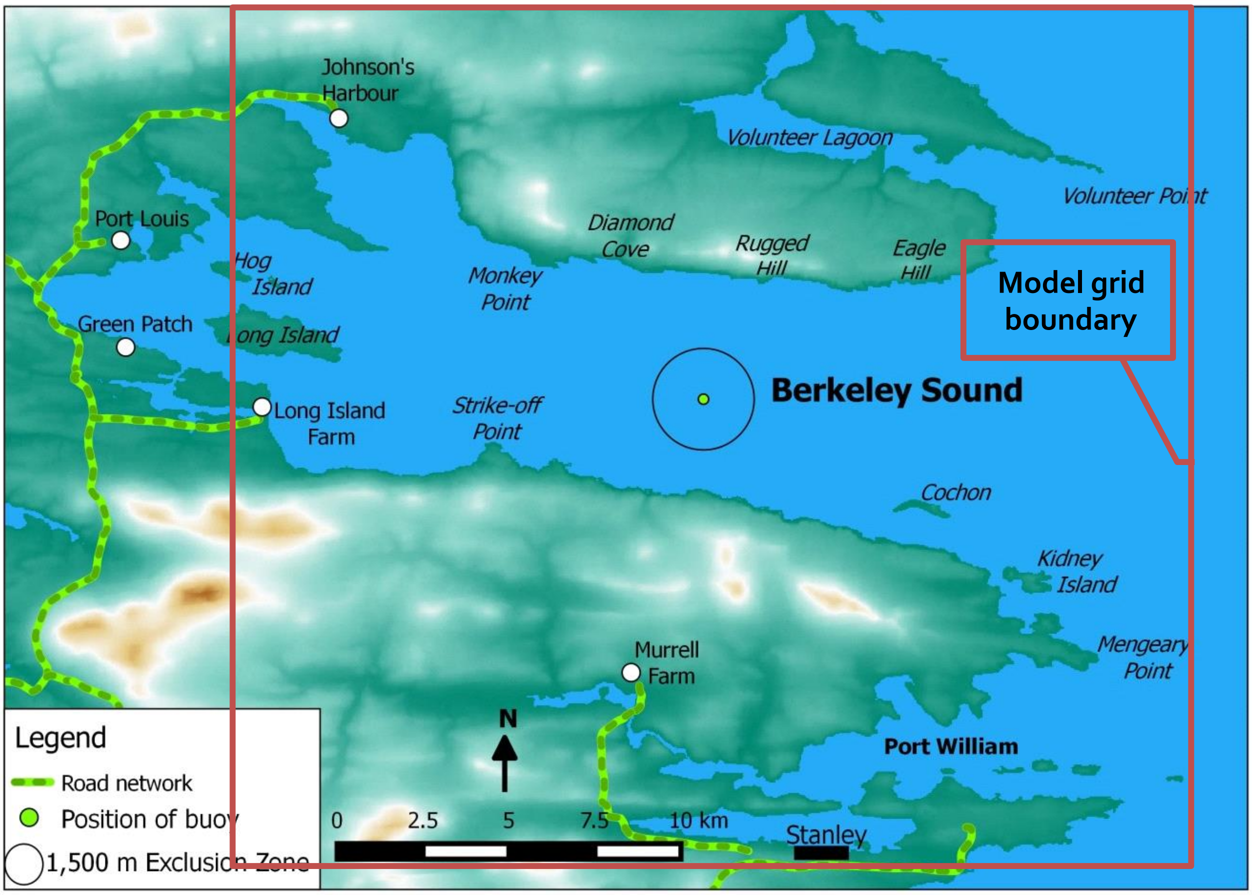


Figure 11.17: The 27 km x 27 km modelling grid used for the air quality modelling, indicating the location of the nearest human receptors

Table 11.62: Key modelling parameters

Modelling parameter	Value		Notes
Model grid coverage	Spatial extent	Approximately 792 km^2	Covers north and south shores of Berkeley Sound, Johnson's Harbour, Long Island Farm, Murrell Farm and Stanley
	Height	1.5 m	Although all heights of the plume are calculated, the model gives output concentrations for a single height. Height is placed at a level close to human receptors and this approach is conservative for plumes that descend to the ground as here
Model duration	3 years of continuous emissions		This is highly conservative as c. 27 loads per year, lasting up to 24 hours, will take place
Model grid resolution	Longitude	100 m	A higher resolution than the meteorological and terrain data, capturing local scale fluctuations
	Latitude	100 m	
	Height	1.5 m	
Release velocity	30 m/s		After BMT (2000)
Temperature modelled	280 Celsius		After BMT (2000)
Location of release	Vertically upwards from exhaust, 30 m		After BMT (2000)
Diameter of release	1,000 mm		Effective diameter that gives release velocity of 30 m/s after BMT (2000)
Density of gases	1.33 kg/m^3 (standard conditions)		Calculated from an overall relative molecular mass of 31 for combustion air, which is a conservatively high value which will cause the plume to descend

11.12.4.4.1.4 *Thresholds of significance defined in the model*

The significance of the concentrations of pollutants at sea level is commonly determined against the UK environmental Air Quality Objectives (AQO) published in the DEFRA Air Quality Strategy for the UK (2007) and by the EU and World Health Organisation (WHO, 2006; WHO, 2014).

It is important to note that UK AQO are based on the EU guideline standards, which allow for a number of exceedances to occur each year in recognition that peak values are not necessarily good descriptors of air quality. In contrast, the World Health Organisation (WHO) standards commonly use the maximum value, thus not allowing any exceedance of the guideline value.

The UK, EU and WHO AQO for NO_2, SO_2, CO and PM are provided in Table 11.63. The UK thresholds are considered the most reasonable standards to apply to the Falkland Islands given its similar latitude. Where available, the limits for Scotland specifically are used.

Air quality is normally measured and assessed using concentrations of particular pollutants (i.e. mass of pollutant per volume). However, where there are fluctuating atmospheric conditions and variability in receptors, air quality standards are also expressed using a 'percentile'. For example, where the benchmark allows for 24 hourly exceedances per year, this equates to the 99.73rd percentile (calculated as: 24 / 8,760 hours per year = 0.27 %, 100 % - 0.27 % = 99.73 %). In this example, the maximum value occurring anywhere in the model domain at the 99.73rd percentile is the value reported.

Table 11.63: Air quality objectives against which the model outputs are measured

Pollutant	Time period	AQO concentration (µg/m^3)		
		UK	EU	WHO
Nitrogen Dioxide (NO_2)	1 hour mean	200 (99.79th %ile) [a]	200 (99.79th %ile)	200 (100th %ile)
	1 year mean	40 (annual average)	40 (annual average)	40 (annual average)
	10 min mean	-	-	500 (100th %ile)
Sulphur Dioxide (SO_2)	15 min mean	266 (99.90th %ile)	-	-
	1 hour mean	350 (99.73th %ile) [b]	350 (99.73th %ile)	-
	24 hour mean	125 (99.18th %ile) [c]	125 (99.18th %ile)	20 (100th %ile)
Carbon Monoxide (CO)	8 hours	10,000 (8 hour running mean) (in Scotland only)	10,000 (8 hour running mean)	-
PM10 (gravimetric)	24 hour mean	50 (99.6th %ile) [d]	50	-
	1 year mean	40 (18 µg/m^3 in Scotland)	40	-
PM2.5 (gravimetric)	1 year mean	25 (10 µg/m^3 in Scotland)	-	-

[a] Not to be exceeded more than 18 times a year.
[b] Not to be exceeded more than 24 times a year.
[c] Not to be exceeded more than 3 times a year.
[d] Not to be exceeded more than 35 times a year (7 times a year in Scotland).

11.12.4.4.1.5 Understanding the model outputs

The EA Air Emissions Risk Assessment (EA, 2016) provides guidance for determining the significance of emissions from industrial sources which is known as the 'Process Contribution' (PC). It is suggested by the EA that emissions can be considered to be insignificant when the PC comprises:

- < 1 % of the long-term environmental benchmark i.e. the AQO; or
- < 10 % of the short-term environmental benchmark.

Importantly however, the EA Guidance states that:

"if an emission is not screened out using this test, it does not necessarily follow that it will have a significant effect or that it will result in an unacceptable environmental risk".

Therefore, judgment on whether an emission is significant or not is made by assessing the overall 'Predicted Environmental Concentration' (PEC) of a pollutant and comparing this to the environmental benchmark. According to the EA guidance, the PEC is determined as follows:

- PEC = Process Contribution + Background Concentration (including contributions from other industrial sources)

The *long-term* PEC can be considered insignificant when:

- The long-term PEC is <70 % of the environmental benchmark (the AQO).

Detailed assessment of *short-term* effects is more complex however, as the maximum PC and the maximum background concentration may be separated both temporally and spatially, so that the addition of the two 'worst case' concentrations may not represent a likely event. A pragmatic approach is suggested in the EA Guidance (2016), where the short-term background concentration is taken to be twice the long-term background concentration such that:

- $PEC_{short\text{-}term} = PC_{short\text{-}term} + (2 \times \text{Background Concentration}_{long\text{-}term})$

Following this, the short-term PEC can be considered insignificant when:

- The short-term PEC is <20 % of the AQO *minus* twice the long-term background concentration (i.e. the pollutant AQO is reduced to take account of the existing levels of a pollutant).

Importantly, while numerous other vessels use Berkeley Sound (section **7.7.3.2**) such that there will be a local background level of NOx and SOx it is not possible to estimate what this background level is. Therefore, when assessing the emissions for project vessels, the assessment is primarily limited to the PC and the lower significance thresholds indicated above.

Therefore, modelling was used to determine the PC ($\mu g/m^3$) of NO_2, SO_2, CO and PM over standard time periods as defined in the UK AQO. The PCs for each time period are expressed as a percentage of the UK AQOs (Table 11.63 above) to indicate those which can be screened out and those which are potentially significant.

11.12.4.4.1.6 Model results

Plume behaviour

The behaviour of the general exhaust plume, with regard to the concentration of emissions at varying distances from the source of the emission, is shown in Figure 11.18, using SOx emissions as an example. This plot represents the range of outputs for a 24-hour period using the conditions experienced on the 1st January 2014 as an example. While this plot is not intended to be fully representative, it provides an indication of the overall plume behaviour on a typical day.

Over this 24 hours period:

- The wind speed varied between 0 - 7.2 m/s;
- The wind direction was from the north and northwest;
- Air temperature was 7 - 13°C;
- Cloud cover varied from 0 - 80 %; and

- There was no precipitation.

The centerline concentrations begin high, with values of 2 g / m^3 (i.e. 2 million µg / m^3) of SO_2 near the exhaust (with a significant dispersion occurring in the initial turbulent release zone). This then drops off rapidly and steadily, bearing in mind that both axes are logarithmic, so that at 20 m, for example, concentrations are down to 300,000 µg / m^3. Ground level concentrations are not recorded until a distance of 60 m is reached, when they are very small, and it is not until 145 m that they reach 1 µg / m^3, still well below any level of concern. At around 550 m, the ground level concentrations stop increasing and they approximate the centerline concentrations. This essentially means that the plume has descended to near ground level at this point. Thereafter the concentrations continue to decline steadily with distance.

With residential receptors between 9 -18 km from the Mooring Buoy, Figure 11.18, shows that it is not conceivable that concentrations of SO_2 at the residential areas could exceed air quality standards for human exposure.

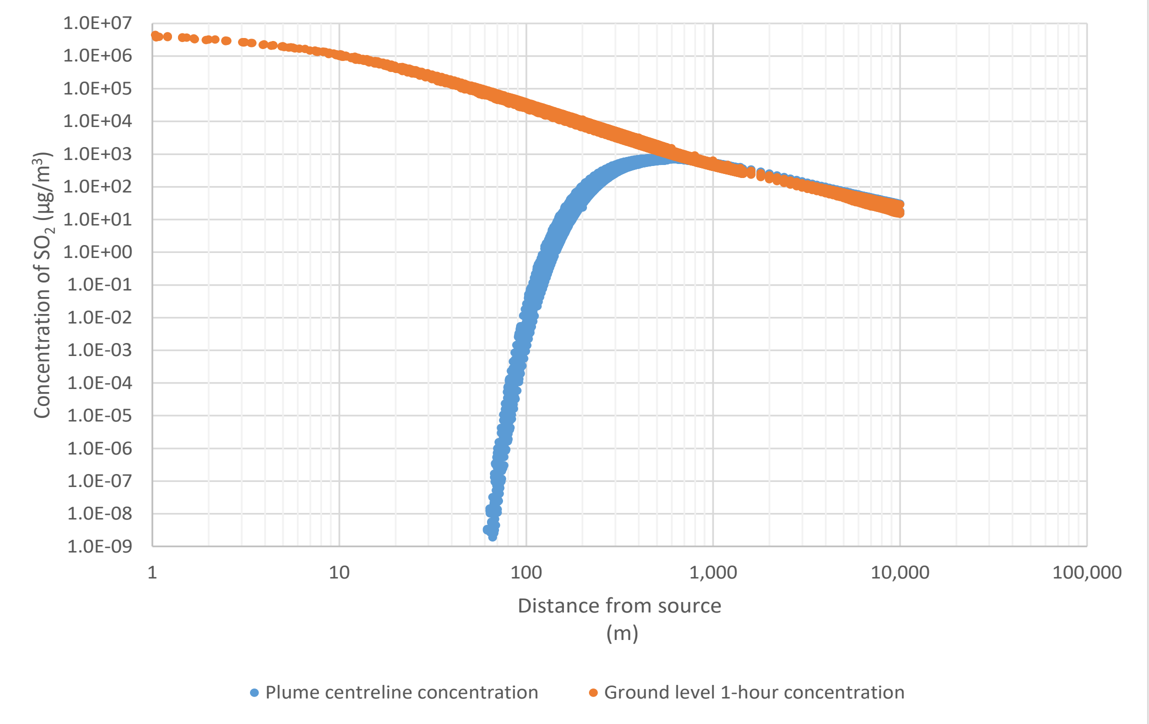


Figure 11.18: Plume centreline concentration and sea / ground level concentrations using SO_2 over a 24-hour period as an example of pollutant concentration at distance from the source

Pollutant concentration and dispersion

Table 11.64 shows the results of the dispersion modelling. For the long-term means, the results are averaged over the grid. However, for short-term means, the results indicate the 'maximum concentration' for each gas and the 'concentration of the gas at the shore'. The former indicates the maximum concentration that was experienced within the 792 km^2 grid. As is indicated in the general behaviour of the plume (Figure 11.18 above), the highest concentration will occur nearest the emissions source (i.e. at sea). As described in section 11.12.3 above, the only receptors that would be at sea are other vessel users, which will have limited opportunity for exposure. Therefore, with regard to the potential for exposure of human beings as a receptor, the important data is the pollutant concentration at-shore and at the location of the nearest residential receptor.

As shown in Table 11.64, the modelling indicated that there are wide margins between the AQOs for many of the gases and the predicted PCs at-shore and at the nearest residential location so that most could be screened out in accordance with the EA guidance (2016) (section 11.12.4.4.1.5). The only concentrations that could not be automatically screened out were:

- The one hour (short term) NO_2 concentration at shore and at the nearest residential location which were both >10 % of the AQO (Table 11.64); and
- The one year (long-term) NO_2 concentration at nearest residential location which was 1 % of the AQO (Table 11.64).

The dispersion plots of the above are provided in Figure 11.19 and indicate the PC levels at the nearest receptors 9 -18 km away.

As the above cannot be automatically screened out, it is necessary to assess these further to determine whether or not the PEC, which takes account of the background levels, could be significant according to the EA guidelines (EA, 2016). As stated above, background levels for Berkeley Sound are not known. Therefore, in the absence of local data, if we assume that the background level of NO_2 could be comparable to the rural UK background level, it is possible to estimate what the PEC (i.e. the PC + background level) might be.

According to the National Environmental Technology Centre, the rural UK background NO_2 concentration is 1.3 µg / m^3 (NETC, 2013). Therefore, according to the EA Guidance (section 11.12.4.4) the short-term PEC of NO_2 would be as follows:

- 1 hour mean (short-term) NO_2 concentration at-shore: PC (59.2 µg / m^3) + (2 x the Rural Background Level (1.3 µg / m^3) = 2.6 µg / m^3) = 61.8 µg / m^3 which is 30.9 % of the AQO. Therefore, the short-term PEC at-shore is **>20 % of the AQO**; and
- 1 hour mean NO_2 concentration at nearest residential location: PC (23.7 µg / m^3) + (2 x the Rural Background Level (1.3 µg / m^3) = 2.6 µg / m^3) = 26.3 µg / m^3 which is 13 % of the AQO. Therefore, the short-term PEC at the nearest residential location is **<20 % of the AQO**.

Similarly, the long-term PEC of NO_2 at-shore would be as follows:

- Annual (long-term) NO_2 concentration at-shore: PC (1.55 µg / m^3) + Rural Background Level (1.3 µg / m^3) = 2.85 µg / m^3 which is 7.13 % of the AQO. Therefore, the long-term PEC is **< 70 % of the AQO**; and
- Annual NO_2 concentration at nearest residential location: PC (0.4 µg / m^3) + Rural Background Level (1.3 µg / m^3) = 3 µg / m^3 which is 1.5 % of the AQO. Therefore, the long-term PEC is **< 70 % of the AQO**.

Therefore, while the SO_2, CO and PM concentrations can be considered insignificant (Table 11.64), there is the potential that the short-term NO_2 PEC could be significant at the shoreline, albeit not at any of the residential locations. It should be noted again however that the modelling predictions are extremely conservative as they assume that emissions will occur for 100 % of the time, rather than an estimated 5 % of the time lifethat the LTVs and installation vessels will be in the Sound.

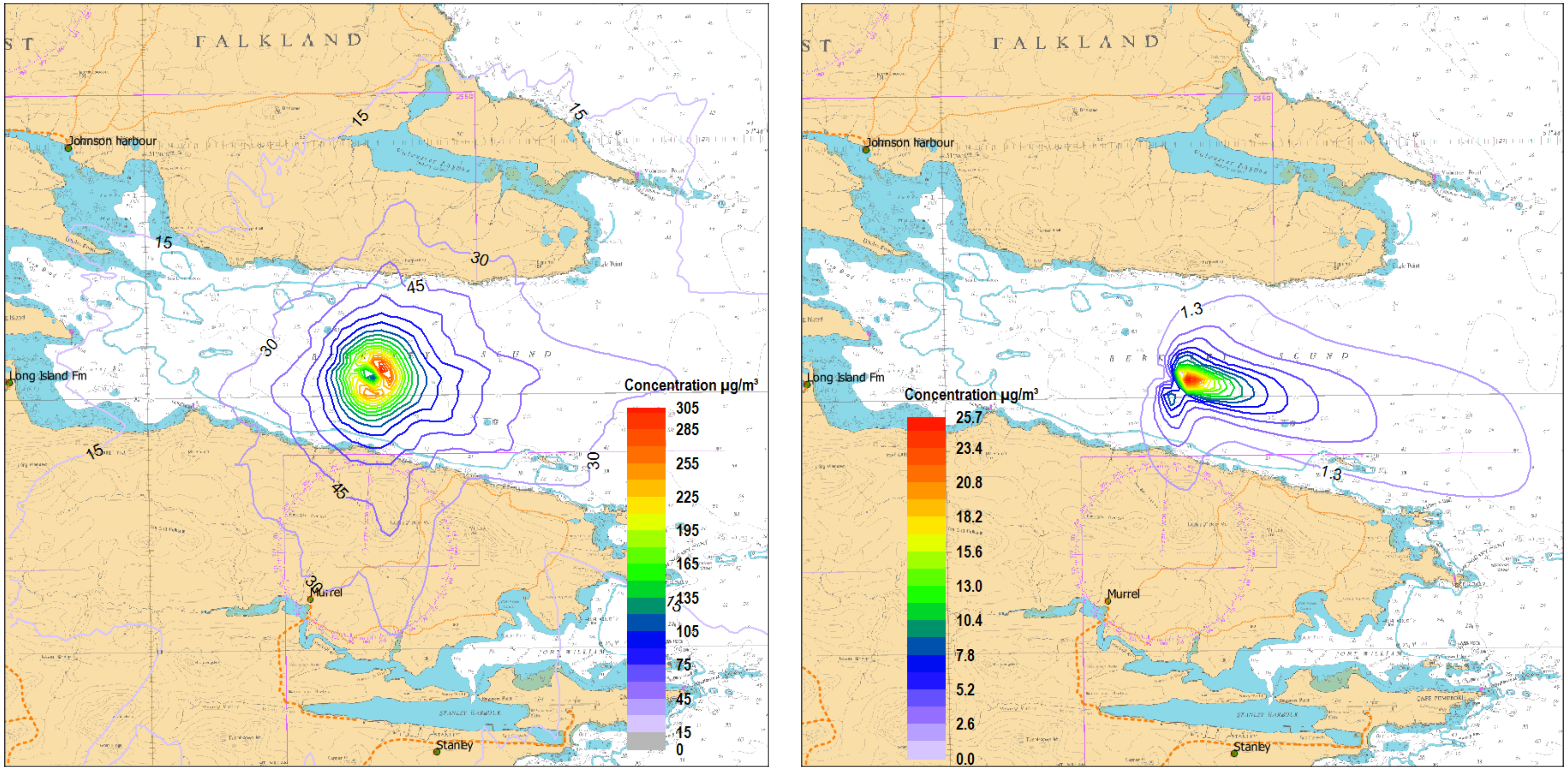
Table 11.64: Air dispersion modelling results for Inshore Transfer operations process contribution, indicating which of these can be screened out form further assessment [a]

Emission	Statistic	Screen out Bench-mark for PC	AQO (µg/m³)	Model outputs					Screen out?
				Maximum PC/PEC (µg/m³)			Maximum PC/PEC as a % of the AQO		
				At sea	At shore	Nearest residential receptor	At shore[b]	Nearest residential receptor	
NO_2	1 hour mean (99.79th %ile)	<10% of short-term AQO	200	308	59.2	23.7	**29.6 % (i.e. >10 %)**	**11.8 % (i.e. >10 %)**	**No**
	1 year mean	<1% of long-term AQO	40	27.3	1.55	0.40	n/a	**1.0 %**	**No**
SO_2	1 hour mean (99.73rd %ile)	<10% of short-term AQO	350	15.5	2.79	1.16	0.8 %	0.3 %	Yes
	24 hour mean (99.18th %ile)	<10% of short-term AQO	125	6.21	0.73	0.23	n/a	0.2 %	Yes
CO	8 hour rolling mean	<10% of short-term AQO	10,000	2.07	0.12	0.03	1.2 %	0.3 %	Yes
PM10 (gravi-metric)	24 hour mean (99.6th %ile)	<10% of short-term AQO	50	4.76	0.81	0.34	n/a	0.7 %	Yes
	1 year mean	<1% of long-term AQO	18 [c]	0.46	0.03	0.01	n/a	0.06 %	Yes
PM2.5 (gravi-metric)	1 year mean	<1% of long-term AQO	10 [c]	0.46	0.03	0.01	n/a	0.1 %	Yes

[a] **Note:** this table shows the predicted Process Contributions (PC) from the (now eliminated) Inshore Transfer to enable comparison with the PC screen-out benchmarks. Where the PC could not be automatically screened out, the Predicted Environmental Concentration (PC + background levels) was calculated assuming background levels in Berkeley Sound would be similar to those of the rural UK. See the narrative above and section 11.12.4.4.

[b] For some objectives, 'at shore' is not a relevant point for compliance with a long-term standard as it is not likely that people will be in that area for that full length of time.

[c] The Scotland AQO thresholds are applied to ensure use of the most conservative thresholds are used.



a) 1-hour NO_2 (99.79 %tile) concentrations for a continuous emission over one year

b) Annual average NO_2 concentrations for a continuous emission over one year

Figure 11.19: Plots of short-term and long-term NO2 concentrations that would result from the [now eliminated] Inshore Transfer tankers in Berkeley Sound

11.12.4.4.2 Existing vessel use in Berkeley Sound

As is detailed in section **7.7.3.2**, many other vessels already use Berkeley Sound, all of which will generate combustion emissions. There is considerable inter-annual variation in the number of vessels using Berkeley Sound but in a good *Illex* fishing year around 1,000 vessel days are recorded in the Sound. The existing sources will usually be much smaller than the two tankers modelled, but may occur nearer to the local receptors (i.e. settlements around Berkeley Sound and at Stanley), and at lower heights than the tanker exhaust stacks (which are taller and promote greater dispersion). Emissions from the tanker support vessels are likely to be similar to these existing sources and are relatively transient.

Automatic Identification System (AIS) records from vessels using Berkeley Sound, used for the Quantitative Risk Assessment (QRA) for the Sea Lion Project, indicate that average speeds of vessels in transit within the Sound are around nine knots, with maximum speeds often around 14 knots, indicating that other vessels are operating at relatively high load levels.

11.12.5 Industry-standard mitigation

In addition to compliance with legislation (section 11.12.1.1) and the base case mitigations (i.e. the use of MGO (lighter fuel) when inshore, and the maximum travel speed of 8 knots in Berkeley Sound which reduces the power usage and exhaust emissions), the industry-standard mitigations used to minimise emissions include:

- Auditing of tankers to ensure compliance with all the requirements of MARPOL Annex VI (section 11.12.1.1.1);
- Use of Best Available Techniques (BAT) in the Development Basis of Design, for example applying BAT if a dedicated waste incinerator is required to ensure appropriate flue gas treatment is applied to minimise pollutants;
- Regular monitoring and inspection of all combustion equipment and use of a Management Maintenance System with Planned Maintenance Routines to ensure all combustion equipment runs as efficiently as possible;
- Monitoring of all emissions; and
- Ongoing ALARP reviews throughout the field life which will take account all emissions monitoring outcomes.

11.12.6 Impact assessment

The following section draws upon all the information provided above to assess the ‘Sensitivity of the Receptor’ and the ‘Severity of Effect’ in order to determine the overall ‘Impact’ of planned activities.

A summary of the impact assessment outcomes is tabulated in section 11.12.12, which shows the worst case impact for each activity and receptor with details provided below.

11.12.6.1 Combustion emissions onshore

The generators will be sited within the proposed supply base which is just over 1 km to the nearest residential receptor (section 11.12.2.1). The site of the municipal incinerator has not been finalized at the time of publication but it is likely to be a similar 1-2 kms from the closest residential receptors. Given the relatively close residential area, albeit to the west of the operations base and therefore out-with the most likely zone of influence given the predominant westerly winds, and the uncertainty surrounding the location of the municipal incinerator, the **sensitivity of the human receptors** in the area is considered to be '**Moderate**'.

A comparative assessment of an incinerator in the UK similar to that anticipated found that within 100 m of the stack, concentrations of pollutants are within the relevant air quality standards for human receptors (section 11.12.4.3.1), such that the severity of effect on the human population is considered to be '**Slight**'.

Therefore, the overall **significance of the impact** of waste incineration in the Falklands on the human population is assessed as '**Very Low (3)**'.

11.12.6.2 Combustion emissions from inshore vessel use

While there are farms on the shores of Berkeley Sound, the anticipated LTV anchorage is located between 9 -18 km from the nearest residential receptors (section 11.12.3) in an area where the predominant winds are westerly (section 7.3.2.2.1). Therefore, the location of the emissions' source is in an unpopulated area and is exposed to strong winds such that **the sensitivity of the receptor** is considered to be '**Very Low'**.

The ADMS modelling indicated that the majority of the gases were sufficiently below the established AQO thresholds for each of the time periods such that they could be screened out. The exceptions were the short-term PCs of NO_2 at-shore and at the nearest residential site which were both >10 % of the short-term AQO (Table 11.64 above). Similarly, the long-term (annual) PCs of NO_2 at the same locations were both equal to or more than 1 % of the AQO (Table 11.64 above). As advised in the EA Guidance (2016), it was therefore considered necessary to calculate the overall PEC. However, as described in section 11.12.4.4.1.2, background levels are not yet available for Berkeley Sound to enable such an assessment. Therefore, an assumption was made that background NO_2 levels in Berkeley Sound could be comparable to the UK rural background levels, with the result that the long-term PECs of NO_2 were both <70 % of the AQO (section 11.12.4.4.1.6) and are therefore considered insignificant. Similarly, the short-term PEC at the nearest residential location was <20 % such that it too can be considered insignificant. However, the short-term PEC of NO_2 at the shoreline was 30.9 % of the AQO (section 11.12.4.4.1.6). While this concentration does not exceed the AQO, it does exceed the short-term PEC significance threshold given by the EA (i.e. it is >20 % of the AQO).

However, the extent of dispersion (Figure 11.19 above), the fact that the modelling is very conservative (i.e. it assumes emissions for 100 % of the time rather than the more realistic average of 5% of the time), the fact that receptors are not regularly exposed at the shoreline and the fact that UK background levels may be higher than those in Berkeley Sound all combine to minimise any concern for exposure of human receptors. On balance therefore, the **severity of effect** is considered to be '**Minor**.

Therefore, the **overall significance of impact** of combustion emissions from the inshore operations are considered to be '**Very Low (2)**'.

11.12.6.3 Particulate matter emissions from the MPC road

There are no populated areas within 20 m of the unpaved sections of the MPC road and all areas are exposed to strong winds such that the **sensitivity of the receptor** is considered to be '**Very Low**'.

It is considered probable that the predominant winds will rapidly disperse PM generated by use of the unpaved sections of the MPC road. Further, Premier's use of the road will not add significantly to the existing use of the road (see section 11.7.4.5.1) such that the **severity of the effect** is considered to be '**Slight**'.

Therefore, the **overall significance of impact** of PM from use of the MPC road is assessed as '**Very Low (1)**'.

11.12.7 Project-specific mitigation measures

Given that the impact of emissions on air quality are '**Very Low**', it is not considered necessary to carry out any project-specific mitigation over and above those that are built into the base case and the industry-standard mitigations specified by MARPOL (section 11.12.1.1.1).

11.12.8 Residual impacts

Not applicable.

11.12.9 Cumulative impact

As is described in section 11.12.4.3, numerous other vessels currently use Berkeley Sound, each of which will generate emissions to which the inshore vessels will contribute. However, it was not possible to accurately quantify the emissions from the existing sources of emissions. Therefore, the overall cumulative impact cannot be quantitatively assessed.

Nonetheless, the remote nature of the area, intermittent use of the Sound and the quantifiably low emissions resulting from the Premier activities are such that the operation is not expected to significantly add to cumulative emissions or the overall PEC. Taking the prevailing wind speed and direction into account, it is expected that the dispersion of all combustion emissions from vessel use in Berkeley Sound are unlikely to impact upon the residential receptors in the region in any way.

11.12.10 Confidence

The duration of the Phase 1 Development is known and the associated vessel use for the LTV operation has been estimated on a very conservative basis in this assessment to provide worst case estimates.

The AQO used are industry-standard and the ADMS model is accepted for use in the UK for assessment of air quality impacts by the EA and BEIS (formerly DECC) and has users across Europe, Asia, Australia, North America, Africa and the Middle East. Therefore, level of confidence in the predictions of impacts to air quality from vessel use is considered to be '**Certain**'. Similarly, use of the MPC road is well understood and confidence in the predictions of associated impacts is considered to be '**Certain**'.

As the make and model of the waste incinerator are not yet known, and until further modelling is carried out, the level of confidence in the predictions of these impacts is considered to be '**Probable**'.

11.12.10.1 Monitoring required

Routine sampling and tests of air quality will be undertaken on all fuel supplies as part of the procurement process and audits. Monitoring of air quality parameters will be conducted over the seasons to establish baseline levels and air quality monitoring during operations will be undertaken to validate predictions and inform ongoing practices.

Monitoring of emissions from the incinerator will be undertaken by FIG and will have regard to relevant standards such as ISO 17025 and relevant pollutants including:

- Total dust (as PM_{10} and $PM_{2.5}$);
- Hydrogen chloride;
- Cadmium and Thallium;
- Heavy metals;
- Mercury;
- Sulphur dioxide;
- Hydrogen chloride
- Hydrogen fluoride;
- Total VOCs;
- Oxides of nitrogen;
- Carbon monoxide
- Total organic carbon; and
- Dioxins and furans.

Ambient air quality monitoring will also be carried out.

Detailed monitoring requirements have been established during the Environmental Monitoring and Management Plan (EMMP) workshop. All monitoring requirements agreed by Premier and FIG will be recorded and managed via the project-specific Phase 1 EMMP (an outline EMMP is provided in Chapter 15).

11.12.11 Offsetting

As no residual impacts or risks identified in this section are considered significant, i.e. Moderate or above, offsetting is not considered (see section 8.9).

11.12.12 Findings summary

Table 11.65: Summary of the assessment of the impact of atmospheric emissions on regional and local air quality

Activity	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Use of standby diesel generators at the supply base near Stanley	Emissions of CO_2, O_2, N_2, water, dioxins and furans, NOx, SOx, CO and PM in the form of dust	Impacts to humans from breaching of air quality standards	Planned	1, 2 & 3	Moderate	Slight	n/a	Very Low (3)	n/a	Probable	Industry-standard: Use of BAT in project design; Monitoring and measuring of emissions; Selection and pre-mobilisation auditing; Optimisation of operations; Management Maintenance System; SMART objectives and targets; and Ongoing ALARP reviews. Project-specific: None proposed
Incineration of waste at the municipal waste site near Stanley	Emissions of CO_2, O_2, N_2, water, dioxins and furans, NOx, SOx, CO and PM in the form of dust		Planned	1, 2 & 3	Moderate	Slight	n/a	Very Low (3)	n/a	Probable	
Fuel combustion by vessels in Berkeley Sound	Emissions of CO_2, O_2, N_2, water, dioxins and furans, NOx, Sox and CO		Planned	1 & 2	Very Low	Minor	n/a	Very Low (2)	n/a	Certain	
Use of MPC road	Emissions of PM2.5 and PM10	Degradation of local air quality with PM	Planned	1, 2 & 3	Very Low	Slight	n/a	Very Low (1)	n/a	Certain	

[a] See Chapter 8 for definitions of sensitivity, severity, likelihood and significance.

12 ACCIDENTAL & CHRONIC OIL POLLUTION

Table of Contents

12.1 Accidental and chronic oil pollution offshore

12.1.1 Introduction

Along with the potential environmental impacts from planned development activities, impacts may arise from unplanned / accidental events and this was raised as a concern by stakeholders during scoping consultations (section 6.3). Crude oil and fuel spills are unplanned events, which would result in environmental impacts if they occurred. The nature, extent and significance of these impacts will depend on a number of variables associated with the event, including, for example, the properties of the oil released, the size of spills, prevailing weather conditions and the sensitivity, density and distribution of environmental receptors in relation to the spill.

This chapter assesses the risks and potential impacts of five oil spill scenarios on environmental receptors in the offshore marine environment as well as those associated with low-level but chronic oil pollution.

Note: the impacts associated with other discharges to sea are described elsewhere in this document, as outlined in section 9.2.

12.1.1.1 Legislation relevant to oil and diesel spills

Much of the legislation applied to the oil and gas (O&G) industry is in place to prevent accidental events and is therefore relevant to oil spills. More specifically, the following legislation is related directly to discharges and spills in the marine environment.

- International legislation:
  - International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC Convention).
  - International Regulations for Preventing Collisions at Sea (ColRegs) (1972).
  - International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78 Annex I on the Prevention of Pollution by Oil.
- UK legislation:
  - The Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1999 (amendment) Regulations 2007.
  - The Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended Regulations 2011).
  - Offshore Installations (Emergency Pollution Control) Regulations 2002.
  - Merchant Shipping (Oil Pollution Preparedness, Response & Co-operation Convention) Regulations 2015.
- Falkland Islands legislation:
  - Merchant Shipping (Regulation of Ships) Regulations 2001.
  - Offshore Petroleum (Licensing) Regulations 1995 (as amended).
  - Offshore Minerals Ordinance 1994 (as amended).
  - Oil in Territorial Waters Ordinance (1960).

- PON 08 Oil Pollution, requires that all release of oil to the sea must be reported as soon as possible to:
  - The Department of Mineral Resources as regulator; and
  - The Department of Natural Resources as incident command, National Oil Spill Contingency Plan (NOSCP).

12.1.1.1.1 National Oil Spill Contingency Plan (NOSCP)

The Falkland Islands Fisheries Department (Directorate of Natural Resources) is the lead agency charged with managing the marine environment and responding to marine oil spills within the 12 nautical mile (nm) territorial limit and 200 nm Exclusive Economic Zone (EEZ). The NOSCP currently reflects the most likely type of spill expected, namely minor spills within the harbours. Oil spill response equipment is stored at the Falklands Interim Port And Storage System (FIPASS) to counter this risk. Offshore, the NOSCP relies on the use of dispersants providing that the oil and environmental conditions are suitable.

Due to the limited response capability in the Falkland Islands, O&G operators are obliged to provide equipment and contingency plans to mount an effective response to oil spilled from their facilities. Oil Spill Contingency Plans (OSCPs) submitted to the Falkland Islands Government (FIG) are required to be compatible with the NOSCP which is currently being reviewed, in part to reflect the growing hydrocarbon activities offshore.

12.1.1.1.2 Offshore Oil Spill Strategy

Premier has developed an Offshore Oil Spill Strategy for the Sea Lion Development (PMO, 2019c), which identifies the essential components of spill response for this operation. It will shape an Oil Spill Contingency Plan (OSCP) that will later (closer to the start of operations) be submitted as a separate document which contains specific operational information such as detailed action lists and contact details for personnel. As described below, the OSCP will outline the organisational responsibilities, actions, reporting requirements and resources available to ensure the effective and timely management of an accidental spill, and will be compatible with the NOSCP.

12.1.1.1.3 Oil Spill Contingency Plan (OSCP)

The OSCP will consist of a tiered response framework that is related to the magnitude of any spill event. Response and preparedness levels will be organised according to the IPIECA / IMO international standard model of 'Tiered preparedness and response', defined as follows:

- **Tier 1 Spills**: An oil spill that will be mitigated solely using the local offshore response resources held by Premier as defined within the OSCP.
  - Tier 1 spills will either be contained using local recovery equipment or monitored as it dissipates. A 300 m boom system and a mechanical belt skimmer will be deployed on the Multi Role Support Vessel (MRSV) and Anchor Handling Vessels (AHVs). Recovered oil will be stored in heated tanks in the MRSV, and/or storage bladders, and returned to the FPSO or a specifically mobilsed recover tanker (a Vessel Of Opportunity (VOO)) for final disposal. Surveillance will be carried out either using aerostat balloons or helicopter.

- **Tier 2 Spills**: An oil spill requiring support and resources from other local Premier resources, oil operators / stakeholders in the FI is classed as Tier 2. In compliance with the FIG PON 8, the spill will be reported and Premier will consult with the FIG NOSCP incident command, as required.
  - Tier 2 spills will be contained using the Tier 1 local equipment as described previously. These resources will be supported by an additional AHV or MRSV. All vessels would be classified to operate in the offshore location and equipped with identical specification response equipment.
  - Surveillance will be carried out either using aerostat balloons or helicopter.
- **Tier 3 Spills**: An oil spill incident requiring international resources is classed as Tier 3. The FIG NOSCP will be deployed with national and potentially international resources being deployed. These resources will be made available from the OSRL stockpile within 96 hours of request; personnel might be deployed more quickly. In addition to the Tier 1 and Tier 2 resources already described, Premier has arrangements in place to mobilise resources from Oil Spill Response Ltd. (OSRL) and local contractors if necessary to:
  - Supply offshore containment and recovery services: at sea recovery may not always be feasible in the FI due to prevailing sea conditions;
  - Request satellite surveillance and conduct oil spill modelling;
  - Prepare for any shoreline response, if required: equipment is available for shoreline protection and clean-up;
  - Aerial surveillance would be conducted using local aviation resources but might be bolstered by experienced observers from OSRL.

12.1.1.1.4 Wildlife Response

Premier has developed a Wildlife Response Strategy as part of the Oil Spill Strategy (see section 12.1.1.1.2). The Wildlife Response Strategy will inform a Wildlife Response Plan, which will be implemented prior to operations commencing.

12.1.1.1.5 Spill reporting and the PON8

In line with the Offshore Petroleum (Licensing) Regulations 1995 and 2000 (Model Clause 21(8) of Schedule 2, the PON8 sets out the requirements for notifying the authorities of any oil spill (regardless of size) and provides a *pro forma* template, with contact details, to be completed.

In summary, spills of any size must be reported, via the PON 8 to the:

- FIG Department of Mineral Resources as regulator; and
- FIG Department of Natural Resources as incident command for the NOSCP.

Note that the PON8 also requires information on oil sheens associated with produced water to be reported (section 3.1.6.4).

12.1.2 Sources of potential offshore oil spills

Sources of oil pollution from the O&G industry are many and varied and include catastrophic spill events as well as small scale and chronic releases.

During the ENVironmental Impact IDentification (ENVIID) workshop, a number of oil spill scenarios were identified and selected for further assessment. These include:

- Large oil spills:
  - Scenario 1: A subsea well blow-out;
  - Scenario 2: The complete loss of the Floating Processing Storage Offloading (FPSO) vessel's crude oil inventory plus two tanks of the offload tanker;
  - Scenario 3: A crude oil transfer spill during FPSO offloading;
  - Scenario 4: The loss of the Mobile Offshore Drilling Unit's (MODU's) diesel inventory;
  - Scenario 5: A diesel bunkering spill; and
- Small scale chronic oil releases; and
- Loss of riser contents.

12.1.2.1 Scenario 1: subsea well blow-out

In the unlikely event that all the preventative industry-standard safeguards and controls fail (section 12.1.5), it is possible that crude oil could 'kick' into the wellbore leading to an uncontrolled release or blow-out. Once drilling finishes the likelihood that a well blow-out may occur decreases (section 5.4.10).

12.1.2.2 Scenario 2: loss of the FPSO crude oil inventory

While it is possible that extreme and freak weather conditions could impact the FPSO, the FPSO will be designed to ensure it is able to withstand the range of environmental conditions in the North Falkland Basin (NFB).

In particular, as described in the Premier FPSO Functional Design Specification (FK-SL-PMO-PM-SPE-0008), the hull design and connections to the topside processing equipment will allow:

- Full production to continue uninterrupted in the one year storm condition (i.e. production will continue uninterrupted under the worst storm conditions experienced on an annual basis);
- 100 year storm condition with production shutdown, without exceeding 90% yield strength; and
- 10,000 year storm condition without exceeding ultimate tensile strength.

In addition to the above, the FPSO will be anchored via a detachable turret and therefore, will be able to move off-station, if considered necessary. Therefore, although highly unlikely to occur, the only credible events that could lead to a scenario in which the FPSO loses its entire crude oil inventory would be a collision with a large vessel transiting through the area (section 11.1) or a collision with an iceberg. Collision risk assessments have been conducted for both of these scenarios and are presented in:

- Anatec (2013) 'Collision Risk Assessment Sea Lion FPSO; Technical Note' (Ref: A3140-PRE-RA-1); and
- Premier (2015f) 'Sea Lion Development; Iceberg Management Strategy' (Doc: FK-SL-PMO-NA-STY-0001).

Previously this scenario considered a worst case where it was assumed a dynamically positioned shuttle tanker collides at speed with the FPSO, due to a DP malfunction ("drive off"), incident resulting in a full inventory loss of crude from the FPSO as well as the loss of two of the tanker's bow tanks. Direct, infield, offloading has now been adopted by the project and transfer to a Conventional Trading Tanker (CTT) will be take place with greater separation between the CTT and FPSO, with the CTT connected to a hold back tug. UK OPEP Guidelines (BEIS, 2016) have been followed which requires that the full FPSO inventory has been assessed.

12.1.2.3 Scenario 3: crude oil transfer spill

Following production and processing, crude oil will be stored on the FPSO. Once full, it will be necessary to offload the crude from the FPSO to a CTT. Offloading to the CTT will occur twice in any given export cycle to ensure that the CTT is full prior to its departure.

While offloading operations are a planned activity, there is the potential for a failure of the transfer hose and the resultant loss of crude at the offshore location during the transfer process. While such spills would most likely be small as the offloading process would cease as soon as any leak or spill was detected, this chapter assess the potential worst case scenario.

The failure modes that can lead to a hose failure (the likelihood of a release) are discussed further below (section 12.1.6.3.2) and a potential worst case is assessed.

12.1.2.4 Scenario 4: loss of the MODU diesel inventory

As with the FPSO in Scenario 3, the only credible scenarios which could lead to the loss of the entire diesel inventory from the rig would involve a catastrophic impact from a large vessel or iceberg. This scenario could equally apply to the FPSO; however, the MODU was modelled as it has a larger diesel inventory.

12.1.2.5 Scenario 5: diesel bunkering spill

While all industry-standard safeguards will be in place (section 12.1.5), there is the potential for spills of diesel to occur during bunkering operations. While such spills would most likely be small as the bunkering process would cease as soon as any leak or spill was detected, this chapter assess the potential worst case scenario.

12.1.2.6 Small scale releases

Chronic oil pollution refers to the accumulation of oil from numerous sources (NRC,1985 and 2003).

Specifically, chronic oil pollution can result from:

- Legally compliant operational discharges with low-level oil in water (OiW) concentrations e.g. drainage, bilge and produced water discharges; and
- Discharge of off-specification operational discharges between samples;
- Small and discrete accidental oil spills.

Note that the potential impacts of oil sheens forming from legally compliant or off-spec operational discharges, and their contribution to chronic oil pollution, are described in section 10.7.

12.1.2.7 Emergency disconnect leading to loss of riser contents

During the 2015 exploration drilling campaign, the MODU lost station due to failure of the Dynamic Positioning (DP) system which resulted in the loss of the riser contents to the sea. This resulted in the loss of 450 kg of Water Based Mud (WBM) to sea. Although the Phase 1 Development wells will use a non-aqueous drilling fluid (e.g. an Oil Based Mud (OBM)), which would cause greater environmental impact than WBM if released, the Development MODU will be anchored to the seabed and will not be maintained on station by DP. The risk of losing station is therefore greatly reduced and the loss of riser contents due to an emergency disconnect has been screened-out of this assessment as is indicated in the ENVIID report (Chapter 9).

However, it is possible that the contents of the riser (approximately 60 m^3 of OBM) may be lost due to other reasons and as such, is included in the assessment below.

12.1.3 Potential environmental receptors

The ENVIID workshop was used to identify those receptors upon which the impacts and / or risks of oil spills warranted further investigation (Chapter 9). These include:

- Plankton (section 7.4.1);
- Benthic communities (section 7.4.3);
- Fish and squid (section 7.4.4);
- Marine mammals (section 7.4.5);
- Seabirds (section 7.4.6);
- Coastal communities (section 7.6);
- Fisheries (Human population) (section 7.7.2.4); and
- Tourism (Human population) (section 7.7.4.6).

These receptors may be impacted upon as they either exist in, or spend time in, the area influenced by oil that might be accidentally discharged into the marine environment.

12.1.4 Characterising and quantifying the risk of oil spills

When characterising and quantifying the impacts of oil spills, it is necessary to consider the following:

- Influencing factors:
  - Type and composition of oil; and
  - The fate of oil in the marine environment.
- The nature of the impact on each of the different receptors;
- Spill modelling parameters; and
- Spill modelling results for:

- Scenario 1: Well blow-out;
- Scenario 2: Loss of FPSO crude inventory;
- Scenario 3: Spill during crude oil transfer;
- Scenario 4: Loss of MODU diesel inventory; and
- Scenario 5: Diesel bunkering spill.

12.1.4.1 Influencing factors

12.1.4.1.1 Oil type and behaviour

The type of oil can influence the nature of the impact to receptors. Some receptors are more vulnerable to the physical impacts of heavier crudes, others to chemical toxicity of lighter oils and Oil Based Mud (OBM), while others still are relatively resilient.

In general, heavier crude oil is more likely to cause fouling but is less toxic than refined oils. Toxic effects occur when oil components are bioavailable to the organisms being exposed. Volatile aromatic compounds, such as benzene, toluene and Poly-Aromatic Hydrocarbons (PAH), are highly toxic, can cause internal damage and can bioaccumulate in food chains. In the water column they are relatively short-lived, e.g. 98 - 99.9% biodegradation of dissolved PAH in 28 days (SINTEF oil weathering database), whereas once in sediments, they can persist for much longer.

12.1.4.1.1.1 Sea Lion crude

Sea Lion crude is an atypical oil given its extremely high wax content (42.3 %), which is greater than any analogue in the oil weathering databases held by the international research centres at CEDRE and SINTEF. Crude oils with high wax contents tend to solidify rapidly on release as it cools to ambient temperature. Tests were undertaken to determine the weathering, behaviour and potential impacts of Sea Lion crude; a summary of results (Table 12.1) and some representative images are presented below (Figure 12.1). For full details see CEDRE, 2017.

The behaviour of oil / wax particles resulting from a release have been tested at CEDRE in simulated exposure in the marine environment over a seven day period and also at breaking wave conditions for a further three days. The oil masses that initially formed from pouring the oil into cold water were in the size range of centimetres and showed little breakdown in particle size over time (CEDRE, 2017). The initial conditions of the release will determine the initial size and shape of cooled oil masses:

- a subsea blow-out will tend to result in small oil masses due to the high turbulence and shear forces including gas at the wellhead (seen in small scale trials (Premier, 2016j));
- small spills similarly may result in small oil masses (CEDRE, 2017); and
- large spills will tend to form larger masses.

There will probably be an upper limit in terms of the thermal properties of the release, i.e. a large mass of hot oil released will remain fluid potentially for some minutes, float and flow into a thinner layer, but it is expected that such a layer would not be strong enough to withstand wave action. To reflect this behavior in the modelling undertaken:

- the initial oil droplet sizes was set as large as possible, in the range of centimetres;
- the 'terminal film thickness' parameter was modified to prevent oil from continuing to spread on the sea surface;
- for subsea releases and smaller surface releases, the initial surface film thickness was set to 20 mm thickness and spreading was limited to 1 mm thickness; and
- for larger losses of inventory, the initial surface film thickness was set to 50 mm and spreading is limited to 5 mm thickness.

Table 12.1: Summary of results of CEDRE Sea Lion crude oil tests (CEDRE, 2017)

Aspect	Test results	Implication for risk assessment and / or spill response
Specific Gravity (s.g.)	S.g. is 0.833, i.e. the density is 0.833 tonnes per cubic metre	Less dense than seawater (s.g. 1.027 and readily floats
Wax content	Very high wax content of 42.3 % measured by gravimetric analysis	The crude is solid at ambient temperature and resists physical breakup into smaller particles
Pour point	Oil remains solid until heated to 36 °C	The crude is solid at ambient temperature and on the sea surface and does not spread once cooled. It must be heated to >36°C to flow under the action of gravity. At higher pressures it can be pumped at lower temperatures e.g. 25°C for oil recovery.
Physical state when in contact with water / ambient air temperature	Immediately solidified in contact with water at Falklands seawater temperature	As above. Individual oil masses do not tend to coagulate together once cooled.
Evaporation	True Boiling Point data indicates that at 140 °C up to 2.8 % volume of the crude evaporates (this is extrapolated to the fraction lost over a weathering period of approximately 0.5 – 1 day in reality). The maximum evaporation was found to be 11.7 % volume, which represents evaporation over 3-7 days weathering in reality	In the event of a spill, very little will evaporate so the mass of oil spilled will not reduce greatly as the crude weathers at sea. The density of the oil will increase slightly by evaporation, but not enough to sink in seawater.
Dispersion	In a test environment, the oil was released in simulated open sea conditions: • Approximated to Beaufort sea state 3 (corresponding parameters in the 'polludrome' (test environment) were wave height 20cm, mean period 3s, current speed 40cm/s, wind 5m/s, volume of seawater 7 m^3); • Sea temperature 8 °C; • Solar energy was created using UV light; and • Water continuously circulated for 7 days. No dispersion of the oil into the water column or significant breakup of the oil masses was recorded. The test environment energy was then increased to breaking wave conditions for 3 days, and no difference in the oil behaviour was observed.	Masses of oil from an oil spill would not break up after weathering at sea but remain in discrete clumps
Response to chemical dispersion	The oil does not respond to chemical dispersants. Dispersants did not penetrate the surface of cooled oil.	Chemical dispersants will not be effective on spilled Sea Lion crude oil and are not recommended

Aspect	Test results	Implication for risk assessment and / or spill response
Biodegradation	The high alkane content of the oil means it will biodegrade but due to the high wax content this is expected to take some time	If not recovered, the oil would remain in the environment as solid components (for at least seven days) until eventually breaking up and biodegrading
Interaction with suspended solids	Tests at 5 and 100 parts per million (ppm) showed that after 5 days there was no interaction between the oil and the suspended solids at 5 ppm, and some particles were adsorbed onto the surface of the oil at 100 ppm but the oil remained floating	This indicates that at low concentrations such as at sea, the oil is unlikely to interact with suspended solids and fall into the water column. At much higher concentrations there will be some interaction, and over long periods of exposure to suspended solids e.g. near beaches, the oil may eventually sink to the seabed
Adhesion to feathers	Adhesion of oil to feathers was tested for nine species found around the Falklands: black-browed albatross, sooty shearwater, thin-billed prion, Antarctic fulmar, Wilson's storm-petrel, South American tern, imperial shag, king penguin and gentoo penguin. For each species, the adhesion of oil to feathers was assessed in respect of two oil spill scenarios and one produced water discharge scenario: *Spill scenario* • Feathers were dipped into a concentration of 100g/m^2 oil in sea water: – No oil was adsorbed by feathers; and – No structural damage was observed. • At a concentration of 1 kg/m^2: – All feathers were stained by the oil and two species (thin-billed prion and imperial shag) had microparticles stick to them; and – No structural damage was observed. *Produced water scenario* • At a concentration of dispersed oil at 10 mg/l with oil droplets of ~100 microns: – Oil particles were observed on all feathers; – All species adsorbed similar amounts of oil; and – No structural damage was observed.	In the event of a spill, the concentration of oil will affect the amount of oil adsorbed by birds' feathers. At concentrations of 1kg/m^2 all species tested were stained but thin-billed prion and imperial shag feathers showed a greater degree of oil adhesion, suggesting these species may be more susceptible once exposed Emulation of produced water discharge caused adhesion of oil particles to all species of feathers tested In all scenarios tested no structural damage to the feathers was observed although the barbules (the 'feathery' linkages in between the feather structure) were dis-arranged The above tests were also completed for an alternative crude oil with a lower pour point and indicated a much higher adhesion of oil to the feathers.
Pelt and fur adhesion	Tests are planned for pelt and fur adhesion	TBC

Aspect	Test results	Implication for risk assessment and / or spill response
Sheen formation and visibility	Hot oil (55°C) released into 18°C calm seawater resulted in a slight sheen being observed by the naked eye for approximately ten minutes. The oil could be perceived by an Infrared camera even when cooled, though sheens were not easily identifiable with the camera and could only be seen in the early stages of the spill. Testing of the water around the spill resulted in no difference between background samples. Total hydrocarbons being quantified in only one background sample, while it was less than 0.1 mg/L in all the samples located near the oil patches.	Sheen formation is very limited around a spill of Sea Lion crude and would only be visible in very calm conditions. It is possible that the temperature of the seawater during the test (18°C as compared to a typical 8°C in the Falklands) could have influenced the creation of a sheen. Calm conditions at the Sea Lion field are anticipated to occur <3 % of the time and in wave conditions sheens will be dispersed.
Emulsification	See above test conditions for 'Dispersion'. Around 5 % emulsification was observed, although in the form of water trapped in solid oil rather than a true emulsion.	During release, and to some extent during dispersion, the volume of oil is likely to increase by around 5 % due to water trapped in the oil. This is a relatively lower value – many oils emulsify to a much larger extent, significantly increasing their volume in the marine environment (up to 5x)
Dissolved fractions in the water column	See above test conditions for 'Dispersion'. No PAH dissolved into the water column after seven days of monitoring	Water column impacts are more likely to arise from ingestion of oil rather than contamination of the water column from any dissolved components of the oil. Low risk to shellfish which tend to accumulate PAH.
Ecotoxicity (diatoms)	Tests on the marine algae *Skeletonema costatum* were carried out for 72 hours to determine the concentration which results in 50 % inhibition of growth rate. Diatom growth was not affected by Sea Lion crude	Sea Lion crude is unlikely to impact upon phytoplankton
Ecotoxicity (copepods)	Tests on the copepod *Arcatia tonsa* were carried out for 48 hours to determine the lethal toxicity of the crude to copepods. 20.7g/l of Sea Lion crude in seawater is the concentration at which 50 % of test organisms died when compared to a control. This is expressed as 'LC_{50} 48 hours > 20.7g/l'	This indicates that Sea Lion crude may impact upon zooplankton in the water column in the event of a spill, dependent on the concentration of oil
Ecotoxicity (amphipods)	Tests on the amphipod *Corophium sp* were carried out for 10 days to determine the lethal toxicity of the crude to amphipods. 392 mg/kg of oil in sediments is the concentration at which 50 % of the test organisms died when compared to a control. This is expressed as 'LC_{50} 10 days >392 mg/kg'	This indicates that Sea Lion crude may impact upon benthic assemblages in the event of a spill, but at a relatively high concentration of oil in the sediments. Amphipods are recognised as good indicators of oil pollution.
Ecotoxicity (fish eggs)	Tests on embryonic zebra fish (*Danio rerio*) were carried out for 96 hours to determine the lethal toxicity of the crude to fish eggs. At all concentrations tested no	This indicates that Sea Lion crude is unlikely to impact fish eggs in the event of a spill

Aspect	Test results	Implication for risk assessment and / or spill response
	toxic effects were observed on the fish eggs when compared to a control. Slight subacute toxicity (<3 %) was noted.	
Adhesion to seaweed	Three types of seaweed were tested for oil adhesion: sea lettuce (*Ulva*), *Laminaria* and *Fucus.* Adhesion to the three seaweeds was tested with hot oil to emulate a spill of crude directly onto the beach at low tide, though it should be noted that this scenario is very unrealistic as any spills at sea would mean the oil solidifies before reaching the shore, even in the case of a tanker grounding, the vessel would ground a distance from the shore due to its hull depth. Oil that had solidified and cooled having been spilled to sea (to emulate a spill which had drifted onto the beach at high tide) was also tested. Adhesion to the seaweed at low tide can be substantial but at high tide interaction was very limited. At high hide, the oil remained on the surface of the water and did not stick to the seaweed. For cold oil, adhesion to sea lettuce and *Laminaria* was strong but less so with *Fucus*. Hot oil directly applied to the seaweed adhered well to sea lettuce and *Fucus* but not as much to *Laminaria*, with the roughness of the seaweed being important in the amount of oil adhesion.	Spills that are direct to the beach, and with the oil still hot would mean substantial adhesion to seaweed; however, this scenario is very unrealistic. Spills to water, which then drift onto the beach are unlikely to adhere to the seaweed if they reach the shore at high tide or if they reach seaweed that is permanently immersed in sea water. If cold oil reaches shallow water at the shore at low tide (i.e. where waves are mixing oil and seaweed on a beach) it may strongly adhere to exposed sea lettuce and *Laminaria*. Roughness of the seaweed plays a role in the adhesion of the oil.
Adhesion to shoreline	Tests were carried out to assess the oil adhesion to different substrates;. When the crude was spilled at high tide (i.e. to water), the oil solidified on contact with the water and no contact occurred between the oil and sediments. After two tidal cycles, no adhesion was observed and the oil stays on the water's surface. When the crude was spilled at low tide (i.e. directly onto the substrate which, as noted above is very unrealistic) the oil stayed stuck to the rocky and cobbled shores and was laid on the sandy sediment. After three hours, the oil lifted off the sandy sediments but stayed stuck to the rocky and cobbled shores. After one week a small amount of oil resurfaced from the rocky sediment but the majority of oil stayed stuck. After one week the majority of oil resurfaced from the cobbled sediment but a small portion remained stuck. After one week no adhesion was observed to the sandy sediment and all oil remained on the surface of the water. A sample of the oil face in contact with	If a spill occurs at high tide (i.e. to water) the oil will stay on the surface of the water and little adhesion to the shoreline should occur. If a spill occurs at low tide, directly onto the coast (as noted above an unrealistic scenario), adhesion is likely in rocky and cobbled areas but for sandy sediment, adhesion should be limited and the oil easily removed. It should be noted here that in the case of Berkeley Sound, the tidal range is relatively small.

Aspect	Test results	Implication for risk assessment and / or spill response
	sediment was also taken and it was identified that sediment had penetrated the surface; a 5g sample showed 31% of the sample by weight was sediment.	
Removal of oil from rocky shores	Hot oil was spread onto standardised granite tiles manually and allowed to cool. Pressure washing was carried out at 15 °C, 50 °C and 50 bar and 100 bar pressures. Pressure did not seem to play an important role for any of the oils but hot water was much more efficient. Cleaning efficiency seemed to be slightly better for the Sea Lion crude oil than heavy fuel oil.	If spilled directly on rocks (very unlikely), the Sea Lion crude oil could be efficiently treated by using a high pressure water washer by using hot water (50°C). It should be noted that, in real conditions, rocks are not totally cleaned and an oil film will remain, to be weathered over time.

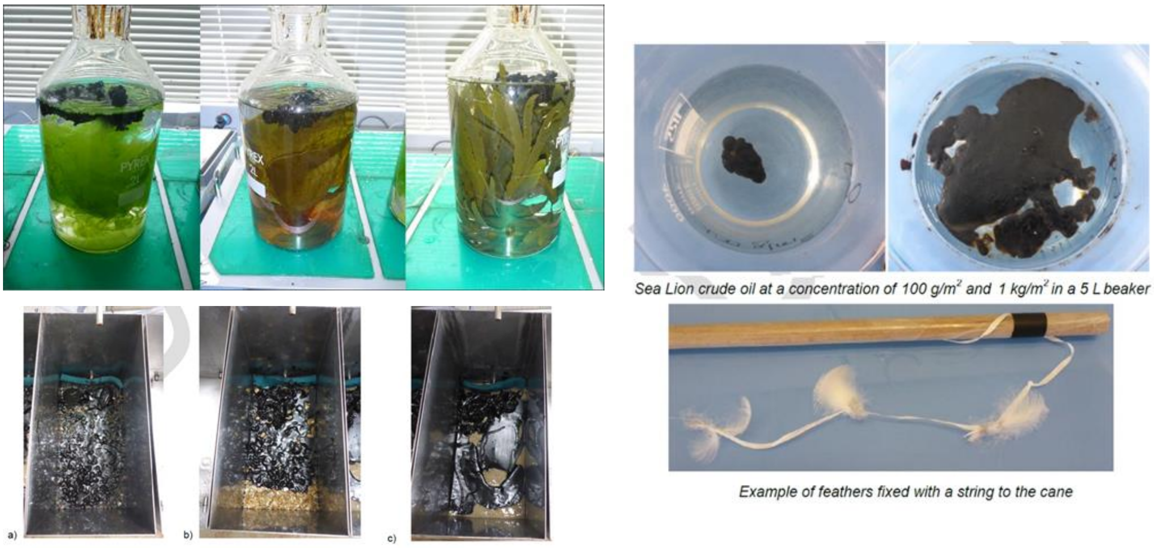


Figure 12.1: Examples of testing images from tests on seaweed, shoreline and feathers (CEDRE, 2017)

12.1.4.1.1.2 Diesel

Diesel and other fuel oils, contain a much higher proportion of light volatile hydrocarbons, and therefore evaporate and dissolve more readily than heavier crude oils. The proportions of each compound can vary in different diesel sources and each compound has a different level of toxicity on marine organisms. Marine diesel is often a heavier intermediate fuel oil that will persist longer when spilled. When spilled on water, diesel oil spreads very quickly to a thin film of rainbow and silver sheens, except for marine diesel, which may form a thicker film of dull or dark colors.

Diesel oil is less dense than water and therefore it is not possible for diesel to sink and accumulate on the seafloor as pooled or free oil unless adsorption occurs with sediment. However, it is possible for the diesel oil that is dispersed by wave action to form droplets that are small enough be kept in suspension and moved by the currents. When diesel dispersed in the water column does adhere to fine-grained suspended particles, these can settle out and reach the seafloor, although this is less likely to occur in open marine settings.

In terms of toxicity to water-column organisms, diesel is considered to be one of the most acutely toxic oil types. Diesel fuels contain volatile aromatic compounds, some of which, including alkylbenzenes, toluene, naphthalenes, and PAH, are known to have acute toxic effects on marine life in the water column. Given its volatile nature however, diesel breaks down more rapidly than crude oil and generally poses shorter exposure risk to environmental receptors. Nonetheless, potential impacts on vertebrates include damage to the liver, kidneys, heart, lungs, and the nervous system. Increased rates of cancer, immunological, reproductive, fetotoxic, genotoxic effects have been associated with diesel contamination (Irwin *et al.,* 1997). PAHs are relatively long-lived in the environment and bioaccumulate in the fatty tissues of animals, resulting in vital organ malfunction (particularly the liver and kidney).

12.1.4.1.1.3 Oil Based Mud

The most likely place for a failure of the riser, which could lead to a loss of Oil Based Mud (OBM) and any associated cuttings in circulation, is at the base of the riser at the lower marine riser package as this section experiences the most stress from the rig moving above and loading from currents. If disconnection happens whilst drilling with OBM, the mud will flow out over the seabed around the well and in a relatively cohesive mixture (a result of the mud being specifically designed to prevent separation of oil, water and solids). The OBM is quite dense and would disperse very little into the water column.

The area directly covered by the OBM will be impacted as the mud itself would be very toxic to local sediments and benthic communities. There is also likely to be an element of smothering, although less so than with cuttings piles as the OBM liquid is assumed to settle out to ~1cm thickness. The OBM would biodegrade over time and release particles into the water column but this will be a slow steady process. The components of OBM are somewhat biodegradable and have to pass CEFAS tests so it would be reasonable to expect the area would recover after a number of years. Deposits of OBM and associated cuttings are well studied in the North Sea. Breuer *et al.* (1999) noted that 8 years after OBM cuttings piles were deposited, biological effects were still noticeable. Change of benthic habitat has also been seen on and around OBM cuttings piles near historic North Sea wells over a period of years (Olsgard and Gray, 1995).

12.1.4.1.2 Fate of oil in the marine environment

As oil is released into the sea it undergoes a number of physical and chemical changes (Figure 12.2). These changes are dependent on the type and quantities of oil spilled and the meteorological and oceanic conditions to which the oil is exposed over time. Detail on the processes which influence the behaviour and fate of oil at sea following a spill are described in Table 12.2.

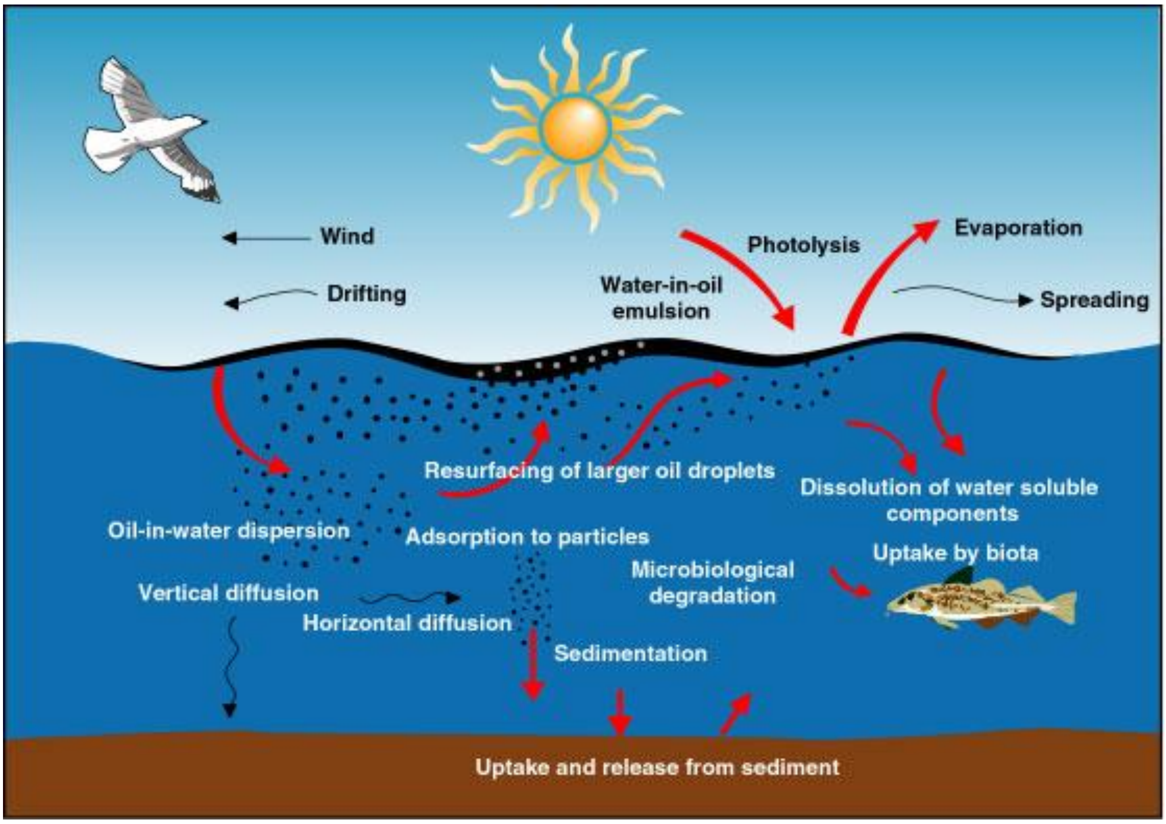


Figure 12.2: Behaviour and fate of oil in the marine environment (after Andreassen and Sørheim, 2013)

Table 12.2: Fate of oil in the marine environment

Oil behaviour	Description
Spreading and advection	When spilled at the surface, oil spreads out on the surface of the water. This increases the surface area of the oil, but reduces the thickness. Sea Lion crude is unlikely to spread out thinly as a 'normal' oil. From behaviour observed during testing of the crude, a 'terminal film thickness' of between 1 and 5 mm has been assumed, dependent on the type of spill (see section 12.1.4.1.1.1).
Evaporation	Evaporation is the main mechanism by which the mass of oil is reduced immediately after a spill and is enhanced by warm air temperatures and moderate winds. It also causes considerable changes in the density, viscosity and volume of the spill over time. The light fractions of the oil (aromatic compounds such as benzene and toluene) evaporate quickly. As noted above (section 12.1.4.1.1.1), a large percentage of Sea Lion crude is not expected to evaporate (CEDRE, 2017).
Dissolution	Some of the lighter components of the oil will go into solution in the surrounding water; however, this only accounts for a very small proportion of the overall spill. As noted above (section 12.1.4.1.1.1), in the CEDRE tests no PAH were observed dissolving into the water column from Sea Lion crude after 7 days (CEDRE, 2017).
Natural dispersion	Once the lighter fractions have evaporated from the oil spill the evaporation process slows down and natural dispersion becomes the dominant mechanism in reducing slick volume. Dependent upon sea surface turbulence, and therefore weather conditions, oil breaks up into droplets in the water beneath the slick and disperses in the water column. As noted above (section 12.1.4.1.1.1), Sea Lion crude is not expected to naturally disperse to any great extent (CEDRE, 2017).
Emulsification	Oil and water combine to form a mousse. The tendency to emulsify depends on the asphaltene content of the oil. Sea Lion crude is likely to absorb around 5% water, see section 12.1.4.1.1.1 (CEDRE, 2017).

Oil behaviour	Description
Photo-oxidation	Sunlight transforms some oil components into new by-products, which may be more toxic and water-soluble than the original components.
Sedimentation	Oil adheres to particles in the water column and sinks to settle in the sediment. Once in the sediment, further degradation slows. As noted above (section 12.1.4.1.1.1), Sea Lion crude is unlikely to interact with particles at sea, but may interact with particles in the water column at concentrations of around 100 ppm e.g. at beaches, and increase in density over a period of days and weeks (CEDRE, 2017).
Stranding	Oil that reaches the shore-line is said to have stranded.
Biodegradation	Biodegradation can occur at the surface, in the water column and within sediments. Oil is slowly broken down by resident bacteria, and other microbes, into water and carbon dioxide. The microbes concerned rapidly multiply in the presence of excess food and produce by-products that can themselves be toxic to other marine organisms. Sea Lion crude is expected to biodegrade eventually but it is thought this will take a long time, see section 12.1.4.1.1.1 (CEDRE, 2017).

12.1.4.2 Nature of the impacts

The impacts of oil spills on marine organisms are well documented and have been the focus of numerous studies, and extensive review (e.g. Moore and Dwyer, 1974; Burger, 1993; Gubbay and Earll, 2000; Kingston, 2002).

There are four main routes of oil contamination. These include:

- Direct contact;
- Ingestion:
- Inhalation; and
- Absorption through skin or respiratory membranes.

The extent of oil spill impacts will be influenced by the environmental conditions and the spreading and dispersion of oil experienced in the period following any spill. Further, the size of a spill is not necessarily the most important factor influencing the extent of impacts on environmental receptors. Small spills can impact disproportionately large numbers of individual receptors if they are present in the affected area at the time. The nature and significance of impacts at a population-level will differ across the range of environmental receptors, and will depend on the type of oil (section 12.1.4.1.1) and the distribution, density, ecological and life-history attributes and the behaviour of each of the receptors at the time of a spill.

12.1.4.2.1 Plankton

Plankton plays a critical role in marine food web dynamics, biogeochemical cycling and fisheries recruitment. Despite their importance in the marine environment our knowledge of the interactions between plankton and anthropogenic pollutants is limited.

Although it is known that low concentrations of hydrocarbons (<0.05 mg/l) may stimulate phytoplankton growth (for some species), higher concentrations are likely to inhibit growth or kill phytoplankton (Boyd *et al.,* 2001). Given that phytoplankton form the base of the food chain, bioaccumulation of hydrocarbons through the planktonic food web would increase exposure of higher trophic-level organisms (Meador, 2003), and lethal contamination could change the distribution and reduce the abundance of plankton communities, and hence the availability of food sources up the food chain.

The oceanography and topography of the southern Patagonian Shelf creates an area of very high zooplankton productivity immediately to the north of the Islands (section 7.4.1). While the distribution and abundance of plankton in the waters of the Falkland Islands varies on a seasonal basis, it is expected that any effects will be greatest during summer when the area of the shelf-break to the south of the Sea Lion Field supports higher densities of plankton. *Themisto gaudichaudii* provides an important ecological link between small zooplankton and top consumers around the Falkland Islands. *Themisto gaudichaudii* is a voracious predator of anything smaller than itself, and occasionally of animals its own size or larger with adults preferentially consuming prey in the size range 1 to 4 mm (Pakhomov and Perissinotto, 1996). Other important plankton species in the Faklands include species in the order Euphausiacea (e.g. *Euphauis lucens*, *E. vallentini* and *Thysanosessa gregaria*) and lobster-krill (*Munida gregaria*) (Agnew, 2002).

Further, eggs and larvae in the zooplankton appear seasonally and many have been shown to be vulnerable to oil during laboratory experiments (Almeda *et al.,* 2013) as they can ingest oil droplets directly (Lee *et al*., 2012; Almeda *et al*., 2014). Testing of the Sea Lion crude (section 12.1.4.1.1.1) on zooplankton (*Arcatia tonsa*) and phytoplankton (*Skeletonema costatum*) indicates that the crude is unlikely to impact upon the phytoplankton species tested but that concentrations of around 20.7 g/l will have lethal effects on up to 50% of zooplankton organisms tested after 48 hours of exposure (CEDRE, 2017).

There are three main types of interactions between zooplankton and pollutants.

- Pollutants can have direct toxic effects on zooplankton, which may have lethal or sub-lethal consequences (Walsh, 1978).
- Zooplankton may influence the physicochemical characteristics of the pollutants in the water column by absorption, transformation and elimination (Walsh, 1978; Fisk *et al.,* 2001; Muschenheim and Lee, 2002).
- Zooplankton may play an important role in the bioaccumulation of pollutants in food chains and webs. Therefore, understanding the interactions between pollutants and zooplankton is crucial to understand the fate of pollution in the pelagic zone and its impacts on marine environments.

Further, in all of the potential impacts described, there is increasing evidence that sunlight, mainly ultraviolet radiation (UVR), can increase the toxicity of petroleum hydrocarbons to marine organisms (e.g. Alloy *et al*., 2016, Almeda *et al*., 2016).

12.1.4.2.2 Benthic communities

Contamination of the benthos in a low energy environment may have long-lasting impacts, as physical breakdown and biodegradation are reduced. Invertebrates vary greatly in their sensitivity to oil contamination but it is known that many are unable to metabolise petroleum (NOAA, 1994) and may therefore accumulate toxins in their bodies. Among the invertebrates, corals are known to be one of the most sensitive groups. Similarly, shellfish may accumulate oil residues with attendant secondary effects, particularly relating to health (OSPAR, 2009a).

Infaunal organisms (i.e. those actually living within sediments) are particularly susceptible to oiling whereas some barnacles and limpets may withstand a degree of oiling. The sub-lethal effects of contamination on the above may include growth reduction, feeding impairment, and behavioural changes. For vertebrates that might be in physical contact with hydrocarbons on the seabed, such as skates, the impacts are generally sub-lethal, including changes in feeding, growth, development, and recruitment (Boyd *et al.,* 2001). Tests of Sea Lion crude on benthic organisms (*Corophium* sp.) indicated that at concentrations of >392 mg/kg oil in the sediment, the oil is lethal to 50% of organisms tested after 10 days (CEDRE, 2017).

To date, surveys in the Sea Lion Field have indicated that the benthic environment is fairly uniform, in terms of habitat classification (section 7.4.3.2). The results of the latest surveys, in the Isobel / Elaine area approximately 40 km south of the Phase 1 Development, indicate that there are some very localised differences in the habitats and species encountered in the North Falkland Basin (NFB), which are largely due to the presence of erratic rocks that provide habitat for corals and other encrusting organisms (section 7.4.3.2).

12.1.4.2.3 Fish and squid

Impacts on fish and squid from oil spills may include:

- Displacement of adults from feeding grounds; and
- Contamination of adult fish, eggs, larvae and juvenile stages.

12.1.4.2.3.1 Displacement from feeding grounds

Typically, adult fish are not considered highly sensitive to impacts of oil spills. Adult fish are mobile and are able to detect areas of heavy contamination or poor water quality and avoid them, particularly in the open ocean. However, such avoidance behaviour may serve to displace them from important feeding areas. The Phase 1 Development is situated within the Falkland Islands Northern Slope (NS) habitat zone which has been identified as an important feeding area for a number of fish species, whose abundance varies with season (section 7.4.4.2.2). As spills could occur at any time throughout the operations they could coincide with recorded high abundances of numerous fish species (section 7.4.4.2.2).

Cephalopods are sensitive to environmental conditions, which can affect their abundance and distribution widely (Pierce *et al.,* 2008; Arkhipkin *et al.,* 2004a). In addition to the importance of squid in commercial fisheries and as prey and predators in the marine environment, they have the potential to act as bioindicator species in environmental monitoring studies. Squid exhibit high growth rates and short life spans and therefore the accumulation of pollutants in their tissues reflect the bioavailability in the immediate environment over a relatively short time period. However, the mobile nature of some species may limit their potential as bioindicators.

12.1.4.2.3.2 Contamination of adult fish and squid, eggs, larvae and juvenile stages

Adverse impacts of oil spills on adult fish are most likely to be observed in the shallow coastal areas of the sea where oil could accumulate and the potential to 'escape' is limited by the land and / or the species' habitat requirements. Fish eggs and larvae are considered to be more susceptible to the toxic effects of oil than adults, due to their reduced ability to avoid contaminated water. However, testing the impact of Sea Lion crude on zebra fish (*Danio rerio*) eggs found that the crude is unlikely to impact these fish eggs in the event of a spill (CEDRE, 2017).

If contaminated, adult fish are able to metabolise small quantities of hydrocarbons, although the toxic effects of the ingested oil may lead to organ damage (OSPAR, 2009a). In particular, fish are susceptible to the water-soluble fractions of oil, such as benzene, toluene ethylbenzene and xylenes (BTEX), which have been shown to cause cardio-edema in larval fish (Incardona *et al.,* 2013). Other toxic components in crude oil such as the PAHs can be mutagenic and carcinogenic in fish. Testing of the Sea Lion crude has shown that PAHs were not observed dissolving into the water column during the seven days of monitoring following the simulated spill, so are unlikely to be present in high concentrations after a spill to sea (CEDRE, 2017). Although squid are unable to metabolise oils, there is little evidence of direct mortality of adult squid following contamination.

Cephalopods have received some attention on account of their capacity to accumulate contaminants and the resultant implications for human health (Gomes *et al.,* 2013; Morais *et al.,* 2013; see section 12.1.4.2.4). In particular, PAHs are of note due to the potential cytotoxic, mutagenic and carcinogenic properties of these chemicals.

Although these components may not be present initially after a spill (CEDRE, 2017), they could dissolve into the water column later if all oil is not recovered. PAHs can be absorbed into the water column from waterborne compounds and contaminated sediments but predominantly via the food chain. In marine food chains, molluscs (including squid) have the poorest capacity to metabolise PAHs, crustaceans are intermediate with fish displaying the best capacity (Gomes *et al.,* 2013). The natural content of PAHs in fish tissues is lower than that in squid because fish are able to oxidise and further metabolise PAHs to water soluble compounds, which can be excreted via gall or urine. In squid, the highest concentrations of PAHs are found in the digestive glands but these compounds are found in all tissues.

The Northern Slope is used by many species of ecological importance, such as *Onykia ingens* squid, myctophids and Falkland sprat (*Sprattus fuegensis*). These species are important food sources for predatory fish, seabirds and marine mammals. Grenadiers also occur in this area, particularly *Macrourus carinatus* and *Coelorinchus fasciatus,* the former of which is considered a potential fisheries resource for the Falkland Islands (Payá, 2009). Other species are resident species within the Phase 1 zone of influence although, many of these, such as skate and eelpout, do not have planktonic egg or larval stages.

12.1.4.2.4 Fisheries (Human population)

12.1.4.2.4.1 Spawning aggregations

Knowledge of the timing and distribution of spawning aggregations and egg and larval transport via oceanographic features is critical to understanding the potential impact of oil spills on fisheries in the Falkland Islands. While the understanding and knowledge of spawning grounds in the Falkland Islands is poor, many of the commercially fished species exploit Falklands waters for feeding rather than spawning (Arkhipkin *et al.,* 2012b). Nonetheless, the following spawning sites have been identified:

- Loligo squid spawn in inshore waters around the Islands (especially the east coast);
- Southern blue whiting and red cod spawning sites south of Cape Meredith (Arkhipkin *et al.,* 2010; Brickle *et al.,* 2011); and
- Toothfish spawning on the southern and eastern parts of the Burdwood Bank (Laptikhovsky *et al.,* 2006).

While the Development is therefore not located in areas that are known to be significant for spawning for commercial species, it is located in the broader area of the Northern Slope which is an important feeding area for numerous commercially important species (section 7.4.4.2.2). Moreover, oil released into the marine environment would disperse and may overlap with the distribution of major finfish and *Illex* squid fishing grounds on the edge of the continental shelf.

12.1.4.2.4.2 Tainting and contamination of fish and squid

The marine environment is contaminated with anthropogenic and natural sources of hydrocarbons. The main anthropogenic inputs include; direct spills of petroleum products and atmospheric deposition from combustion. Natural sources include atmospheric deposition from forest fires and volcanic eruptions. Oil pollutants have greater impacts in enclosed and semi-enclosed marine environments than the open sea. In coastal waters, PAHs are concentrated in marine sediments where squid and other molluscs are particularly subject to exposure, and PAHs can be persistent in marine sediments or in the tissues of some animals. However, as noted above, the CEDRE analysis of the Sea Lion crude indicates that PAHs did not dissolve into the water column during the seven day monitoring period. PAHs could potentially dissolve into the water column over longer periods of time, but the intrinsic levels of PAH in the crude are still relatively low (0.15% versus 0.3-0.5% for many crudes).

Pelagic fish that swim with their mouths open to maintain a continuous current of water across their gills (e.g., scombrid fish; Klinger *et al*., 2015) could experience increased oil exposure from suspended or sinking waxy crude (Drewery and Wolfaardt, 2017). Ingestion of hydrocarbons by fish can lead to tainting of the flesh. The degree of tainting depends on the type of oil, the species concerned and the exposure time but can persist even after the source of the contamination is removed. Unlike vertebrates, invertebrates, such as shellfish or squid, are less able to metabolise hydrocarbons and therefore tainting can persist for longer periods. In finfish, which have the enzyme systems necessary to metabolise petroleum (NOAA, 1994); tainting is not believed to persist for more than a few days following exposure (Boyd *et al.,* 2001). Even if tainting does not persist within finfish, the public perception of tainting may last longer and this may have implications for commercial fisheries. Moreover, concentrations that do not lead to tainting may still affect the physiology of the fish.

The accumulation of hydrocarbons in squid tissue has implications for tainting and human health. In recognition of the risk of potential contamination of the human food chain, the European Union established a maximum level of 5.0 µg / kg wet weight for benzo(a)pyrene (the marker used for PAHs carcinogenic risks) in cephalopods. Some studies have been carried out to look at the background level of contamination in several cephalopod fisheries around the world (Gomes *et al.,* 2013; Morais *et al.,* 2013), which found relatively high background levels in Loligo squid from the South Atlantic. Consequently, should a significant oil spill overlap with squid fisheries, this would pose a risk to human health. The impact may also be cycled through the food chain due to squid's pivotal role as a consumer and prey species. The persistence of these chemicals, which can be subject to long-range transport impacting areas a considerable distance from the point of discharge, may lead to long-lasting impacts to the fishing industry, including fishery closures and reduced confidence from consumers.

Although there is little direct fishing effort in the immediate vicinity of the Sea Lion Field (section 7.7.3.1.1.1), the Field sits between two major fishing areas. Deeper waters to the north and northeast are subject to a longline fishing for Patagonian toothfish. Waters on the edge of the Continental Shelf to the south and southwest of the Development are targeted by finfish trawlers. The catch of these vessels is mixed but comprises predominantly Patagonian rock cod, hake, hoki and skate (section 7.7.3.1.1.1). However, the commercially targeted Argentine shortfin squid migrates into deeper water in May and June, to access the Falkland Islands current to aid passage to their northerly spawning migrations (Arkhipkin *et al.,* 2015), and a significant proportion of the South Patagonian Stock passes through the Northern Slope.

12.1.4.2.5 Seabirds

Seabirds are particularly susceptible to oil floating on the surface of the sea and millions of seabirds have been killed globally by oil pollution (e.g. Goldsworthy *et al.,* 2000; García Borboroglu *et al.,* 2006 and 2010; Wolfaardt *et al.,* 2009). Seabirds tend to be the most conspicuous group affected during oil spill events. When considering the impacts of oil spills on seabird populations, the volume of oil released is not necessarily the most important factor (Hunt, 1987; Tasker and Pienkowski, 1987; Burger, 1993), but rather the location of the spill relative to concentrations of vulnerable seabirds. A relatively small spill in close proximity to large numbers of vulnerable seabirds will likely have a much more severe impact than a larger spill in an area with few seabirds. Indeed, tens of thousands of birds can be killed by a relatively minor spill (e.g. Barrett, 1979). Equally, chronic oil pollution from operational discharges (section 10.7) and small spills may have severe long-term effects on seabird populations (e.g. García Borboroglu *et al.,* 2006). About half of the input of oil into the marine environment is due to chronic oil pollution (GESAMP, 2007), highlighting its potential to impact seabirds.

The effects of oil on birds include both immediate impacts on survival, and longer-term sub-lethal impacts that could affect individual birds and populations over many years (e.g. Camphuysen *et al.,* 2005; Perez *et al*. 2009).

Impacts of large oil spills and / or small-scale unplanned but chronic releases include:

- Direct contamination and fouled plumage;
- Ingestion:
  - Direct ingestion e.g. from preening contaminated feathers; and / or
  - Indirect ingestion e.g. from consuming contaminated prey (Committee on Oil in the Sea, 2003).

The consequences of the above also depend upon the vulnerability of bird species, their behaviour and the feasibility of post-contamination treatment.

12.1.4.2.5.1 Direct contamination

Fouled plumage is recognised as the primary cause of mortality and stress in oiled birds (NRC, 1985; Leighton, 1991). Direct contact between seabirds and oil can contaminate feathers such that the barbules become bound together by oil which leads to a loss of feather condition and function. Plumage is essential for flight, heat insulation and waterproofing, and even small effects on any of these functions can compromise survival. Waterlogging and loss of buoyancy in oiled birds further exacerbate oil impacts and can rapidly lead to drowning. Additionally, oil can also directly affect reproductive success as eggs contaminated with oil from fouled feathers can have lethal effects on the embryo (Rocke, 1999).

Along with environmental factors; such as sea state, the chemical and physical properties of the specific type of oil discharged will influence how the oil behaves in the environment and the effects it is likely to have on seabirds (section 12.1.4.1). Testing of Sea Lion crude oil adhesion to feathers showed that adhesion was determined by the concentration of oil, with no oil adsorbed by feathers dipped into a concentration of 100g/m^2 but staining and microparticles were observed at a concentration of 1kg/m^2 (CEDRE, 2017). No structural damage was observed to any feathers tested, although the barbules were noted as ‘messy’ (CEDRE, 2017).

Most of our knowledge of how oil spills contaminate seabirds is based on experiences with fluid oils that form slicks or sheens (O’Hara and Morandin, 2010). Observations from such incidents are not directly applicable to the current assessment however, because they do not reflect the waxy oil type found in the Sea Lion Field and initial testing indicates that the highly waxy crude may pose less of a risk to seabirds in respect of feather contamination when compared to other crude oils tested in the same way (CEDRE, 2017).

With regard to the far lighter diesel oils, seabirds can be oiled by direct contact although the higher volatility of diesel means that the oil remains on the surface for a relatively short time, which may influence the number of birds affected. However, as described by O’Hara and Morandin (2010), the potential for these impacts to occur largely depends upon the degree of oil fouling, which is affected by the:

- Thickness of the sheen and the area of sheen that comes into contact with the bird;
- Oil type;
- Patchiness of the oil;
- Movement patterns of the bird at the sea surface; and
- Preening capacity.

While there are limited data on the thickness of sheen required to affect the microstructure of feathers in practise, it is believed that small quantities of oil contamination could have lethal consequences (O’Hara and Morandin, 2010). Laboratory based experiments determined that exposure to oil sheens at a thickness of only 0.1 µm could result in measurable oil transfer to feathers and thus impact upon their microstructure. Further, it was concluded that lethal consequences could result from a bird being exposed to as little as 10 ml of oil (O’Hara and Morandin, 2010). In order to become contaminated with 10 ml of oil, it is estimated by O’Hara and Morandin (2010) that a bird would have to swim through approximately 100 m^2 of a sheen of 0.1 µm thickness. Although hypothermia due to matted feathers does occur, the toxicity of diesel means that mortality is most commonly caused by ingestion during preening (NOAA, 2014).

Although the oil in water (OiW) concentrations of operational discharges are tightly controlled by legislation, chronic oil pollution, in the form of rainbow effects, and blue / silver / gray discoloration (Fraser *et al.,* 2006), may occur even at OiW concentrations of 25 mg/l when discharged on calm days (Wills, 2000). Potential sources of chronic oil pollution from legally compliant operational discharges e.g. produced water, are assessed in section 10.7 while the contribution of small accidental spills are assessed here.

Once attached, oil of either form can be ingested, either directly, or through preening, leading to a number of toxic effects that compromise the health of the animal, and may eventually lead to its death.

12.1.4.2.5.2 Ingestion

It is likely that seabirds may ingest floating waxy oil masses (pellets), in much the same way that they ingest floating particles of plastic (BirdLife International, 2008). Whereas penguins and other seabirds that spend a lot of their time at the surface and dive to obtain their prey are particularly vulnerable to plumage contamination and ingestion of the oil, surface foraging Procellariiformes (albatrosses and petrels) would be particularly susceptible to ingesting the floating wax pellets, especially as many of the birds in this group habitually congregate around offshore vessels / structures. This stems from their scavenging nature, which also predisposes them to misdirected foraging - ingesting the wax pellets which they mistake for food. The wax pellets may also be ingested incidentally with prey in the same way fur seals ingest plastic incidentally via myctophid fish (de Bruyn & Bester, 2016). Smaller petrels, such as prions and storm-petrels, filter feed or pick at planktonic organisms. These birds will all be vulnerable to ingesting oil masses of differing sizes and therefore the range of species potentially impacted will change as the oil masses break down and spread.

Although the issue of ingesting plastic and other debris, such as tar balls, is known to occur amongst a wide range of seabird species, there has been limited research to quantify the impacts of such ingestion (BirdLife International, 2008). The ingestion (through preening, consumption of contaminated prey and of oil) or inhalation of hydrocarbons has been documented, mostly through experimental studies, to cause a number of lethal and sub-lethal toxicological effects on seabirds. These include:

- Gastrointestinal irritation;
- Pulmonary congestion;
- Adrenocortical hyperplasia;
- Fluid and electrolyte loss;
- Detrimental effects on salt glands and osmoregulation; and
- Fatty liver and mutagenic (cancer causing) effects.

Further, the absorption of toxic components from the oil can lead to damage of the liver, pancreas and kidneys, amongst other organs. Where sub-lethal, these impacts may reduce reproductive rates, leave the animal open to secondary infection and act synergistically with other environmental stressors, leading to reduced survival in the medium to long-term (Boyd *et al.,* 2001, Wolfaardt *et al*. 2008, 2009). On the basis of studies investigating the impacts of ingested plastic on seabirds, species that seldom regurgitate indigestible stomach contents, and therefore accumulate large debris loads, are most susceptible to the adverse effects of ingesting these items. For example, immature petrels that would not be feeding chicks would be particularly vulnerable as they cannot offload their accumulated load (Drewery and Wolfaardt, 2017). Oil can also indirectly influence the survival or reproductive success of seabirds by affecting the distribution and / or abundance or availability of prey but this is much more difficult to assess.

12.1.4.2.5.3 Seabird vulnerability to oil pollution

Seabird species in the waters around the Falkland Islands differ in their susceptibility to contamination from oil pollution due to differences in foraging ecology, geographical distribution and other life history traits, such as reproductive biology. Although a wide variety of seabirds may be affected, the greatest impact is generally observed in those species that spend a large amount of time at the sea surface, such as penguins and shags. Additionally, the behavioural traits of some species increase the likelihood that they will be attracted to vessels; due to the presence of artificial light (section 10.1) discharged waste water and food (section 10.10); or simply to investigate a novel object in an otherwise uniform environment.

Although there are gaps in the data, a general picture of seabird distribution within the NFB has been, and continues to be, acquired through a combination of satellite tracking and visual surveys. However, the presence of the vessels associated with the Sea Lion development will attract birds (see Wiese *et al.,* 2001; Munro, 2011), which distorts the natural distribution of these species. This will result in elevated numbers of sensitive species in an area of high risk, in the immediate vicinity of Development vessels, and it is these birds that are at greatest risk of being impacted by discharged diesel or other oils.

Albatrosses are the most threatened group of birds in the world (Croxall *et al.,* 2012), large numbers of which use the waters of the Falkland Islands. Although the most recent archipelago-wide surveys of black-browed albatross and southern giant petrel breeding in the Falkland Islands reveal that these populations are currently increasing, the populations of most ACAP listed species have declined significantly and continue to do so (e.g. Poncet *et al.,* 2006; Poncet *et al.*, 2017; see section 7.4.5.2.3). Moreover, several species that breed elsewhere, including wandering, southern and northern royal albatrosses, are regular visitors to the waters of the Falkland Islands (White *et al.,* 2002). Albatrosses and petrels are therefore of considerable, and international, conservation concern, which is exacerbated by their life-history traits, such as: a long life-span, high adult survival rates, delayed sexual maturity and low fecundity. Given these extreme life-history attributes, impacts that contribute to adult mortality, such as oil contamination, have a significant influence on population trajectories, because the ability of these populations to recover quickly from such impacts is limited. Nonetheless, in respect of numbers of birds affected, the impacts of oil spills on albatrosses and petrels appear lower compared with other seabirds, such as penguins, although birds oiled at-sea may go unobserved and unrecorded. In addition, pelagic seabirds, such as albatrosses and petrels are generally less successfully rehabilitated following oil spill events than penguins, such that it may not be possible to treat and rehabilitate many of the procellariiform species that occur around the Falklands.

To date, the birds most affected directly by oil pollution in the southern hemisphere have been penguins and shags (García Borboroglu *et al.,* 2006 and 2008; Altwegg *et al.,* 2008; Wolfaardt *et al.,* 2009). Although less likely to associate with vessels, at certain times the area of the NFB is utilised by several penguin species (section 7.4.5.2.2). Given their foraging behaviour and ecology, and especially the amount of time they spend at the sea surface, penguins are particularly susceptible to becoming contaminated following an oil spill. There are five species of penguin breeding in the Falklands, although the macaroni penguin occurs in very small numbers. Amongst the four major penguin species breeding in the Falkland Islands, the rockhopper penguin is the species of greatest conservation concern (section 7.4.5.2.3). The global population has exhibited a long-term decline and the species is currently classified as 'Vulnerable' under the IUCN threat designations and has been highlighted as a species of priority conservation concern (Crofts, 2014).

A preliminary assessment of seasonal vulnerability of seabirds to oil contamination within Falkland Islands waters was performed on data collected by the Joint Nature Conservation Committee (JNCC) to produce an Oil Vulnerability Atlas, (White *et al.,* 2001). Further information and vulnerability maps from the Atlas are provided in section 7.4.5.6. The area around the Sea Lion Field was not considered to be of 'very high' vulnerability during any period of the year, although adjacent areas of the continental shelf - to the south, in January, and the southwest in September - were of 'very high' vulnerability.

12.1.4.2.6 Marine mammals

All marine mammals are afforded priority conservation status as part of the Falklands biodiversity action plan (FIG, 2008b). Both pinnipeds (seals) and cetaceans (whales and dolphins) may be affected by oil spills in numerous ways. These include:

- Direct contamination through contact;
- Ingestion; and
- Inhalation of toxic fumes.

12.1.4.2.6.1 Pinnipeds

Like seabirds, pinnipeds (seals) may be directly impacted through contact with or ingestion of hydrocarbon pollution, or indirectly through impacts to prey at lower trophic levels.

Marine mammals that rely on fur for insulation, such as fur seals, are vulnerable to oil contamination of their coats, which could lead to hypothermia. Fur seals groom extensively to maintain their coats and are therefore more likely to ingest hydrocarbons than other seals. The latter may not result in mortality in all but the most severe cases. However, it may lead to short-term disruption of breeding (Atlantic OCS, 1988) and to some level of bioaccumulation of trace metals and intermediate metabolites (Ridoux *et al.,* 2004).

Phocids (true seals) are generally considered less sensitive to the effects of direct hydrocarbon fouling than otariids (eared seals - fur seals and sea lions) and seabirds. Although the pelage of phocids can be coated / fouled with oil, it is the sub-dermal fat layer that provides the most insulation.

Besides hypothermia, there are a number of other potential impacts of oil pollution on seals. Exposure may cause severe eye watering (lacrimation), conjunctivitis, and corneal abrasions and ulcers if debris becomes mixed with encrusted oil. This may subside if exposure is short but prolonged exposure could result in more permanent damage (Atlantic OCS, 1988; Salaza, 2003). Severe fouling of their pelage may lead to an inflammatory response in the dermis and to skin ulcers following contamination but with subsequent recovery if contamination is of short duration (Atlantic OCS, 1988; Salazar, 2003). The greatest risk of mortality may result from inhalation of toxic volatile compounds from the surface of oil spills, which will be exacerbated if the animal is already stressed from the secondary effects of the spill and disturbance associated with response operations (Atlantic OCS, 1988; Jenssen, 1996).

12.1.4.2.6.2 Cetaceans

There is a growing body of information highlighting the potential impacts of oil spills on cetaceans (Gubbay and Earll, 2000; Matkin *et al.,* 2008; Schwacke *et al.,* 2014; Venn-Watson *et al.,* 2015). Observations of cetaceans indicate that they are aware of slicks but the animals do not necessarily avoid contact with them. Compared to seabirds and pinnipeds, cetaceans generally spend longer periods submerged than at the surface of the water where contaminants are likely to be more concentrated. The behaviour, diet and habitat use of cetaceans will determine their level of contact with an oil spill (Wursig, 1988). Species that forage in mid- or deep-waters will be at lower risk than species that feed at the surface. Species such as right whales and rorquals that surface skim or lunge feed, respectively, are therefore more sensitive and likely to consume surface oil directly than species that feed in deeper waters. This may also be true for some dolphins that 'chase' prey to the surface. Ingestion of oil by marine mammals can cause damage to the digestive system or affect the functioning of the liver and kidneys. Further, where oil is in contact with the skin there is the potential for it to cause irritation to the eyes or to burn mucous membranes.

Moreover, all cetaceans can be fouled or inhale the volatile components of hydrocarbons when they surface to breath and rest. In cetaceans, the respiration of volatile chemicals at the surface of a slick or the ingestion of oil may be lethal or chronic affecting longer term foraging performance and susceptibility to disease, which may ultimately affect survival (Schwacke *et al.,* 2014). The lighter BTEX fractions of crude are the most volatile (evaporate readily) and are also the most toxic. If inhaled, hydrocarbons can impact the respiratory system, which is also a pathway for chemicals to enter the circulatory system. PAHs tend not to be accumulated in marine mammals but certain metallic trace elements present in oil can be transferred and bioaccumulate.

Moreover, many species of cetacean are late to mature and reproduce at a slow rate. Combined with complex social group structures, such as that displayed by killer whales, the loss of relatively few adult animals can lead to long-lasting impact on family groups or sub-populations (Matkin *et al.,* 2008).

Numerous species of cetacean have been recorded in the NFB. Species of note include; sperm whale (IUCN 'Vulnerable') and fin whale (IUCN 'Endangered') were recorded acoustically throughout the year in the NFB and sei whales (IUCN 'Endangered') are known to be seasonal visitors (section 7.4.6.2).

A description of the spatial and temporal distribution of marine mammals in the NFB can be found in section 7.4.6.2.2.1.

A recent set of tests involving whale baleen and six petroleum-based oils (Werth *et al*. (2019) has indicated that whale baleen is oleophobic and does not adsorb oil and that oil is readily rinsed from baleen by flowing water. There was minimal wrinkling or peeling of baleen's cortical keratin layers in the tests and filter porosity was not appreciably affected. Oil ingestion risks remain although particle capture studies suggest potentially greater danger to mysticetes from plastic pollution than oil.

12.1.4.2.7 Potential coastal impacts

Premier has conducted an environmental assessment of the sensitivity of the north Falklands coastline to the potential impacts of an oil spill (Premier, 2014b). This study used oil spill modelling (not the same as that described later in this chapter) to ascertain the potential distribution of oil in the unlikely event of a worst case oil spill from the proposed Sea Lion Field Development. The North Falklands Coastline Environmental Sensitivity study has been used to identify the most sensitive sites along the north Falklands coastline in the event that a shoreline oil spill response operation needs to be initiated. The Environmental Sensitivity classification does not take into account sensitivity of the specific wildlife at the sites but is a more general ranking of sensitivity based on the physical characteristics of the shoreline - ranging from high energy rocky shores to sandy beaches, mud flats and wetlands. These sites have been outlined in section 7.6.

Throughout the year, inshore and coastal waters are important feeding grounds for numerous species. Inshore waters support large quantities of lobster krill and Loligo squid, which in turn are major food resources for higher predators. At certain times of the year marine animals return to land to breed or moult, increasing the densities of vulnerable species in the coastal waters during these times. However, inshore waters support seabird assemblages that were assessed by White *et al.* (2001) as being of very high vulnerability to the potential impacts of oil pollution throughout the year (section 7.4.5.6).

Laboratory results (CEDRE, 2017) and experience indicate that while tar balls are normally possible with this type of oil, they would take a long time to form as the cold oil shows little affinity for suspended solids or shoreline sediments and remains buoyant after losses to evaporation. Tar balls that did form over time will sink to near the seabed where they will move much more slowly, potentially travelling for long distances. While they do so they have relatively little interaction with the environment. Tar balls can then emerge on shorelines a long time after the initial release, where they cause nuisance and can break down in higher temperatures. Most reports of tar balls focus on their interference with human activities at coastlines when they adhere to shoes and clothes, and it is conceivable that other large mammals or seabirds (such as penguins and steamer ducks) could be impacted by smearing and ingestion on the shoreline.

The likelihood of any oil reaching the shore remains very low, however, and oil would be significantly weathered. Tarballs are normally quite visible and affected areas can be typically manually cleaned without further damage.

As noted above, testing of the Sea Lion crude indicated that the crude may stick to seaweed if spilled directly onto the coastline, although it is considered that this is not a realistic scenario given planned operations. However, if the oil reaches the coast from a spill at sea, the adhesion will be limited though roughness of the seaweed, for example if bryzoan colonies are attached to the kelp creating rough patches, means the oil is more likely to stick (see section 12.1.4.1.1.1). Testing also indicated that oil reaching the coast from a spill at sea is not likely to stick to the shoreline; if oil spilled directly onto the coast (again not considered realistic), it will likely stick to rocky and cobbled shores (CEDRE, 2017).

12.1.4.2.8 Tourism

The natural environment and abundant wildlife are amongst the main attributes that draw tourists to the Falkland Islands. Even if oil does not reach the coast following a spill, news of an oil spill in what is perceived to be a remote and wild destination will result in negative publicity. In a wildlife destination like the Falklands, this could adversely impact public perception and experience of the Islands, and undermine its status as an internationally renowned eco- and wildlife destination.

12.1.4.3 Oil spill modelling

In order to assess the potential impacts of oil spills on environmental receptors, five oil spill, or release, scenarios were modelled by Premier using the OSCAR model (Premier, 2017d).

The main aims of the modelling were to understand the:

- Probability of hydrocarbons accumulating on the surface or reaching the shore;
- Characteristics of hydrocarbons dissolved in the water column;
- Fate of the hydrocarbons in terms of the relative amounts dispersed, evaporated, beached, biodegraded and deposited in sediments; and
- Overall likely transport of oil at sea in terms of density, direction and time.

The oil spill modelling associated with this project has undergone significant improvements over several years as better data has become available. In particular, there are two factors that make a significant difference between the results presented in this document and modelling that has been presented in work on the 2015 exploration wells campaign and in earlier presentations, in particular on the issue of whether oil could reach the Falkland Islands shoreline. For the Sea Lion Phase 1a Development, with the most accurate oil properties and metocean data to date, it is predicted that the Falkland Islands coastline is on the fringe of the maximum area that could potentially be reached by oil from a large release. The likelihood of such an outcome has a very low probability, and consequently quite subtle changes in metocean data, location and release size can have apparently large effects on shoreline impacts. The predictions consistently show low (if any) probabilities and oil masses. The following observations can be made:

- A blow-out from the second, more southerly, Drill Centre is predicted to result in a very small mass of oil to shore in 11% of scenarios modelled, whereas oil from a blow-out from the main Drill Centre is not predicted to reach the Falklands. An FPSO loss, being a larger, more persistent mass of oil, could also reach the coast of the Falkland Islands in 8% of scenarios.
- In comparing the consequences of a blow-out with those of an FPSO release, it should be noted that due to the more energetic release conditions and greater initial dispersion, oil resulting from a blow-out degrades faster and spends less time on surface than oil from an FPSO release. For oil to reach the north Falklands coastline it must travel a long distance south which is only realistic when oil is on the sea surface for some time being driven by a northerly wind; oil from a blow-out does not spend long enough on the surface to reach the coast.
- The original EIA submission for the exploration well campaign incorporated modelling conducted using an enhanced version of the 'POLPRED' hydrodynamic model for the area, which was the best available data at the time, while Premier undertook work to generate a much more detailed dataset using the 'NEMO PS4' model. When the campaign was amended during 2015 to include the 'Elaine' target and a second 'Isobel Deep' target, the NEMO PS4 outputs had been completed and scenarios were re-modelled using these data.
- All the exploration well modelling considered releases at the 'Isobel Deep' location which is some 45 km south of the Sea Lion development location and was the southernmost well of the campaign. This was used as a conservative approach in respect of shoreline oiling. Since the Sea Lion Field is further north, it is closer to the stronger northerly Falklands Current and given the regional current patterns, the propensity for oil to travel north, away from the Falkland Islands, increases the further north in the region. The Isobel Deep prospect is not part of the Sea Lion development or the scope of this assessment.

12.1.4.3.1 The OSCAR modelling approach

The SINTEF OSCAR software is a sophisticated multifunction model that computes surface and subsurface transport, behaviour, weathering and fate of oil, as well as potential ecological impacts. The model has been the subject of verification and calibration by numerous field experiments both on surface spills and subsea releases in offshore and nearshore locations, e.g. as described in Reed *et al*. (1995; 1996) and Johansen *et al*. (2001).

The OSCAR model is primarily written to predict the physical behaviour for Newtonian fluids, which includes the majority of crude oils. However, it is possible to input specified measured parameters for individual crude oils including the hydrocarbon characterisation and weathering parameters, which now includes Sea Lion Crude, following the most recent round of crude oil tests (CEDRE, 2017).

The following describes only the information required to ensure appreciation and understanding of the modelling results. Full details with regard to the method, Sea Lion Pseudo-assay generated by OSCAR to model biodegradation and toxicity, and metocean data used, are provided in Premier's Inshore Environmental Modelling Report (Premier, 2017d). Full details on the OSCAR methodology are also provided in the same report.

12.1.4.3.2 Discharge parameters and assumptions used in the modelling

The release parameters used in the oil spill dispersion modelling for each scenario are summarised in Table 12.3. These parameters are based on worst case scenarios so as to set an upper boundary in relation to the potential effects.

Table 12.3: Parameters included in the oil dispersion modelling for the oil and diesel spill scenarios

Scenario	Fluids discharged	Release volume (tonnes)	Release duration	Release location	Release temp. (°C)	Release diameter (mm)	Model run duration	Worst case assumptions
1: Well blow-out scenario	Sea Lion crude oil	Worst case declining rate: 1,695 – 954 tonnes/d (24,359 tonnes total)	29 days	Sea bed	68	230	100 days	Release duration assumes 29 days to employ a well capping device. Worst case declining flow rate used
2: FPSO crude oil inventory loss	Sea Lion crude oil	136,789	1 day	Surface release	60	n/a	100 days	Release volume based on total loss of FPSO inventory at 60°C storeage temperature over one day
3: Crude oil transfer spill	Sea Lion crude oil	62	10 minutes	Surface release	60	n/a	30 days	Volume and duration reflect the fact that operations would cease as soon as a leak / spill was detected. The longer hose length for Direct Offtake to CTT has been used to calculate hose volume, and the volume also reflects the largest comparable spill recorded.
4: Diesel inventory loss	Diesel	3,936	1 hour	Surface release	8 (ambient)	n/a	30 days	Release volume based on total loss from an analogue MODU.
5: Diesel bunkering spill	Diesel	26	10 minutes	Surface release	8 (ambient)	n/a	30 days	Volume and duration reflect the fact that operations would cease as soon as a leak / spill was detected.

12.1.4.3.3 Reporting thresholds defined in the model

In order to give meaning to the models, it is necessary to determine thresholds (based on industry best practice), beyond which the predicted levels of contamination are insignificant. Once a threshold is reached, the model terminates oil particles (assuming loss of mass to evaporation, decay or deposition) or ceases recording them.

The spill properties to which the thresholds apply include:

- Thickness / density of oil on the surface; and
- Total water column concentration.

The model generates output data (maximum oil concentrations, surface thickness etc.) by tracking numerous particles placed throughout a specified grid that is manually selected in the locality of the release site. Typically, this grid will be set to capture the majority of the plume as it disperses across the sea.

12.1.4.3.4 Thickness / density of oil on the surface

Significant, and relevant, surface thicknesses depend on the specific properties of the oil under consideration. Although it is noted that there is no consensus on thicknesses of surface oil that corresponds to impacts, here it is assumed that a visible sheen would impact birds.

For the diesel spill scenarios that have been modelled in this study, a surface thickness threshold of 0.3 µm has been adopted (Table 12.4). Under the Bonn Agreement 'Oil Appearance Code of oil thicknesses' (Bonn Agreement, 2009), this thickness value corresponds to a rainbow sheen and any surface oil thickness below this value is unlikely to be visible.

For the Sea Lion crude oil type however, the overwhelming properties of the wax components mean that a surface thickness parameter is not meaningful, and a scale has therefore been devised to reflect the density of waxy oil droplets on the sea surface.

The scale of oil density chosen to represent results is 1, 10, 100, and 1,000 grams per square metre (g/m^2). This unit has been used previously for similarly waxy crudes, for example, the Montara spill used a density of $10g/m^2$. Here the chosen threshold is 1 g/m^2 and below this value the oil ceases to be shown in model outputs, although it remains present in the calculations in the model (Table 12.4). Importantly, the scale selected here is not intended to imply significance in terms of the impact assessment below, but to convey factual information regarding the model predictions and allow a means of visualising the results.

It is noted that in the laboratory tests, feathers exposed to 100 g/m^2 of oil showed no oil being adsorbed by the feathers, and no structural damage was observed. At an oil concentration of 1000 g/m^2, all the feathers were stained by oil, and for 2 bird species, micro particles of oil adhered. Thus, the outputs showing levels of 1 g/m^2 must be viewed in context that risks to seabird plumage are most likely in a much more confined area.

12.1.4.3.4.1 Total water column concentration

Water column concentrations refer to dissolved hydrocarbons plus droplets. A threshold of 25 parts per billion (ppb) has been used in the models for all spill scenarios and oil types, below which the oil in the water column is not expected to have acute toxic effects. This threshold reflects a worst case and it is noted that 50 pbb is the lowest predicted no effect concentration for acute toxicity of the oil components in the OSCAR database and is also the mid-range of the concentrations of crude oil found to give sub-lethal effects (Patin, 2004).

Table 12.4: Oil density thresholds used in the Sea Lion development oil spill modelling study

Scenario	Oil type discharged	Surface threshold	Water column concentration threshold
1: Subsea well blow-out	Sea Lion crude oil	1 g/m^2	25 ppb
2: FPSO inventory loss			
3: Crude transfer spill			
4: Diesel inventory loss	Diesel	0.3 µm	25 ppb
5: Diesel bunkering spill			

12.1.4.3.5 Understanding the model

Oil spill modelling incorporate the following two types of model run:

- **Stochastic modelling** - carried out by running individual discharge scenarios multiple times over different time periods (thereby utilising different wind and current conditions) and aggregating the results in order to report behaviour in some probabilistic or statistical manner. For each oil spill scenario, the aggregated stochastic modelling results present:
  - The probability (%) of hydrocarbons accumulating to levels above the stated thresholds:
    - On the sea surface;
    - In the water column; and
    - On any shorelines.
  - The minimum times taken (days) for hydrocarbons to arrive at any location at levels above the stated thresholds:
    - On the sea surface;
    - In the water column; and
    - On any shorelines.
  - The maximum length of time (days) any area is exposed to oil at levels above the stated thresholds:
    - On the sea surface;
    - In the water column; and
    - On any shorelines.
- **Deterministic modelling** - conducted over a particular time frame which is selected based on the results of the stochastic model results, deterministic modelling is used to highlight

hydrocarbon behaviour over a specific time frame. The time period for each deterministic run was selected to highlight either the worst case mass of oil arriving on shore, or the largest mass of oil on the sea surface both of which are predicted by the stochastic modelling results. For each oil spill scenario, the deterministic modelling results present:

- The predicted worst case shoreline oiling concentrations (kg/m^2) (if applicable);
- The maximum surface area affected by levels above the stated thresholds for a single spill scenario; and
- The total hydrocarbon concentration (ppb) in the water column for a single spill scenario.

The OSCAR model used in this assessment, while being the most advanced tool available, includes some differences between stochastic and deterministic mode that affect the outputs. To accommodate the large number of runs required in stochastic mode, the model simplifies the way temperature and depth information is used, and importantly, deposition in sediments is excluded. This has the effect of increasing the mass of oil in the other fate compartments (evaporated, surface, water column, shoreline, biodegradation) since there is no sink into sediments. Overall, stochastic outputs have been used here to assess impacts to achieve consistency across all the data presented, and the outputs are therefore slightly worse than would be found from a more detailed deterministic assessment. When the model is run in deterministic mode, due to the buoyancy of the wax and the deep water in which it is released, a small fraction of oil (up to 15%) is predicted to transport into sediments, and this is only predicted when the oil approaches a shoreline and the cloud of suspended droplets makes contact with the seabed after around 60 days. In the majority of scenarios where the oil remains at sea, <5% oil is predicted to transition into sediments. The recent bench tests (Premier, 2016j) and laboratory tests (CEDRE, 2017) have reinforced the description that the Sea Lion crude is very buoyant; this attribute keeps it away from sediments, and should tar balls form and cause the oil to sink, the majority of oil would become enclosed in a crust which tends to reduce the risk of acute impacts.

The OSCAR model does allow a suspended solids concentration to be entered which will increase the deposition of sediments out of the water column and into the sediments. This has not been used because there are little data on suspended solids in the region, and laboratory testing has shown little uptake of suspended solids. By omitting it, there is confidence that the amount of oil in other compartments is not underestimated.

For the stochastic modelling, an output grid layout has been chosen that maximises the accuracy of the outputs by focusing on the vast majority of oil particles that remain near the sea surface. For the deterministic model, a full cross section of the water column to the seabed has been modelled and the presence of oil in the water column can be observed. Extensive modelling of potential offshore releases, including the results presented here, confirms that oil can reach the edge of the model domain in 30 days, and takes 60 days in the majority of cases, giving a desirable scenario length of 100 days (29 day blow-out followed by 71 days dispersion). Using 51 stochastic scenarios, the individual runs are spaced at approximately 17 day intervals across the 3-year metocean dataset, and periods being modelled overlap very significantly. This means that the release of oil at every time interval within the dataset has been modelled with subsequently at least 83 days to disperse to identify all possible trajectories. Experience has also shown that increasing the number of stochastic runs beyond this number does not significantly alter the results, which complies with UK government recommendations (BEIS, 2016). This can be seen by the projection that while four scenarios for well blow-out reach the shore, they all occupy the same set of north winds in the metocean record, i.e. increasing the number of runs would not alter the proportion that occupy this set of winds.

For the FPSO inventory release, the release takes place over a very short period and it is not practical to model release at every time point but the oil stays much denser for longer. Therefore, a longer dispersion period is used so that the scenario runs for 100 days in total. Again, experience of numerous model runs has shown that this combination of parameters identifies the range of possible trajectories and outcomes.

Where model particles exit the grid to the north of the area, they are recorded as 'outside grid'. The northern boundary has been chosen to be as far north as possible within the high resolution NEMO PS4 currents dataset, and by the time oil exits this area, its environmental properties are known and relatively stable and conclusions on impacts can be drawn.

12.1.4.4 Scenario 1: Subsea well blow-out - modelling results

12.1.4.4.1 Predicted behaviour of oil

The behaviour of Sea Lion crude is shown in Figure 12.3: Behaviour of oil over time during the modelled blow-out. These results represent the scenario giving rise to the maximum oil coming ashore, and are also representative of the general oil behavior over a wide range of conditions. The 'spikiness' of the surface and dispersed oil values reflects periods of rough and calm weather, when oil moves between surface and water column, resurfacing when calm.

Since the well blow-out discharge is assumed to occur on the seabed, crude oil is not immediately present on the sea surface. However, due to the buoyancy of the oil, it is predicted to surface very quickly after it has been discharged. The modelling predicts that after 20 days from the start of the discharge, 24,359 tonnes of oil has been released, 81 % (19,780 tonnes) will be found on the sea surface, 9% (2,309 tonnes) will be dispersed in the water column, 7 % (1,767 tonnes) will have evaporated, and 2% (503 tonnes) will have biodegraded.

After approximately 30 days, model particles begin to leave the modelling grid. Model particles were only observed to leave the modelling grid initially via the northern boundary due to the strong northerly currents and then after 45-60 also via the eastern boundary. It is expected that any oil that has travelled this far will be insignificant as it will be in a highly dispersed state, having been at sea for a minimum of 30 days. Thus, any oil that leaves the model grid is not expected to significantly affect the overall conclusions of the model predictions. It should also be noted that extending the model grid northwards is not practical since this boundary is set to coincide with the boundary of the NEMO PS4 currents grid. However, it is important to note that the results in Figure 12.3 show that oil starts to leave the grid after 30 days and the fate of oil once it leaves the grid is unknown. Therefore, the total masses of oil in each fate category beyond 30 days may be larger than those shown in Figure 12.3 as the oil that leaves the modelling grid is not accounted for.

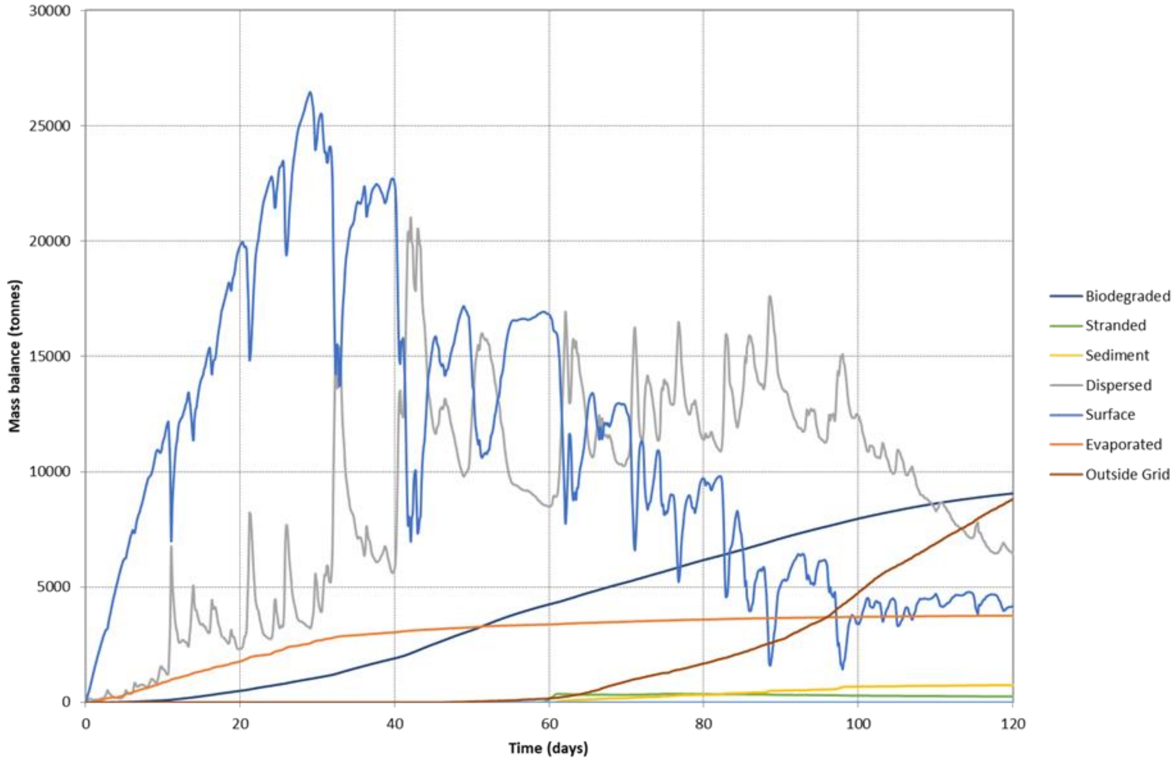


Figure 12.3: Behaviour of oil over time during the modelled blow-out

12.1.4.4.2 Subsea Well Blow-Out - Surface results

Figure 12.4 below shows the probability of oil appearing on the sea surface above the threshold of 1 g/m^2 following a subsea well blow-out throughout the whole model run. Because Sea Lion crude is a low density oil, and the oil masses that form after the oil is discharged to the marine environment are buoyant, there is a high probability that oil will appear on the sea surface above the threshold. There is a large area of the sea surface that has 100% probability of surface oil above 1 g/m^2 (Figure 12.4). The oil is predicted to travel on the sea surface primarily in a northerly direction due to the predominant surface current direction. Some wax is also likely to be found to the south-east of the discharge location, as a result of wind driven Ekman currents. It is predicted that there is a 5-10% probability of oil reaching the coastline of the Falklands via the sea surface.

Figure 12.5 shows the minimum arrival times of Sea Lion crude above the threshold of 1 g/m^2 on the sea surface. In most conditions, the Sea Lion crude can potentially travel up to 30 km within one day of being discharged, 105 km within 5 days, and up to 260 km within 10 days. Although the crude oil can potentially travel very Figure 12.7 long distances within a relatively short period of time, it is predicted that after 10 days the oil will be in a highly dispersed state. The oil rises quickly to the surface and spends little time in the zone of strongest currents which is around 30 m below the surface, and after surfacing is driven by winds and prevailing currents. Oil takes at least 7.5 days to reach the outer boundary of the FOCZ.

Figure 12.6 shows the maximum time that any sea surface location is exposed to Sea Lion crude above the surface density threshold of 1 g/m^2. The sea surface around and to the east of the well blow-out discharge location can potentially be exposed to Sea Lion crude oil for up to 30 days. At locations further away from the discharge, the maximum exposure times decrease as the oil spreads and the likelihood of oil above 1 g/m^2 on the sea surface decreases. At locations outside of the FOCZ boundary it is unlikely that the surface will be exposed to oil above the 1 g/m^2 threshold for more than three days and will probably be less than a day.

All of the outputs shown in these figures are based on an aggregation of results from all the stochastic model runs and therefore do not represent a single spill scenario, and certainly do not reflect the manifestation of oil on the sea surface at any single instance in time.

Tests on oiling of feathers were conducted at CEDRE (2017) looking at densities of 100 g/m^2 and 1,000 g/m^2; minor changes to barbules were noted at 100 g/m^2, and adhesion of oil and some feather staining was observed at 1,000 g/m^2 surface density.

In the blow-out scenario, very little area is predicted to be exposed at a concentration of more than 10 g/m^2 and there are no sustained areas predicted to be above 100 g/m2. Levels of 1,000 g/m2 were necessary in the laboratory to induce oil staining and adhesion, with minor changes to barbules noted at 100 g/m2. (Figure 12.8). Note that due to averaging and contouring functions in the stochastic model, some individual cells may exhibit a transient concentration of above 100 g/m^2 but remain absent from the plots, which can be seen in the deterministic example in Figure 12.7 very close to the release. The conclusion remains that there is negligible area of sea at risk > 100 g/m^2 at this scale.

Based on the stochastic simulation results of the worst case well blow-out scenario, a single deterministic model run was conducted to demonstrate the predicted total impacted surface area for a single, worst case, scenario. Figure 12.7a shows the total impacted surface area for the single deterministic model run, and shows the maximum oil densities on the sea surface that were observed at each geographical location throughout the whole model run duration of 137 days. This graphic illustrates every location where wax might be found throughout the entire model period. Again, this is not reflective of the extent of wax distribution at a single point in time. An example typical snapshot of surface wax densities for the single deterministic well blow-out model run is shown in Figure 12.7b.

12.1.4.4.2.1 Model predictions after oil has been at sea for long periods

It is normal to run scenarios for the entire duration of a blow-out, and for some time following the cessation of the release, to determine the behaviour and location of oil before taking a view on whether this poses a risk to receptors. There are reasons to view the longer-term surface predictions as conservative, as the particles at sea will eventually be biodegraded or combine with suspended solids and sink. It is also not certain that the model physics for very weathered oil masses is representative. The representation of the oil as a density, which appears to evenly cover grid cells of 2 km^2 in the well blow-out model run, is a reasonable way to envisage it during the early stages of a release but may lose relevance when the oil masses are extremely small and widely dispersed. It is possible to employ a higher threshold to 'screen out' smaller concentrations, but this has not been done in the interest of transparency.

Overall, the interpretation of results over long timescales should be done with caution and experience, and, in general, the model results may exaggerate the apparent impact of dispersed oil and are therefore considered to be conservative.

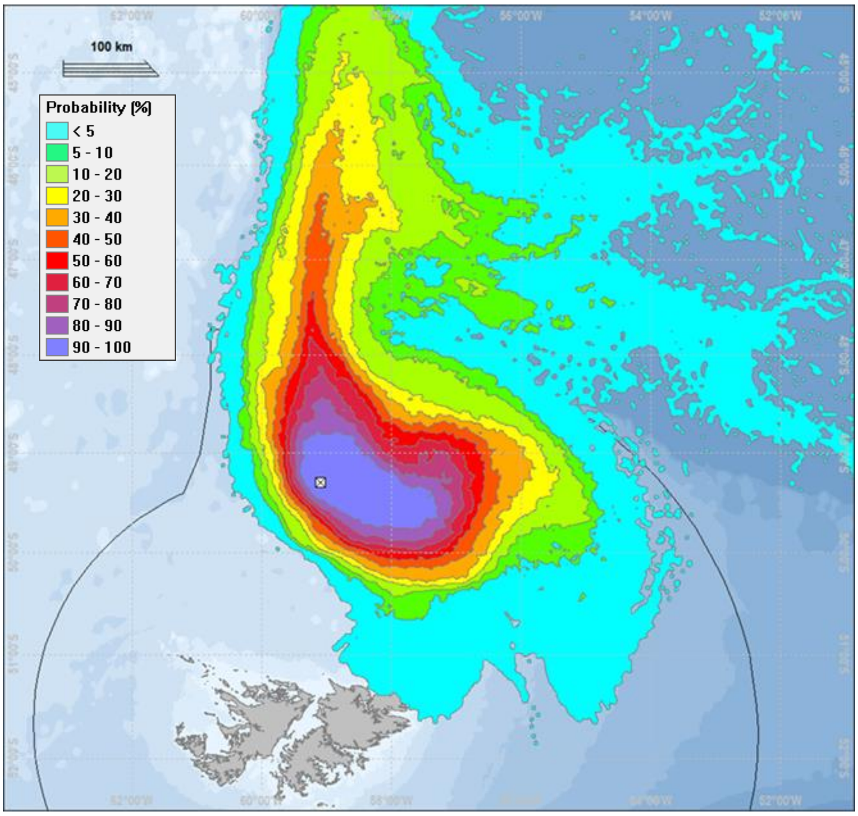


Figure 12.4: Probability of surface contamination above threshold of 1 g/m^2 for worst case well blow-out scenario

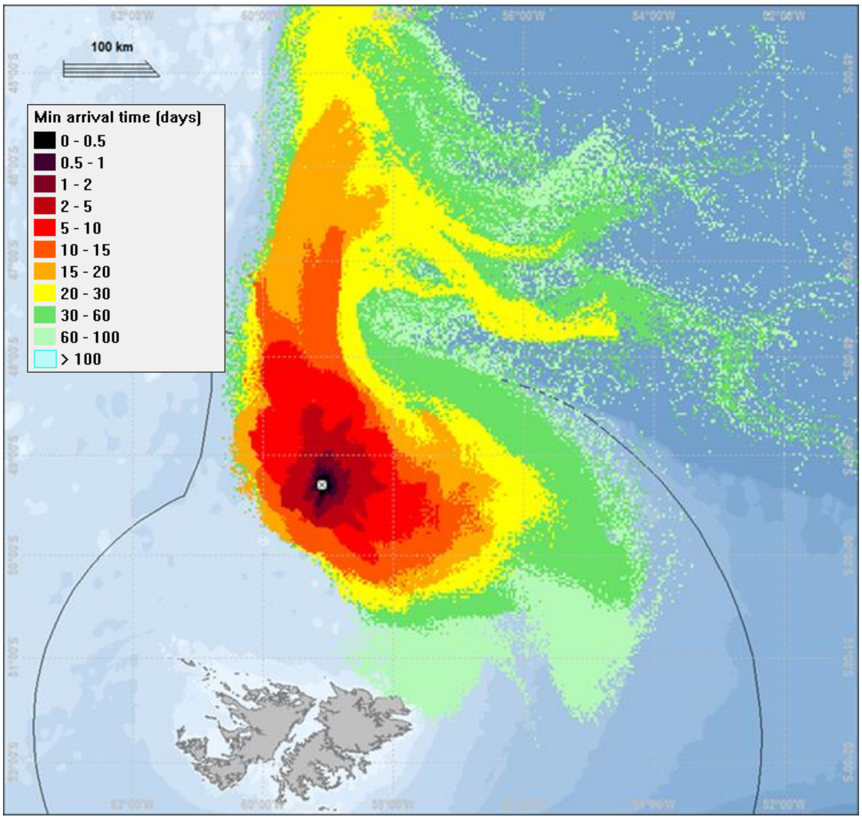


Figure 12.5: Minimum arrival times of Sea Lion crude above 1 g/m^2 on the surface

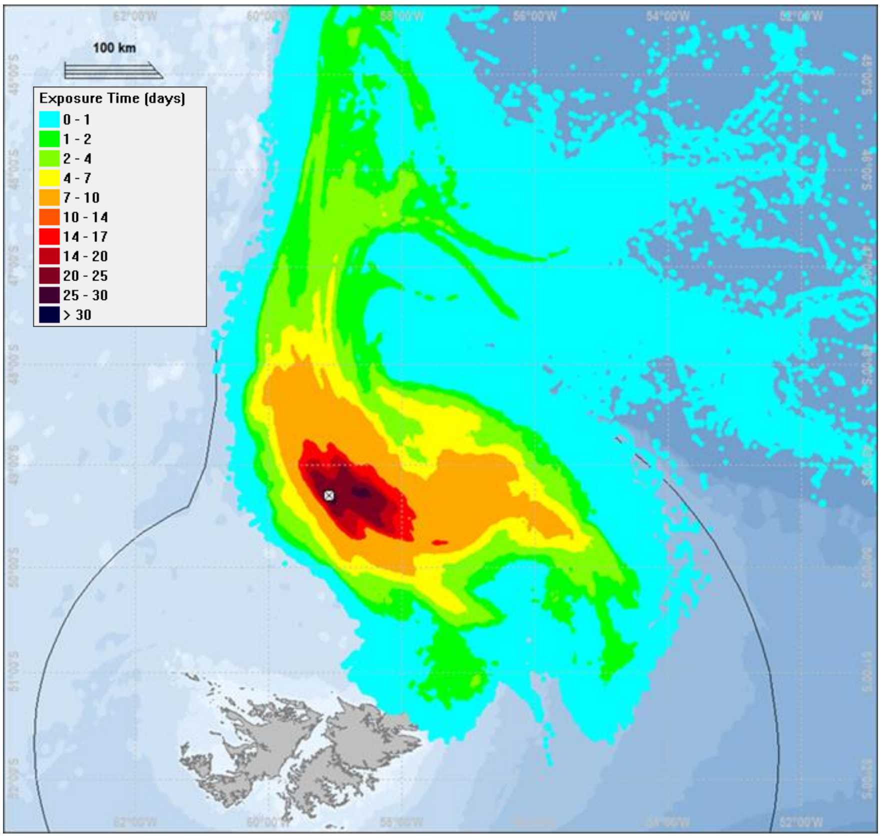
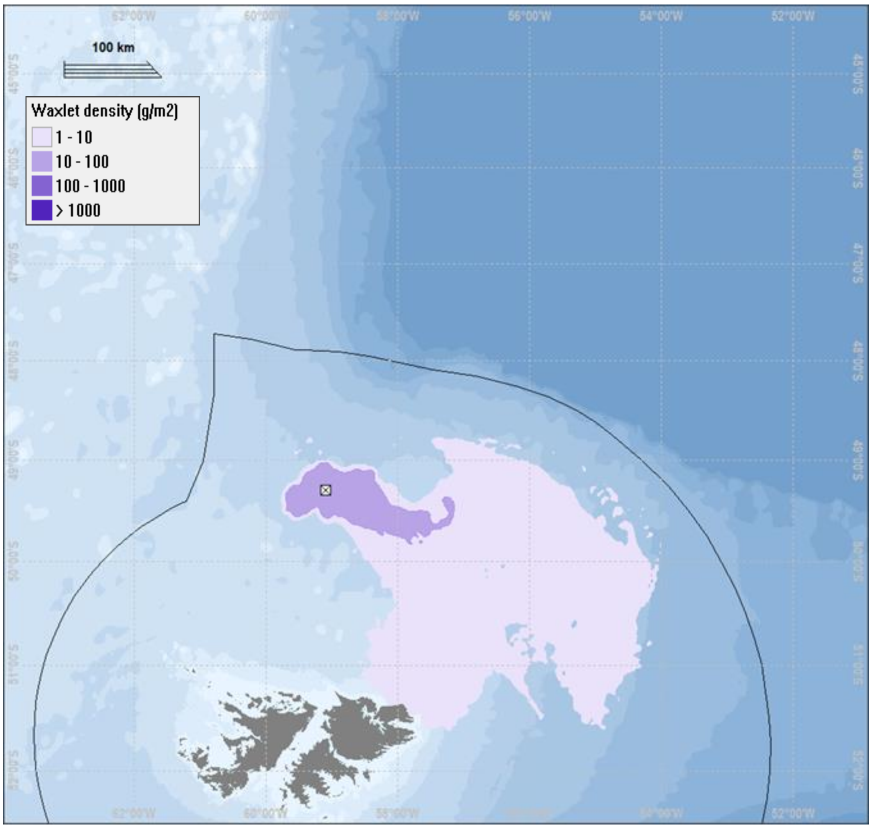
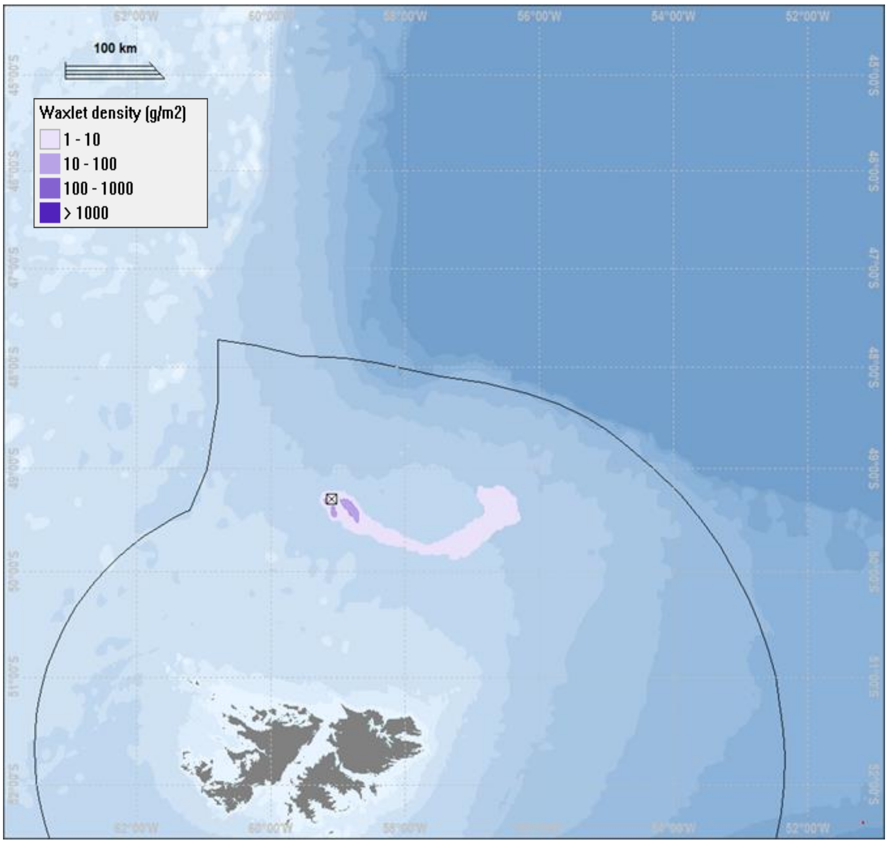


Figure 12.6: Maximum time surface is exposed to Sea Lion crude above 1 g/m^2

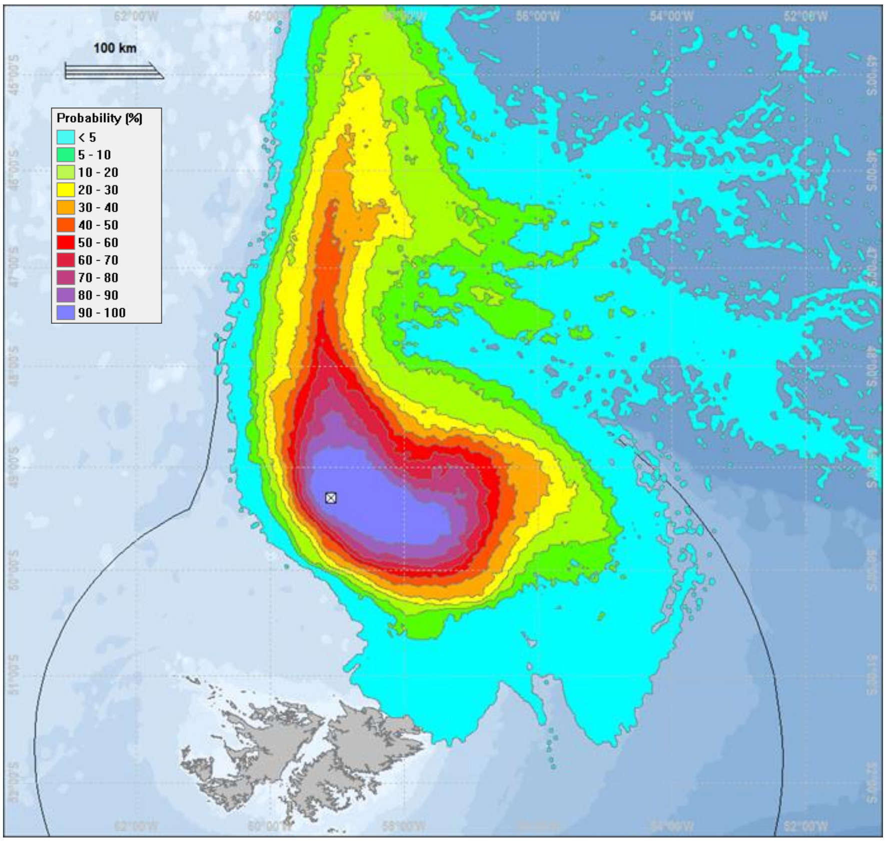


a) Total impacted surface area above threshold of 1 g/m^2 for single deterministic model run

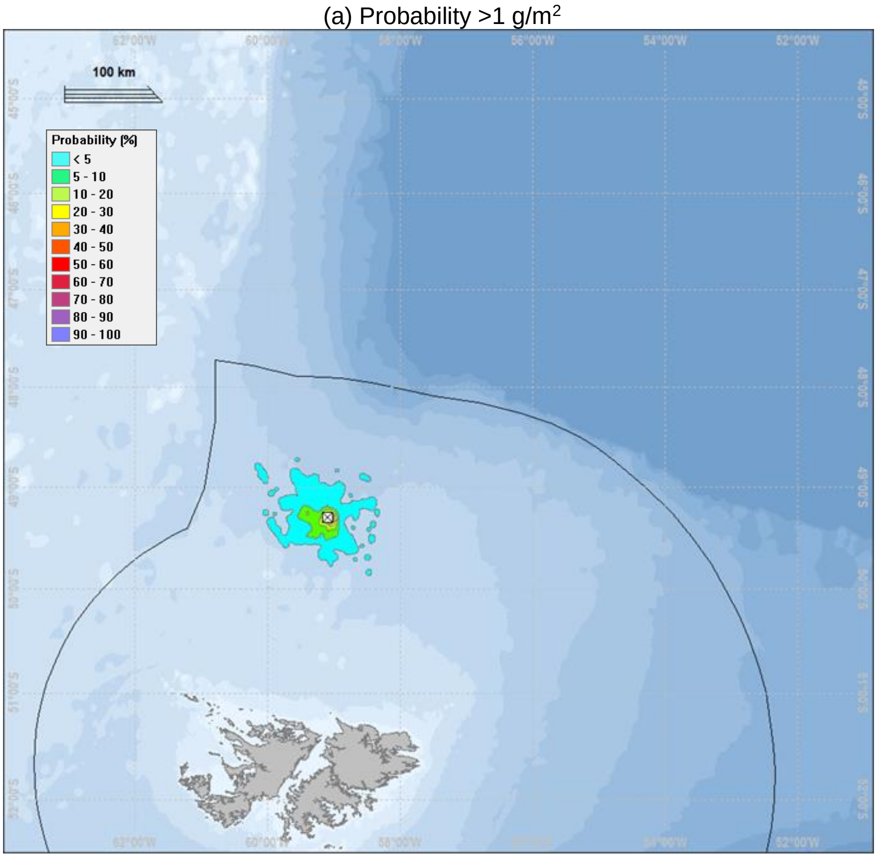


b) Example snapshot of surface wax above 1 g/m^2 (at 30 days)

Figure 12.7: Surface results (deterministic) for worst case well blow-out



(a) Probability >1 g/m^2



(b) Probability >10 g/m^2

Figure 12.8: Probability of Surface Oiling at Differing Oil Densities for Subsea Blow-out (stochastic)

Note: No results are reported for 100 g/m^2 and 1,000 g/m^2 although occasional values of 100 g/m^2 may occur.

12.1.4.4.3 Subsea Well Blow-Out - Water column results

Figure 12.9 shows the probability of oil accumulating in the water column above the threshold of 25 ppb for the worst case well blow-out scenario. As expected, since the discharge is modelled to occur subsea for a duration of 29 days, there is a high probability that the water column will be exposed to crude oil above the concentration threshold of 25 ppb. The crude oil is predicted to travel predominantly in northerly and south-easterly directions, which is likely caused by currents and the predominant winds from the north-west dispersing surface oil into the water column. The discharged oil at the seabed is expected to rise through the water column quickly and there is a high probability that it will accumulate in the topmost layer (<60m) of the water column in concentrations above 25 ppb.

Figure 12.10 shows the maximum exposure times the water column will be >25 ppb, showing clearly longer exposure times near the blow-out location.

A cumulative plot of water column concentrations of dissolved oil and oil droplets for the worst case well blow-out is shown in Figure 12.11a; Figure 12.11b shows a cross section of the same results.

Figure 12.12a shows the water column concentrations of dissolved oils only and a cross section of the same is presented in Figure 12.12b. This indicates that dissolved oils are contributing very little to concentrations of oil in the water column, and the subsea concentrations probably relate to the smallest wax droplets generated by the blow-out that rise more slowly.

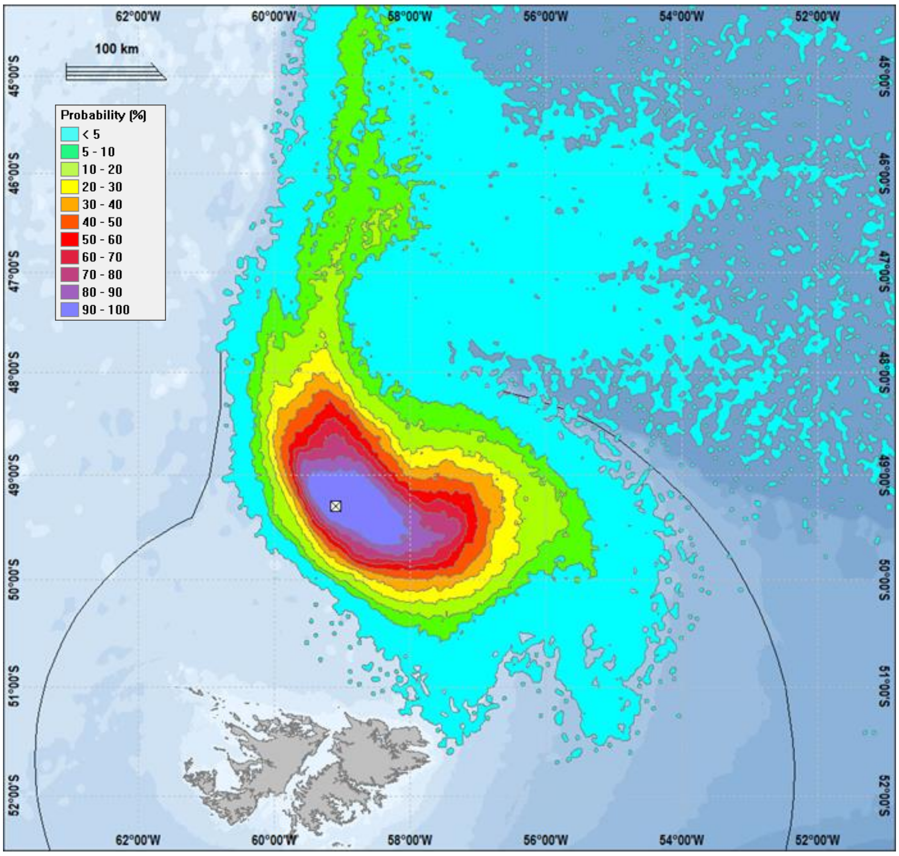


Figure 12.9: Probability of water column concentrations of >25 ppb in a worst case blow-out

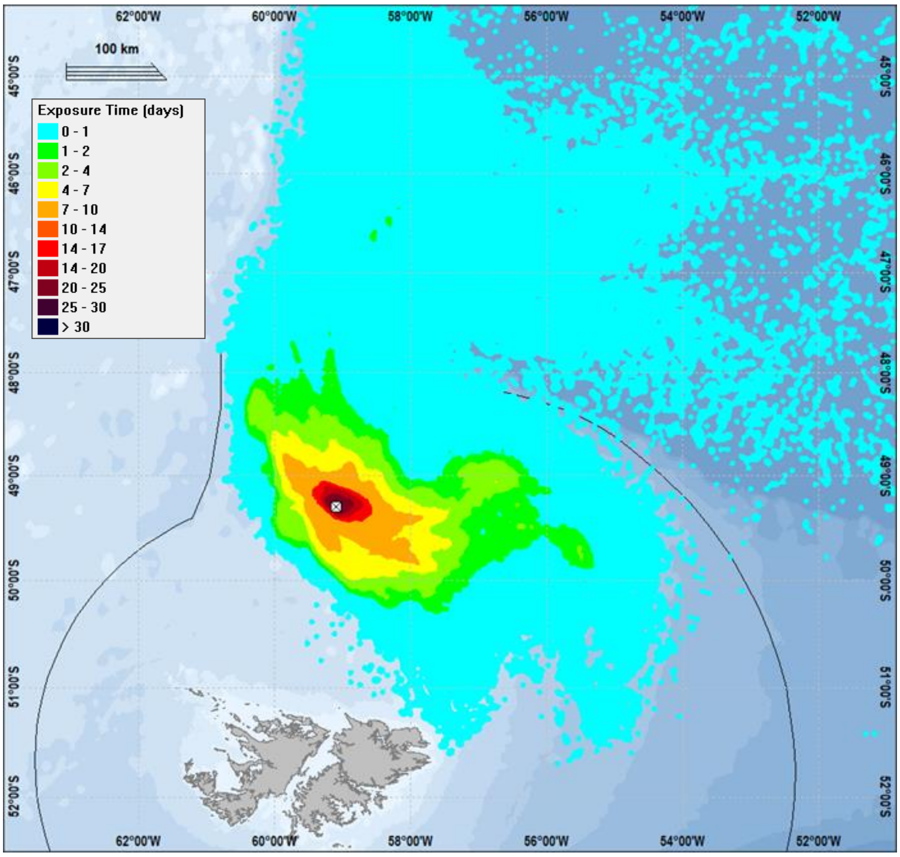
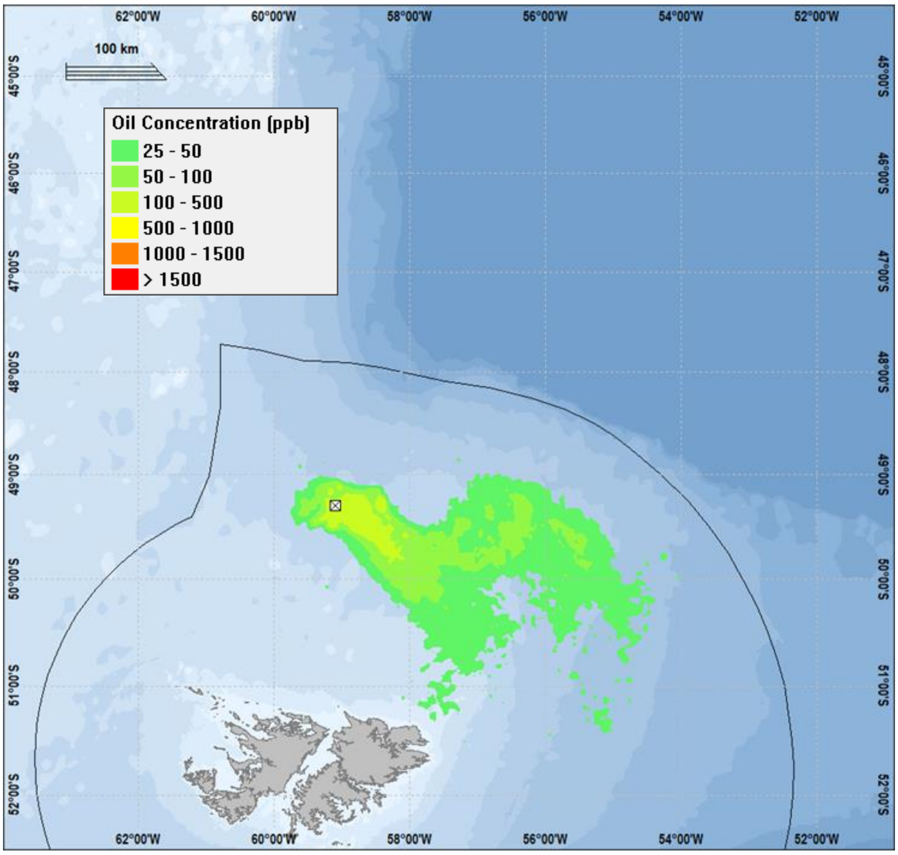
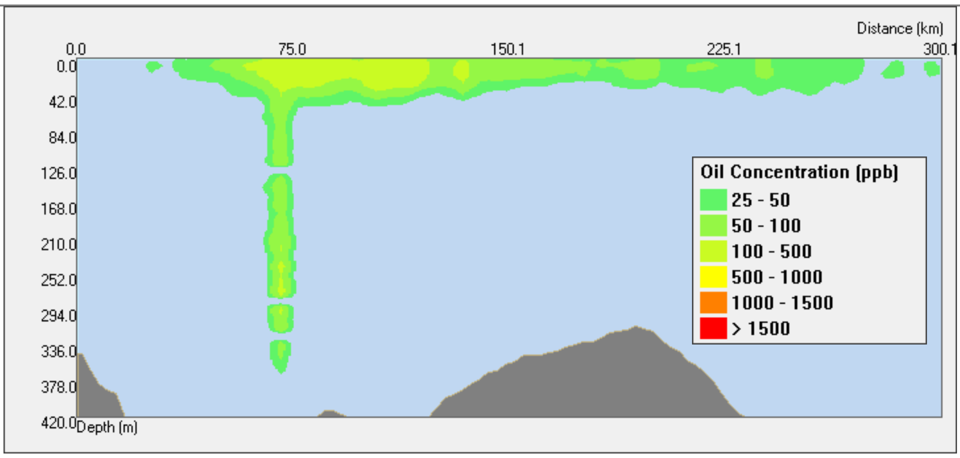


Figure 12.10: Water column maximum exposure time >25 ppb

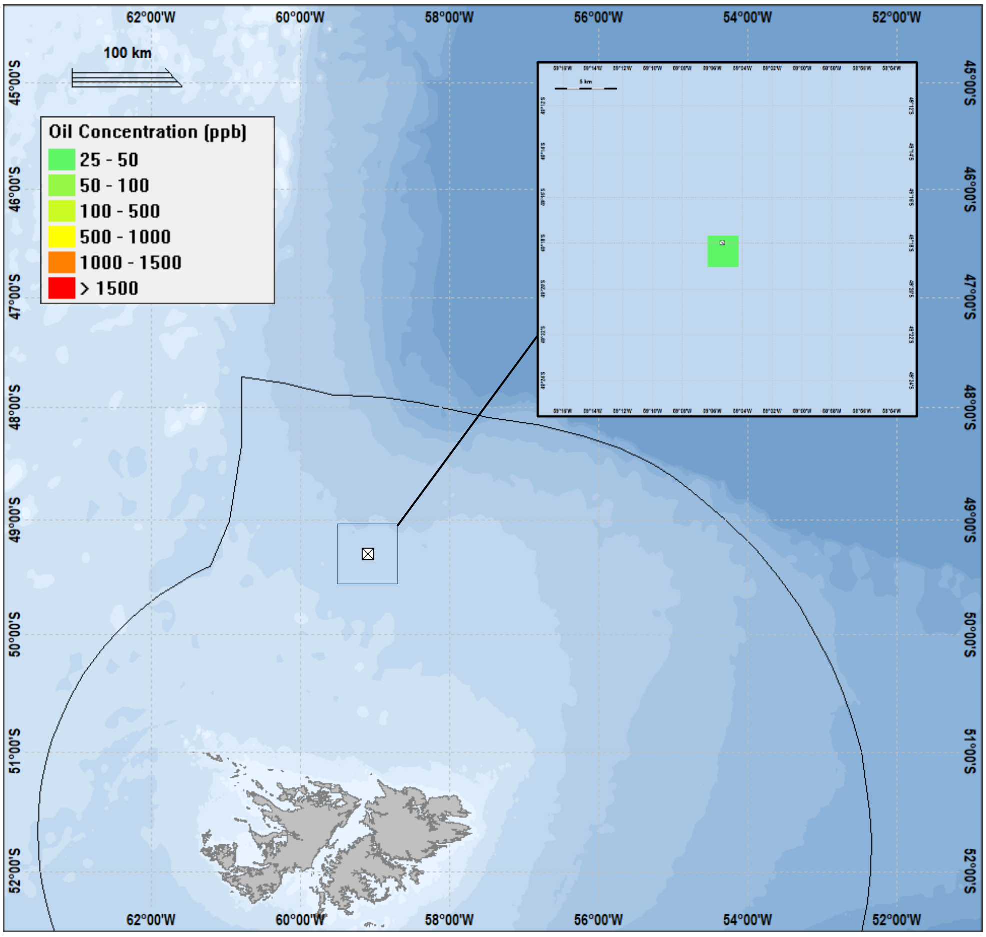


a) Cumulative water column concentration dissolved oil and oil droplets

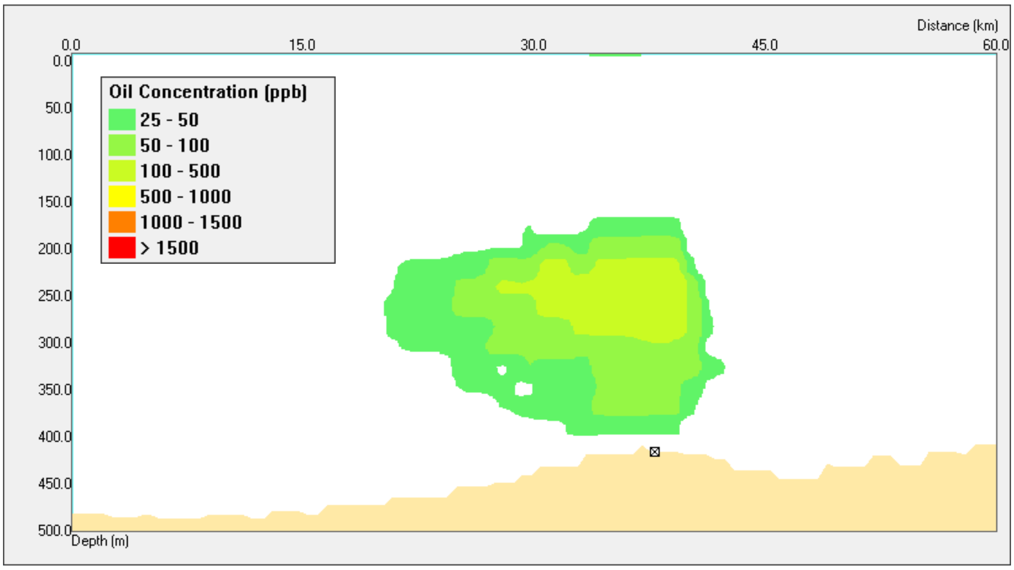


b) Cross-section of cumulative water column concentration dissolved oil and oil droplets

Figure 12.11: Cumulative water column concentrations from a worst case blow-out



a) Cumulative water column concentration dissolved oil only



b) Cross-section of cumulative water column concentration dissolved oil only

Figure 12.12: Water column results (dissolved oil only) for worst case well blow-out

12.1.4.4.4 Subsea Well Blow-Out - Shoreline results

Figure 12.13 shows the probability of oil reaching the Falklands coastline after a worst case blow-out by identifying the initial beaching locations. The modelling results indicate that there is a low probability of crude oil reaching the shoreline. The northern coastline of East Falkland is predicted to be the most likely place where oil could beach. The greatest probability of shoreline oiling was observed to be 8 %, indicating that only four of the 51 individual stochastic simulations resulted in crude oil reaching the Falklands coastline. Examining the metocean record, this only occurs when there is a prolonged period of northerly winds for some weeks, and this occurred once in the record, and four scenarios had this weather episode within their duration for long enough for oil to reach the coast. Consequently, in the event of a worst case blow-out, shoreline oiling is possible, but highly unlikely.

Figure 12.14 shows the minimum arrival times for shoreline oiling for a worst case blow-out indicating that arrival times are 56-99 days (in the small fraction of conditions where oil is blown towards the Falkland Islands) along the northern coast of East Falkland, with an average of 79 days.

Figure 12.15 shows the concentration of oiling on the shore for a deterministic scenario to predict the worst case oiling on the shore. The maximum volume of oil predicted to reach the coastline is approximately 400 tonnes and the average amount of oil on shore (of the 10 % of scenarios in which oil does reach the shoreline) of 118 tonnes. Minimum arrival times for oil reaching the shoreline averages 80 days, with a minimum of 56 days (Figure 12.14).

Figure 12.16 shows the forecast for any oil to reach the shoreline. It is predicted that any crude oil that eventually reaches the Falklands coastline would be in a highly dispersed state due to it having been at-sea for 80 days before reaching the coastline. It is therefore likely that the oil would reach the shoreline as small masses.

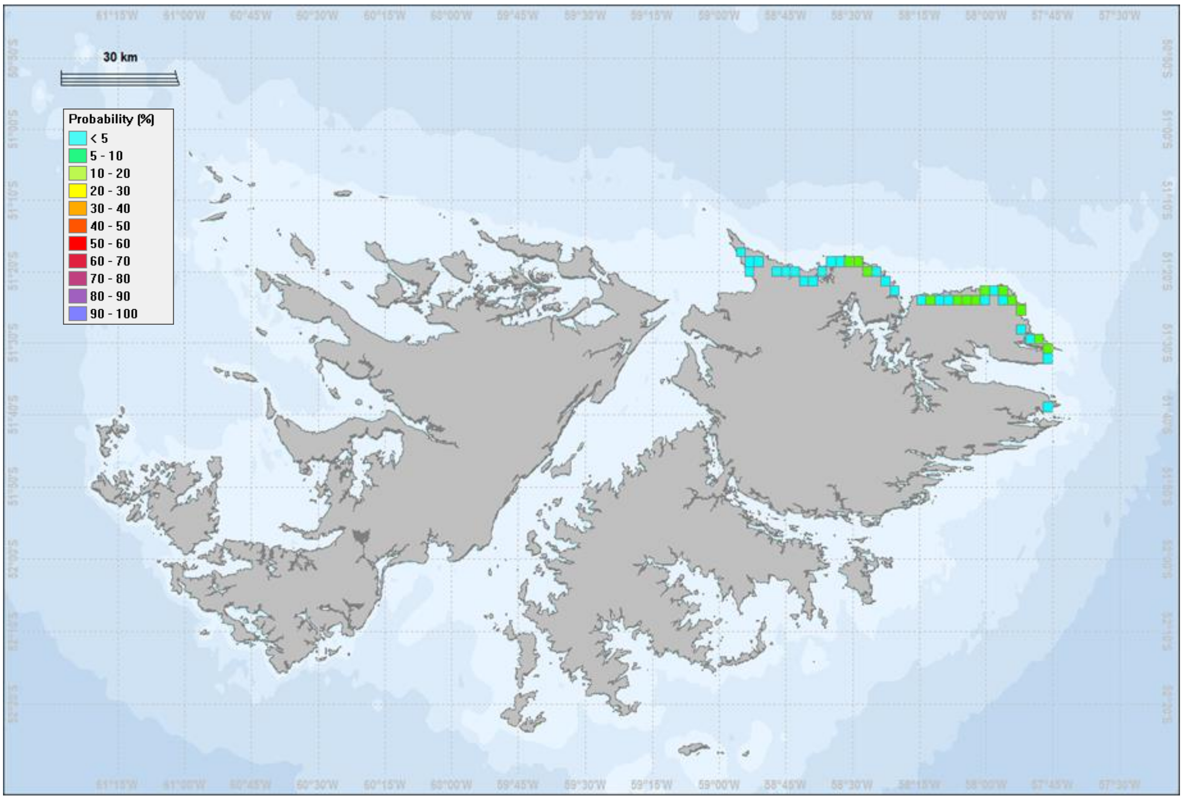


Figure 12.13: Probability of shoreline oiling for a worst case blow-out

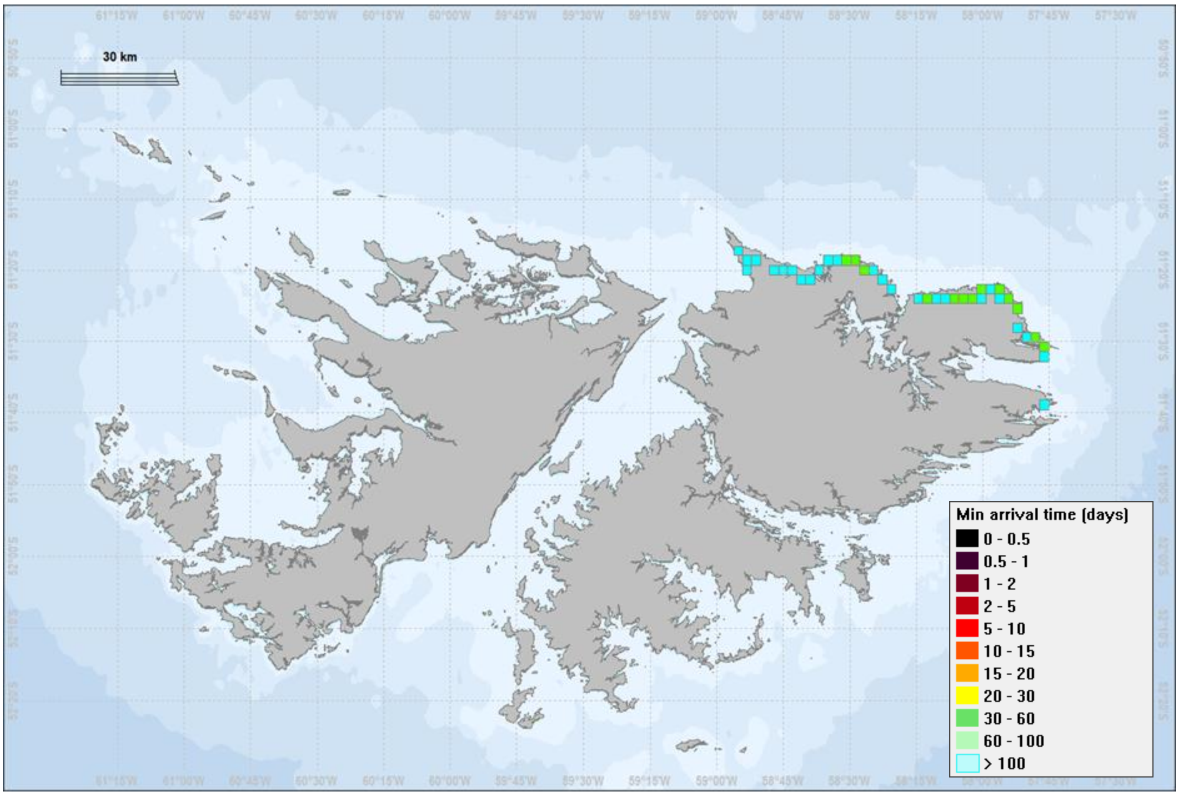


Figure 12.14: Minimum arrival times for shoreline oiling for a worst case blow-out

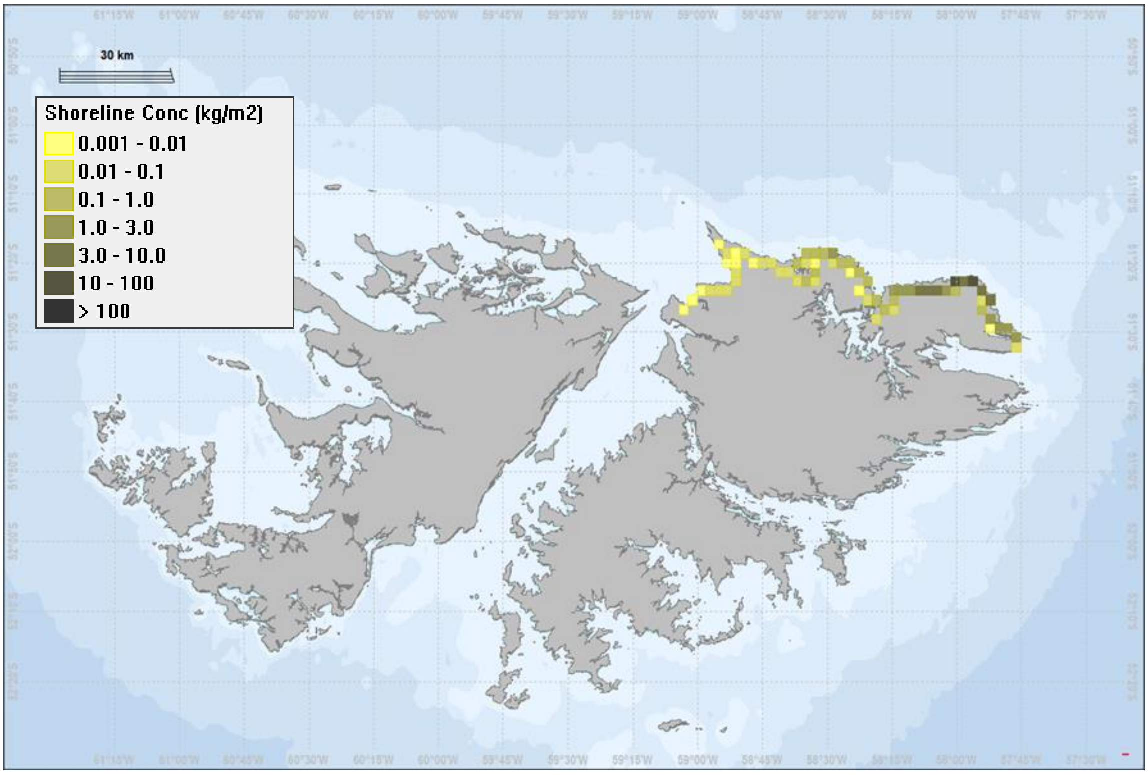


Figure 12.15: Concentration of oiling on the shoreline for a worst case blow-out (deterministic)

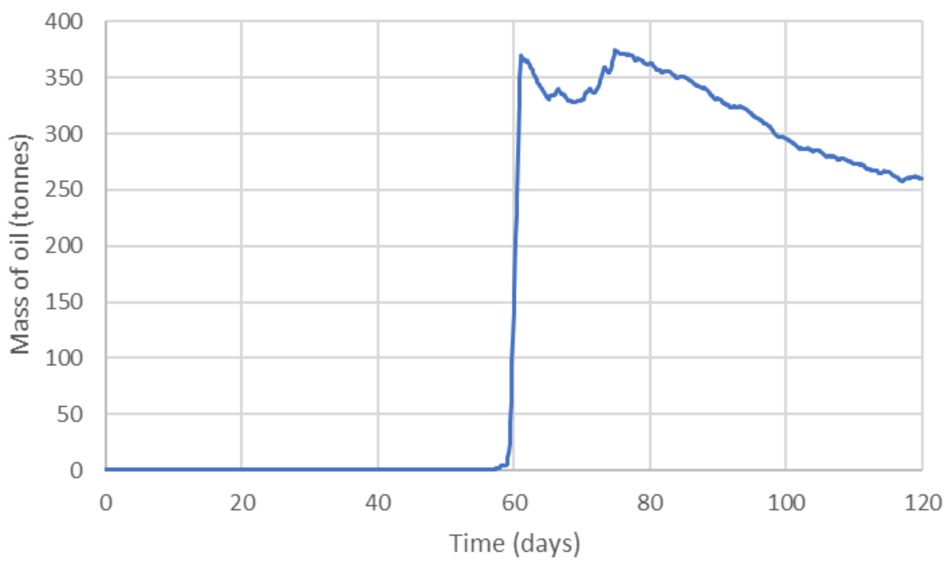


Figure 12.16: Forecast of oil arriving onshore in a worst case blow-out scenario

12.1.4.4.5 Subsea Well Blow-Out - Effect of oil spill response measures

The OSCAR model has been used to predict the effectiveness of oil spill response measures. Oil containment and recovery is the principal means of response, as dispersants are ineffective and burning is not expected to be successful. Oil containment and recovery has limited effectiveness in offshore sea states where significant wave height is > 2m), and a dedicated oil spill response vessel is not planned, but the available resources will be capable of response and this improves the potential outcomes. The assumptions around response resources are as follows and the initial model setup is illustrated in Figure 12.17.

- In the case of a blow-out, it is assumed that any vessels present would support rescue or source control activities for the first 24 hours, and there would be no recovery.
- After that, it is assumed that two recovery units would be available using a sidesweep boom system.
- Each recovery unit would have a boom encounter width of 15 m and a single skimmer capable of recovering 30 tonnes per hour (if that much oil is encountered by the boom) and could operate at a wave height of up to 2 m.
- Each recovery unit would store 200 tonnes of oil and take 48 hours to offload, as it is assumed that no offshore storage would be available.
- After 10 days, five recovery vessels contracted from the spot market in South America arrive on site, and it is assumed that each is able to recover 30 tonnes per hour.
- After 20 days, a further five recovery vessels contracted from the spot market in Africa arrive on site, and it is assumed that each is able to recover 30 tonnes per hour.

Note: It may be possible to recover oil to the FPSO. Alternatively, a specific recovery tanker will be mobilised (a Vessel Of Opportunity (VOO)).

Overall, these are relatively pessimistic assumptions and in reality, more resources may be available depending on other activities and vessels of opportunity. During production, MRSVs will be available with spill response capability or if any other vessel were available offshore, tanks could be offloaded more quickly. For the purposes of the assessment, the predicted recovery is seen as conservatively small. There are also many uncertainties in these predictions, both potentially positive and negative.

Applying these resources to the spill scenario, a new set of outputs is obtained. Key comparison data are provided in Table 12.5 and a graphical comparison of surface oil probability and the swept path of the surface oil in the deterministic case is shown in Figure 12.18.

Although the assumed response has a very modest effect and recovers 9% (2,419 tonnes) of the oil on average, it does improve the outcomes and represents realistic recovery assumptions under challenging sea conditions.

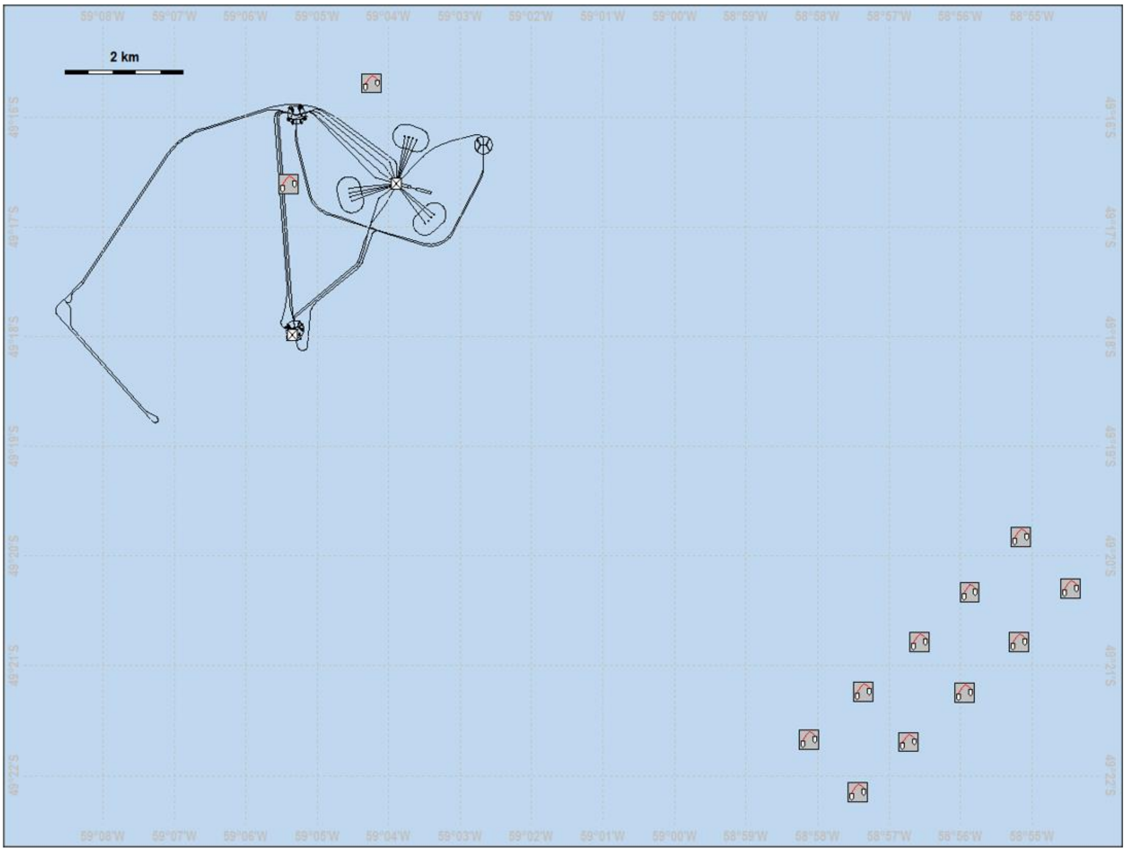
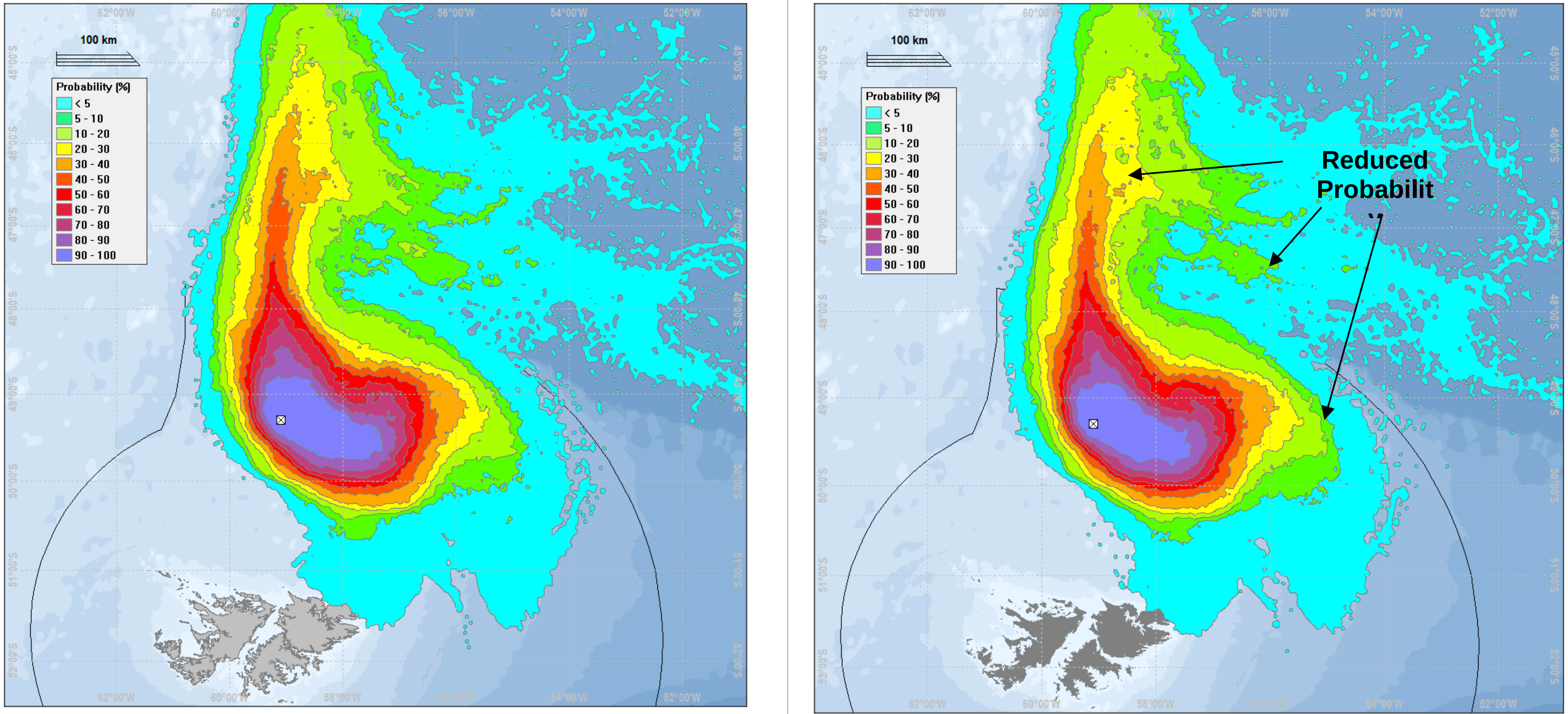


Figure 12.17: Spill response setup in OSCAR for well blow-out

Table 12.5: Summary of oil spill response effectiveness

Parameter	No response	With response
Proportion of scenarios reaching shore	8%	10%
Maximum mass of oil on shore	395 tonnes	304 tonnes
Average mass of oil on shore	118 tonnes	74 tonnes
Average proportion of oil recovered	Zero	9% (2,419 tonnes)

Note: Due to the particle motion physics, response modelling can result in fragmentation of large oil masses and a larger number of small particles in the model which are available to reach more shoreline cells, and therefore occasionally more scenarios will reach shore when response is applied. This is an artefact of the model and overall the response modelling shows that response reduces the maximum and average volume of oil reaching shore.



No Response – Surface Appearance Probability (1g/m^2)

Response - Surface Appearance Probability (1g/m^2)

Figure 12.18: Comparison of surface oil probability for well blow-out - no response/with response

12.1.4.5 Scenario 2: Loss of FPSO crude oil inventory and two offload tanker tanks - modelling results

12.1.4.5.1 Predicted behaviour of oil

The predicted overall behaviour and fate of Sea Lion crude after a FPSO crude inventory loss is shown in Figure 12.19. These results represent the scenario giving rise to the maximum oil on shore, and are also representative of the general oil behavior over a wide range of conditions.

Initially, the largest proportion of Sea Lion crude is found on the sea surface, however this will start to decrease after the discharge ceases, as the oil disperses in the water column and evaporates. The modelling predicts that after 20 days from the start of the discharge, 72 % (103,500 tonnes) of the oil will remain on the sea surface, approximately 16 % (23,620 tonnes) will be dispersed in the water column, and 7% (9,669 tonnes) is expected to have evaporated. Similar to the well blow-out scenario, Figure 12.19 indicates that crude oil begins to move outside the modelling grid after approximately 40 days. However, the fact that oil goes beyond the modelling grid does not affect the overall conclusions drawn from the model.

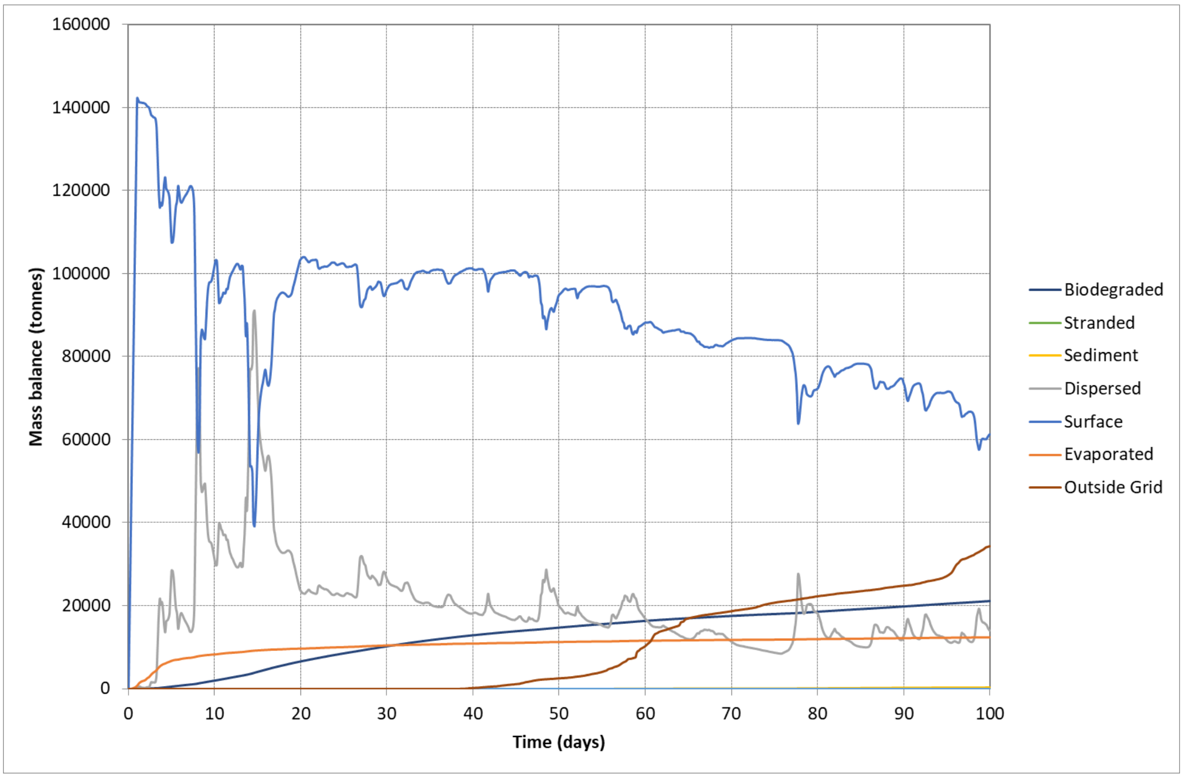


Figure 12.19: Predicted overall behaviour of Sea Lion crude oil after FPSO inventory loss

12.1.4.5.2 FPSO Inventory Loss - Surface results

Figure 12.20 shows the probability of Sea Lion crude oil occurring above the threshold of 1 g/m^2 on the sea surface at any time throughout the entire model period. Because Sea Lion is such a low density waxy crude oil that is persistent and does not biodegrade quickly, there is a high probability that wax will be found on the sea surface at large distances from the initial discharge location. The modelling predicts that there is a greater than 90% probability that wax could be found up to 220 km north of the FPSO location, and that surface oil is more likely to spread in a northerly direction from the FPSO. This is due to the predominant currents around the Sea Lion location, which travel in a northerly direction. Surface oil is also predicted to appear at locations to the south-east of the FPSO location, which is likely due to wind driven surface currents. The modelling predicts that, in the unlikely event of a full FPSO inventory loss, there is a high probability (above 90 %) that the crude oil will travel on the sea surface outside of the FOCZ and into international waters.

Figure 12.21 shows the predicted minimum time taken for oil above the threshold of 1 g/m^2 to arrive at any location on the sea surface after a full FPSO inventory loss. Due to the persistence and low biodegradation rate of Sea Lion crude, the oil can potentially travel very long distances. In the most mobile of conditions, the crude oil can travel up to 35 km within one day, 97 km within five days, and up to 350 km within 15 days from the start of the discharge. However, it is predicted that after 15 days the oil will be in a highly dispersed state. In the event of the loss of the full FPSO crude inventory, it is predicted that oil will cross the FOCZ boundary after approximately five days.

Figure 12.22 shows the maximum time that any sea surface location is exposed to crude oil above the surface threshold of 1 g/m^2. At locations close to the FPSO location, the sea surface could be exposed to oil for up to 23 days. Further away from the discharge location, the maximum exposure time decreases as the oil becomes dispersed due to wave action and weather conditions.

A cumulative area of 14,000 km^2 over the whole scenario is predicted to be exposed at a concentration of more than 100 g/m^2 and 3,000 km^2 is predicted to be above 1,000 g/m^2, again as a cumulative total. 1,000 g/m^2 is the level at which staining and adhesion of oil on feathers has been observed in the laboratory (CEDRE, 2017). At any instant, the area exposed to oil densities above 1,000 g/m^2 is much smaller, e.g. 44 km^2 at 10 days after the start of the release (at 20 days there is no area above 1,000 g/m^2).Figure 12.24 compares the outputs for the different levels of oil concentration.

The results in Figure 12.24 are based on an aggregation of results from all the stochastic model runs and therefore do not represent a single spill scenario.

Therefore, a single deterministic model run of the FPSO inventory loss scenario was conducted to show the behaviour of discharged oil for a single, worst case, spill scenario. The total impacted surface area above the threshold of 1 g/m^2 is shown in Figure 12.23a, in which the maximum oil densities observed at any location throughout the whole modelling duration of 120 days are presented. An example snapshot of the surface wax after three days from the start of the discharge is shown in Figure 12.23b.

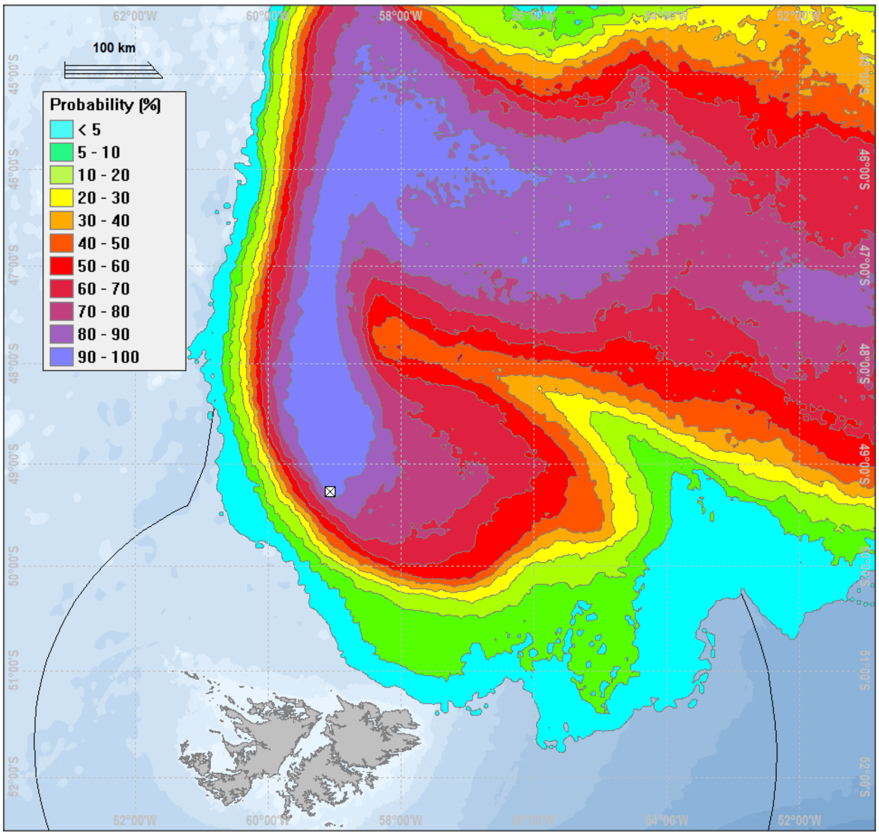


Figure 12.20: Probability of surface contamination above threshold of 1 g/m^2 following FPSO inventory loss

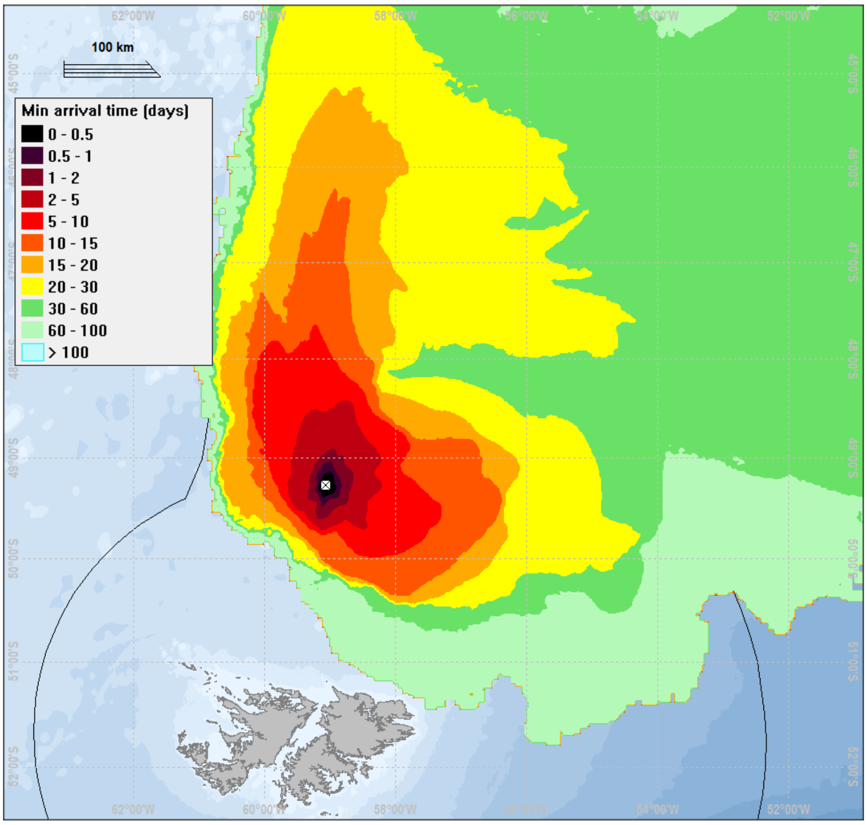


Figure 12.21: Minimum arrival times of Sea Lion crude above 1 g/m^2 on the surface following FPSO inventory loss

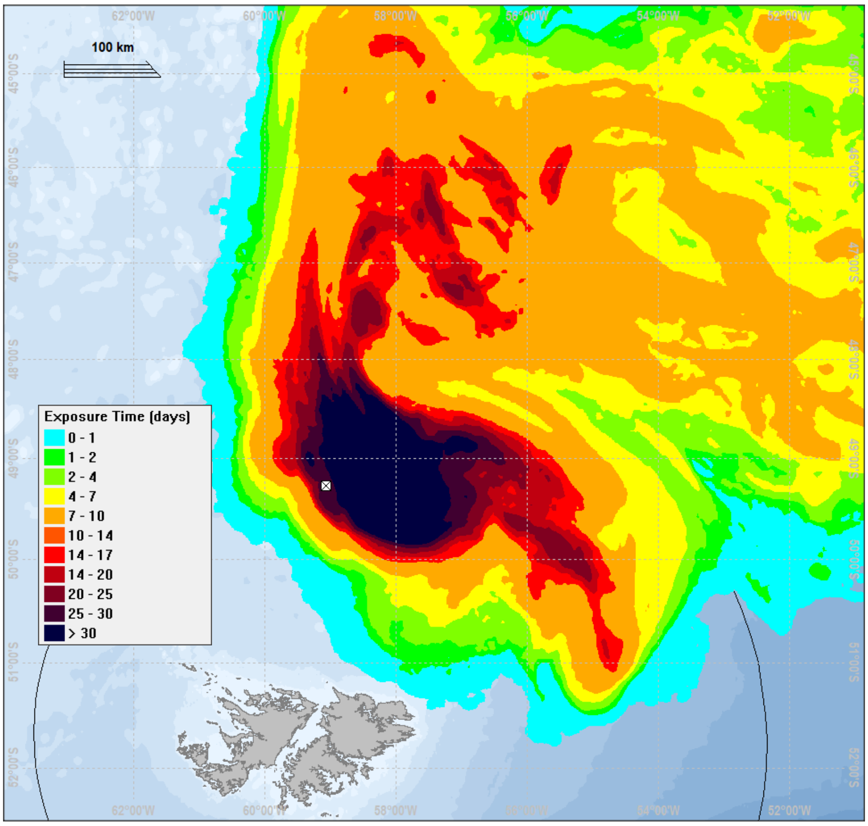
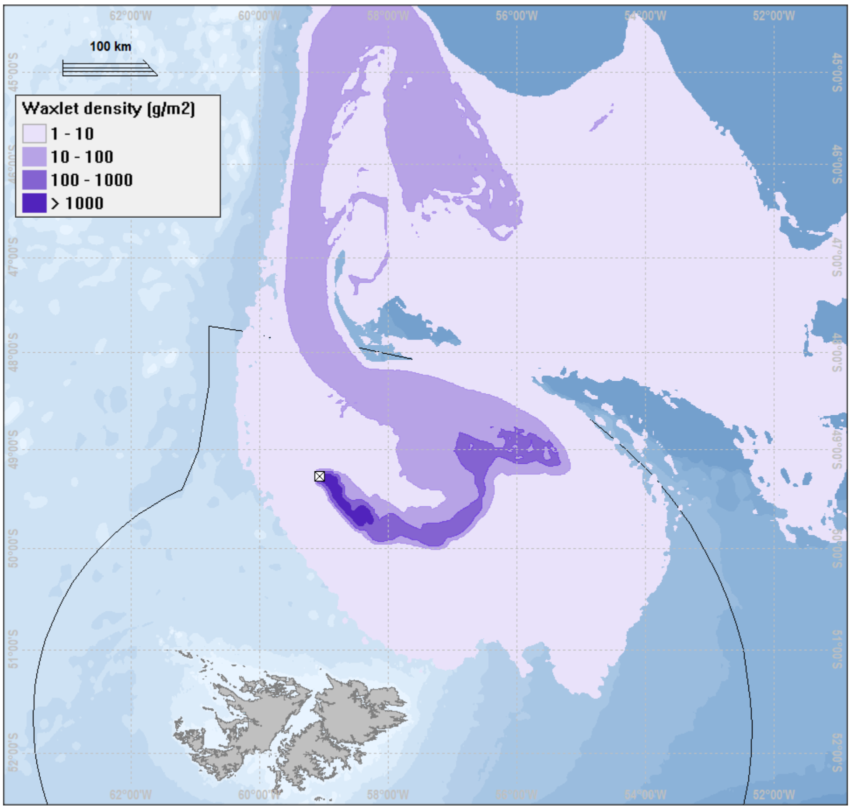
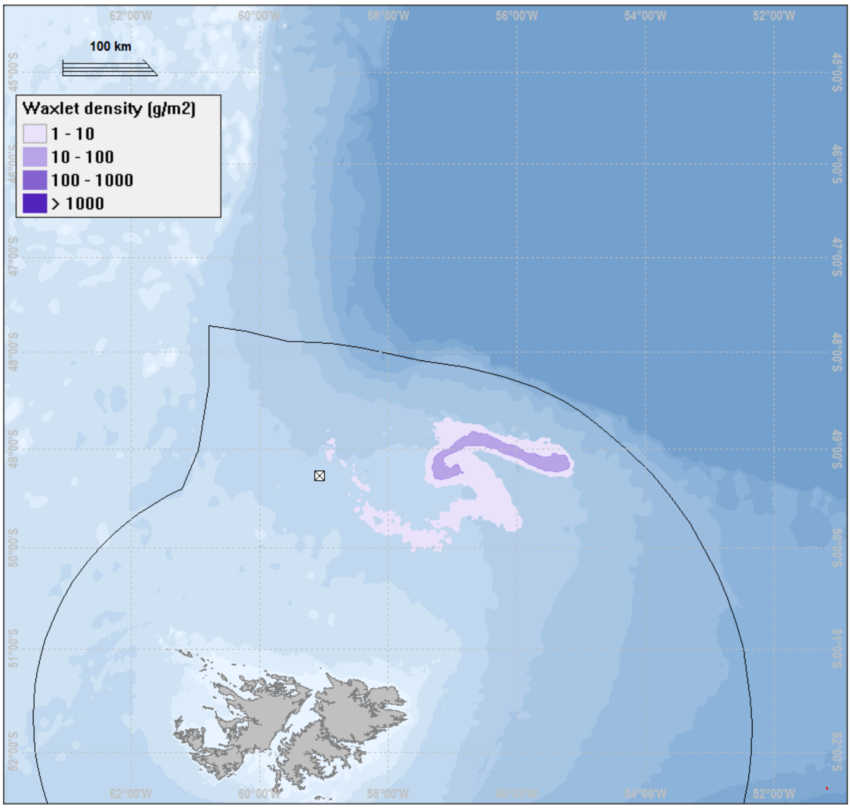


Figure 12.22: Maximum time surface is exposed to Sea Lion crude above 1 g/m^2 following FPSO inventory loss

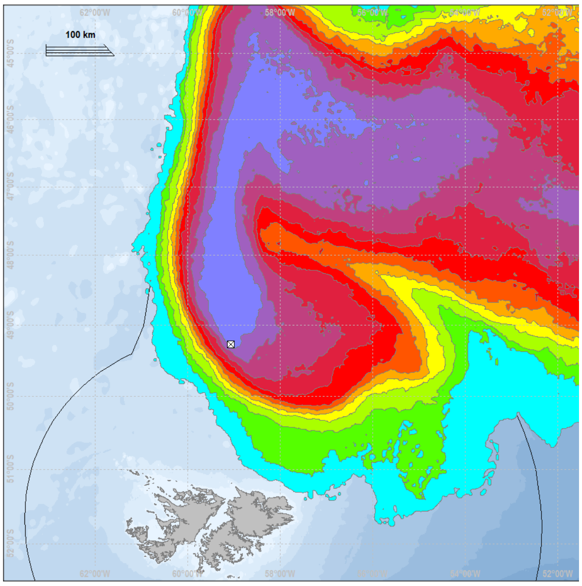


a) Total impacted surface area above threshold of 1 g/m^2 for single deterministic model run

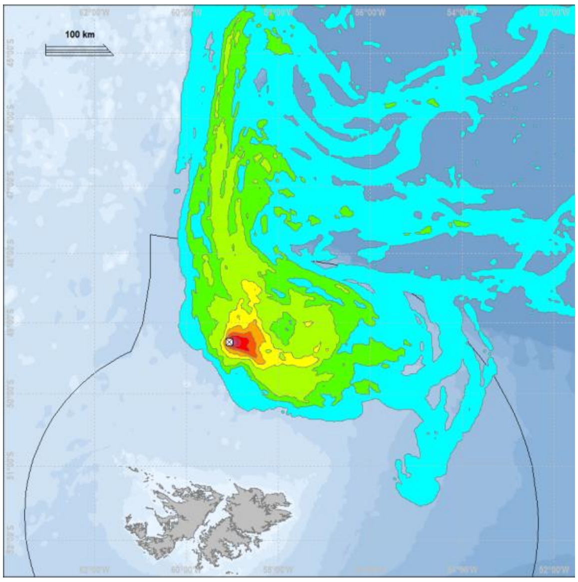


b) Example snapshot of surface wax above 1 g/m^2

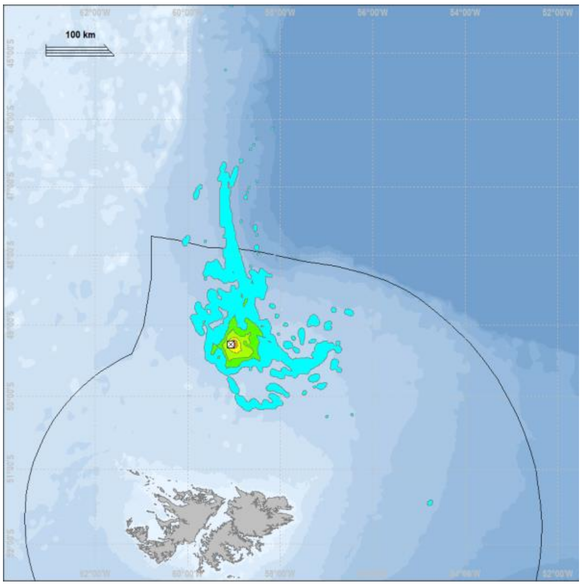
Figure 12.23: Surface results (deterministic) for FPSO inventory loss (at 30 days)



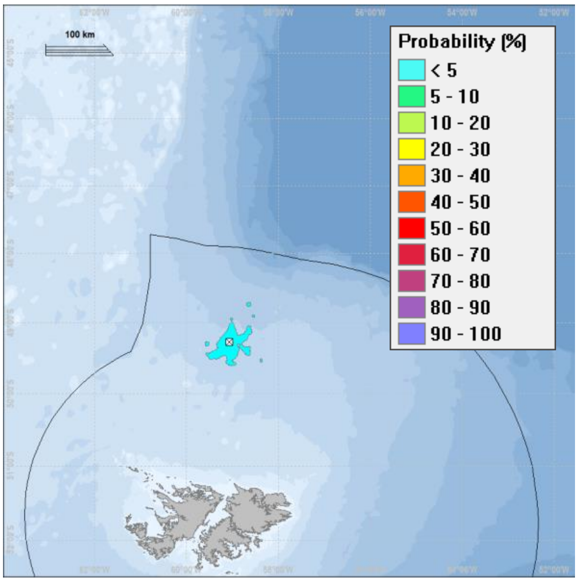
a) Probability >1 g/m^2



b) Probability >10 g/m^2



c) Probability >100 g/m^2



d) Probability >1,000 g/m^2

Figure 12.24: Probability of Surface Oiling at Differing Oil Densities following FPSO inventory loss

12.1.4.5.3 FPSO Inventory Loss - Water column results

The probability of oil occurring in the water column above the threshold of 25 ppb is presented in Figure 12.25. The model predicts that in the event of the entire FPSO crude inventory being lost, there is high probability that large areas of the water column will have concentrations of crude oil above the 25 ppb threshold. The crude oil is carried predominantly northwards through the water column by the strong underlying Falklands Current (Figure 12.25).

It is predicted that a large volume of water around the discharge location will be exposed to water column concentrations exceeding 25 ppb for over 30 days (Figure 12.26). The longest time that any location is predicted to be exposed to crude oil above 25 ppb is approximately 16 days. At distances further from the discharge location, the water column exposure time declines significantly as the crude oil becomes more dispersed through wave action and sea conditions.

The probability and maximum water column exposure times shown in Figure 12.25 and Figure 12.26 represent the aggregation of results from the stochastic simulations that cover a wide range of metocean conditions, which influence the transport of released crude oil through the water column. These results should therefore not be misinterpreted as being representative of a single spill scenario.

A deterministic model was conducted to predict the total area in which the threshold of 25 ppb would be exceeded for a single run, based on the worst case metocean conditions identified from the stochastic modelling. Figure 12.27a illustrates the maximum total water column concentrations that were observed at any time during the deterministic model run period of 120 days. The model predicts that, at some time after the start of the release, areas of the water column close to the discharge location could be subjected to water column concentrations in excess of 1,000 ppb (1 ppm). The cross-sectional plot in Figure 12.27b shows that crude oil is typically expected to reach depths of 150 m. Figure 12.27b shows a snapshot of the water column concentrations at a single instance in time.

Figure 12.28 shows the water column concentrations of dissolved oils only and a cross section of the same is presented in Figure 12.28b. This indicates that dissolved oils are contributing very little to concentrations of oil in the water column.

It is predicted that initial oil concentrations in the water column shortly after the release will be in the tens of parts per million. Such high concentrations result from the model setting the FPSO inventory loss / discharge to just one day, and the initial release of water soluble components from the surface of the oil. It is predicted that the maximum oil concentrations in the water column will very rapidly decrease after this initial period of high concentrations.

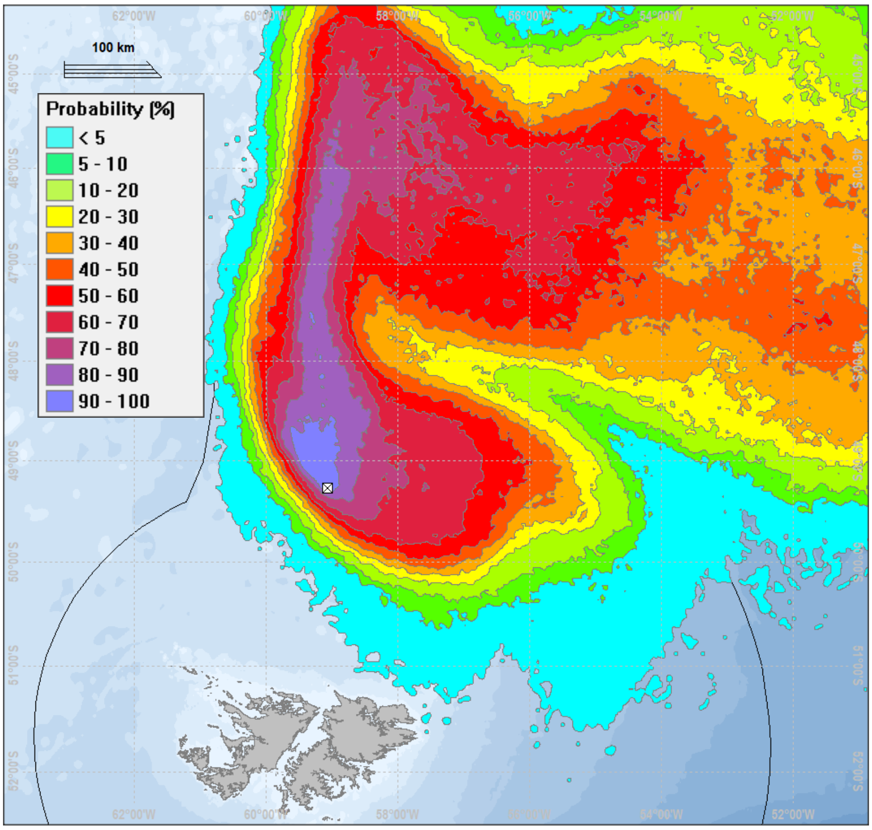


Figure 12.25: Probability of water column contamination above threshold of 25 ppb (stochastic) for FPSO inventory loss

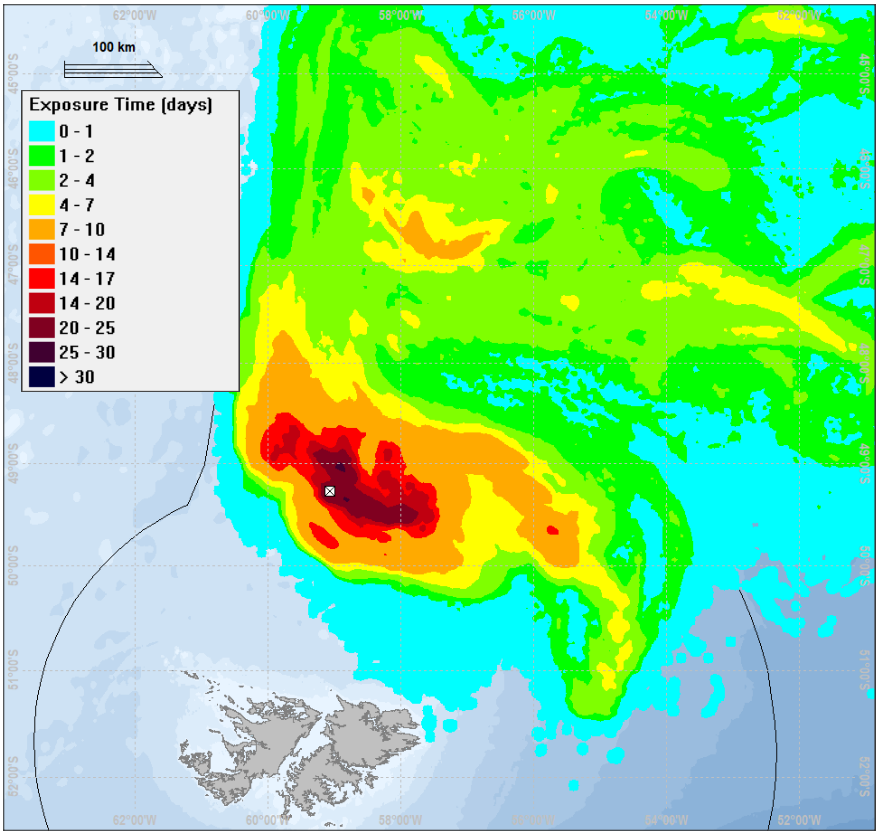
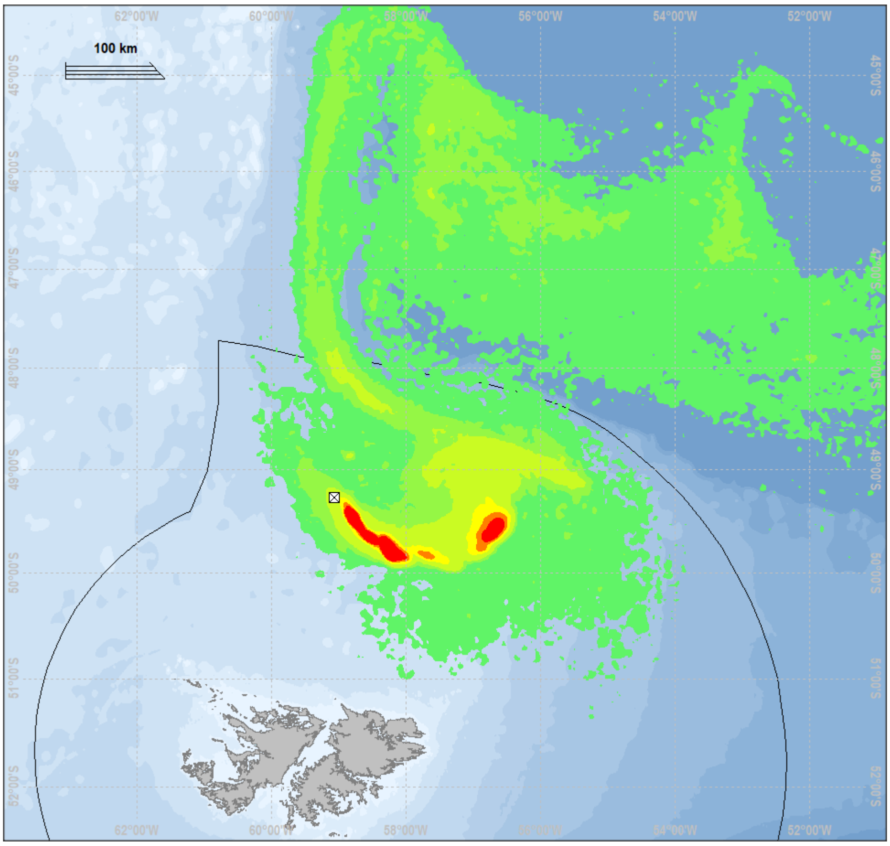
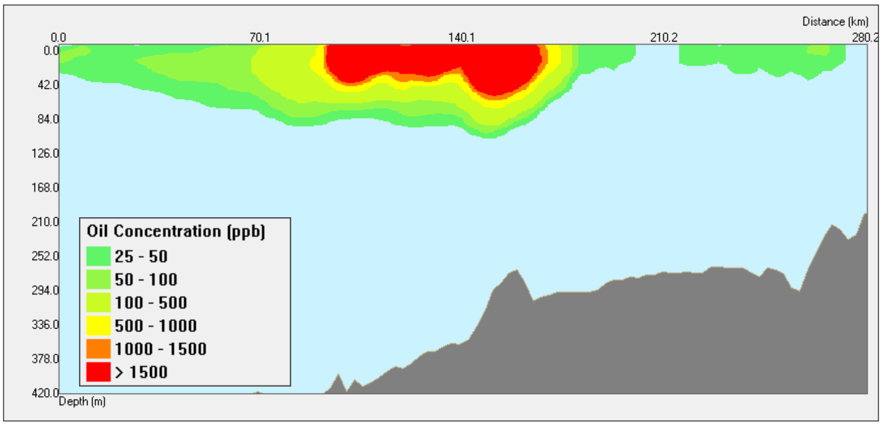


Figure 12.26: Maximum time water column is exposed above threshold of 25 ppb (stochastic) for FPSO inventory loss

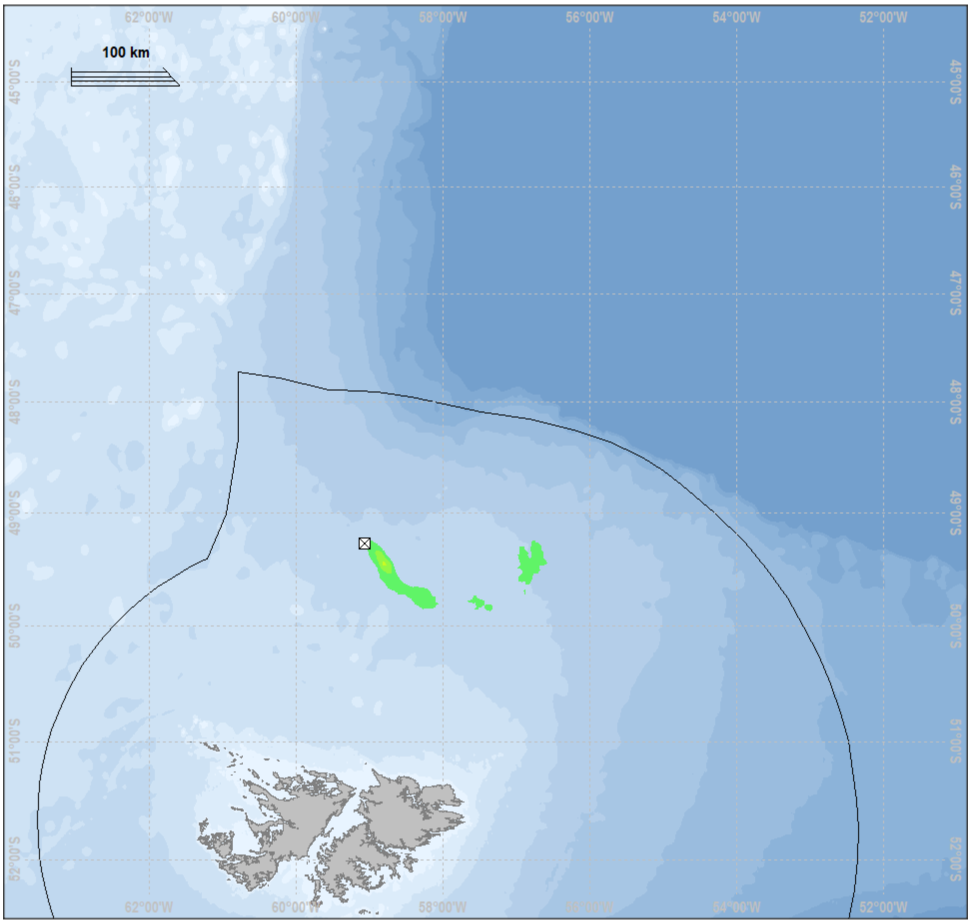


a) Cumulative water column concentration dissolved oil and oil droplets

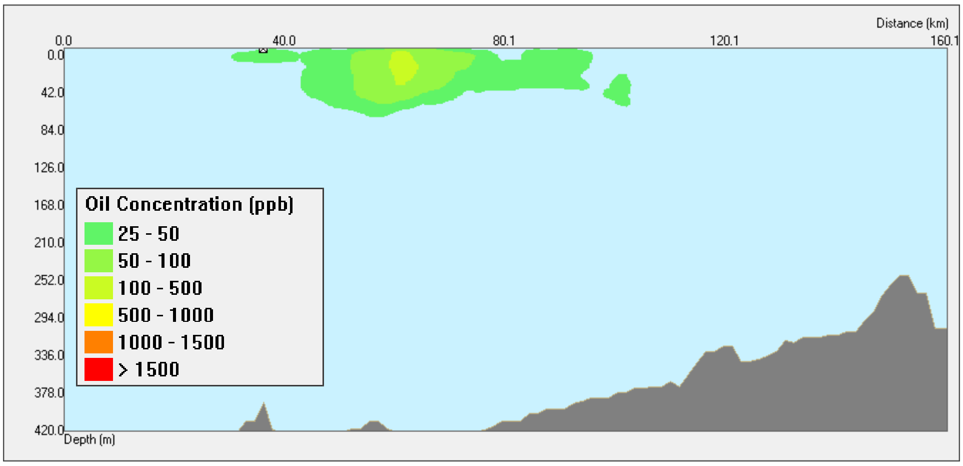


b) Cross-section of cumulative water column concentration dissolved oil and oil droplets

Figure 12.27: Cumulative water column concentrations from an FPSO inventory loss



a) Cumulative water column concentration dissolved oil only



b) Cross-section of cumulative water column concentration dissolved oil only

Figure 12.28: Water column results (dissolved oil only) from FPSO inventory loss

12.1.4.5.4 FPSO Inventory Loss - Shoreline results

Figure 12.29 shows the probability of oil reaching the Falklands coastline after the loss of the entire FPSO crude oil inventory by identifying the initial beaching locations. The modelling results indicate that there is a low probability of crude oil reaching the shoreline. The northern coastline of East Falkland is predicted to be the most likely place where oil could beach. However, the greatest probability of shoreline oiling was observed to be 6%, indicating that only three of the 51 individual stochastic simulations resulted in crude oil reaching the Falklands coastline.

Consequently, in the event of the complete loss of the FPSO crude oil inventory, shoreline oiling is possible, but highly unlikely. The maximum mass of oil on shore was predicted to be 27 tonnes, and the average was 19 tonnes. Given the highly dispersed state of the oil when encountering shore and the long length of coast over which the oil is predicted to arrive, it is possible that this would not be detectable.

Figure 12.30 shows the minimum time taken for any oil to reach the shoreline in the worst case oil beaching scenario, which was observed to be approximately 66 days. It is predicted that any crude oil that eventually reaches the Falklands coastline would be in a highly dispersed state due to it having been at-sea for at least 66 days before reaching the coastline. It is therefore likely that only small individual masses of oil would reach the shoreline.

A single deterministic run of the FPSO crude inventory loss scenario was conducted to further investigate shoreline oiling. The time frame for this single deterministic run was selected to coincide with the stochastic simulation that resulted in the worst case mass of oil arriving onshore. The predicted worst case shoreline oiling is shown in Figure 12.31. The worst case shoreline concentration at this instance in time was predicted to be just over 1 kg/m^2.

Figure 12.32 shows the temporal pattern of oil arriving onshore for the deterministic scenario for the most oil beaching. Again, this illustrates that only an extremely small proportion of the total mass discharged eventually reaches the shoreline. Note that there are some small differences between the stochastic and deterministic plots, which are a product of slightly simplified algorithms used in the stochastic runs and the sensitivity of the model to the very small amount of oil reaching shore in this case.

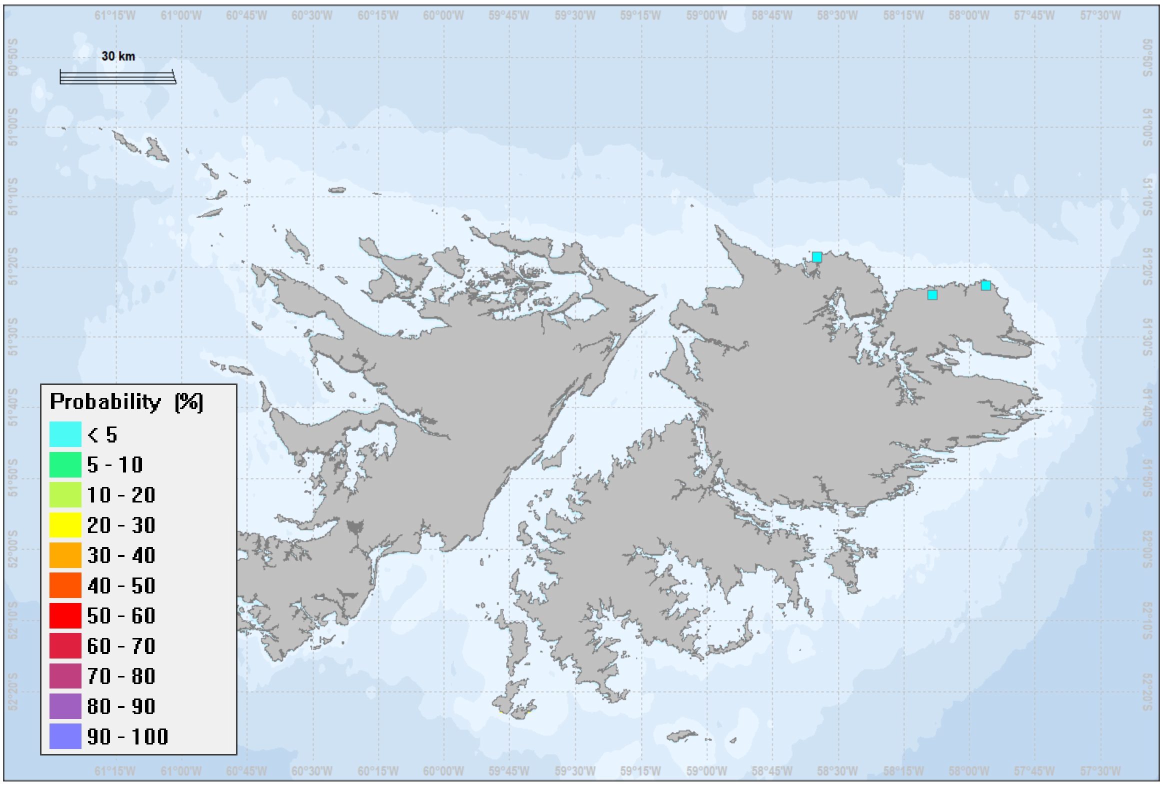


Figure 12.29: Probability of shoreline oiling for an FPSO inventory loss

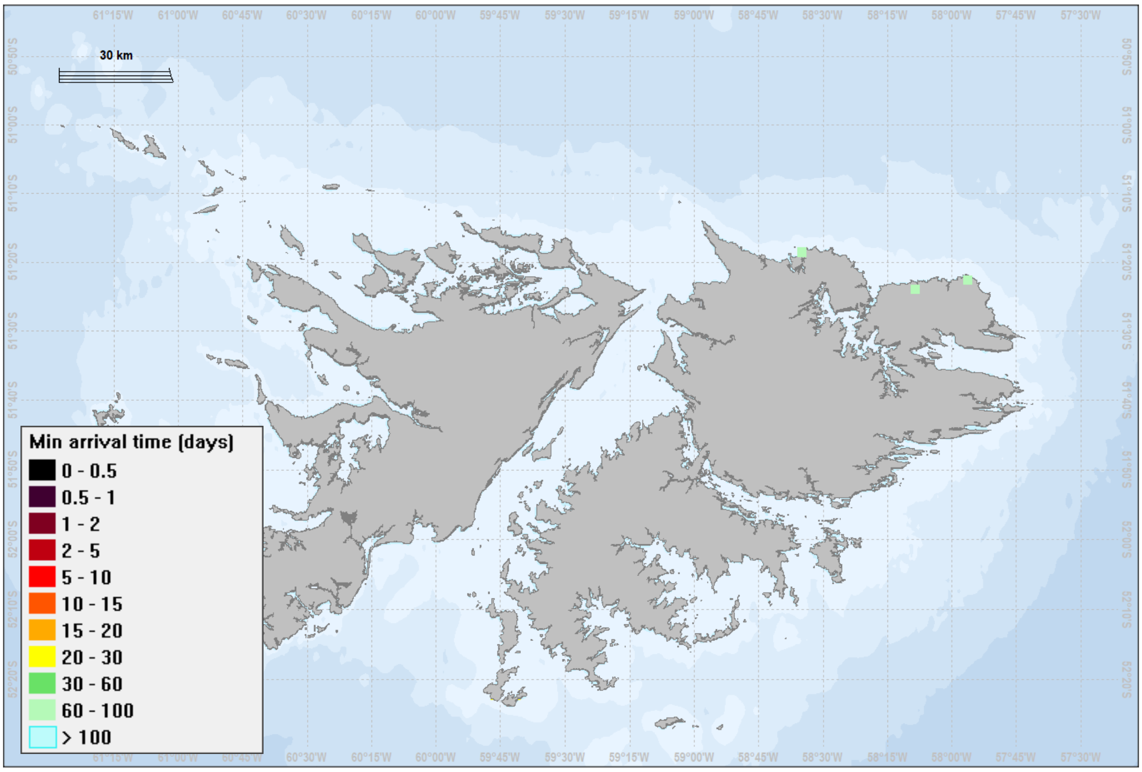


Figure 12.30: Minimum arrival times for shoreline oiling for an FPSO inventory loss

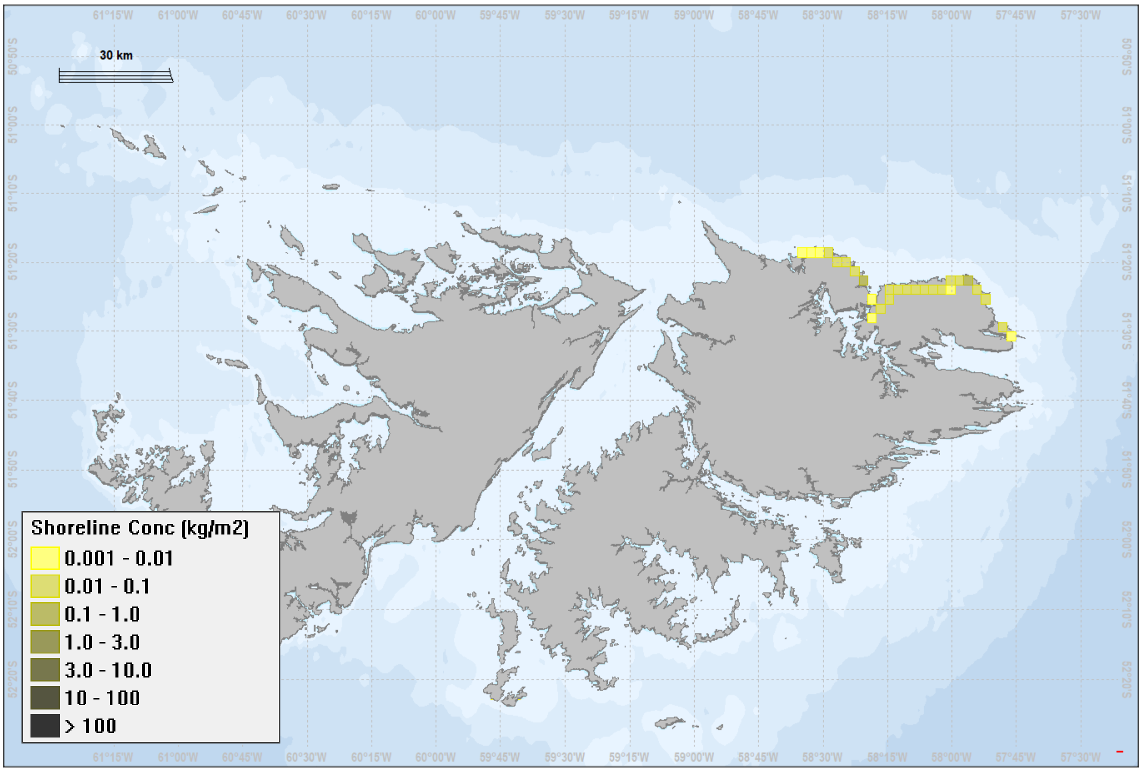


Figure 12.31: Concentration of oiling on the shoreline for an FPSO inventory loss (deterministic)

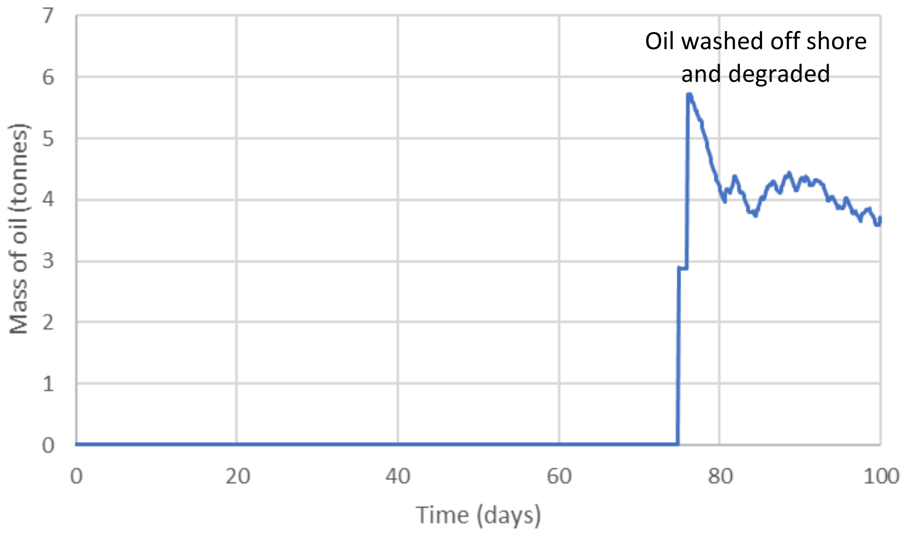


Figure 12.32: Time evolution of oil on shoreline for FPSO inventory loss (deterministic)

12.1.4.5.5 FPSO Inventory Loss - Effect of oil spill response measures

The OSCAR model has been used to predict the effectiveness of oil spill response measures. Oil containment and recovery are the principal means of response, as dispersants are ineffective and burning is not expected to be successful. Oil containment and recovery has limited effectiveness in offshore sea states, and a dedicated oil spill response vessel is not planned, but the available resources will be capable of response and this improves the potential outcomes. The assumptions around response resources are as follows and the initial model setup illustrated in Figure 12.33.

- During the type of incident that might lead to a full release of FPSO inventory, it is assumed that any vessels present would be occupied with rescue or source control activities for the first 24 hours, and would therefore not be involved in any oil recovery operations.
- After that, it is assumed that two recovery units would be available using a sidesweep boom system.
- Each recovery unit would have a boom encounter width of 15 m and a single skimmer capable of recovering 30 tonnes per hour (if that much oil is encountered by the boom) and could operate at a wave height of up to 2 m.
- Each recovery unit would store 200 tonnes of oil and take 48 hours to offload, as it is assumed that no offshore storage would be available.
- After 10 days, five recovery vessels contracted from the spot market in South America arrive on site, and it is assumed that each is able to recover 30 tonnes per hour.
- After 20 days, a further five recovery vessels contracted from the spot market in Africa arrive on site, and it is assumed that each is able to recover 30 tonnes per hour.

Note: A specific recovery tanker will be mobilised (a Vessel Of Opportunity (VOO)).

Overall, these are relatively pessimistic assumptions and in reality, more resources may be available depending on other activities and vessels of opportunity. An additional MRSV would normally be available or if any other vessel were available offshore, tanks could be offloaded more quickly. For the purposes of the assessment, the predicted recovery is seen as conservatively small. There are also many uncertainties in these predictions, both potentially positive and negative.

Applying these resources to the spill scenario, a new set of outputs is obtained. Key comparison data is given in Table 12.6 and a graphical comparison of surface oil probability and the path of the surface oil in the deterministic case is shown in Figure 12.34.

Although the assumed response has a very modest effect and recovers 2% (2,448 tonnes) of the oil on average, it does improve the outcomes and represents realistic recovery assumptions under challenging sea conditions. Recovery for this case is proportionally smaller because the inventory loss volume is much larger than the well blow-out volume and because the oil is largely dispersed by the time the OSRL recovery vessels arrive.

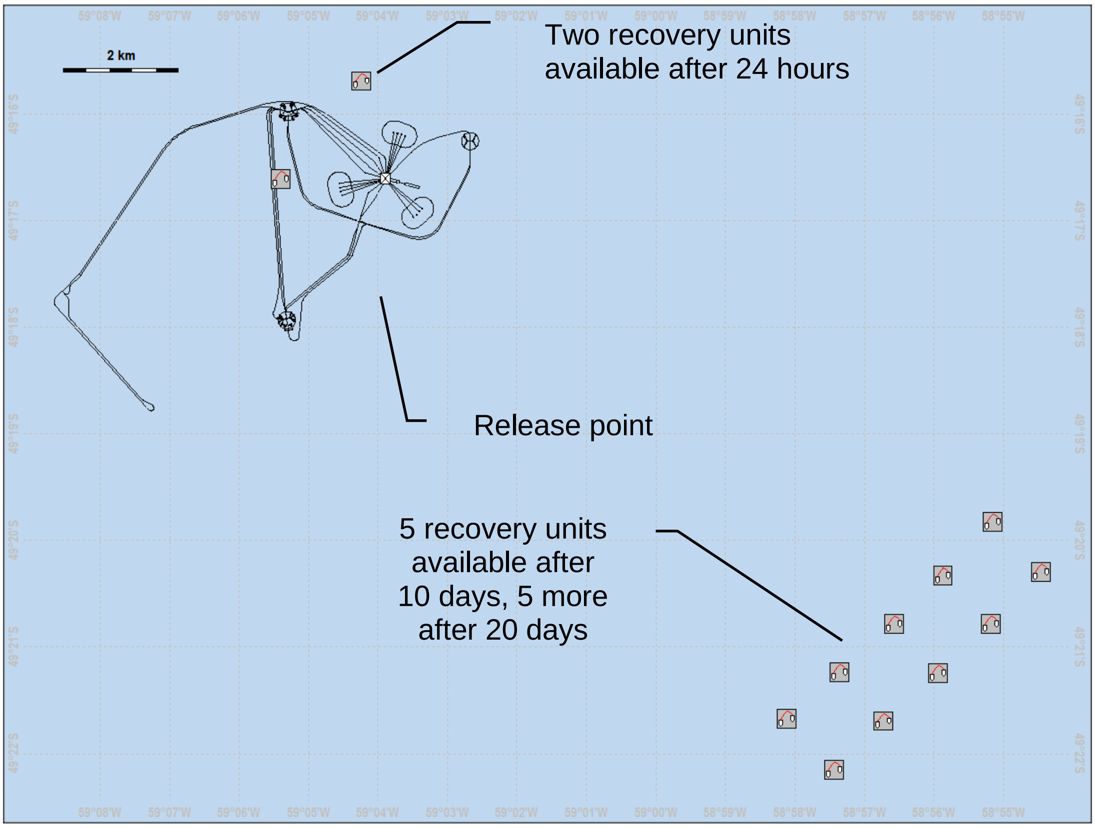


Figure 12.33: Spill response setup in OSCAR for FPSO inventory loss

Table 12.6: Summary of oil spill response effectiveness

Parameter	No response	With response
Proportion of scenarios reaching shore	4%	6%
Maximum mass of oil on shore	27 tonnes	11 tonnes
Average mass of oil on shore	19 tonnes	6 tonnes
Average proportion of oil recovered	Zero	1.45% (1,901 tonnes)

Note: Due to the particle motion physics, response modelling can result in fragmentation of large oil masses and a larger number of small particles in the model which are available to reach more shoreline cells, and therefore occasionally more scenarios will reach shore when response is applied. This is an artefact of the model and overall the response modelling shows that response reduces the maximum and average volume of oil reaching shore.

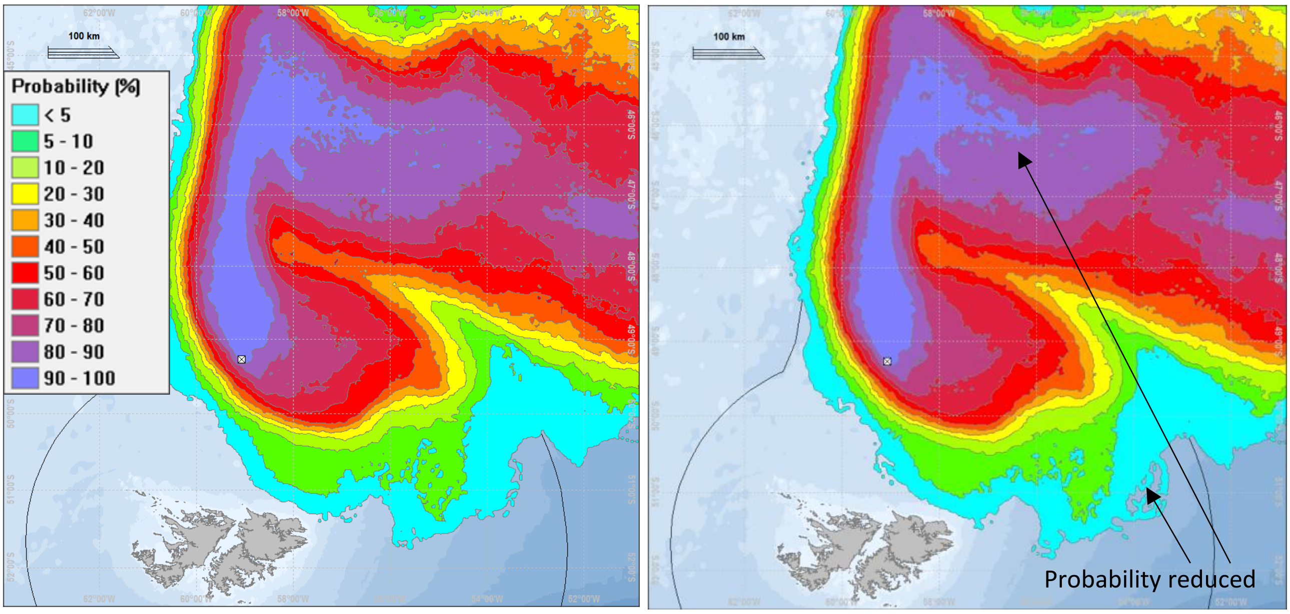


Figure 12.34: Comparison of surface oil probability for FPSO inventory loss - no response/with response

12.1.4.6 Scenario 3: Crude oil transfer spill - modelling results

12.1.4.6.1 Predicted behaviour of oil

The predicted overall behaviour of the Sea Lion crude after an offshore crude transfer spill is shown in Figure 12.35. The results here have been obtained by averaging masses over all the stochastic modelling runs. These results therefore do not represent a single model run, but serve to illustrate the expected overall behaviour of the discharged oil.

The discharge has been set to occur on the sea surface, so this is where the highest mass of crude oil will initially be found. After release, the crude oil is predicted to begin to evaporate from the surface, as well as being dispersed in the water column. Five days after the start of the discharge it is predicted that 94 % (58 tonnes) of the discharge will be left on the sea surface, with 1 % (0.62 tonnes) dispersed in the water column, and 5 % (3 tonnes) evaporated. Due to the Sea Lion oil being a persistent waxy crude, it is predicted that biodegradation will occur at a very slow rate. By the end of the model run duration (30 days), it is predicted that over 86% (53 tonnes) of the Sea Lion crude will still be on the surface at low densities, 7% (4 tonnes) will have evaporated, 4% (2 tonnes) will be in the water column, and biodegradation will have risen to 2-3% (1 – 2 tonnes).

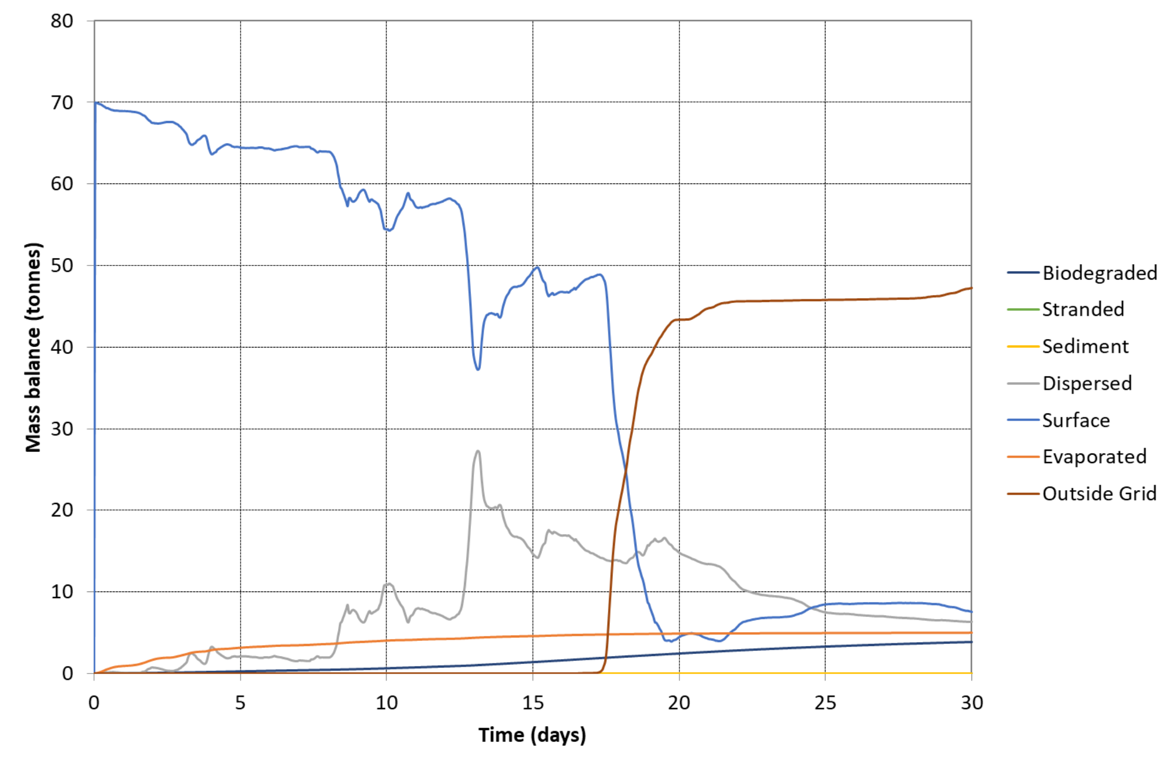


Figure 12.35: Predicted overall behaviour of Sea Lion crude oil after a crude transfer spill

12.1.4.6.2 Crude oil transfer spill - Surface results

Figure 12.36a shows the probability of oil contamination on the sea surface, the minimum time taken for oil to disperse on the sea surface, and the maximum time that any surface location is exposed to oil above the threshold of 1 g/m^2. These maps are based on the aggregation of results from different stochastic modelling runs and are not indicative of a single model output.

The probability of Sea Lion crude accumulating on the sea surface above the threshold of 1 g/m^2 is relatively low (Figure 12.36a), particularly in comparison with the larger well blow-out and FPSO inventory loss scenarios presented and discussed in the previous sections. The low probabilities illustrate that the small volume of crude oil discharged (63 tonnes) is expected to disperse very quickly in the water column (see Figure 12.35 above), and a small fraction will evaporate from the surface.

Figure 12.36b shows the minimum time taken for oil from a crude transfer spill to arrive at any location on the modelling grid. In the most mobile of conditions, the Sea Lion crude oil could potentially disperse up to 20 km within one day, and up to 45 km within four days. The model predicts that after four days, most of the crude oil on the sea surface will either have evaporated or have been dispersed in the water column (Figure 12.36c).

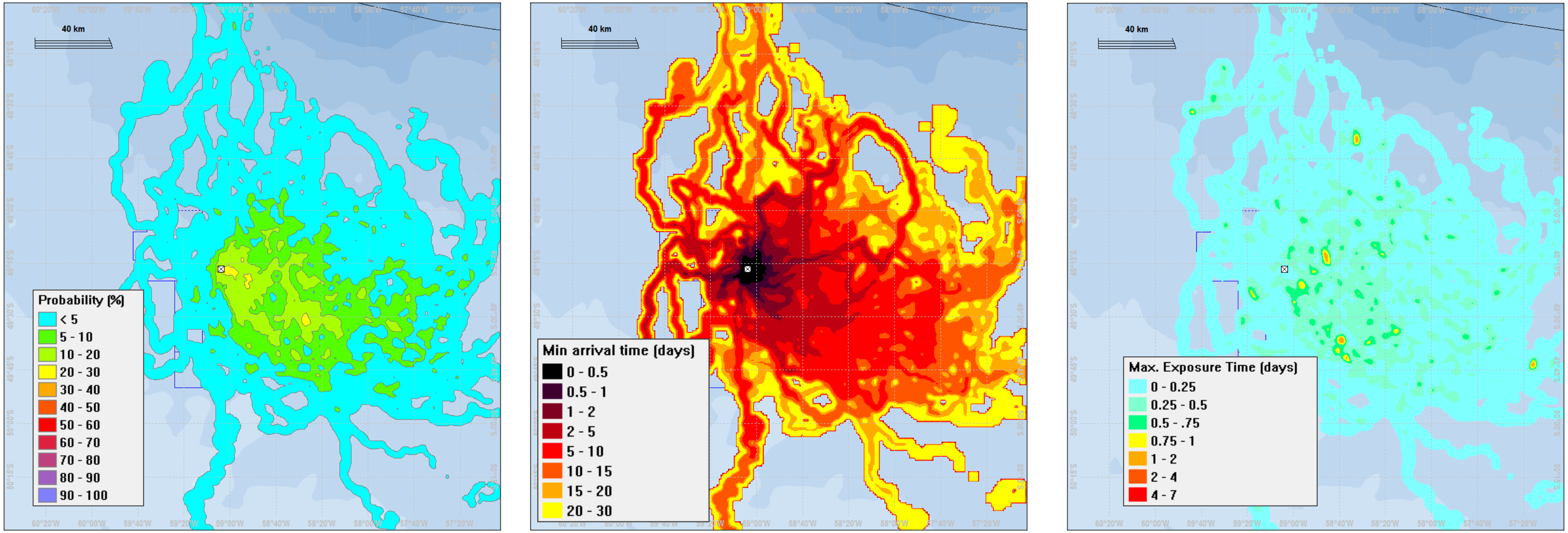
Figure 12.37 shows the total surface area impacted above the threshold of 1 g/m^2 for a single deterministic run of the crude transfer spill scenario. This graphic shows the typical area that will be affected after a crude transfer spill of 70 m^3 (63 tonnes).

12.1.4.6.3 Crude oil transfer spill - Water column results

None of the stochastic simulations resulted in oil concentrations in the water column exceeding the threshold of 25 ppb at any point during the model run duration (30 days). Water column concentrations are expected to decrease rapidly after the end of the discharge, with concentrations typically decreasing back to ambient conditions after a few days.

12.1.4.6.4 Crude oil transfer spill - Shoreline results

No shoreline oiling was predicted during any of the stochastic simulations of the crude oil transfer spill scenario. Due to the small volume of oil being discharged, and the large distance between the discharge location and the Falklands coastline, it is extremely unlikely that such a spill would result in any oil reaching the coastline of the Falkland Islands.



a) Probability of surface contamination above threshold of 1 g/m^2

b) Minimum arrival times of Sea Lion crude above 1 g/m^2 on the surface

c) Maximum time surface is exposed to Sea Lion crude above 1 g/m^2

Figure 12.36: Surface results (stochastic) for crude transfer spill

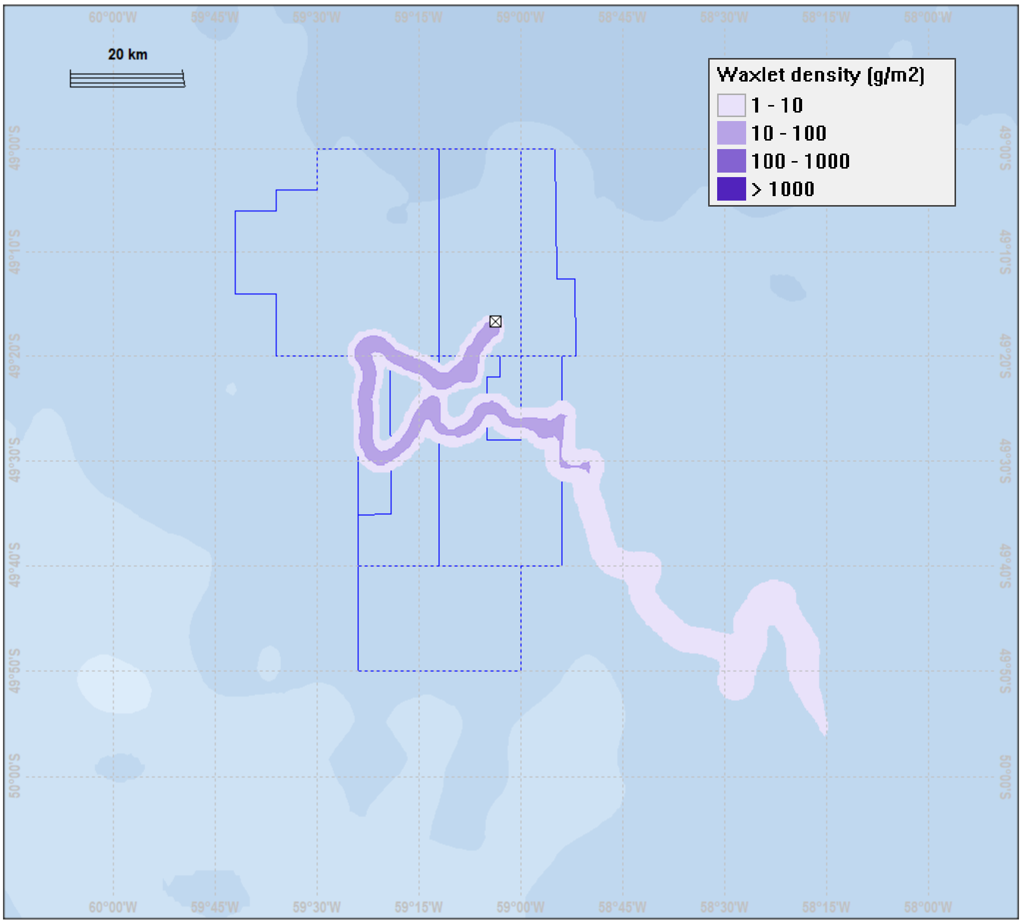


Figure 12.37: Total impacted surface area above threshold of 1 g/m^2 for single deterministic model run of crude oil transfer spill scenario

12.1.4.7 Scenario 4: Loss of MODU diesel inventory - modelling results

12.1.4.7.1 Predicted behaviour of oil

Figure 12.38 shows the predicted behaviour and fate of the discharged diesel following the accidental loss of the full diesel inventory of the MODU. These results are based on 99 stochastic model runs of the diesel inventory loss scenario.

Initially, most of the diesel will be found on the sea surface, after which it is likely to be quickly dispersed in the water column and evaporated or biodegraded from the sea surface owing to its higher volatility (section 12.1.4.1.1). The modelling predicts that after 10 days, none of the discharged diesel will be left on the sea surface, as 47% (1,850 tonnes) of it will have evaporated, and 31% (1,220 tonnes) of the total discharge will have biodegraded. After 30 days, it is predicted that 50% (1,968 tonnes) of the diesel will have evaporated and 45% (1,771 tonnes) will have biodegraded.

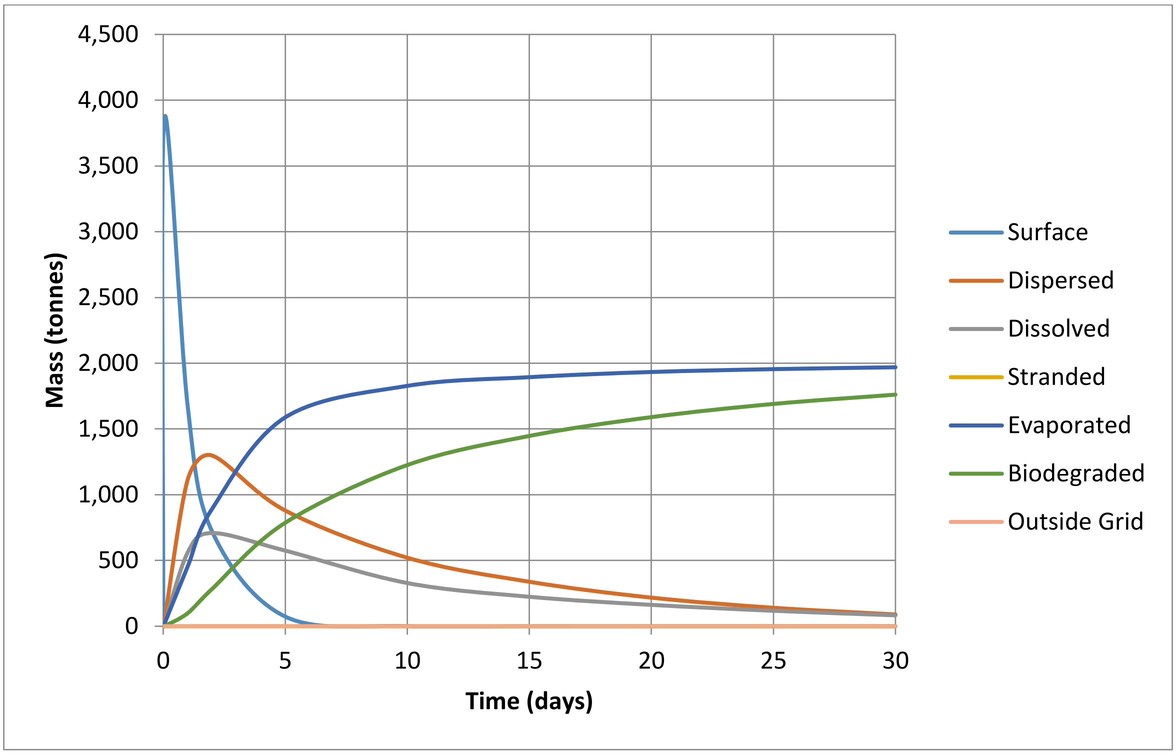


Figure 12.38: Predicted overall behaviour of diesel after a diesel inventory loss

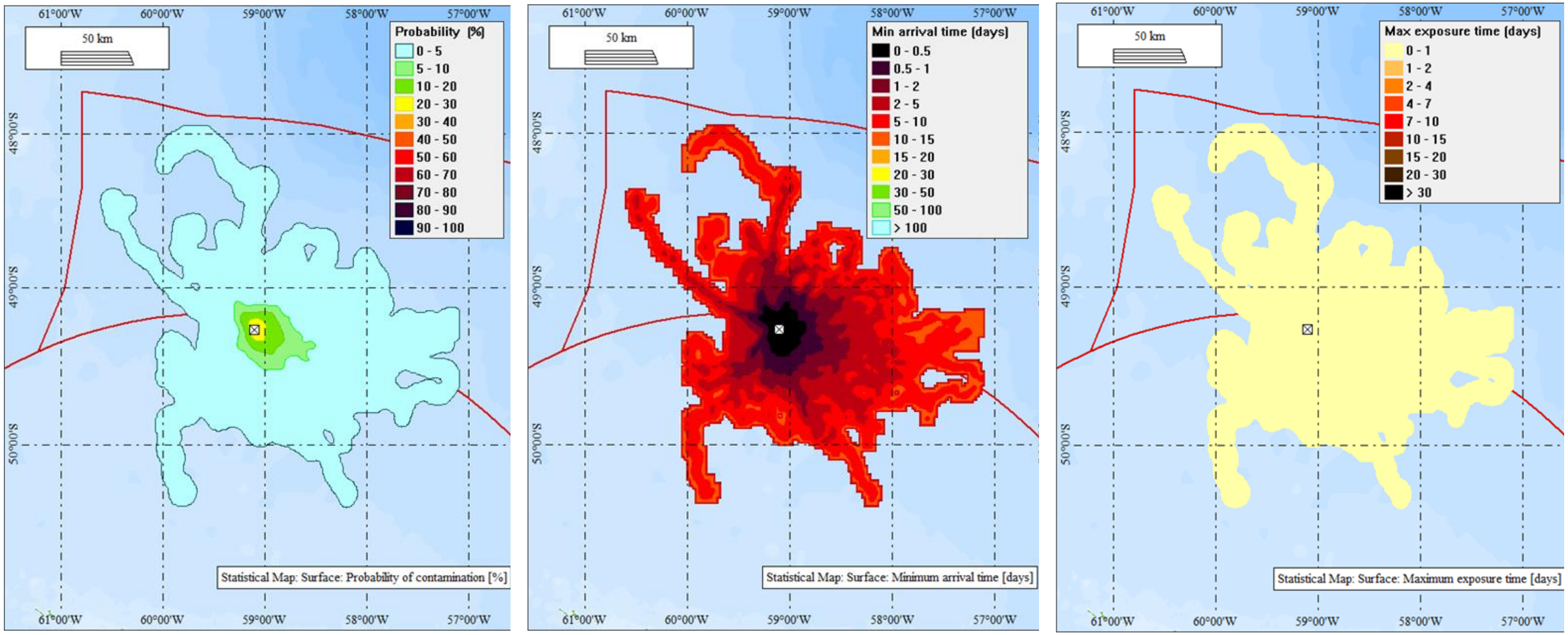
12.1.4.7.2 Loss of MODU diesel inventory - Surface results

Figure 12.39a shows the probability of diesel occurring above the threshold of 0.3 µm on the sea surface. The probabilities vary from 20-30% near the discharge location to less than 5% at locations further from the discharge site (beyond approximately 30 km). The low probabilities of diesel occurring above 0.3 µm on the sea surface is due to the diesel evaporating quickly and also being dispersed in the water column. The results in Figure 12.39a show that there is zero percent probability of diesel crossing the outer boundary of the FOCZ.

Figure 12.39b shows the minimum time taken for diesel above the surface thickness threshold of 0.3 µm to arrive at any location on the sea surface after the diesel inventory is discharged. In the most mobile of conditions, the diesel can travel up to 30 km within one day, up to 50 km within two days, and up to 90 km within five days. After approximately seven days, it is predicted that no diesel will remain on the sea surface.

Figure 12.39c shows the maximum length of time that any location is exposed to diesel above the thickness threshold of 0.3 µm. The model predicts that in the event of a catastrophic discharge of the rig's full diesel inventory, no surface location will be exposed to diesel for more than one day.

The results presented in Figure 12.39 are based on an aggregation of results from all the stochastic model runs and therefore do not represent a single spill scenario. To show the predicted surface area that will be impacted by a single spill scenario, a deterministic model run of the diesel inventory loss was conducted using the worst case metocean conditions from the stochastic modelling. The total surface area predicted to be impacted by a single spill is shown in Figure 12.40. In the case of a single spill, it is predicted that a continuous sheen will form in the immediate vicinity of the discharge location (approximately 100 km^2 in Figure 12.40), which corresponds to a surface thickness above 200 µm.



a) Probability of surface contamination above threshold of 0.3 µm

b) Minimum arrival times of oil above 0.3 µm on the surface

c) Maximum time surface is exposed to oil above threshold of 0.3 µm

Figure 12.39: Surface results (stochastic) for diesel inventory loss

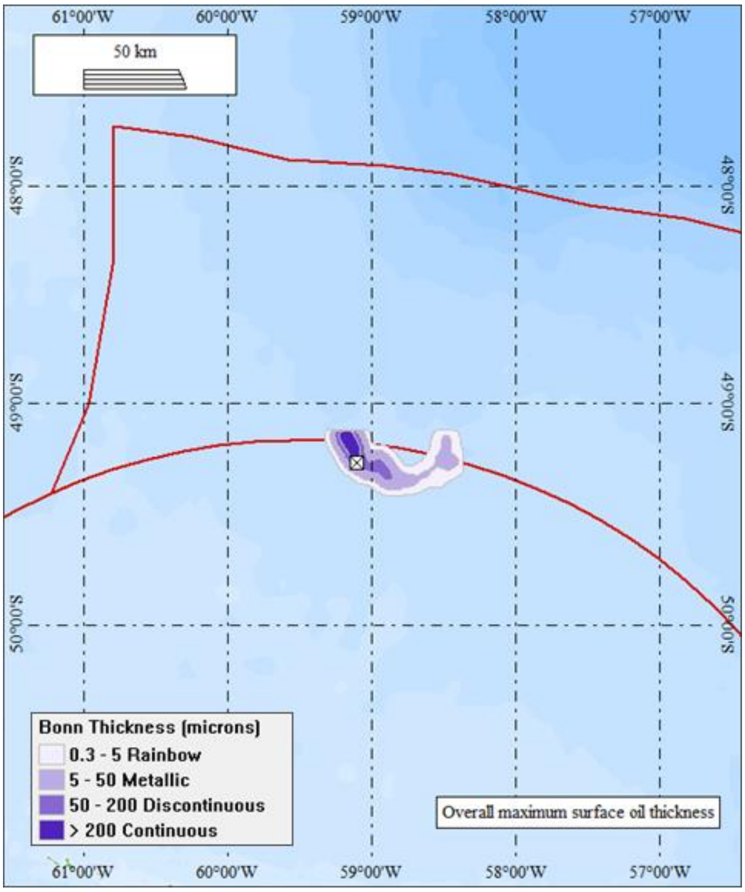


Figure 12.40: Total impacted surface area above threshold of 0.3 µm for a single deterministic model run of the diesel inventory loss scenario

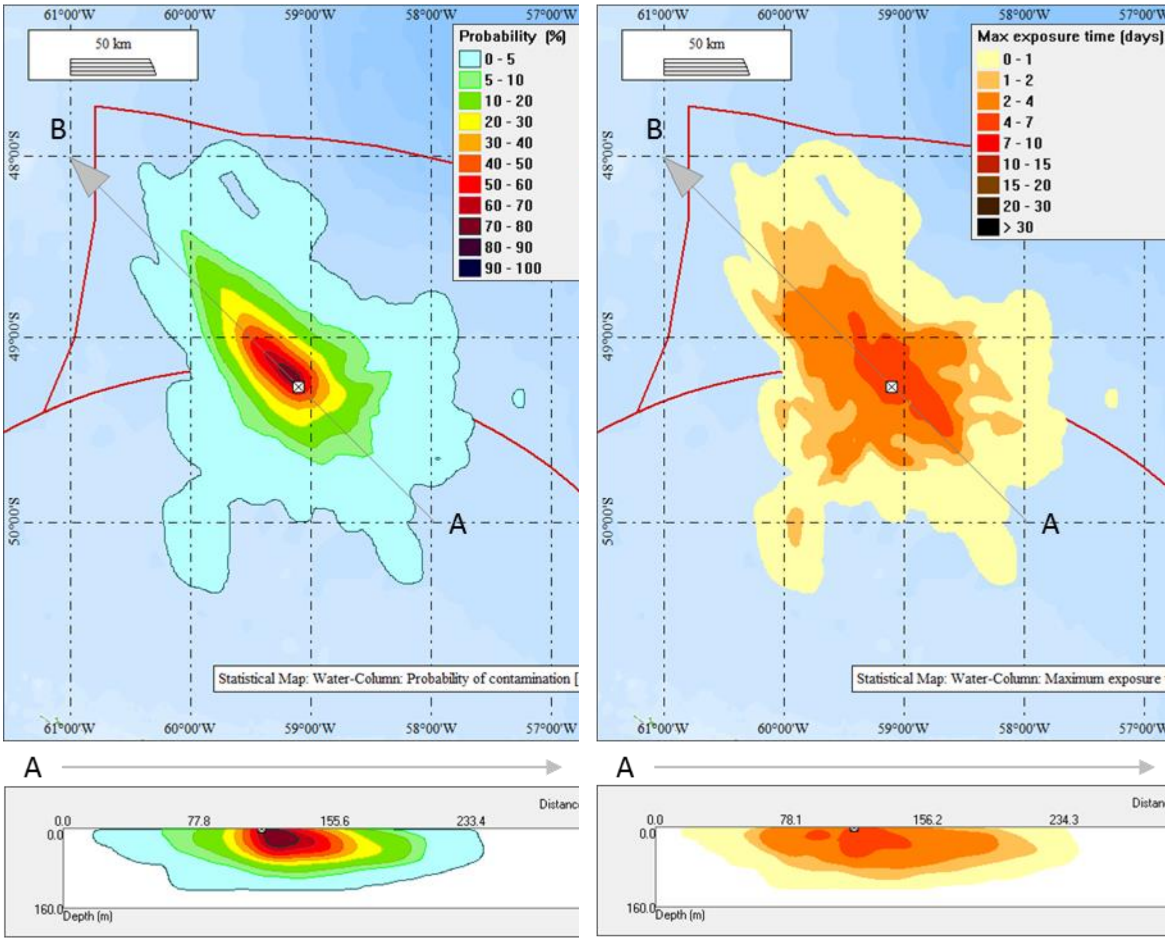
12.1.4.7.3 Loss of MODU diesel inventory - Water column results

Figure 12.41a shows the probability of diesel above the threshold of 25 ppb occurring in the water column following the loss of the drilling rig's diesel inventory. The corresponding maximum time that the water column is exposed to diesel is shown in Figure 12.41b. The modelling predicts that the threshold of 25 ppb will be exceeded following a discharge. As shown in the cross-sectional plot in Figure 12.41a, diesel is most likely to occur in the water column above the threshold value in the top 100 m of the water column. In the immediate vicinity of the discharge location and down to depths of 60 m, the water column could be exposed to concentrations in excess of 25 ppb for up to six days.

A single deterministic model run of the diesel inventory loss scenario was conducted to show the total impacted water column for a single, worst case, spill scenario. The maximum concentrations that were observed at any point during this run are shown in Figure 12.42a, and an example snapshot of water column concentrations at a single moment in time is shown in Figure 12.42b. In the event of the rig's full diesel inventory being discharged, water column concentrations exceeding 1,000 ppb (1 ppm) could be observed at locations near the discharge site. However, these concentrations would only be present for a short period of time after the discharge.

12.1.4.7.4 Loss of MODU diesel inventory - Shoreline results

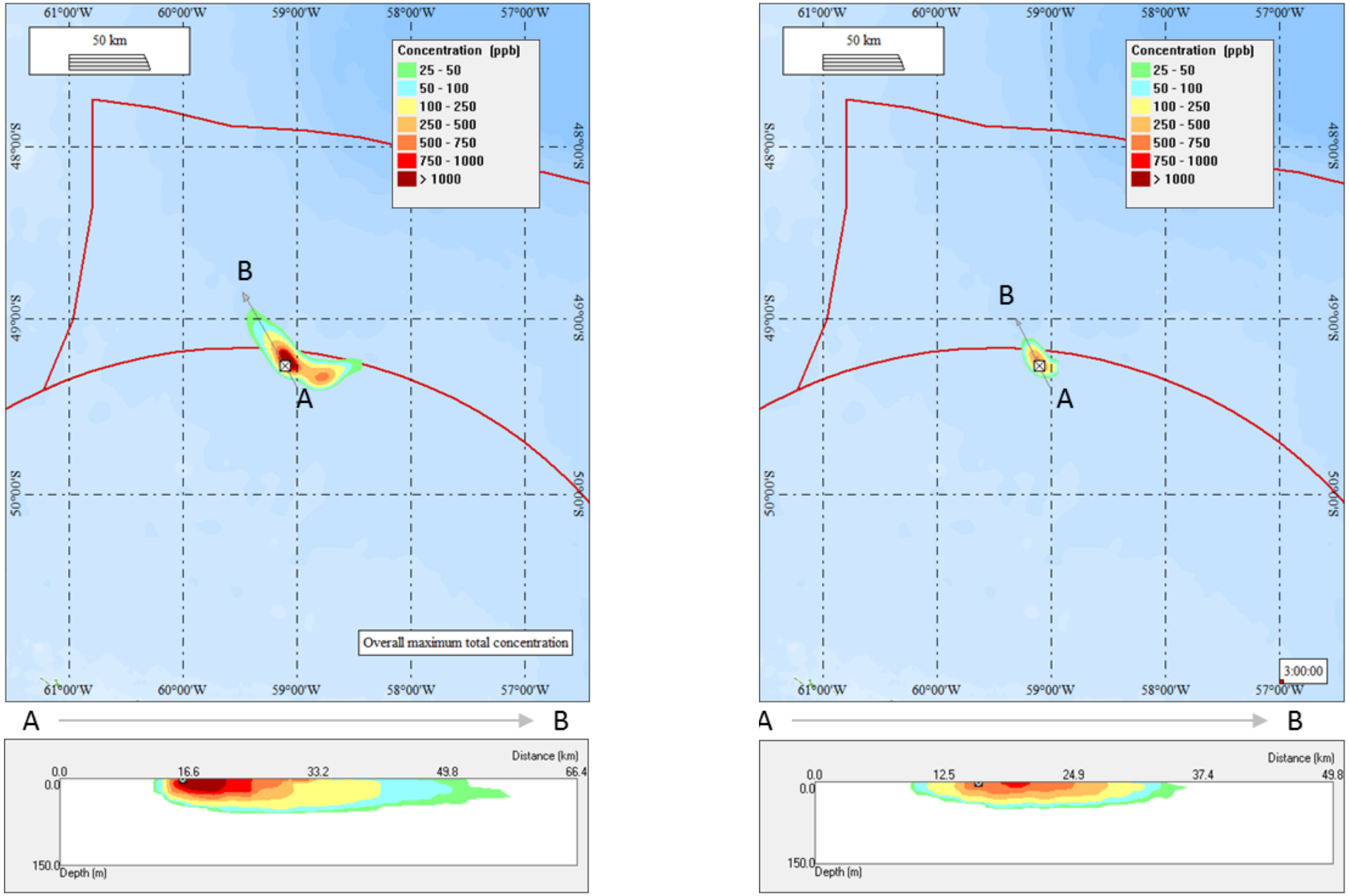
No shoreline oiling was predicted from any of the stochastic simulations of the diesel inventory loss scenario. With the discharge occurring so far from the Falkland Islands, it is extremely unlikely that any diesel discharged will reach the coastline of the Falkland Islands.



a) Probability of water column contamination above threshold of 25 ppb

b) Maximum time water column is exposed to diesel above 25 ppb

Figure 12.41: Water column results (stochastic) for diesel inventory loss



a) Total impacted area above a threshold of 25 ppb for a single deterministic model run

b) Snapshot of water column concentrations above 25 ppb for a single deterministic model run

Figure 12.42: Water column results (deterministic) for diesel inventory loss

12.1.4.8 Scenario 5: Diesel bunkering spill - modelling results

12.1.4.8.1 Predicted behaviour of oil

The predicted overall behaviour of diesel after it has been discharged to the sea following a bunkering spill (26 tonnes) is shown in Figure 12.43. These results are based on the aggregated outputs of all the stochastic modelling runs, and do not therefore represent a single model run (spill scenario).

The overall behaviour of the discharged diesel is broadly similar to the larger diesel inventory loss scenario but on a much smaller scale. It is predicted that a large proportion of the diesel will be on the sea surface immediately following the spill. However, this surface diesel is expected to decline very quickly, as it gets dispersed by wave action and also evaporates and biodegrades. The model predicts that after five days from the discharge, no diesel will remain on the sea surface; 52 % (14 tonnes) will have evaporated, 24 % (6 tonnes) will have biodegraded, and the remainder of the discharge will either be dispersed in the water column or dissolved. At the end of the model run duration of 30 days, 56 % (15 tonnes) of the diesel is predicted to have evaporated and 42 % (11 tonnes) will have biodegraded.

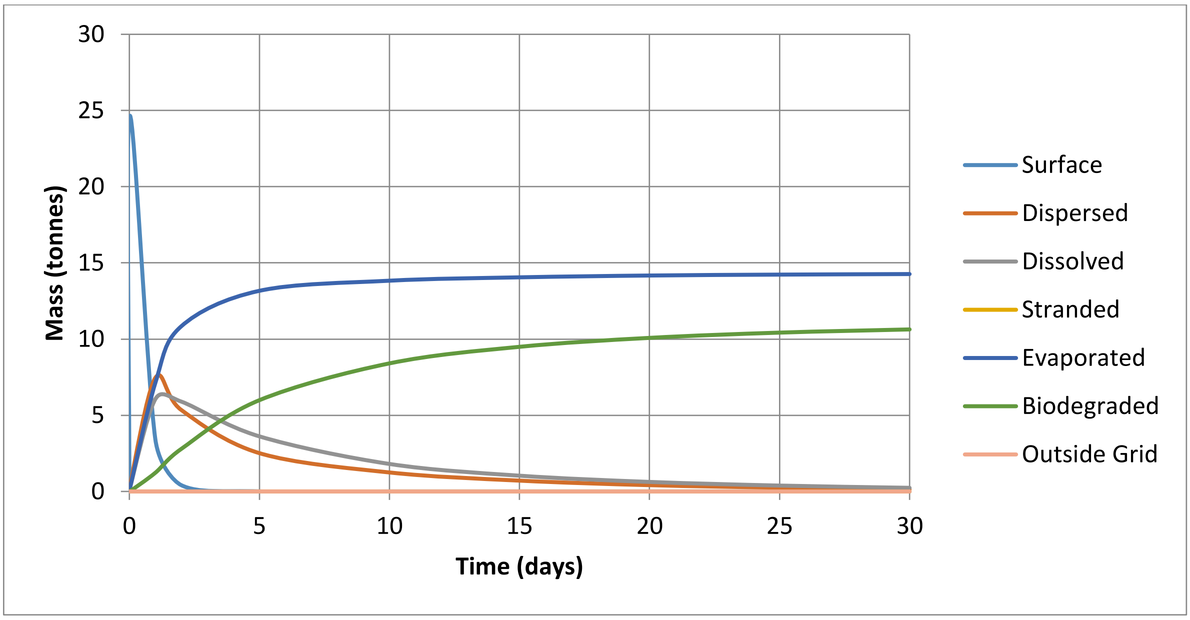


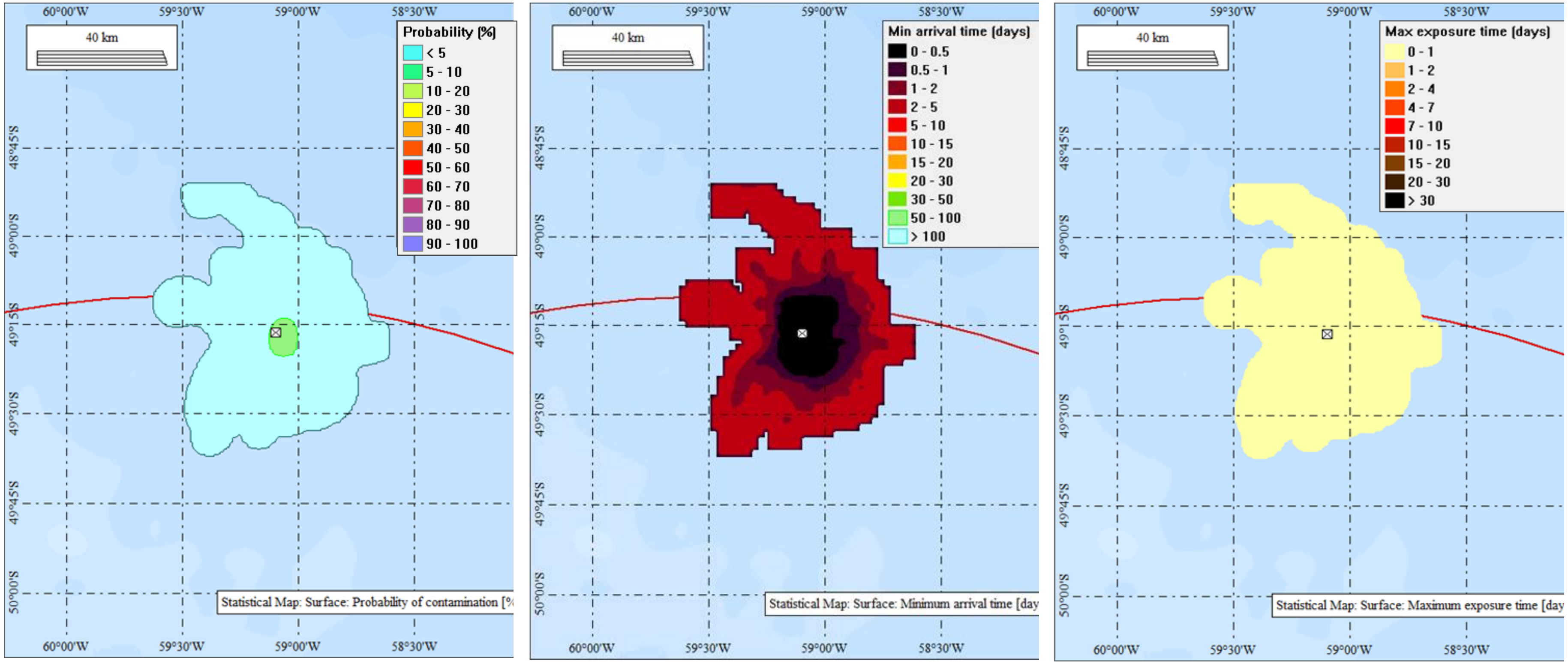
Figure 12.43: Predicted overall behaviour of diesel after a diesel bunkering spill

12.1.4.8.2 Diesel bunkering spill - Surface results

Figure 12.44a shows the probability of diesel occurring above the threshold of 0.3 µm on the sea surface. Following a bunkering spill, the probability of diesel occurring on the sea surface above the 0.3 µm thickness threshold is between 5 and 10% at locations near the discharge site, decreasing to less than 5% further away from the discharge location. These low probabilities are due to the small volume of diesel released following a bunkering spill, and the rate at which the diesel evaporates, biodegrades, and becomes dispersed. Diesel from a bunkering spill is not predicted to cross the FOCZ.

Figure 12.44b shows the minimum time taken for diesel above the surface thickness threshold of 0.3 µm to arrive at any location on the sea surface after the bunkering spill. In the most mobile conditions, the diesel can travel up to 20 km within one day, up to 30 km within two days, and up to 55 km within four days. After approximately four days, it is predicted that no diesel will be left on the sea surface, as the majority will have evaporated. No surface location is predicted to be exposed to diesel above the surface thickness threshold of 0.3 µm for more than one day (Figure 12.44c).

The results in Figure 12.44 are based on an aggregation of results from all the stochastic model runs and therefore do not represent a single spill scenario. To illustrate the impacted surface area for a single, worst case, spill scenario, a deterministic model run of the diesel bunkering spill was conducted. The total impacted surface area is shown in Figure 12.45. Following a diesel bunkering spill, it is predicted that 'rainbow' sheen could form on the sea surface, but would likely only be visible for a short period of time.



a) Probability of surface contamination above threshold of 0.3 µm

b) Minimum arrival times of oil above 0.3 µm on the surface

c) Maximum time surface is exposed to oil above threshold of 0.3 µm

Figure 12.44: Surface results (stochastic) for diesel bunkering spills

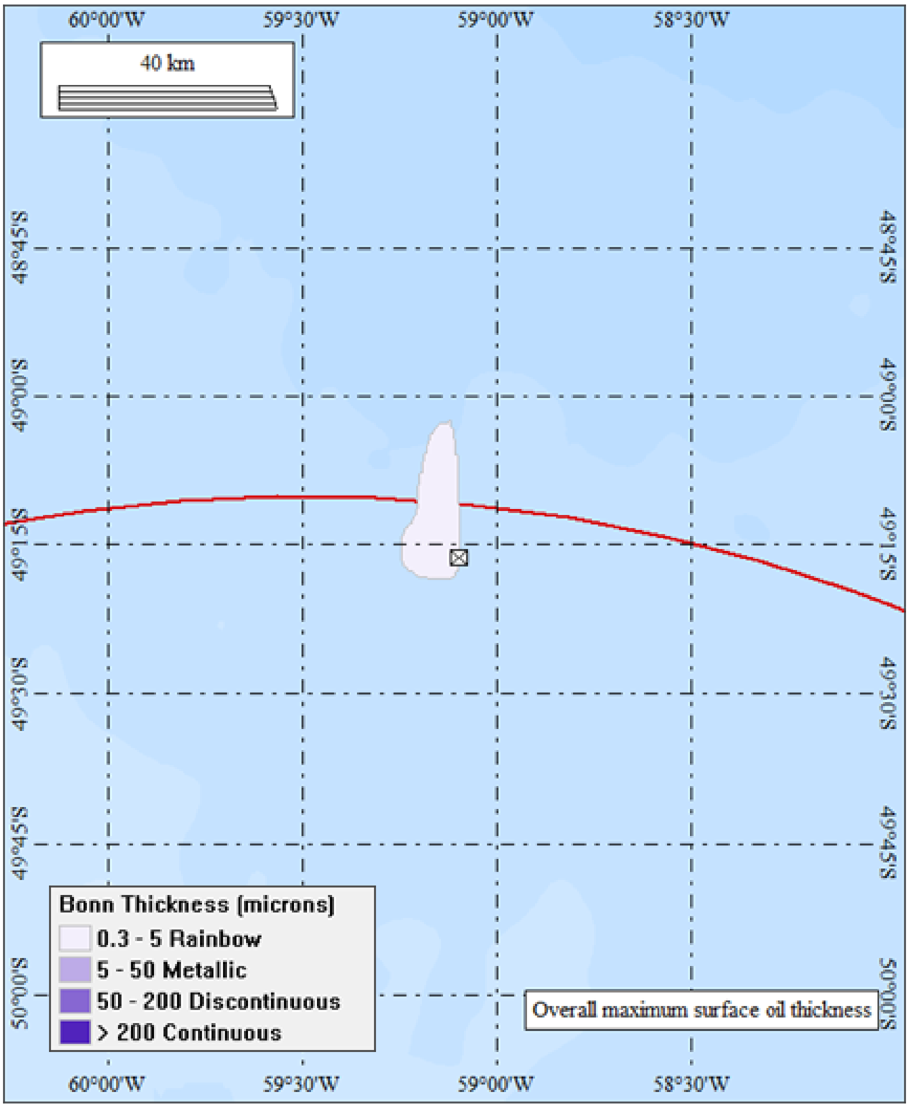


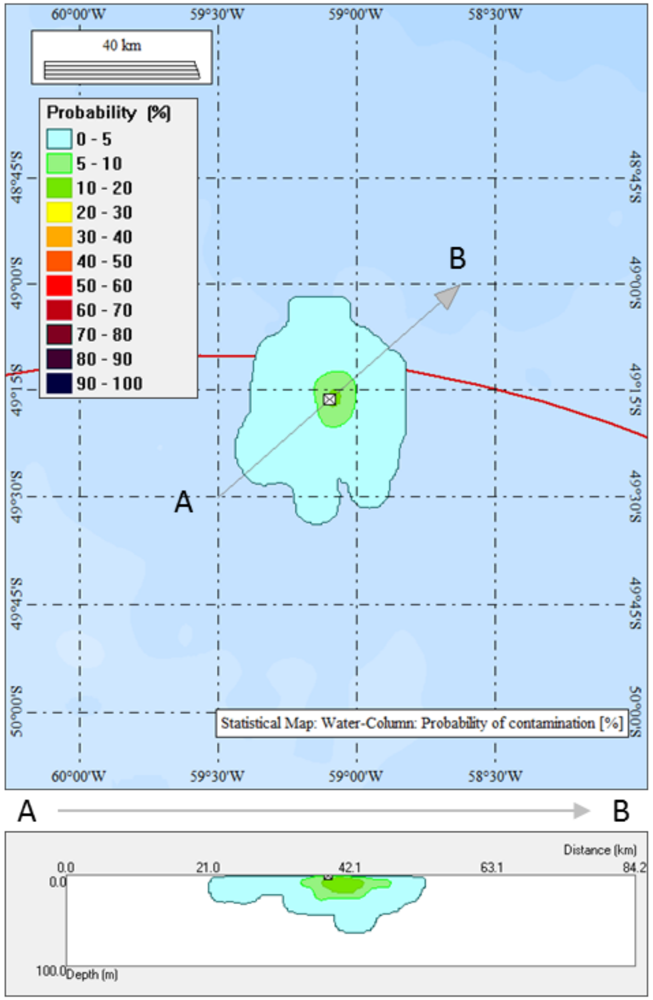
Figure 12.45: Total impacted surface area above threshold of 0.3 µm for the single deterministic model run of the worst case diesel bunkering spill

12.1.4.8.3 Diesel bunkering spill - Water column results

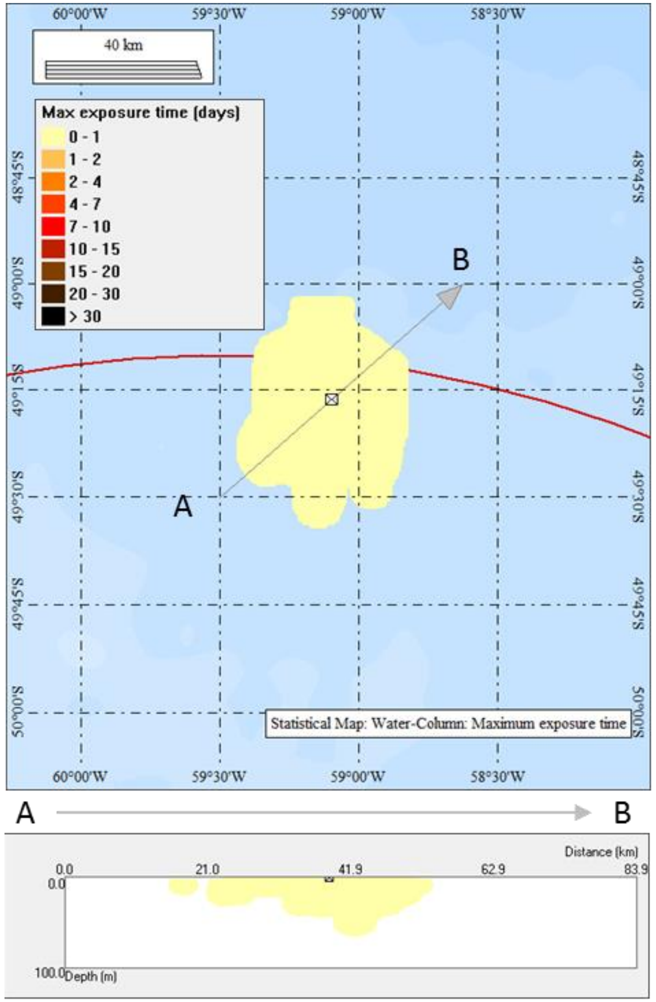
The probability of diesel occurring in the water column above 25 ppb is low, with only 12 % of the 99 stochastic simulations exhibiting concentrations above this threshold, (Figure 12.46a). The cross sectional plot in Figure 12.46a shows that it is possible for diesel to be found at depths up to 50 metres, but this occurs with low probability. This is due primarily to the rate at which the diesel will evaporate from the sea surface. No water column location is expected to be exposed to diesel above 25 ppb for more than one day (Figure 12.46b). It is expected that for a single spill scenario, the water column threshold of 25 ppb will only be exceeded for short intermittent periods of time, and that the concentration of diesel in the water column will be below this threshold after only a few days.

12.1.4.8.4 Diesel bunkering spill - Shoreline results

No shoreline oiling was predicted in any of the stochastic simulations of the diesel bunkering spill scenario. Due to the small volume of diesel involved, and the distance from the discharge location to the Falklands coastline, it is extremely unlikely that such a spill would result in any diesel reaching the Falklands shoreline.



a) Probability of contamination above threshold of 25 ppb



b) Maximum time water column is exposed to diesel above 25 ppb

Figure 12.46: Water column results (stochastic) for diesel bunkering spill

12.1.4.9 Small scale releases

During the ENVIID workshop (Chapter 9), a number of sources of small spills were identified that, should they occur, could contribute to chronic oil pollution in addition to the low-level contribution made by legally compliant discharges (section 10.7). Sources of chronic oil pollution from small scale accidental releases range from small subsea leaks of reservoir hydrocarbon or hydraulic oil to the potential for flare-drop out during emergency blowdowns. These may result from equipment failure or human error and may be very small owing to early detection or discrete volumes of oil, or they may be ongoing e.g. small subsea leaks.

Given that small accidental releases could arise from different sources, it is not possible to estimate the potential volumes of release. However, these will be dealt with appropriately on a case-by-case basis, should they occur. In the event of small spills, the most appropriate response is sometimes for the spill to be monitored and allowed to disperse naturally. All spills, regardless of size, would be reported to FIG via the PON 8 (section 12.1.1.1.5).

As with large accidental spills in the scenarios described above, the behavior, fate and impact of small releases of oil will depend upon the source of leak and the type of the oil. However, it is understood that small spills can result in surface sheens and low-level increases in the background contaminant levels of dispersed and dissolved oils e.g. polyaromatic hydrocarbons (PAHs) etc.

12.1.4.10 Loss of riser contents

If there is a loss of riser contents whilst drilling with OBM, the mud is likely to flow out over the seabed. The volume of mud lost will be in the region of 60 m^3 as the whole riser volume would always be lost in this situation. The loss of contents would trigger a rapid BOP activation and shutdown of mud pumps to restore the necessary barriers so is unlikely to a be higher volume. It is assumed the mud would flow out to a thickness of 1 cm, covering an area of approximately 0.006 km^2 around the MODU.

It is not conceivable that a spill from loss of riser contents would reach the shoreline.

12.1.5 Industry-standard mitigation measures

The majority of industry-standard mitigations are built-in to the Phase 1 Development basis of design and all are factored into the initial risk assessment. These are listed in Table 12.7.

Table 12.7: Industry-standard mitigation measures relevant to each of the oil spill risk scenarios

Scenario	Industry-standard mitigation (and base case) measures
General	• All activities with the potential to result in an oil spill will be carried out by competent personnel in accordance with operational controls, the permit to work system, the requirements of the Premier HSES-MS (Chapter 3) and Premier's Drilling Management System (CP-BA-PMO-DR-DE-ST-0001); • Development of the Safety and Environmentally Critical Equipment (SECE) register with appropriate performance standards developed (section 3.2.8); • Offshore spills, large or small will be reported in compliance with the FIG PON8 using the supplied *pro forma* (section 12.1.1.1.5); and • Offshore spills will be managed in line with the Sea Lion Field OSCP (section 12.1.1.1.3) which will be submitted to FIG as a separate document for approval prior to the commencement of operations. The offshore OSCP is currently under development, however, in line with the FIG NOSCP, response and preparedness levels will be organised according to the IPIECA / IMO international standard model of "*Tiered preparedness and response*". While full details will be provided in the OSCP, spills occurring offshore at the Sea Lion Field will be defined and managed as described in section 12.1.1.1.2.
1: Subsea well blow-out	The drilling operations will follow established international drilling safety standards to minimise the risk of loss of well control. Well control systems and procedures will be in place as per all Premier and drilling contractor well control guidelines. Preventative and mitigation controls include: • The drilling crews will be adequately experienced, trained in well control techniques and supervised at all times. Training will be continuous with regular emergency drills. • Well designs will be reviewed by an independent well examiner. • Primary well control is achieved by: – Development of an appropriate well design for the expected pore pressures with regard to casing etc. (section 5.4.5); – Use of appropriately weighted drilling muds to maintain a hydrostatic pressure in the wellbore greater than the pressure of the fluids in the formation being drilled, but less than the formation fracture pressure (section 5.4.6);

Scenario	Industry-standard mitigation (and base case) measures
	– The use of appropriate mud additives to prevent problems when drilling which can lead to the well becoming underbalanced e.g. lost circulation, fluid loss. The requirement for mud additives e.g. lost circulation material is assessed based on the expected qualities of the reservoir formation. • During drilling a blow-out preventor (BOP) will be in place and will be subject to regular maintenance and testing. BOP equipment / controls and emergency / contingency controls will be tested both prior to and immediately after deployment onto the wellhead. The BOP will be subject to a third party verification and audit prior to drilling operations commencing. • During production a subsea xmas tree will be in place on each well. • In the event of a sub-sea well blow-out (i.e. failure of primary and secondary well control), a capping device would be sourced to stem the flow. This is assumed in the modelling parameters to take a maximum of 77 days (worst case scenario) and has been incorporated into the initial assessment.
2: FPSO inventory loss	• A 1,275 m radius Safety Zone will be established around the FPSO; • Cargo and fuel tanks of the vessel will be double skinned; • An ERRV (MRSV) vessel will be on permanent stand-by to intercept any vessel that enters the Safety Zone or assist in the event of emergency situations; and • Use of AIS / radar surveillance and radio broadcasts to mariners (advising on the position of the rig and the exclusion zone).
3: Crude transfer spill	For safety and environmental reasons, the Oil and Gas (O&G) industry employ many standard practices to prevent the release of hydrocarbons. Provision of physical barriers, maintenance to minimise leaks and procedures and training to influence human factors have significantly reduced spills in the industry. Premier working procedures will provide the operational control measures that are designed to minimise the risks. These measures include: • Bulk Management in line with procedural control to ensure inspections, and verification of bulk hoses; • Hose quick break connectors to prevent spills on disconnection; • Reporting anything that is leaking, or defective equipment; • Investigating any leaks to determine root causes and take action to prevent reoccurrence; and • Ensuring that all pipe-work is isolated, drained and purged as required by the permit to work before breaking containment.
4: Diesel inventory loss	Working practices will follow industry best practice guidelines designed to prevent the loss of diesel inventory from the drilling rig. Measures such as the use of a 500 m exclusion zone around the MODU, a guard ship, AIS / radar surveillance and radio broadcasts to mariners will further reduce the risk of collisions between vessels and the drilling rig.

Scenario	Industry-standard mitigation (and base case) measures
5: Diesel bunkering spill	Premier working procedures will provide the operational control measures that are designed to minimise risks associated with diesel bunkering spills. These measures include: • Bulk Management in line with procedural control to ensure inspections, and verification of bulk hoses; • Hose quick break connectors to prevent spills on disconnection; • Reporting anything that is leaking, or defective equipment; • Investigating any leaks to determine root causes and take action to prevent reoccurrence; and • Ensuring that all pipe-work is isolated, drained and purged as required by the permit to work before breaking containment.
Small scale releases	• Implementation of the Management Maintenance System (MMS) and inspection protocols; • Use of all standard operating procedures and best practise; • Bunding of all liquid containing equipment and chemicals; • Open deck drains to catch and collect spills to a dedicated slop tank; • High level tank filling alarm and emergency shutdown of the process; • Reporting anything that is leaking, or defective equipment; and • Use of spill kits for deck spills.
Loss of riser contents	Compliance with Premier Drilling Management System (CP-BA-PMO-DR-DE-ST-0001 - section 1.5 High Pressure Drilling Risers). This includes compliance with industry-standards for design, specification, materials, workmanship, testing, operations and maintenance. For example: • ISO 13628-7 - Design and Operation of Subsea Production Systems: Completion / Workover Riser Systems; • API 16F - Specification for Marine Drilling Riser Equipment; and • DNV RP F204 - Riser Fatigue.

12.1.6 Risk Assessment

The following section draws upon all the information provided above to assess the 'Sensitivity of the Receptor' and the 'Severity of Effect' in order to determine the overall 'Impact' of planned activities. Assessment of unplanned events includes an assessment of the 'Likelihood of Occurrence' to determine the 'Risk' associated with these.

A summary of the risk assessment outcomes for this Development is tabulated in section 12.1.12, which shows the worst case risk for each activity and receptor, the details of which are provided below.

Owing to the number of receptors to the differing oil spill scenarios, and the number of scenarios, the layout of this chapter is slightly different to the other chapters within this EIS. As with all risk assessments, it is necessary to consider first the potential impact of the event (i.e. Sensitivity of Receptor x Severity of Effect) and *then* to considered the likelihood of occurrence to establish the overall risk (see Chapter 8). The impact on each receptor is tabulated in each section below, and the likelihood of occurrence, which will be consistent within each scenario, is then described as a whole.

The following assessments take account of all industry-standard and base case mitigations described in section 12.1.5.

12.1.6.1 Scenario 1: Subsea well blow-out

12.1.6.1.1 Sensitivity of receptor and severity of effect (impact assessment)

A subsea well blow-out is highly unlikely to occur in the lifetime of the proposed Sea Lion Development. The oil dispersion modelling for a subsea blow-out used worst case conditions to set an upper boundary on potential effects, in line with DECC (now BEIS) guidance.

In the unlikely event of a well blow-out, prevailing currents and winds in the area will tend to keep oil (wax) at sea where it is subject to dispersion, evaporation and biodegradation. The oil generally travels north as it is transported by dominant currents, or in an arc to the south-southeast, as it is forced by the wind driven surface currents (section 12.1.4.4.1).

Given its high wax content, extensive surface slicks are not predicted from a Sea Lion crude well blow-out (section 12.1.4.4.2). Instead, a raft of waxy oil masses is predicted to form and migrate from the area predominantly near the water surface. The oil masses will not coalesce but rather become increasingly dispersed with distance, and their visibility will reduce with distance from the release (section 12.1.4.4.2). The amount of energy experienced during any release determines the initial size of the oil masses and relatively small droplets are likely to be formed during a blow-out. Some degradation of particle size is expected through prevailing shear forces from waves and turbulence, but very slowly based on laboratory experience. Ultimately, oil may attach to suspended solids and sink, or be biodegraded in the water column, involving an element of ingestion potentially by a range of biota.

Soluble components, which pose a risk to water column ecology, have been shown not to dissolve into the water column in the first seven days after a spill (CEDRE, 2017), and it is assumed any dissolution will happen slowly as permeation through the wax is very slow and dissolution relies on new faces being exposed during shearing, and the oil masses appear resistant to shearing from typical wave energies in the laboratory. The modelling predicts that toxic water column impacts are not above a widely accepted level of concern, except directly above a blow-out or directly beneath a surface accumulation, and that this occurs for short periods (section 12.1.4.4.3).

Generally, even in examples where large fractions of the oil budget transition to sediments, impacts on the benthos show good recovery in the timescale of years and, while effects on lower trophic levels can be observed, little change in higher trophic levels tends to be observed. Tests on the Sea Lion crude indicate that a spill would impact upon on benthic species tested at concentrations >392 mg/kg in the sediments (see section 12.1.4.1.1.1). This is not predicted to occur anywhere. A level of 50 mg/kg is a more general level of oil contamination where toxic effects may be discernible, referenced in OSPAR Recommendation 2006/5 on the management of drill cuttings piles. No predicted levels are above this threshold. A more precautionary threshold of 10 mg/kg is put forward in Patin (2004) as being the zone of no observable effect concentrations, and 644 km^2 of seabed would be above this level, the maximum level predicted being 29.3 mg/kg assuming oil is mixed over a 5 cm layer. In context, the area of the western South Atlantic continental shelf is 700,000 km^2). A well-documented example is the *Braer* incident in 1993 where over 84,000 tonnes of oil was released. Overall, the oil spill caused minimal effect on the ecology of South Shetland (Law and Moffat, 2011). Around 30-35% of the oil budget was estimated to have transitioned to sediments, some near the coast and some much further offshore. The nearshore contamination led to a restriction on shell fisheries in the area for a period of between 18 months and seven years and the sandeel population, which is a key component in the food chain and a sediment-dweller, exhibited clear increases in hydrocarbon presence but showed only a slight decrease in population that reversed in one year (Davies and Topping, 1997). In contrast, although the area of sediment contamination further offshore (a better analogue for any Sea Lion impacts) was clearly identified and analysis of fish, including taint testing was undertaken, it did not lead to any closure of fisheries.

Given the above, the potential sediment impacts from a Sea Lion crude release are considered to be low.

The modelling results suggest that there is a possibility that a subsea well blow-out, with the parameters of location and blow-out rate specified, would lead to hydrocarbons reaching the Falklands coastline.

The assessment of the ‘Sensitivity of Receptor’ and the ‘Severity of Effect’ for each receptor are provided in Table 12.9. The ‘Likelihood of Occurrence’ of a well blow-out is described below and is also included in Table 12.9 to show how the overall significance ratings of risks associated with a subsea well-blow-out were derived.

12.1.6.1.2 Likelihood of occurrence

Although known in the oil and gas industry, uncontrolled releases / blow-outs and major losses of containment are extremely rare events. The frequencies of blow-out events in the North Sea are presented in Table 12.8. Here the frequency of blow-out events has been calculated per well drilled, per operation, or per well year in the North Sea (OGP Risk Assessment Data Directory, Report No. 434-2, March 2010). Table 12.8 indicates that the likelihood of a blow-out is generally very low, and is higher for gas High Pressure / High Temperature (HP / HT) reservoirs than for normally pressured reservoirs. The Sea Lion reservoir is not a HP / HT reservoir.

Nonetheless, strict regulations governing working practices and lessons learnt from previous incidents have helped to further minimise the likelihood of accidental events leading to major losses of containment. Following the Deepwater Horizon incident in the Gulf of Mexico, the Oil Spill Prevention and Response Advisory Group (OSPRAG) was established to review all UK Continental Shelf (UKCS) regulations and pollution response arrangements and to assess the adequacy of financial provisions for that response. This has resulted in significant amendments to the legislation pertaining to oil spill prevention and response.

The International Association of Oil & Gas Producers has issued datasheets (OGP, 2019) on blow-out frequencies for offshore operations of North Sea Standard (NSS). These operations are performed with a Blow-Out Preventer (BOP) installed following the 'two barrier' principle, meaning that there are always two physical barriers preventing the oil from flowing to the seabed, as will be the case with the Sea Lion Development. Taking account of the industry-standard mitigations (section 12.1.5), the **likelihood of occurrence** of a subsea blow-out occurring is considered to be '**Unlikely**' (Table 12.9), as it has happened in the industry but on extremely rare occasions.

Table 12.8: Blow-out frequencies for offshore operations of North Sea Standard (OGP, 2019)

Operation	Frequency of oil spills	Unit	Proportion Subsea
Development Drilling, Deep (Normal Wells)	3.4×10^{-5} or 0.000034 (1 in every 20,834 wells drilled)	Per well drilled	0.47
Development Drilling (HP/HT)	2.1×10^{-4} or 0.00021 (1 in every 3,333 wells drilled)	Per well drilled	0
Completion	1.4×10^{-4} or 0.00014 (1 in every 18,519 completion operations)	Per operation	0
Producing Wells (Excluding External Causes)	2.1×10^{-5} or 0.000021 (1 in every 384,615 production well year)	Per well year	0.43
Producing Wells (External Causes)	2.7×10^{-5} or 0.000027 (1 in every 25,641 produciton well year)	Per well year	0

12.1.6.1.3 Overall risk significance

As is shown in Table 12.9 the highest **significance of the risk** posed by a well blow-out is to human population (fisheries and tourism), seabirds, marine mammals and coastal areas all of which are considered to be '**Moderate**' and therefore, project-specific mitigation measures will be required.

Table 12.9: Risk assessment of a subsea well blow-out

Receptor	Sensitivity of Receptor and Severity of Effect (Impact)	Likelihood of occurrence	Overall risk significance
Plankton	Plankton show high seasonal and spatial variation in abundance and productivity, and it is expected that any effects will be greatest during summer when the area of the shelf-break to the south of the Sea Lion Field supports higher densities of phyto- and zooplankton (section 7.4.1). At other times, the area is less significant for zooplankton but is still considered highly productive. Therefore, the **sensitivity of plankton** is considered to be '**Moderate**'. Although, oil from a blow-out is likely to rise to the upper water column, due to a combination of short generation times, high reproductive rates, known concentration of oil to effect lethal contamination on representative species (section 12.1.4.1.1.1) and the potential for immigration from outside contaminated areas, the effects on whole plankton communities are expected to be of a short-term and reversible in nature. Due to the temporary impact on plankton in a localised area around the spill site, the **severity of the effect** of an uncontrolled release / blow-out of Sea Lion crude on plankton has been assessed as '**Moderate**'. Therefore the **significance of the impact** on plankton is assessed as '**Moderate (9)**'.	**Unlikely**	**'Low (6)'**
Benthic communities	In the majority of scenarios where the oil remains at sea, <5% oil is predicted to transition into sediments. The recent bench tests (Premier, 2016j) and lab testing (CEDRE, 2017) have reinforced the finding that the crude is very buoyant. This keeps it away from sediments, and should tar balls form and cause the oil to sink, the majority of oil becomes enclosed in a crust which tends to avoid acute impacts. Testing of one benthic species indicated that relatively high concentrations of oil in sediments would impact benthic communities (section 12.1.4.1.1.1). These concentrations are not predicted to occur; the maximum level predicted is 29.3 mg/kg. The **sensitivity of the benthic community** is considered to be '**Very Low**' due to uniform nature of the benthic community over much of the NFB. The **severity of effect** is considered to be '**Serious**' due to the potential widespread impact that could take several years to recover. The **significance of impact** on the benthic community is therefore assessed as '**Moderate (4)**'	**Unlikely**	**'Low (6)'**
Fish and squid	Known fish and squid spawning sites of commercial species are significant distances from the Sea Lion Field (section 12.1.4.2.4) and it is unlikely that they will be impacted. Investigations of the effects of Sea Lion oil on fish eggs indicates that a spill is unlikely to have an impact (section 12.1.4.1.1.1). While the adults of many species use the Northern Slope as a feeding ground these are likely to be able to avoid areas of contamination (section 12.1.4.2.4). Nonetheless, it is possible that more than 1 % of the Falklands population of fish and squid species using the Northern Slope could be within the zone of influence of a subsea blow-out either directly while foraging or passing through during migration (section 12.1.4.2.4) and, therefore, the **sensitivity of fish and squid** receptors to a blow-out is considered to be '**Moderate**'. The impact of a subsea blow-out will have a temporary and reversible impact on the adult fish and squid exposed to crude oil and therefore the **severity of the effect** on fish is considered to be '**Moderate**'. The **significance of the impact** of a subsea blow-out on fish and squid is assessed as '**Moderate (9)**'.	**Unlikely**	**'Low (6)'**

Receptor	Sensitivity of Receptor and Severity of Effect (Impact)	Likelihood of occurrence	Overall risk significance
Human population (fisheries)	The main commercial fisheries in the NFB target squid and finfish (section 12.1.4.2.4). While the squid fishing grounds are not usually near the Sea Lion field, in May and June it is believed that a significant proportion of the *Illex* stock pass through the NFB. A blow-out that happened to coincide with this migration could lead to contamination of the spawning stock with unknown implications for reproduction (section 12.1.4.2.4). The Patagonian toothfish fishing grounds are to the north and east of the Sea Lion Field and the results of modelling indicate that oil is likely to spread over part of the area fished (section 12.1.4.2.4). Given the importance of these fisheries to the Falklands' economy, and the uncertainty over the extent of any impacts, a precautionary approach should be taken and it is assumed that a blow-out could result in economic impacts for the fishing industry. Given the low capacity for the fishing industry to absorb the losses in revenue, and that such impacts to fisheries would be unacceptable to a majority of stakeholders, the **sensitivity of the human population** is considered to be '**Very High**'. An uncontrolled release could result in the closure of the fishing grounds due to potential tainting and contamination and therefore, the **severity of the effect** of an uncontrolled release on fisheries is considered to be '**Serious**' Therefore the **significance of the impact** on the human population via fisheries is assessed as '**High (20)**'.	**Unlikely**	**'Moderate (10)'**
Seabirds	Drilling and production will occur throughout the year and seabird vulnerability varies on a monthly / seasonal basis (section 7.4.5). Given the waxy nature of the Sea Lion crude, seabirds are generally considered to be less susceptible to fouling compared to other crude oils (section 12.1.4.2.5). However, testing has shown that at concentrations of 1kg/m^2 feathers become stained and microparticles of oil are adsorbed by two of the species tested (section 12.1.4.1.1.1). Also, there is concern that birds will ingest oil, in much the same way that they ingest plastics. The available data, presented as an oil vulnerability atlas, indicate that at times there are areas of relatively high seabird vulnerability in or close to the Sea Lion Field. Further, the presence of the Development vessels will attract groups of scavenging seabirds, many of which are ACAP species and others that are of global conservation concern (section 7.4.5.5.2). Therefore, given their susceptibility to the ingestion of oil (and other oil impacts), their presence in the wider NFB, their propensity to associate with vessels, and rigs, and the threatened conservation status of many species, the **sensitivity of seabirds** to the effects of a blow-out, is considered to be '**Very High**'. While the direct impact of Sea Lion crude by fouling is expected to be less than for more fluid crudes (section 12.1.4.2.5), testing has indicated that there will be impacts to birds contaminated with higher concentrations (1kg/m^2) of oil (section 12.1.4.1.1.1). Crude from a well blow-out is expected to rise to the upper water column and to remain above 1 g/m^2 in the area immediately above the well for up to 30 days (section 12.1.4.4.2), although it is not predicted to be above levels shown to cause staining and adhesion in laboratory tests. Nonetheless, the behavioural traits of some species increase the likelihood that they will be attracted to the area through their association with vessels, due to the presence of artificial light, discharged waste water and food, or simply to investigate a novel object in an otherwise uniform environment (12.1.4.2.5.3). This increases the likelihood of contact with and ingestion of oil, potentially resulting in direct mortality or chronic impacts on the survival and reproductive biology of long-lived, late reproducing species (section 12.1.4.2.5). The **severity of the effect** of an uncontrolled release on seabirds is therefore considered to be '**Serious**'. Therefore the **significance of the impact** on seabirds is assessed as '**High (20)**'.	**Unlikely**	**'Moderate (10)'**
Marine mammals	Owing to the presence of the sperm whale (IUCN 'Vulnerable'), the fin whale (IUCN 'Endangered') and the sei whale (IUCN 'Endangered') in the NFB (section 7.4.6), all of which also have priority conservation status under the Falklands biodiversity action plan (section 7.4.6), the sensitivity **of marine mammals** is assessed as '**High**'.	**Unlikely**	**'Moderate (8)'**

Receptor	Sensitivity of Receptor and Severity of Effect (Impact)	Likelihood of occurrence	Overall risk significance
	Away from the immediate release site at which oil densities > 1g/m^2 may persist for up to 30 days, marine mammals are not considered significantly at risk due to the semi-solid nature of the waxy crude and the rapid dispersion of contaminants (section 12.1.4.1.1and section 12.1.4.2.6). However, while not causing significant immediate impact or mortality, the longer-term effects of sub-lethal exposure or ingestion are not fully understood, and may lead to long-term impacts (section 12.1.4.2.6). Therefore, taking a precautionary approach, the **severity of effect** of a subsea blow-out on marine mammals has been assessed as '**Moderate**' Therefore the **significance of the impact** on marine mammals is assessed as '**Upper Moderate (12)**'.		
Coastal	There is a possibility of oil reaching East Falkland (section 12.1.4.4.4). Parts of this area (Seal Bay; Volunteer Point and Cow Bay) are designated as IBAs (section 7.5.2.3.1). The likelihood of oil reaching the shore is low (predicted in only approximately 10 % of stochastic model runs) and the average quantity likely to beach is approximately 1,070 tonnes (section 12.1.4.4.4). The areas that are potentially at risk are of national importance. Therefore, the **sensitivity of the coastal environment** is considered to be '**High**'. Given that there is still some uncertainty regarding the long-term chronic impacts of such a waxy crude on this environment, the **severity of effect** of an uncontrolled blow-out on coastal environment is considered to be '**Moderate**'. Therefore the significance of the impact of an uncontrolled blow-out is assessed as '**Upper Moderate (12)**'.	**Unlikely**	**'Moderate (8)'**
Human Population (tourism)	The model predicts that some oil could reach the shore following a well blow-out, which will result in an average quantity of 1.070 tonnes beaching (section 12.1.4.4.1). Given the distance offshore and the relatively long travel times of the oil (section 12.1.4.4.2) it is unlikely that tourists would see oil at-sea arising from a well blow-out. However, media publicity may influence the experience and perceptions of tourists, which may then impact upon their propensity to visit. Given that a well blow-out would be unacceptable to the majority of stakeholders, the **sensitivity of tourism** is considered to be '**High**'. Due to the long lasting negative impacts of perceived environmental degradation, the **severity of effect** of an uncontrolled release on tourism has been assessed as '**Serious**'. Therefore the **significance of the impact** on the human population (tourism) is assessed as **'High (16)**'.	**Unlikely**	**'Moderate (10)'**

12.1.6.2 Scenario 2: Loss FPSO crude oil inventory

12.1.6.2.1 Sensitivity of receptor and severity of effect (impact assessment)

The results of the oil dispersion modelling indicate that the behaviour of Sea Lion crude following a complete loss of FPSO crude oil inventory are similar to the worst case well blow-out scenario. The main difference is the reduced potential for oil to reach the north Falklands coastline, which in the case of the FPSO inventory loss scenario occurred in 6 % of the stochastic model runs in specific metocean conditions (section 12.1.4.5.4), as opposed to 10% in the case of the well blow-out scenario. Furthermore, when considering the worst case scenarios, the average mass of beached oil predicted by the models was 9.5 tonnes for the FPSO inventory loss scenario, compared to 1,070 tonnes in the case of a well blow-out. The potential deposition in sediments is also much smaller, largely because oil is assumed to remain in larger, more buoyant masses. Deposition above a level of 392 mg/kg is not predicted; in fact the maximum predicted deposition concentration over a 5 cm mixed layer is 2.6 mg/kg, well below the OSPAR threshold of 50 mg/kg and the 'no observable effect' concentration of 10 mg/kg.

Following an FPSO release, the potential for tar ball formation is higher than for the well blow-out scenario. Recent tests have reinforced the finding that the Sea Lion crude is very buoyant, an attribute, which would generally keep it away from sediments (section 12.1.4.1.1) Should tar balls form and cause the oil to sink, the majority of oil would likely become enclosed in a crust, which tends to reduce acute impacts.

Containment and recovery operations are overall less effective due to the large volume of oil and the dispersion of oil before significant oil spill response resources arrive, but are predicted to be sufficient to prevent oil from reaching the Falkland Islands coastline.

The 'Sensitivity of Receptor' and the 'Severity of Effect' for each receptor are provided in Table 12.10. The 'Likelihood of Occurrence' of losing the crude from the FPSO is described below and is included in Table 12.10 to show how the overall significance ratings of risks associated with the loss of the FPSO crude oil inventory were derived.

12.1.6.2.2 Likelihood of occurrence

There are no recorded examples that match the worst case scenario modelled here in over 20 years of global FPSO operations. One possible incident that could result in the complete loss of crude inventory from the FPSO however, is the collision with a large vessel. As detailed in section 11.1, the likelihood of collisions between vessels operating in the southwest Atlantic and the FPSO on station in the Sea Lion Field was assessed using the COLLRISK model (Anatec, 2013).

Based on vessel activity, the COLLRISK model was used to estimate the collision risks on an annual basis and distributed the predicted frequency of collision according to the level of impact energy based on the sizes and speeds of vessels involved. Specifically, information on shipping movements in the NFB was used to investigate the risk of vessels colliding with an FPSO stationed in the Sea Lion Field (Anatec, 2013). On average, 85 vessels pass within 10 nautical miles of the Sea Lion Field per year. Ninety percent of these were less than 5,000 DWT (Dead Weight Tonnage) but five were tankers on passage between South Africa and Cape Horn. Given the size of the tankers, at >40,000 DWT, these vessels pose a greater threat in terms of the force of a collision.

Overall, the annual risk of a collision with a passing vessel was calculated as 3.5×10^{-8} per year and the risk, or probability, of a collision with a larger vessel (collision energy >200 MJ) was assessed as 1.2×10^{-8} per year (section 11.1).

The other credible collision risk for vessels located within the Sea Lion Field is that posed by icebergs. An iceberg management strategy has been produced under consultation to the British Antarctic Survey (BAS) and the results of their assessment are presented in Premier (2015f). Using the available information (satellite and visual observations the 1990s), it is predicted that an iceberg will pass within 30 nautical miles of the FPSO with a mean return period of 20 years. The strategy indicates that this is a manageable risk but iceberg management zones and protocols will be developed during FEED.

With industry-standard mitigation measures in use (section 12.1.5), the **likelihood of occurrence** of a full loss of FPSO crude inventory is considered to be '**Very Unlikely**' (Table 12.10).

12.1.6.2.3 Overall risk significance

As is shown in Table 12.10, the highest **significance of the risk** posed by the loss of crude from the FPSO is to the human population (tourism and fisheries) seabirds, marine mammals and coastal ecology, all of which were assessed as '**Low**'.

Table 12.10: Impact assessment for loss of FPSO crude oil inventory

Receptor	Sensitivity of Receptor and Severity of Effect (Impact)	Likelihood of occurrence	Overall risk significance
Plankton	Justification for this assessment is the same as that for a blow-out and can be found in Table 12.9. The **sensitivity of plankton** is considered to be '**Moderate**' and the **severity of the effect** to be '**Moderate**'. Therefore the overall **significance of the impact** is assessed as '**Moderate (9)**'.	**Very Unlikely**	'Very Low (3)'
Benthic communities	Due to the buoyancy of the wax and the deep water in which it is released, the deterministic model predicts that a small fraction of oil (<1%) could move into sediments; this is only predicted when the oil approaches shallower water and the cloud of suspended droplets makes contact with the seabed after around 40 days after discharge. Testing of one benthic species indicated that relatively high concentrations of oil in sediments would impact benthic communities (section 12.1.4.1.1.1) and these concentrations are not predicted to occur; the maximum concentration predicted is 2.6 mg/kg. The **sensitivity of the benthic community** is considered to be '**Very Low**' due to the uniform nature of the benthic community over much of the NFB. The **severity of effect** is considered to be '**Serious**' due to the potential widespread impact that could take several years to recover. The **significance of impact** on the benthic community is therefore assessed as '**Moderate (4)**'	**Very Unlikely**	'Very Low (3)'
Fish and squid	Justification for this assessment is the same as that for a blow-out and can be found in Table 12.9. The **sensitivity of fish and squid** is considered to be '**Moderate**' and the **severity of the effect** to be '**Moderate**'. Therefore the overall **significance of the impact** is assessed as '**Moderate (9)**'.	**Very Unlikely**	'Very Low (3)'
Human population (fisheries)	Justification for this assessment is the same as that for a blow-out and can be found in Table 12.9. The **sensitivity of fisheries** is considered to be '**Very High**' and the **severity of the effect** to be '**Serious**'. Therefore the overall **significance of the impact** is assessed as '**High (20)**'.	**Very Unlikely**	**'Low (5)'**
Seabirds	Justification for this assessment is the same as that for the well blow-out scenario and can be found in Table 12.9, except that there are areas of oil above 100 g/m^2 and above 1,000 g/m^2 near to the release where impacts on plumage are more likely. Additionally, the north Falkland coastline includes the IBA at Seal Bay, Volunteer Point and Cow Bay. However, by the time oil reaches the coastline it is predicted to be very degraded and dispersed. Penguins breeding at this and other sites are far more likely to come into contact with oil at sea. The **sensitivity of seabirds** is considered to be '**Very High**' and the **severity of the effect** to be '**Serious**'. Therefore the overall **significance of the impact** is assessed as '**High (20)**'.	**Very Unlikely**	**'Low (5)'**
Marine mammals	Justification for this assessment is the same as that for a blow-out and can be found in Table 12.9. The **sensitivity of marine mammals** is considered to be '**High**' and the **severity of the effect** to be '**Moderate**'. Therefore the overall **significance of the impact** is assessed as '**Upper Moderate (12)**'.	**Very Unlikely**	**'Low (4)'**
Coastal	There is a possibility of oil reaching the coastline of East Falkland (section 12.1.4.5.4). Parts of this area (Seal Bay; Volunteer Point and Cow Bay) are designated as IBAs (section 7.5.2.3.1). Although the likelihood of oil reaching the shore is very low	**Very Unlikely**	**'Low (4)'**

Receptor	Sensitivity of Receptor and Severity of Effect (Impact)	Likelihood of occurrence	Overall risk significance
	(predicted in 8 % of stochastic model runs with no oil spill response but 0 % if oil spill response is implemented) and the quantities involved are barely detectable in the modelled scenario (section 12.1.4.5.4). However, the areas that are potentially at risk are of national importance. Therefore, the **sensitivity of the coastal environment** is considered to be '**High**'. Given that there is still some uncertainty regarding the long-term impacts of such a waxy crude on this environment, the **severity of effect** of the FPSO crude inventory loss on coastal environments is considered to be '**Moderate**'. Therefore the significance of the impact on a complete loss of FPSO inventory is assessed as '**Upper Moderate (12)**'.		
Human population (tourism)	The potential fouling of iconic tourism destinations would impact greatly on the pristine image of the Falkland Islands and would likely have a negative impact on visitor numbers. While the model predicts that under very specific metocean conditions, oil could reach the shore, the concentrations would be so low (section 12.1.4.5.4) that it is unlikely that tourists would see oil at sea or along the shore. However, reports, observations and photos of the incident, including affected wildlife that may come ashore will certainly influence the experience and perceptions of tourists. Moreover, international news coverage of the incident (offshore) will potentially influence the perception of the public, whether they see the oil or not. As there is limited capacity to absorb and manage change in visitor numbers in the aftermath of a major incident, and given that this will be unacceptable to the majority of stakeholders, the **sensitivity of tourism** is assessed as '**High**'. Due to the potentially long-lasting negative impacts of perceived environmental degradation the **severity of effect** of an uncontrolled release on tourism has been assessed as '**Serious**'. Therefore the **significance of the impact** on tourism is assessed as '**High (16)**'.	**Very Unlikely**	**'Low (5)'**

12.1.6.3 Scenario 3: Crude oil transfer spill

12.1.6.3.1 Sensitivity of receptor and severity of effect (impact assessment)

The modelling approaches considered a crude oil spill of 70 m^3 (62 tonnes) that may occur during FPSO crude offload operations. The potential impacts of such a spill on the environmental receptors are similar to that of a larger spill, the main difference being the volume discharged, the extent of the area affected, the duration of the spill and the number of individuals and proportions of populations of the key environmental receptors exposed to the oil and impacted, which will generally be smaller.

The 'Sensitivity of Receptor' and the 'Severity of Effect' for each receptor are provided in Figure 12.11. The 'Likelihood of Occurrence' of a spill during crude oil transfer is described below and is included in Figure 12.11 to show how the overall significance ratings of risks associated with crude oil transfer spills were derived.

12.1.6.3.2 Likelihood of occurrence

The likelihood of a crude oil transfer spill associated with the FPSO offload operation can be assessed by investigating the frequency of oil spills associated with such installations in other parts of the world. Figure 12.47 shows the number of all recorded oil spill events associated with offshore O&G installations on the United Kingdom Continental Shelf (UKCS) between 2009 and 2013. Over this period the number of installations increased slightly from 482 in 2010 to 496 in 2013 (OSPAR, 2015). After accounting for the number of installations, the average number of oil spill events per installation was reasonably consistent over this period although it is important to note that these were not all the result of offloading operations. Less than 3% of the total number of spills were greater than 1 tonne in volume, but these small spills contributed between 58% and 89% of the oil spilled on an annual basis from offshore oil and gas installations in the UKCS.

Figure 12.48 illustrates the distribution of oil spills of different sizes for different installation types (note, data comes from a different period to that presented in Figure 12.47). Fixed and floating facilities are quite similar with typical spills occurring at a frequency of 1-2 incidents per year per facility with a typical spill size range of between 1 litre and 10 tonnes. The chart illustrates that spills in the region of 70 m^3 (62 tonnes) are very infrequent events.

The information presented above suggests that several small spills (from all sources) may occur at an installation each year, although most of these are not necessarily associated with crude oil transfer. The combined impact of these small spills may be more significant than a larger but far less likely spill.

A potential risk associated with the offloading operation is the risk of drive-off, i.e. the CTT inadvertently propelling itself off-station during transfer operations. However, mitigations are in place for this. The CTT is held by a tug when connecting to the FPSO, thus mitigating the risk. Taking all the industry-standard mitigation measures into account (section 12.1.5), the **likelihood of occurrence** of a 70 m^3 (62 tonnes) spill is assessed as '**Possible**' (Table 12.11).

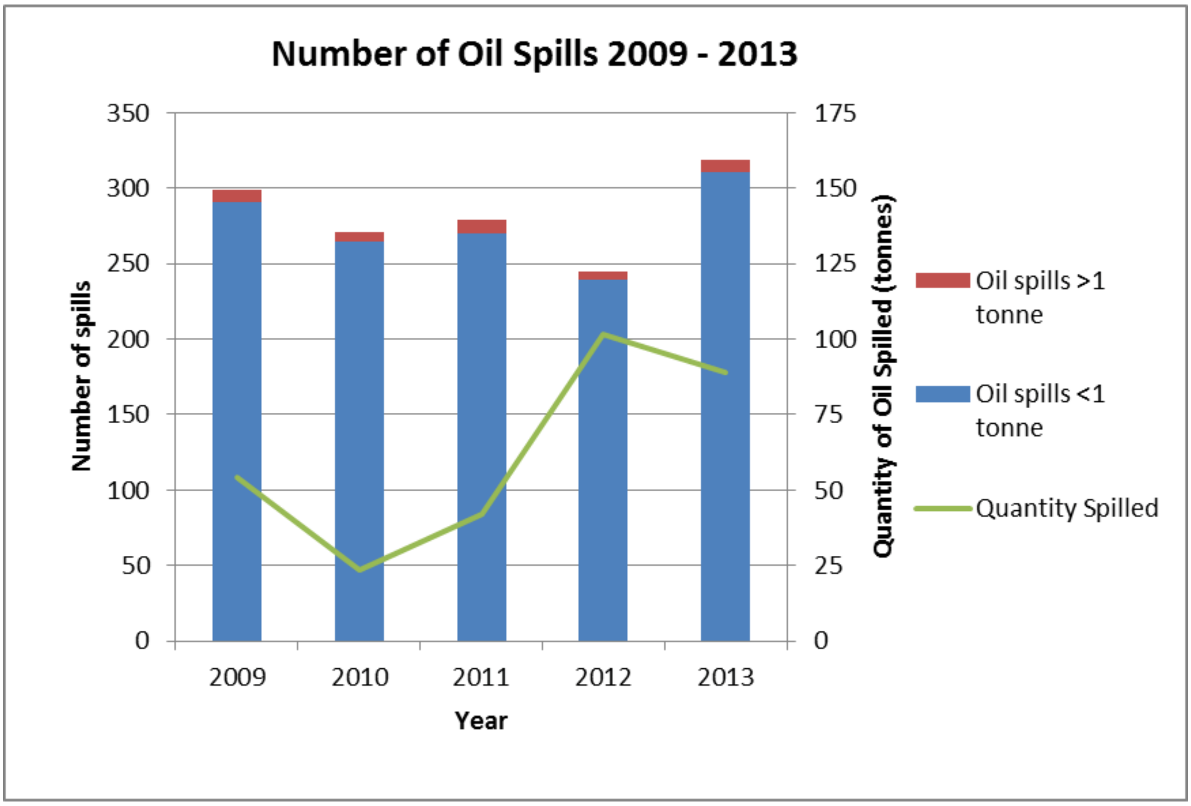


Figure 12.47: Number of oil spills and quantity of oil spilled in UKCS (2009 – 2013) *(Source: OSPAR, 2015)*

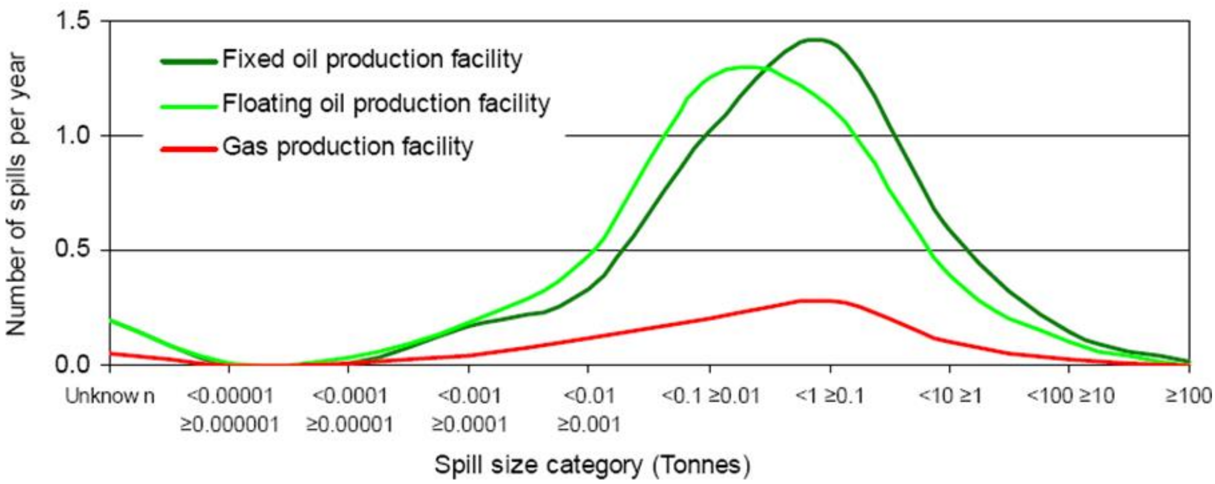


Figure 12.48: Spill size distribution for different installations (Source: Oil and Gas UK)

12.1.6.3.3 Overall risk significance

As is shown in Table 12.11, the highest **significance of the risk** posed by the loss of crude during offloading is to seabirds and the human population (tourism) and is considered to be '**Moderate**' and therefore, project-specific mitigation measures will be required.

PremierOil

Table 12.11: Risk assessment associated with crude oil transfer spills

Receptor	Sensitivity of Receptor and Severity of Effect (Impact)	Likelihood of occurrence	Overall risk significance
Plankton	The impact of a crude transfer spill will affect a very small area and therefore a small proportion of the local plankton populations. Consequently the **sensitivity of plankton** is assessed as '**Low**'. A combination of short generation times, high reproductive rates and immigration from outside the affected area would likely see a quick recovery of the affected communities. The **severity of the effect** of a crude transfer spill on plankton is therefore considered to be '**Slight**'. Therefore the **significance of the impact** is assessed as '**Very Low (2)**'.	Possible	Very Low (3)
Fish and squid	The zone of influence of a crude transfer spill will be small in space and time and will therefore impact a small proportion of the local fish and squid populations. The **sensitivity of fish and squid** is considered to be '**Low**'. Any effect will be highly localised and short-term and therefore the **severity of the effect** is considered to be '**Slight**'. Therefore the overall **significance of the impact** is assessed as '**Very Low (2)**'.	Possible	Very Low (3)
Human population (fisheries)	The **sensitivity of fisheries** is considered to be '**Low**', and given the low volume of oil that is expected to be rapidly dispersed in the water column, the **severity of the effect is therefore considered** to be '**Minor**'. The overall **significance of the impact** is therefore assessed as '**Low (4)**'.	Possible	Low (6)
Seabirds	Although the volume of oil discharged following a crude oil transfer spill is relatively small, the highest density of seabirds in the area will be closely associated with the Development vessels. It is these birds that are at greatest risk of exposure to oil, regardless of the size of the spill (section 12.1.4.2.5). The **sensitivity of seabirds** is considered to be '**Very High**'. The impact of a crude oil transfer spill will be short-lived and restricted to the local area. The **severity of the effect** of a crude oil transfer spill is considered to be '**Minor**'. The overall **significance of the impact** is consequently assessed as '**Moderate (10)**'.	Possible	Moderate (9)
Marine mammals	Given the limited extent and duration of an oil spill associated with crude oil transfer operations, and the tendency for marine mammals to associate less with vessels and structures at sea than seabirds, the **sensitivity of marine mammals** is considered to be '**Moderate**' and the **severity of the impact** to be '**Slight**'. Therefore the overall **significance of the impact** is assessed as '**Very Low (3)**'.	Possible	Very Low (3)
Coastal	No shoreline oiling was predicted in any of the stochastic simulations of a crude transfer spill.	n/a	n/a
Human population (tourism)	Given the small volume of oil involved, the distance offshore and the low exposure time (section 12.1.4.6.2) it is highly unlikely that tourists would see any of the oil discharged following an offshore crude oil transfer spill. While news of an oil spill, even if minor, may influence the perception of the public, whether they see the oil or not, it is very unlikely that smaller spills would come to the attention of tourists. Therefore, the **sensitivity of tourism** to a crude oil transfer spill, is considered to be '**Moderate**'. Due to the short-term and reversible impacts of a small spill on the perception of tourists regarding environmental degradation, the **severity of effect** of a crude transfer spill on tourism has been assessed as '**Minor**'. Therefore the overall **significance of the impact** is assessed as '**Moderate (6)**'.	Possible	Moderate (9)

12.1.6.4 Scenario 4: Loss of MODU diesel inventory

12.1.6.4.1 Sensitivity of receptor and severity of effect (impact assessment)

Diesel is predicted to remain on the sea surface for a short period of time before it either evaporates or disperses in the water column (section 12.1.4.7.1). The extent of the sea surface and water column areas likely to be affected by diesel spills is generally more restricted (close to the release point) than crude oil spills. However, the higher volatility of diesel is such that it is more likely to release toxic substances, such as PAHs into the water column (section 12.1.4.1.1). These chemicals are toxic to marine life and will have localised impacts following exposure. The larger the spill, the greater the area over which the diesel will spread and the longer it will take for the diesel to be reduced to insignificant concentrations.

The 'Sensitivity of Receptor' and the 'Severity of Effect' for each receptor are provided in Table 12.12. The 'Likelihood of Occurrence' of a diesel spill from the MODU is described below and is also included in Table 12.12 to show how the overall significance ratings of risks associated with the loss of MODU's diesel inventory were derived.

12.1.6.4.2 Likelihood of occurrence

One of the most plausible events that could result in a complete loss of the MODUs diesel inventory is a collision with a large vessel. When in the field, during Development Stages 1 and 2, the MODU will be anchored within the vicinity of the FPSO, which will also be anchored. Therefore, the likelihood of a vessel colliding with the MODU can be assessed based on the same Anatec COLLRISK study described in section 11.1.

The predicted collision frequency is very low, as for the FPSO, and it is useful to note that only three semi-submersible drilling rigs have ever sunk in the O&G industry. One incident occurred in the Canadian waters of the North Atlantic and was due to a catalogue of errors initiated by a major hurricane (US Coastguard, 1983). The other two incidents occurred in African waters when the MODUs were being towed. No incidents have been recorded on the UKCS, or anywhere since 1995.

With industry-standard mitigation measures in place (section 12.1.5), the **likelihood of occurrence** of a vessel colliding with the rig, potentially leading to a loss of containment of the entire diesel inventory, is assessed as '**Unlikely**' (Table 12.12).

12.1.6.4.3 Overall risk significance

As is shown in Table 12.12, the highest **significance of the risk** posed by the loss of diesel from the MODU is to seabirds and tourism, both of which are considered to be '**Moderate (8)**' and therefore require project-specific mitigation measures.

Table 12.12: Risk assessment of MODU diesel spill

Receptor	Sensitivity of Receptor and Severity of Effect (Impact)	Likelihood of occurrence	Overall risk significance
Plankton	Following the loss of drilling rig diesel inventory, the models predict that the diesel will remain on or close to the surface of the water initially but is rapidly removed by evaporation, biodegradation and dispersion (section 12.1.4.7.1). Diesel concentrations in the water column are only expected to exceed 1,000 ppb in a small area around the discharge site (section 12.1.4.7.3), but these levels should decrease rapidly and reach negligible levels after 10 days. While deleterious impacts would generally be greatest during periods of increased plankton productivity, the planktonic organisms will be contaminated over a small area of low productivity for a relatively short period of time. Any impacts will affect a small proportion of the local populations and therefore the **sensitivity of plankton** is considered to be '**Low**'. A combination of short generation times, high reproductive rates and immigration from outside the affected area would likely see a quick recovery of the affected plankton communities. The **severity of the effect** of diesel spills on plankton is therefore considered to be '**Minor**'. Therefore the **significance of the impact** is assessed as '**Low (4)**'.	**Unlikely**	**Very Low (4)**
Fish and squid	Fish and squid could experience lethal effects if they come into contact with high concentrations of diesel; eggs and larvae are particularly vulnerable as they occupy the surface layers of the sea and are immobile (section 12.1.4.2.3). In the offshore environment, diesel spills will be dispersed and evaporate rapidly and so fish may be more vulnerable to sub-lethal effects and accumulation of toxins (that can taint the flesh of fish) than direct mortality (section 12.1.4.2.3). However, because no known spawning sites are in the immediate vicinity of the Development area, and adult fish are likely to move away, any impacts of a diesel spill will affect a small proportion of the local fish and squid populations. Therefore the **sensitivity of fish and squid** is considered to be '**Low**'. The impacts of the spills modelled here are very localised and short-term in nature and the **severity of the effect** is assessed as '**Minor**'. Therefore the **significance of the impact** is assessed as '**Low (4)**'.	**Unlikely**	**Very Low (4)**
Human population (fisheries)	Although some tainting of fish is possible following the loss of the MODU diesel inventory, fisheries in the NFB are not located near to the Phase 1 Development area and the diesel is unlikely to extend to the fishing grounds before it has evaporated (section 12.1.4.7.1). The **sensitivity of fisheries** is therefore considered to be '**Low**'. Given the rapid rate at which the discharged diesel will evaporate and biodegrade, and thus the limited extent and relatively short duration of a diesel spill associated with the loss of the MODU diesel inventory, the impacts on commercial fisheries are likely to be confined to a relatively small area. The **severity of effect** of the modelled spill on fisheries is considered to be '**Moderate**', as the effects are expected to be localised and of a short-term nature but could result in localised fisheries closures. The **significance of the impact** on human population (fisheries) is therefore assessed as '**Moderate (6)**'.	**Unlikely**	**Low (6)**
Seabirds	The MODU will be on location for 36 months in total and seabird vulnerability varies on a monthly / seasonal basis (section **7.4.5.2**). Further, diesel has greater potential to cause fouling than the Sea Lion crude oil and has greater potential for impacts associated with toxicity (section 12.1.4.2.5). Following a discharge, diesel rapidly spreads to form a sheen on the surface of the water and the potential impact is proportional to the extent to which seabirds overlap with and encounter the diesel; this is linked to the size of the spill. The presence of the MODU and other vessels associated with the project will attract some seabirds and	**Unlikely**	**Moderate (8)**

Receptor	Sensitivity of Receptor and Severity of Effect (Impact)	Likelihood of occurrence	Overall risk significance
	therefore the density of birds in the immediate vicinity of the vessels, and any spill, will be far higher than the baseline density in surrounding waters (section 12.1.4.2.5). Due to the potential for the presence of a large number of seabirds, many of which will be ACAP species and / or are of global conservation concern, the **sensitivity of seabirds** to the effects of a large diesel spill, is considered to be '**Very High**'. Nonetheless, the area affected by the spill is predicted to be relatively small (on the scale of the NFB) and given the relatively rapid rates of evaporation and dispersion, the slick will be short-lived. The **severity of effect** of a spill resulting from a large diesel spill is therefore considered to be '**Moderate**'. Therefore, the **significance of the impact** of a loss of diesel inventory from the largest vessel associated with the development on seabirds is assessed as '**Upper Moderate (15)**'.		
Marine mammals	Pinnipeds, and particularly fur seals, that come into contact with a diesel spill may suffer adverse consequences (section 12.1.4.2.6). However, it is expected that a spill resulting from the loss of the drilling rig's diesel inventory would impact a relatively small area for a short period of time. Cetaceans are more vulnerable to inhaling toxic vapour and are less affected by contact with the skin (section 12.1.4.2.6). They would therefore be most likely to be affected for a short period immediately following a spill before the diesel is dispersed from the release point. Due to seasonal fluctuations in abundance (section **7.4.6.2**), the timing of a spill will influence the likely presence, and potential exposure, of different receptor species to a spill of the rig's diesel inventory. Nonetheless, given that all marine mammals are protected and considered conservation priority species by FIG, the **sensitivity of marine mammals** to discharged diesel during the development is assessed as '**High**'. Like seabirds, the potential impacts are related, to some extent, to the size of the spill. Diesel spills are predicted to be short-lived and localised. The **severity of effect** of a large diesel spill on marine mammals is therefore considered to be '**Minor**'. Therefore, the **significance of the impact** of a loss of the MODU diesel inventory on marine mammals is considered to be '**Moderate (8)**'.	**Unlikely**	**Low (6)**
Coastal	No shoreline oiling was predicted in any of the stochastic simulations of the MODU diesel spill scenario.	**n/a**	**n/a**
Human population (tourism)	The modelling predicts that no diesel would reach the shore and given the rapid rate at which diesel will evaporate and disperse, and the distance offshore, it is highly unlikely that tourists would experience or see diesel at sea. However, observations and photos of oiled wildlife that come ashore will certainly influence the experience and perceptions of tourists. Additionally, media publicity may influence the experience and perceptions of tourists, which may then influence their propensity to visit. Given that there would be moderate capacity to absorb change in the aftermath of a large diesel spill, the **sensitivity of tourism** is considered to be '**Moderate**'. Due to the long lasting negative impacts of perceived environmental degradation, the **severity of effect** of an uncontrolled release on tourism is considered to be '**Serious**'. Therefore the **significance of the impact** of a loss of the MODU diesel inventory on tourism is considered to be '**Upper Moderate (12)**'.	**Unlikely**	**Moderate (8)**

12.1.6.5 Scenario 5: Diesel bunkering spill

12.1.6.5.1 Sensitivity of receptor and severity of effect (impact assessment)

The main difference between a diesel bunkering spill and a spill associated with the loss of the drilling rig's diesel inventory is the volume of diesel discharged: 4,631m^3 (3,983 tonnes) in the case of the diesel inventory loss scenario as opposed to 30m^3 (26 tonnes) in a bunkering spill (section 12.1.5). In both cases, the diesel is expected to evaporate and disperse rapidly. Especially in the case of the diesel bunkering spill, it is expected that the area and duration of impact will be small and short-lived.

The 'Sensitivity of Receptor' and the 'Severity of Effect' for each receptor are provided in Table 12.13. The 'Likelihood of Occurrence' of a diesel spill during bunkering is described below and is included in Table 12.13 to show how the overall significance ratings of risks associated with a diesel bunkering spill were derived.

12.1.6.5.2 Likelihood of occurrence

Section 12.1.6.6 discusses the likelihood of small spills (from all sources). Assuming the use of industry-standard mitigation measures (section 12.1.5), the likelihood of small-scale diesel spills during fuel transfer has been assessed as '**Possible**' (Table 12.13).

12.1.6.5.3 Overall risk significance

As is shown in Table 12.13, the highest **significance of the risk** posed by the loss of diesel during bunkering is to Seabirds and is considered to be '**Moderate (9)**' and therefore, project-specific mitigation measures will be required.

Table 12.13: Risk assessment of diesel bunkering spill

Receptor	Sensitivity of Receptor and Severity of Effect (Impact)	Likelihood of occurrence	Overall risk significance
Plankton	While any effects will be greater during periods of high plankton productivity, impacts of a diesel bunkering spill will affect a very small proportion of the local populations and therefore the **sensitivity of plankton** is assessed as '**Low**'. A combination of short generation times, high reproductive rates and immigration from outside the affected area would likely see a quick recovery in the affected communities. The **severity of the effect** on plankton is therefore considered to be '**Slight**'. Therefore the **significance of the impact** associated with a diesel bunkering spill is assessed as '**Very Low (2)**'.	**Possible**	Very Low (3)
Fish and squid	The sensitivity assessment is the same as for a diesel inventory spill from the MODU (Table 12.12), and the **sensitivity of fish and squid** in relation to a diesel bunkering spill is considered to be '**Low**'. Given the small volume of diesel involved the impact of the spills modelled here will be very localised and short-term in nature and so the **severity of the effect** is considered to be '**Slight**'. Therefore the **significance of the impact** associated with a diesel bunkering spill is assessed as '**Very Low (2)**'.	**Possible**	Very Low (3)
Human population (fisheries)	The sensitivity assessment is the same as for a diesel spill from the MODU (Table 12.12), and the **sensitivity of fisheries** in relation to a diesel bunkering spill is considered to be '**Low**'. Given the small volume of diesel involved and the rapid rate at which diesel will evaporate and biodegrade, any impacts on commercially important fish are assessed to be highly localised and short-term in nature. The **severity of the effect** of a diesel bunkering spill is therefore considered to be '**Slight**'. The **significance of the impact** on human population (fisheries) is therefore assessed as '**Very Low (2)**'.	**Possible**	Very Low (3)
Seabirds	The sensitivity assessment is the same as for a diesel spill from the MODU (Table 12.12), and the **sensitivity of seabirds** in relation to a diesel bunkering spill is considered to be '**Very High**'. The impact of small diesel spills will be extremely localised and short-term and therefore the **severity of the effect** of a small transfer diesel spill (30 m^3 / 26 tonnes) on seabirds is considered to be '**Minor**'. Therefore, the **significance of the impact** of small diesel bunkering spills on seabirds is assessed as '**Moderate (10)**'.	**Possible**	**'Moderate (9)'**
Marine mammals	The sensitivity assessment is the same as for a diesel spill from the MODU (Table 12.12), and the **sensitivity of marine mammals** in relation to a diesel bunkering spill is considered to be '**High**'. There is no indication that the presence of a rig attracts associating marine mammals, although they could be attracted by potential prey species that may shelter near the rig. The **severity of the effect** of a small short-term release of diesel on marine mammals is therefore considered to be '**Slight'**. Consequently, the **significance of the impact** of a small diesel transfer spill on marine mammals is assessed as '**Low (4)**'.	**Possible**	**Low (6)**
Coastal	No shoreline oiling was predicted in any of the stochastic simulations of the diesel bunkering spill.	**n/a**	**n/a**

Receptor	Sensitivity of Receptor and Severity of Effect (Impact)	Likelihood of occurrence	Overall risk significance
Tourism	Tourists are highly unlikely to observe, directly or indirectly, any evidence of a diesel bunkering spill of the volume considered here. and the **sensitivity of tourism** is considered to be '**Low**'. Due to the short-term and reversible impacts of a small spill on the perception of tourists regarding environmental degradation, the **severity of the effect** of a diesel bunkering spill on Tourism considered to be '**Minor**'. Therefore, the **significance of the impact** of small diesel spills on seabirds is assessed as '**Low (4)**'.	**Possible**	**Low (6)**

12.1.6.6 Small scale releases of oil

12.1.6.6.1 Sensitivity of receptor and severity of effect (impact assessment)

As described in section 12.1.4.9, it is not possible to predict or quantify the volumes that may be released during small accidental spills. Small spills may create surface sheens which have the potential to cause environmental impacts, primarily upon seabirds (section 12.1.4.2.5).

It is likely that several seabird species present in close proximity to the Development vessels will be classified as 'Vulnerable' or 'Endangered' by the IUCN (which equates to 'High' sensitivity). Some of the species of seabird that associate with vessels in Falkland Islands waters are also listed under ACAP (Agreement on the Conservation of Albatrosses and Petrels). These are species that are considered to be under wider threat (largely from fisheries related mortality). Moreover, the use of artificial light (section 10.1) and the discharge of macerated food waste (section 10.10) may also attract additional species. Various studies have highlighted the risk and impacts to seabird populations associated with small-scale, but chronic, oil pollution from sources such as shipping. Therefore, overall, the **sensitivity of the seabird receptors** to chronic oil pollution from discharges is considered to be '**Very High**'.

There are no clear guidelines regarding the degree of impact from sheens of a given thickness and the impact may either be reversible or lethal to the individual depending on the amount of fouling (possibly species specific). A sheen of even 0.1 µm could cause an effect that may reduce fitness. However, given the metocean conditions in the region, any sheen resulting from discharges is likely to be temporary. Therefore, the **severity of the effect** is considered to be '**Minor**'.

The overall **significance of the impact** on seabirds associated with chronic oil pollution from the Sea Lion activities is therefore considered to be '**Moderate (10)**'.

12.1.6.6.2 Likelihood of occurrence

Given industry figures for small spills, the need for breach of procedural controls to occur, the **likelihood of a sheen forming and seabirds becoming oiled** is considered to be '**Possible**'.

12.1.6.6.3 Overall risk significance

The overall **significance of the risk** of a chronic oiling of seabirds is considered to be '**Moderate (9)**'.

12.1.6.7 Loss of riser contents

12.1.6.7.1 Sensitivity of receptor and severity of effect (impact assessment)

It is anticipated that any loss of riser contents would release approximately 60 m^3 of OBM to sea, which would settle to cover an area of around 0.006 km^2 around the MODU. It is likely to impact benthos and sediments in the vicinity via both smothering and toxic effects. According to the surveys already carried out in the area (section 7.2.2), there are no known vulnerable species recorded within the benthos and the community structure is widespread and typical of the area. However, a data gap exists because the Sea Lion environmental baseline survey did not sample the site-specific drilling locations. Therefore, although the **sensitivity of the receptor** is likely to be 'Very Low', to take a precautionary approach it is assessed here as '**Low**'.

The area predicted to be impacted by a loss of riser contents would be in close proximity to the drill centre and reversible after a number of years; therefore the **severity of the effect** is considered to be '**Moderate**'

The overall **significance of the impact** on the benthos and sediments due to the loss of riser contents is therefore considered to be '**Moderate (6)**'.

12.1.6.7.2 Likelihood of occurrence

Given the need for malfunction to occur, and the incidence of loss of riser contents being known within industry but infrequently, the **likelihood of a loss of riser contents** is considered to be '**Unlikely**'.

12.1.6.7.3 Overall risk significance

The overall **significance of the risk** associated with a loss of riser contents is considered to be '**Low (6)**'.

12.1.7 Project-specific mitigation measures

The remoteness, poor transport infrastructure and abundant wildlife in the Falklands pose unique and significant challenges in responding to a major oil pollution incident. Therefore, in addition to the industry-standard mitigation measures (section 12.1.5) and those that are required by legislation, Premier has spent considerable time and effort determining what additional oil spill response measures may be appropriate. This process was driven primarily by the proposal to export the oil via ship-to-ship transfer at an inshore location (Berkeley Sound). The measures that will be put in place by Premier to prevent and mitigate the impacts of an inshore oil spill are described in section 12.2.2 and all oil spill response strategies and equipment will be described in the Sea Lion OSCP (section 12.1.1.1.3).

While oil spill response (OSR) equipment will be carried on the ERRV (MRSV) offshore, and it may be possible to deploy the containment and recovery equipment under the right conditions, in reality it is unlikely to be effective in the prevailing offshore weather conditions of the Sea Lion Field. A comparison of a worst case blow-out scenario with and without response is shown in Table 12.14, demonstrating that offshore, oil spill response is not considered effective in respect of a larger event.

Table 12.14: Comparison of worst case well blow-out scenario with and without proposed oil spill response

Without response	With response
8 % of scenarios reach the shore	10 % of scenarios reach the shore
Maximum oil on shore: 395 tonnes	Maximum oil on shore: 304 tonnes
Average oil on shore within the 8% that reach shore: 118 tonnes	Average oil on shore within the 10% that reach shore: 74 tonnes
Arriving on the shore 66 days	Arriving on the shore >81 days
-	9 % (2,419 tonnes) oil recovered

Note: Due to the particle motion physics, response modelling can result in fragmentation of large oil masses and a larger number of small particles in the model which are available to reach more shoreline cells, and therefore occasionally more scenarios will reach shore when response is applied. This is an artefact of the model and overall the response modelling shows that response reduces the maximum and average volume of oil reaching shore.

Therefore, in order to ensure a precautionary approach, these mitigations are not considered applicable to this *offshore* oil spill assessment. Although, the deployment of oil spill response equipment is considered impractical, it is likely that oil will eventually be dispersed through natural wave and wind action, evaporate and biodegrade. However, it is currently unknown how long Sea Lion crude will remain in the environment beyond seven days, as indicated in section 12.1.4.1.1.1.

12.1.8 Residual impacts and risks

In the worst case scenario, weather conditions offshore will be such that effective recovery of oil spills will not be possible and therefore the residual significance of the risk remains the same as in the initial assessment which takes account of all the legal requirements and the industry-standard mitigations. For ease of reading, these are summarised again in Table 12.15.

Table 12.15: Residual risks for each scenario

Scenario	Impact assessment	Likelihood	Overall risk significance
1: Subsea well blow-out	High for Seabirds and Human Population (Fisheries)	Unlikely	**Moderate (10)**
2: FPSO inventory loss	High for Seabirds and Human Population (Fisheries and Tourism)	Very Unlikely	**Low (5)**
3: Crude transfer spill	Moderate for Seabirds	Possible	**Moderate (9)**
4: Diesel inventory loss	Upper Moderate for Seabirds and Human Population (Tourism)	Unlikely	**Moderate (8)**
5: Diesel bunkering spill	Moderate for Seabirds	Possible	**Moderate (9)**
Small scale releases	Moderate for Seabirds	Possible	**Moderate (9)**
Loss of riser contents	Moderate for Benthos	Unlikely	**Low (6)**

12.1.9 Cumulative impact

Not applicable.

12.1.10 Confidence

The Sea Lion Field has now been evaluated by a number of test wells. The properties of Sea Lion crude and probable flow rates are relatively well defined. However, the very waxy nature of the crude means that the behaviour of the oil in the marine environment will be quite different to that of a lighter (fluid) crude. Recent testing of the Sea Lion crude (CEDRE, 2017) has confirmed and expanded on earlier studies of the properties of Sea Lion crude in the event of a spill, specifically:

- Physical state in contact with seawater at ambient temperatures (8 °C);
- Evaporation after three – seven days at sea;
- Dispersion (how the oil would break up at sea);
- Biodegradation of the oil after seven days at sea;
- Interaction of spilled oil with suspended solids at various concentrations;
- Adhesion of the oil to feathers;
- Emulsification of the oil;
- Dissolved fractions of the oil after seven days at sea;
- Ecotoxicity to four marine species;
- Adhesion to three types of seaweed; and
- Adhesion to various shoreline types.

Further testing is still ongoing on the visibility and sheen formation of the oil, as well as the adhesion to marine mammal pelts and fur, and these are acknowledged as data gaps in this assessment. The behaviour and nature of the impact of diesel is relatively well known from several decades of research and also from model validation studies. Modelling uncertainties have been identified (Table 12.16) and while their potential to materially alter the outcome of the modelling has been considered, it is acknowledged that improvements in the modelling design could increase accuracy of quantification of the impact. The confidence assessments for each scenario are described in Table 12.17.

The seasonal distribution of potential receptors in the NFB is reasonably well understood but further research is required to improve our knowledge of species distributions, and these are acknowledged as data gaps. The Gap Analysis Programme (GAP) is conducting ongoing research to fill some of these knowledge gaps. Some receptors, especially seabirds (see Wiese *et al.,* 2001), are known to congregate around vessels (including O&G installations) at-sea, which places artificially higher numbers of receptors in close proximity to sources of oil spills. Surveys are required to assess the influence of project vessels and activities on seabird abundance within the Sea Lion Field.

Table 12.16: Oil spill uncertainties

Uncertainty	Description
Release volumes	Well blow-outs are extremely rare events that are often controlled within a matter of days using subsea intervention techniques or by the well ‘bridging’ over and restricting flow. The assumed total duration for the well blow-out in this EIS is 29 days, which is the time required to mobilise and install a capping device and is considered be the worst case blow-out duration. The inventory loss scenarios that have been considered in this EIS are also extremely rare events. The crude inventory loss scenario was modelled as being the worst possible case of inventory loss whereby all tanks available on the FPSO for crude storage are discharged to sea, as well as two tanks from the offload tanker. In the extremely rare event of this type of spill, it is very unlikely that the complete inventory would be discharged as has been modelled here.

Uncertainty	Description
Oil characterisation and behaviour	The properties of the Sea Lion crude, based on the CEDRE testing (CEDRE, 2017), along with input from oil weathering experts, has been used in the modelling predictions and the risk assessment procedures. The OSCAR model is primarily designed to predict physical behaviour for Newtonian fluids which includes the majority of crude oils. As above, choices have been made within the hydrocarbon characterisation and weathering parameters to allow as close a match as possible between the model algorithms and the expected non-Newtonian behaviour of the wax. The outputs appear to be consistent with expectations based on examining intermediate model steps and the overall outputs.
Metocean conditions	The metocean dataset covers three years. This includes a wide range of weather conditions and the modelling results consistently show a tendency for dispersion to the northwest of the site. However, the currents do move in all directions at different times and deposition is locally variable due to the short nature of each release. During operations a real time offshore hydrodynamic model covering 3-day detailed current and wind forecasts will be run and available in the event of a spill.
Model predictions after the oil has been at sea for a long period of time	It is normal to run scenarios for the entire duration of a blow-out, and for some time following an inventory release, to determine the behaviour and location of oil before taking a view on whether this poses a risk to receptors. There is uncertainty around the fate of oil masses in the long term (several months), given its apparent buoyancy and stability in laboratory tests. Overall, the interpretation of results at long timescales should be done with caution and experience. In general, the model results may exaggerate the apparent impact of dispersed oil.
The performance of containment and recovery equipment	*In situ* performance is uncertain and could affect residual impacts post-response (positively or negatively) particularly for larger spills. This can be further investigated by pursuing industry trials and potentially designing site-specific trials.

Table 12.17: Confidence assessments

Scenario	Description	Confidence
1: Subsea well blow-out **2: FPSO inventory loss** **3: Crude transfer spill**	There are many uncertainties and assumptions associated with the modelling of oil spills, both in terms of the properties of the oil and the environmental conditions (currents, wind and wave action) that influence its dispersion. The modelling component of the oil spill risk assessment has used the highest resolution metocean data sets available, as well as direct inputs from oil testing to replicate Sea Lion crude parameters, which provide the best possible basis for predicting oil behaviour at sea. However, there is always an inherent uncertainty when predicting the fate and behaviour of oils using hindcast winds and currents derived from hydrodynamic models. The sensitivities of many of the environmental receptors to a well blow-out vary due to seasonal changes in their distribution, and a well blow-out could potentially happen at any time of the year. Wherever possible, worst case scenarios have been used to ensure that the potential impacts are not under-estimated.	Due to the uncertainties associated with major accidental events, the confidence in the significance of the risk presented in this assessment is '**Uncertain**'.
4: Diesel inventory loss **5: Diesel bunkering spill**	The modelling component of the oil spill risk assessment has used the highest resolution metocean data sets available, which provide the best possible basis for predicting oil behaviour at sea. However, there is always an inherent uncertainty when predicting the fate and behaviour of oils using hindcast winds and currents derived from hydrodynamic models. The volatile nature of diesel fuel means that spills will evaporate, disperse and biodegrade relatively rapidly, and the impact will be localised and short-lived. The exact nature and extent of the impacts will depend on the concentration of environmental receptors in the immediate vicinity of the MODU / FPSO at the time of a spill, which is not possible to predict with precision. The MODU / FPSO itself will influence the distribution of some seabirds and may also influence the distribution of some marine mammals and their prey.	The confidence in the impact assessment of diesel spills on the marine environment is '**Probable**'.

12.1.10.1 Monitoring required

Seabird and Marine Mammal Observers (SMMOs) will be used on support vessels (most likely the MRSVs) and the possibility of a collaborative survey with Falkland Islands Fisheries Department (FIFD) will be investigated.

The development of a seabird distribution monitoring programme over several years aimed at improving understanding of species-specific distribution patterns will be established, potentially in collaboration with FIFD.

Once production has commenced, the modelled flow rates will be compared with actual flow rates. If the actual flow rates are higher than predicted, the modelling exercises will be re-run with the revised parameters.

The spill modelling and hydrodynamic data will be used to develop a means of forecasting spill trajectories pre-operation to enable rapid and targeted response in the event of a spill.

Detailed monitoring requirements will be established during the Environmental Monitoring and Management Plan (EMMP) workshop. All monitoring requirements agreed by Premier and FIG will be recorded and managed via the project-specific Phase 1 EMMP (Chapter 15).

12.1.11 Offsetting

For significant residual and impacts and risks (Moderate or above), offsetting via an Environmental Fund is proposed, see section 8.9 for further details.

12.1.12 Findings summary

Table 12.18: Summary of the risk assessment for all oil spill scenarios

Activity	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
Well drilling and oil production	Scenario 1: Subsea well blow-out	Lethal and sub-lethal toxic effects on Plankton	Accidental	1, 2 & 3	Moderate	Moderate	Unlikely	**Low (6)**	**n/a**	**Uncertain**	**Industry-standard:** Use of standard operating procedures; Compliance with HSE MS and Drilling Management System; SECE Register and performance standards; Primary and secondary well control; Development and implementation of the OSCP; Use of a well capping device. **Project-specific:** Additional oil spill recovery equipment on support vessels.
		Lethal and sub-lethal toxic effects on Benthic communities	Accidental	1, 2 & 3	Very Low	Serious	Unlikely	**Low (6)**	**n/a**	**Uncertain**	
		Lethal and sub-lethal toxic effects on Fish and squid	Accidental	1, 2 & 3	Moderate	Moderate	Unlikely	**Low (6)**	**n/a**	**Uncertain**	
		Impact on fisheries from tainting of fish and contamination of fishing grounds	Accidental	1, 2 & 3	Very High	Serious	Unlikely	**Moderate (10)**	**Moderate (10)**	**Uncertain**	
		Plumage contamination and oil ingestion by Seabirds	Accidental	1, 2 & 3	Very High	Serious	Unlikely	**Moderate (10)**	**Moderate (10)**	**Uncertain**	
		Skin contamination and ingestion of toxins by marine mammals	Accidental	1, 2 & 3	High	Moderate	Unlikely	**Moderate (8)**	**Moderate (8)**	**Uncertain**	
		Impact on coastal ecology	Accidental	1, 2 & 3	High	Moderate	Unlikely	**Moderate (8)**	**Moderate (8)**	**Uncertain**	

Activity	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
		Negative publicity impacting tourist numbers	Accidental	1, 2 & 3	High	Serious	Unlikely	**Moderate (10)**	**Moderate (10)**	**Uncertain**	
Catastrophic loss of the FPSO	Scenario 2: Loss of the full FPSO crude oil Inventory plus two offload tanker tanks	Lethal and sub-lethal toxic effects on Plankton	Accidental	2 & 3	Moderate	Moderate	Very Unlikely	**Very Low (3)**	**n/a**	**Uncertain**	**Industry-standard:** SECE Register, HSE MS and performance standards; A 500 m radius Safety Zone; A ERRV vessel; AIS and Radar surveillance; Radio broadcasts; and Development and implementation of the OSCP. **Project-specific:** Additional oil spill response equipment on support vessels.
		Lethal and sub-lethal toxic effects on Benthic communities	Accidental	2 & 3	Very Low	Serious	Very Unlikely	**Very Low (3)**	**n/a**	**Uncertain**	
		Lethal and sub-lethal toxic effects on Fish and squid	Accidental	2 & 3	Moderate	Moderate	Very Unlikely	**Very Low (3)**	**n/a**	**Uncertain**	
		Impact of fisheries from tainting of fish and contamination of fishing grounds	Accidental	2 & 3	Very High	Serious	Very Unlikely	**Low (5)**	**n/a**	**Uncertain**	
		Plumage contamination and oil ingestion by Seabirds	Accidental	2 & 3	Very High	Serious	Very Unlikely	**Low (5)**	**n/a**	**Uncertain**	
		Pelage / skin contamination and ingestion of toxins by marine mammals	Accidental	2 & 3	High	Moderate	Very Unlikely	**Low (4)**	**n/a**	**Uncertain**	
		Impact on coastal ecology	Accidental	2 & 3	High	Moderate	Very Unlikely	**Low (4)**	**n/a**	**Uncertain**	

Activity	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
		Negative publicity impacting tourist numbers	Accidental	2 & 3	High	Serious	Very Unlikely	**Low (5)**	**n/a**	**Uncertain**	
Offshore transfer of crude from the FPSO to the CTT	Scenario 3: Crude oil transfer spill	Lethal and sub-lethal toxic effects on Plankton	Unplanned	2 & 3	Low	Slight	Possible	**Very Low (3)**	**n/a**	**Uncertain**	**Industry-standard:** SECE Register, HSE MS and performance standards; Pipelines will be protected by pressure alarms; A leak detection system will be fitted; Dry break couplings; Development and implementation of the OSCP. **Project-specific:** Additional oil spill response equipment on support vessels.
		Lethal and sub-lethal toxic effects on Fish and squid	Unplanned	2 & 3	Low	Slight	Possible	**Very Low (3)**	**n/a**	**Uncertain**	
		Impact on fisheries from tainting of fish and contamination of fishing grounds	Unplanned	2 & 3	Low	Minor	Possible	**Low (6)**	**n/a**	**Uncertain**	
		Plumage contamination and oil ingestion by Seabirds	Unplanned	2 & 3	Very High	Minor	Possible	**Moderate (9)**	**Moderate (9)**	**Uncertain**	
		Pelage / skin contamination and ingestion of toxins by marine mammals	Unplanned	2 & 3	Moderate	Slight	Possible	**Very Low (3)**	**n/a**	**Uncertain**	

Activity	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
		Negative publicity impacting tourist numbers (human population Tourism)	Unplanned	2 & 3	Moderate	Minor	Possible	**Moderate (9)**	**n/a**	**Uncertain**	
Catastrophic event leading to the loss of the MODU or FPSO	Scenario 4: Loss of MODU / FPSO full diesel inventory	Lethal and sub-lethal toxic effects on Plankton	Accidental	1, 2 & 3	Low	Minor	Unlikely	**Very Low (4)**	**n/a**	**Probable**	**Industry-standard:** SECE Register, HSE MS and performance standards; A 500 m radius Safety Zone; A ERRV vessel; AIS and Radar surveillance; Radio broadcasts; and Development and implementation of the OSCP. **Project-specific:** Additional oil spill response equipment on support vessels.
		Lethal and sub-lethal toxic effects on Fish and squid	Accidental	1, 2 & 3	Low	Minor	Unlikely	**Very Low (4)**	**n/a**	**Probable**	
		Impact on fisheries from tainting of fish and contamination of fishing grounds	Accidental	1, 2 & 3	Low	Moderate	Unlikely	**Low (6)**	**n/a**	**Probable**	
		Plumage contamination and oil ingestion by Seabirds	Accidental	1, 2 & 3	Very High	Moderate	Unlikely	**Moderate (8)**	**Moderate (8)**	**Probable**	
		Pelage / skin contamination and ingestion of toxins by marine mammals	Accidental	1, 2 & 3	High	Minor	Unlikely	**Low (6)**	**n/a**	**Probable**	

PremierOil

Activity	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
		Negative publicity impacting tourist numbers (human population Tourism)	Accidental	1, 2 & 3	Moderate	Serious	Unlikely	**Moderate (8)**	**Moderate (8)**	**Probable**	
Offshore transfer of diesel fuel	Scenario 5: Diesel bunkering spill	Lethal and sub-lethal toxic effects on Plankton	Unplanned	1, 2 & 3	Low	Slight	Possible	**Very Low (3)**	**n/a**	**Probable**	**Industry-standard:** SECE Register, HSE MS and performance standards. Pipelines will be protected by pressure alarms; A leak detection system will be fitted; Dry break couplings; and Development and implementation of the OSCP. **Project-specific:** Additional oil spill response equipment on support vessels.
		Lethal and sub-lethal toxic effects on Fish and squid	Unplanned	1, 2 & 3	Low	Slight	Possible	**Very Low (3)**	**n/a**	**Probable**	
		Impact on fisheries from tainting of fish and contamination of fishing grounds	Unplanned	1, 2 & 3	Low	Slight	Possible	**Very Low (3)**	**n/a**	**Probable**	
		Plumage contamination and oil ingestion by Seabirds	Unplanned	1, 2 & 3	Very High	Minor	Possible	**Moderate (9)**	**Moderate (9)**	**Probable**	
		Pelage / skin contamination and ingestion of toxins by marine mammals	Unplanned	1, 2 & 3	High	Slight	Possible	**Low (6)**	**n/a**	**Probable**	

Activity	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
		Negative publicity impacting tourist numbers (human population Tourism)	Unplanned	1, 2 & 3	Low	Minor	Possible	**Low (6)**	**n/a**	**Probable**	
Small scale releases	Development of a sheen on the water	Oiling of seabirds	Unplanned	2 & 3	Very High	Moderate	Possible	**Moderate (9)**	**Moderate (9)**	**Probable**	**Industry-standard:** SECE Register, HSE MS and performance standards; Maintenance Management System (MMS); Use of spill kits for spills to deck; Development and implementation of the OSCP; Bunding of all liquid containing equipment and chemicals; Open deck drains to catch and collect spills to a dedicated slop tank; and High level tank filling alarm and emergency shutdown of the process. **Project-specific:**

Activity	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
											Additional oil spill response equipment on support vessels.
Riser dis-connection	Loss of riser contents to sea	Smothering and toxic effects on benthos and seabed	Unplanned	1 & 2	Low	Moderate	Unlikely	**Low (6)**	**n/a**	**Probable**	**Industry-standard:** Compliance with Premier HSE MS and Drilling Management System **Project-specific:** Additional oil spill response equipment on support vessels.

[a] See Chapter 8 for definitions of sensitivity, severity, likelihood and significance.

12.2 Inshore fuel oil spill

12.2.1 Introduction

The project activities within Berkeley Sound are limited to the relatively short periods of time when the Sound will be utilised as a sheltered operational area for Large Transport Vessels (LTVs) supporting the offshore installation activities. The main activities during this time will be transit to location, initial anchor and transfer (i.e. heavy lift) of subsea structures and materials to installation vessels.

As a result, the remaining credible oil spill scenarios are associated with fuel oil releases from:

- Ship-to-Ship (STS) fuel oil bunkering activities; or
- Vessel incidents (e.g. collisions, or drift grounding incidents, section 12.2.2.1.1).

Note: Although the risks from air quality following a fuel oil spill were not identified in the ENVIID process for the Sea Lion Project and were not raised by stakeholders during consultation, the issue of air quality impacts from oil spills has been raised as part of a scientific review of the Sea Lion EIS by the Scottish Association for Marine Science and Premier has assessed the potential impact of fuel oil spills on regional air quality to address the comments made.

12.2.1.1 Relevant legislation

The legislation relevant to inshore oil spills is as described in the offshore oil spill chapter (section 12.1.1.1), with details provided on the requirements of the project-specific Oil Spill Contingency Plan (OSCP), the Falklands National OSCP and the PON 8.

12.2.1.1.1 Inshore Oil Spill Strategy

Premier has developed an Inshore Oil Spill Strategy for the Sea Lion Development (Premier, 2017e), which identifies the essential components of spill response for this operation. The Inshore Oil Spill Strategy will inform an Oil Spill Contingency Plan (OSCP) that will later be submitted as a separate document containing specific operational information such as contact details and detailed action lists for personnel. The OSCP will outline the organisational responsibilities, actions, reporting requirements and resources available to ensure the effective and timely management of an accidental spill and will be compatible with the Falkland Islands' NOSCP. Additional information regarding the OSCP can be found in section 12.1.1.1.3.

12.2.2 Sources of potential inshore oil spills

During the subsea installation stage of the Sea Lion Development Phase 1, Berkeley Sound will be utilised as a sheltered operational area for anchored LTVs supporting the offshore installation activities for the storage and transfer (i.e. heavy lift) of subsea structures and materials to installation vessels. Ship to ship diesel bunkering of the installation vessels and LTVs will also be undertaken within Berkeley Sound.

Using real life spill data from US lightering / ship-to-ship (STS) transfer experience, a Quantitative Risk Assessment (QRA) previously performed by DNV-GL (2016) identified the maximum credible spill volume that could occur during inshore operations was 130 tonnes.

However, in this section, worst case assumptions (i.e. the maximum vessel fuel oil inventories, Table 12.19: Potential maximum hydrocarbon inventories) were used as inputs to the inshore oil spill modelling.

When considering the inshore activities and the sources of spills, it is necessary to consider both:

- Accidental event categories: and
- Oil spill scenarios.

Table 12.19: Potential maximum hydrocarbon inventories

Source	Vessel	Inventory	Volume / Type
LTV / HLV	Happy Star	Intermediate Fuel Oil[a]	1,526 m^3
		Marine Diesel Oil [b]	287 m^3
	Happy D	Intermediate Fuel Oil[a]	1,500 m^3
		Marine Diesel Oil [b]	310 m^3
	P8/P14	Intermediate Fuel Oil[a]	1, 500 m^3
		Marine Diesel Oil [b]	200 m^3
Support Vessels	Severn Arctic	Marine Gas Oil [b]	3,700 m^3
Third-party vessels	Jigger	Diesel tanks	600 m^3
	Fuel bunker	Marine Diesel Oil / Marine Gas Oil (MGO)[b]	1,000 m^3
Workboat	N.A	Diesel Tanks	1 m^3

[a] Intermediate Fuel Oil (IFO) is a viscous fuel oil that is often blended with marine gas oil or diesel to use in engines in transit. Premier will eliminate IFO from these vessels if it is practicable to do so.

[b] Marine Gas Oil (MGO), marine diesel and diesel are available in a number of different forms with similar properties and all represent a light, dispersible and evaporative fuel.

12.2.2.1 Accidental event categories

In this assessment, accidents are defined as unplanned events with the potential to cause a release of fuel oil.

Worst case spills from inshore vessel can result from a number of accidental events, including:

- Vessel collision;
- Powered and drift grounding; and
- Fuel bunkering operations.

12.2.2.1.1 Vessel collision

Vessel collisions can occur for example, between the LTV and installation vessel, or with a third party vessel (e.g. Jigger). The collision risk is considered to be the same for each type of vessel interaction.

12.2.2.1.1.1 Powered and drift grounding

Powered grounding is usually caused by navigational error. Possible causes include:

- Human performance error, e.g. watch-keeper fails to maintain the intended coastal course, typically due to onshore wind, current or bad visibility; or
- Technical failure resulting in a course deviation while under power.

Drift grounding may occur if a vessel loses power, is pushed towards the shore by wind or currents, or if it loses anchor.

12.2.2.1.1.2 Fuel bunkering operations

All industry-standard safeguards will be in place (section 12.2.5), there is the potential for spills of diesel to occur during bunkering operations. While such spills would most likely be small as the bunkering process would cease as soon as any leak or spill was detected.

12.2.2.2 Oil spill scenarios

Following selection of the Direct Offtake oil export option for the Sea Lion Phase 1 Development, the remaining credible inshore oil spill scenarios are associated with fuel oil releases from:

- Ship-to-Ship (STS) fuel oil bunkering activities; or
- Vessel incidents (e.g. collisions, or drift grounding incidents).

The three identified fuel oil spill scenarios, discussed further below, potentially resulting from Premier's planned operational activities in Berkeley Sound, include:

- Scenario 1: Loss of fuel during a bunkering Incident;
- Scenario 2: Total inventory loss from an installation vessel as the result of a collision incident; and
- Scenario 3: Total inventory loss from an LTV as the result of a drift grounding incident.

12.2.2.2.1 Scenario 1: 10 tonne MGO Bunkering Incident Marine Gas Oil (Fuel Oil) Spill

A review of historic oil spill incidents suggests that the accidental release of MGO during a bunkering operation is the most likely incident to occur as a result of Premier's planned operations within Berkeley Sound.

A worst case release of 10 tonnes was selected to determine the consequences of a bunkering incident.

12.2.2.2.2 Scenario 2: 3,700 Tonnes of MGO Due to Installation Vessel Collision with Jigger/Reefer

This scenario was identified as the potential worst case in terms of volume hydrocarbon loss into Berkeley Sound. The only credible event that could cause such a release is from a collision with a vessel (e.g. during a period of low visibility). To illustrate the outer envelope, in terms of spill response the modelling assumes that the inventory is lost over a 24hr period. Whilst, there is no credible event that could cause the full contents of an Installation vessel to be released in 24hrs, this is included as a worst case scenario.

12.2.2.2.3 Scenario 3: 1,526 Tonnes IFO 380 Oil Spill Due to Drift Grounding

This scenario was identified as the potential worst case in terms of impact to sensitive receptors within Berkeley Sound. The only credible event that could cause such a release is from a drift/powered grounding, or a significant explosion on the vessel. To illustrate the outer envelope in terms of spill response, the modelling assumes that the inventory is lost over a 48hr period. This is presented as a maximum possible case.

12.2.3 Potential receptors

The ENVironmental Impact IDentification (ENVIID) workshop was used to identify those receptors for which the risks of inshore oil spills warranted further investigation (Chapter 9). These include:

- Plankton (section 7.4.1);
- Marine flora (section 7.4.2);
- Berkeley Sound benthic communities (section 7.4.3.3);
- Fish and squid in Berkeley Sound (section 7.4.4.3);
- Birds in Berkeley Sound (section 7.4.5.3);
- Marine mammals in Berkeley Sound (section 7.4.6.3);
- Coastal communities (section 7.4.7);
- Fisheries (Human population) (section 7.7.3.2.1);
- Tourism (Human population) (section 7.7.4.6.1); and
- Air quality (Humans, flora and fauna).

These receptors may be impacted upon as they either exist in, or spend time in, the area influenced by fuel oil that might be accidentally discharged into the marine environment.

12.2.4 Characterising and quantifying the risk and potential impacts of inshore fuel oil spills

When characterising and quantifying the impacts of fuel oil spills, it is necessary to consider the following:

- Influencing factors:
  - Summary of fuel oil properties and its anticipated behaviour at the shoreline; and
  - Interactions with the kelp forests.
- The nature of the impact on each of the receptors;
- The frequency of occurrence of accidents and spills;
- Oil spill modelling methodology:

- The OSCAR model;
- The modelling approach inshore;
- Release parameters;
- Thresholds of significance;
- Understanding the model; and
- Air quality assessment.

- Spill modelling results for:
  - Scenario 1: 10 tonne MGO Bunkering Incident Marine Gas Oil (Fuel Oil) Spill;
  - Scenario 2: 3,700 Tonnes of MGO Due to Installation Vessel Collision with Jigger/Reefer; and
  - Scenario 3: 1,576 Tonnes IFO 380 fuel Oil Spill Due to Drift Grounding.
- Regional air quality; and
- A summary of the fuel oil spill characteristics with regard to:
  - Fuel oil spill characteristics; and
  - Fuel oil fate predictions.

12.2.4.1 Influencing Factors

Over and above the details provided in the offshore oil spill chapter (section 12.1.4.1), additional factors that may influence the behaviour of fuel oil spills in inshore waters include:

- Inshore vessel fuel oil properties; and
- The potential for interactions with kelp forests.

12.2.4.1.1 Inshore vessel fuel oil characteristics

The type and composition of different oils and the fate of oil in the marine environment all influence how spills may impact upon the environment. These influencing factors have already been described in the offshore oil spill chapter (section 12.1.4.1). However, a summary of specific details regarding the properties and behaviours of fuel oils used inshore that will influence their behaviour is provided below and in Table 12.20:

- MGO contains lighter hydrocarbon compounds compared with IFO and will readily spread in the marine environment where it will change under the processes of dissolution, evaporation and dispersion;
- Diesel and MGO spread very quickly to a thin film of rainbow and silver sheens while IFO may form a thicker film of dull or dark colors;
- IFO containing heavier hydrocarbon compounds is known to be more ‘persistent’ in the marine environment remaining visible and undergoing the weathering processes at a slower rate;
- IFO contains Asphaltene giving it a moderate tendency to form stable water in oil emulsions when mixed with sea water. In terms of response measures this is a negative process as emulsified oils are highly viscous and can increase the volume of the oil fivefold;

- Both IFO and MGO have a low wax content and will adhere to surfaces, fur and feathers, and penetrate substrates much more easily and release an iridescent/silvery sheen on the surface of the water; and
- IFO will be very viscous and tarry at ambient temperatures, while MGO will continue to flow readily even at very low temperatures.

Table 12.20 Summary of Typical Fuel Properties

Oil type	API (°)	Specific Gravity	Viscosity (cP)	Pour point
IFO-380 (typical)	15.2	0.965	10,000 cP at 13 ºC	20ºC
MGO (typical)	36.4	0.843	3.9 cP at 13 ºC	-36ºC

12.2.4.1.2 Fuel oil interactions with kelp forests

It is important to consider the potential for inshore fuel oil spills to interact with kelp for a number of reasons:

- Kelp can promote bio-remediation of certain pollutants; and
- Kelp can impede the spread, and the recovery, of oil.

12.2.4.1.2.1 Kelp as a bioremediation

There is evidence from laboratory studies that kelp may play an important role in the removal of PAH from the coastal marine environment. Wang and Zhao (2007) found that the brown seaweed *Laminaria japonica* was able to take-up and metabolise two PAHs (phenanthrene and pyrene). This biodegradation appears to be a rapid process and concentration dependent.

At a PAH concentration level of 0.1 mg/l, *Laminaria japonica* tolerated the contamination and survived well with >90 % phenanthrene and pyrene removed, and subsequently degraded, over a two week period. The metabolism of phenanthrene and pyrene in seaweed tissues was carried out mainly by the enzyme-oxidation process converting PAHs to less or non-toxic forms of these compounds. The authors of this study suggest therefore, that, at lower contamination levels, the seaweed could play a role in removing PAHs and possibly other organic pollutants from sea water, thus serving as an 'environmentally-friendly' bioremediation system.

12.2.4.1.2.2 Kelp as a barrier to oil spread and clean-up

Kelp has the potential to impede the spread and the clean-up of fuel oil spills by:

- Slowing the progress of fuel oil towards the shoreline;
- Trapping fuel oil close to the shoreline;
- Impeding the progress of oil response vessels and equipment; and
- Dampening swell, thus reducing the break-down and dispersal of fuel oil along the shore through reduced wave-action.

Mats of floating kelp fronds may well halt the progress of oil as it moves towards the coast. The retention of oil by kelp soon after it is spilled may lead to higher impact on marine organisms in the immediate vicinity, due to the release of the water soluble fractions. However, it is likely that oil will become more dispersed once the current or wind direction changes. Delaying the arrival of oil ashore may help to protect a coastline, if changes in current or wind subsequently move oil away from shore. However, if current and wind conditions continue to push oil shore-wards, the kelp may retain oil close to shore where boat-based recovery is more difficult. Due to propeller fouling, it is not possible to operate small boats within thick kelp beds, which in some cases may hamper the vessels employed to respond to oil spills which reach the shoreline.

Additionally, floating rafts of kelp dampen wind driven waves and swell. This will reduce the natural break-down and removal of oil on the shoreline through wave-action.

12.2.4.2 The nature of the impact on each of the different receptors

The nature of the impact of hydrocarbons (both crude and fuel oils) on the majority of the receptors, which may be affected by an oil spill has already been described in the offshore oil spill chapter (section 12.1).

However, the potential for inshore fuel oil spills necessitate the additional consideration of:

- Marine flora (kelp);
- Inshore benthic communities;
- Inshore fisheries;
- Intertidal habitats and organisms; and
- Changes in air quality.

12.2.4.2.1 Marine Flora (Kelp)

Notwithstanding the fact that kelp can be a source of bioremediation with regard to the metabolisation of PAH's (section 12.2.4.1.2.1 above), it should be noted that at higher concentration levels (>0.2 mg/l), the toxic nature of PAHs to the seaweed was significant, and resulted in serious damage and destruction to the kelp tissue (Wang and Zhao, 2007).

Nonetheless, 'real-life' oil spill incidents of fuel oil spills have not highlighted seaweeds as being particularly sensitive environmental receptors. Worldwide examples of the impact of fuel oils on kelp and other seaweeds are summarised in Table 12.21. However, notwithstanding the general finding that seaweeds are not particularly vulnerable to oil contamination, uncertainties regarding the potential for fuel oil to impact local kelp species must be acknowledged, such as whether or not the more viscous IFO will adhere to it, and the potential consequences of oil adhesion

Table 12.21: Case studies on the impact of oil spills on kelp communities

Historical spill	Nature of the impact
World Prodigy Oil Spill 1989 (Peckol *et al.*, 1990) 922 tonnes of No.2 fuel oil (MGO)	Contamination of subtidal kelps *Laminaria saccharina* and *Laminaria digitata* occurred following this spill. Pre-spill measurements of condition, growth rates and pigment acclimation were compared with post-spill measurements, and there was no evidence that kelps were detrimentally affected by the oiling. Kelp densities were normal and no necrotic or bleached tissue was observed on any kelp in an oiled cove. Background growth rates and other parameters showed wide variation in the absence of oil. Lowest growth rates coincided with an unrelated algal bloom, which also caused high mortality of bivalves. It was concluded that the bay where the spill occurred was spared disaster because little fuel oil mixed into the water column.
Tamano oil spill, Maine, 1975 (USEPA, 1975) 182 tonnes heavy fuel oil	Following the spill, 46 miles of varied coastline was contaminated and subsequently cleaned. Of the two seaweed species investigated, *Fucus* accumulated the oil to a much greater extent than *Ascophyllum*. Possible reasons put forward were the relative surface area, the lipophylic nature of the mucopolysaccharide substances on the fucoids and simply the degree of exposure related to the location of the seaweed. Oiled seaweed was harvested and was found to be an effective way of removing oil from the intertidal area. When re-surveyed some months following the spill, contaminated *Fucus* was found to have shed much of the oil that had become attached during the oiling incident. Fucoid algae and barnacles were lost from the shoreline and snails, whelks and limpets suffered narcosis.
Evidence from other spills	In Norway, *Laminaria digitata* grown in large concrete basins was continuously exposed to diesel oil for two years. With diesel oil at 130 µg/l, lengthwise growth was reduced by about 50 %. At the lower concentration of 30 µg/l there was no overall inhibition of growth. After two years of continuous exposure, the plants completely recovered during a subsequent oil-free growing season.

12.2.4.2.2 Berkeley Sound benthic communities

Benthic communities consist largely of sessile organisms that are unable to physically move away from areas contaminated by oil or other pollutants and may be affected by MGO / IFO releases in inshore waters. Invertebrates such as arthropods and molluscs are known to bioaccumulate hydrocarbons in their tissues (section 12.1.4.2.4.2). Most of the literature detailing the impacts of hydrocarbon spills on inshore benthic communities refer to inshore crude spills (Glemarec and Hussenot, 1982; Dauvin and Gentil, 1990; Law and Moffat, 1993; and Glegg and Rowland, 1996) (section 12.1.4.2.2), and given that no crude bearing vessels will be entering or approaching inshore waters during the Phase 1 Development, these studies are not relevant to this chapter. The only means by which crude could impact benthic communities in inshore waters during the Phase 1 Development is if offshore crude spills reached the shoreline. As is shown in section 12.1.4.3, the likelihood of this is very low and should it occur, the oil would be very weathered by the time of beaching such that the impacts are expected to be minimal (section 12.1.4.2.7 and section 12.1.6).

However, the following case-studies illustrate the potential impacts on benthic communities of fuel oils and other pollutants:

- Stark *et al.* (2003) found that experimental contamination of marine sediments with hydrocarbons (diesel and lubrication oils) in Antarctic waters led to changes in recruitment and thus assemblage structure within benthic communities and that hydrocarbon contamination resulted in more severe effects than contamination with metals. This emphasises the potential for ecological switching (changes in community structure) following events that cause significant environmental impact.
- University of California (1971) describes the decimation of a small rocky cove by a 59,000 barrel spill of 'dark diesel oil'. Almost the entire flora and fauna succumbed to the spill, but the elimination of grazers allowed the profusion of giant kelp.

12.2.4.2.3 Inshore fisheries receptors

The Falkland Islands are important for several commercially harvested fish species including Patagonian toothfish (*Dissostichus eleginoides)* and squid, comprising both Argentine short-finned squid (*Illex argentinus*) and loligo (*Doryteuthis gahi*) (section 7.7.3.1.1). Loligo is the target species of the largest domestic fishery in the Falklands. Although fishing is not permitted within three nautical miles of the coast, the stock migrate into inshore waters. Loligo have a short lifespan (growing rapidly for one year before breeding and dying) and normally survive in only two cohorts, potentially making populations more vulnerable to short-term impacts e.g. during spawning. For many years their spawning grounds were thought to be associated with kelp beds. However, it is now recognised that there does not appear to be sufficient habitat to support the observed populations. Therefore, it is likely that squid also spawn in other habitat types but the location of principle spawning grounds currently remain unknown. Squid and other molluscs are known to bioaccumulate hydrocarbons (such as PAH) in their tissues, which has potential human health implications. section 12.1.4.2.3.2 provides further details regarding the impact of oil on squid.

The impact from any spill is related to the type of oil, quantity of oil, environmental conditions and the receptors present at the time of the spill. As described in section 12.1.4.1.1.2, spills of fuel oil will lead to dissolution of toxic compounds such as PAH, into the water column, the amount of which may depend upon the levels of evaporation, which in turn may be affected by the water temperature at the time of the spill. According to Brown *et al*. (2016), such compounds may persist for up to seven days in lower water temperatures of 0-5 °C, while sea temperatures in Berkeley Sound range from 3.5-9 °C . While it would be useful to draw from learnings obtained from historical oil spills, few reports exist for fuel oil spills as opposed to crude spills.

Nonetheless, the crude spilled by the *Braer* in 1993 (Gulfaks) was a heavily biodegraded oil with high PAH levels and this resulted in elevated levels of PAH in both wild fish and farmed fish. However, this spill was of 84,000 tonnes rather than the more modest scenarios of a maximum 3,700 tonnes of MGO (section 12.2.2.2.2) or 1,526 tonnes of IFO (section 12.2.2.2.3). Further, even in the *Braer* example, concentrations of PAH in wild fish, fell rapidly from a maximum of 2,650 mg/kg wet weight to reference concentrations of less than 40 mg/kg over several months, by which time there was also an absence of tainting.

12.2.4.2.4 Intertidal habitats and organisms

This section is informed by a review of the impacts of oil spills on shorelines by IPIECA (2016).

The fate of oil that reaches the shoreline is not only determined by the properties of the oil but also the topography of the shore and exposure of the oil to wave and tidal energy. For example, stranded oil that is exposed to heavy wave action is unlikely to remain on the shore for long. However, small scale features such as rocks or crevices may create shelter where oil residues can persist. Where oil strands on sheltered coasts with limited water movement it could persist for several years.

Penetration of oil in sediments depends on a number of factors such as porosity (sediment type and size), the depth of the water table, the viscosity of the oil and the presence of burrowing animals. Penetration of oil is unlikely in most tidal flats due to fine particle size and saturation with water. With increasing grain size, the likelihood that oil will penetrate sediments increases. Pebble or cobble beaches have the highest potential for penetration. Once contaminated, the subsurface layer can be highly persistent.

The characteristics of the shoreline and behaviour of oil were used in the Environmental Sensitivity Index (ESI) to classify shores according to the likely persistence of oil. The ESI for Berkeley Sound is presented in section 7.6.3. Table 12.22 summarises the general features of shorelines in relation to the potential impact from oil spills. The greater the ESI number, the greater the potential for oil persistence.

During the 2018 coastal bird surveys in Berkeley Sound, observations of typical Falkland Islands shoreline types were recorded and given a classification index for the purposes of oil spill planning that parallels the IPIECA (2011) system of Environmental Sensitivity Index. This improves the mitigation measures of oil spill response and more detailed detailed oil spill contingency planning that will follow approval of the project. An example of shoreline type 1A is shown in Figure 12.49.

Figure 12.49: Proposed local shoreline classification 1A, reference location as the north coast of Kidney Island

Table 12.22: General features of shorelines that influence their potential susceptibility to oil spill impacts, as classified on the ESI scale

ESI	Shoreline description
1	Exposed rocky shores, steeply sloping. • Oil is typically held offshore by reflecting waves. • Any oil deposited is rapidly removed by wave action. • Impacts on intertidal communities are typically short-term, unless acute exposure of a fresh light oil product causes high mortality.
2	Exposed wave-cut platforms in bedrock. Shelf or platform of variable width and gentle slope. Often backed by steep scarp, sometimes with sediment at base. Pools and crevices are common, possibly with some loose gravel. • Oil will not adhere to the platform, but may accumulate among gravel at the high tide line. • Persistence is usually short-term.
3	Fine- to medium-grained sand beaches. Flat to moderately sloping and hard packed. Wrack may accumulate along the strandline. • Oil may cover large areas but will lift off the lower beach and become concentrated along the upper intertidal zone. • Oil may penetrate sand or become buried and there may be a decline in sediment fauna. • These beaches are among the easiest to clean.
4	Course-grained sand beaches. Moderate slope of soft sediment. Sediment fauna is limited. Sediment is too soft for vehicles. • Oil may cover large areas, but will lift off the lower beach and become concentrated along the upper intertidal zone. • Oil may penetrate sand or become buried to depths greater than 1 m and there may be a decline in sediment fauna.
5	Mixed sand and gravel beaches. There may be zones of mobile sand, pebbles or cobbles, and distribution may change. Fauna and flora is generally limited, except on the more stable substrata. • Oil may cover the whole beach, but will lift off the lower beach and become concentrated along the upper intertidal zone. • Oil may penetrate sediment or become buried. • Asphalt pavement may form in sheltered locations.
6	Gravel beaches, ranging from pebbles to boulders. Can be steep with wave-built berms. Fauna and flora is generally limited except on the more stable sub-strata on the lower beach. • Stranded oil is likely to penetrate deeply, can be pushed over the high tide line and can be very persistent. • Asphalt pavement may form in sheltered locations. • Potential for chronic oiling.
7	Exposed tidal flats. Broad, flat areas of sand with some mixed shell or mud. Usually in tidal inlets. Water-saturated except on higher ridges. Can have dense sediment life and be important for wetland birds. • Oil does not adhere to wet sediment, but accumulates at the high tide line and may penetrate at the tops of ridges. • There may be a severe decline in sediment fauna.
8	Sheltered rocky shores. Variable permeability depending on substrata. Can have high densities of attached fauna and flora. • Oil will adhere to rough surfaces along the high tide line, but not on wet lower shore surfaces. • Oil will penetrate loosely packed angular rubble with potential for long-term persistence.
9	Sheltered tidal flats. Soft mud, with some sand and shell. Frequently backed by marshes. Can have dense sediment life and be important for wetland birds. • Oil does not adhere to wet sediment, but accumulates at the high tide line and may penetrate burrows. • Potential for deposition of contaminated sediments.

ESI	Shoreline description
	• There may be a severe decline in sediment fauna.
10	Saltwater and brackish-water marshes. Temperate and subtropical wetlands dominated by marsh plants. Sediments are organic-rich muds, except on the edge of tidal channels where they may be sandy. Abundant flora and fauna. • Oil adheres to emergent vegetation. • Heavy oil coating restricted to outer fringe of marsh, but lighter oils may penetrate more deeply. • Medium and heavy oils do not penetrate wet sediments, but can pool in depressions. • Light oils can penetrate the upper few centimetres. • There may be a severe decline in flora and fauna.

12.2.4.2.4.1 Shoreline plants and invertebrates

All intertidal species can potentially be affected directly or indirectly by oil contamination, but some are more susceptible and vulnerable than others. Organisms can interact with shoreline oiling in a number of ways. Direct physical oiling can smother plants and animals, which may interfere with filter feeding appendages. Prolonged exposure to oil may result in direct toxicity. However, tolerance to the toxic effects of oil varies considerably between organisms. For example, filter feeding bivalves can accumulate hydrocarbons in their tissues, which may take weeks or months to purge. Although bivalves are able to tolerate high concentrations of hydrocarbons, there may be sub-lethal effects, such as reduced growth and reproductive capacity.

Limpets and other marine snails graze on algae and are regarded as one of the most sensitive groups of intertidal invertebrates to the acute toxic effects of oil. A small amount of fresh oil on a limpet’s foot has a narcotic effect leading to the limpet falling from the rock, where it is then unlikely to survive. Impacts on the populations of these taxa, and the consequent effects on the abundance of the plants and algae they feed on, have been described following many oil spill incidents. For these reasons, limpets are widely used as the focus of rocky shore monitoring programmes near oil facilities (e.g. SOTEAG).

12.2.4.2.5 Air quality receptors

There are a number of small settlements around the coast of Berkeley Sound with the nearest habitation approximately 8.5 km south of the indicative LTV anchorage locations, and the majority of the Falkland’s population live in Stanley, which is approximately 13 km south of Berkeley Sound (Figure 10.6). As a case study, it is perhaps useful to look again at the *Braer* incident in which 84,000 tonnes of light Gulfaks crude oil was released at the shoreline. While this was a crude, it was of a type more evaporative than most. The *Braer* was driven onshore by high winds and broke up releasing its cargo, and the winds drove hydrocarbon vapours onshore. The official government inquiry recorded the scientific investigations undertaken (Davis and Topping, 1995), which included air quality monitoring. Initially, members of the public close downwind of the tanker complained of a strong smell of oil and irritation to eyes and nose. Air quality monitoring at coastal locations near to the wreck detected levels of Volatile Organic Compounds (VOCs) initially of 0.264 ppm a few hundred metres away, rising to a peak of 6.33 ppm the day the tanker broke up but dropping to below 0.01 ppm the following day. However, again, it must be noted that the *Braer* spilled 84,000 tonnes at the shoreline, as opposed to the relatively modest volumes of MGO / IFO that could realistically be released offshore in Berkeley Sound.

Even in the *Braer* incident, there was no evacuation of local people on health grounds. Further, a systematic study of the health of 420 of the local people against a control group was carried out and no obvious ill health was recorded, beyond initial irritation due to VOCs and spray. The report also notes that the initial irritation symptoms were probably exacerbated by the dispersants being used to treat the *Braer* spill (which would not be used on a fuel oil spill) and salt spray. No wildlife implications due to air quality are recorded in the investigations, which were extremely thorough. Davies and Topping (1995) notes that occupational health exposure limits would have to be exceeded many times over if they were to pose the same sorts of risk as lifetime exposure levels designed for the workplace.

12.2.4.3 Oil spill modelling methodology

In order to assess the potential impacts of inshore oil spills on environmental receptors, the three oil spill scenarios were modelled by Premier using the OSCAR model (Premier, 2017e).

The main aims of the modelling were to understand the:

- Fate of the hydrocarbons in terms of the relative amounts dispersed, evaporated, beached, biodegraded and deposited in sediments;
- Probability of hydrocarbons on the sea surface or reaching the shore;
- Characteristics of hydrocarbons dissolved in the water column; and
- Overall likely transport of oil at sea in terms of density, direction and time.

To assess the likely impacts on regional air quality, the results of the oil spill modelling for each scenario have been used, taking into consideration the evaporative properties of each oil type.

The following section summarises the key information to facilitate an appreciation and understanding of the inshore modelling results. Full details of the modelling studies, including the methodology, the Sea Lion crude inputs following lab testing, and metocean data used, are provided in the Premier report (Premier, 2017d).

12.2.4.3.1 The OSCAR model

The OSCAR model used for the inshore oil spill modelling is the same as that carried out for the offshore spill modelling (section 12.1.4.3).

12.2.4.3.2 The approach for inshore oil spill modelling

The results of two different modelling approaches (‘stochastic’ and ‘deterministic’) are taken to determine the behaviour of oil released into the environment. Stochastic results combine the results of many different model runs, covering the range of possible metocean conditions (data are relevant to the specific location), to understand the variety of possible outcomes. By running the model multiple times the probability of events, minimum, average and maximum values for the fate of hydrocarbons and distribution of oil in terms of density, direction and time can be calculated and used to predict possible output scenarios.

The results from the stochastic model were then used to determine the 'worst case' conditions, in this case the conditions that result in most oil ashore. A deterministic model was parameterised using these specific metocean conditions to examine the transport, dispersion and fate of oil for the 'worst case' and 'typical' conditions. The same process was used to determine the behaviour of oil offshore and is described in the offshore oil spill chapter (section 12.1.4.3).

12.2.4.3.2.1 Modelling sediments

A recent addition to the deterministic model is the addition of 'sediment to oil' when oil is in contact with a shoreline, which is related to the shoreline type. Thus, oil 'particles' which are shed from a shoreline over time by wave action are given an increased density which causes them to sink more quickly than they would otherwise, elevating oil concentrations in the sediment next to coastlines. This is believed to represent more accurately the behaviour of oil washed off a shore, and is in line with the results of the recent crude oil tests (CEDRE, 2017). The effect of this is that the overall mass of oil in sediments would stay the same, but the location could change over time rather than being relatively static as in the model.

OSCAR provides a feature whereby the enhanced deposition of oil via contact with suspended solids e.g. silt or sand, can be simulated. However, since little adhesion of solids was observed in the CEDRE tests, this has not been applied, and has the effect that larger masses of oil will tend to remain floating and may travel long distances. Oil can still reach the seabed after contact with the shoreline, and through vertical dispersion of small droplets through the water column, both of which are modelled.

12.2.4.3.2.2 Oil spill response mode

In 'response mode', the model can predict how oil can be contained and recovered, or dispersed by applying dispersant chemicals. The model is capable of evaluating the effectiveness of OSR strategies and allows the assignment of specific operational tactics and equipment parameters for simulated containment, storage, booming, skimming and dispersant operations. Responses can also be run as deterministic or stochastic, and each is used to illustrate the range of conclusions reached.

12.2.4.3.2.3 Modelling grids

The model generates output data (maximum oil concentrations, surface thickness etc.) by tracking numerous particles placed throughout a specified grid that is manually selected in the locality of the release site. Typically, this grid will be set to capture the majority of the plume as it disperses across the sea.

The inshore modelling was undertaken using two grids, as shown in Figure 12.50. These grids were used as follows:

- The 'inner' grid gives a high resolution of oil fate in Berkeley Sound and some 15 km to the north and south of the mouth of Berkeley Sound, and also seawards; and
- The 'outer' grid was used to explore the wider scale fate of oil and deposition in sediments, primarily in relation to potential impacts on fishing.

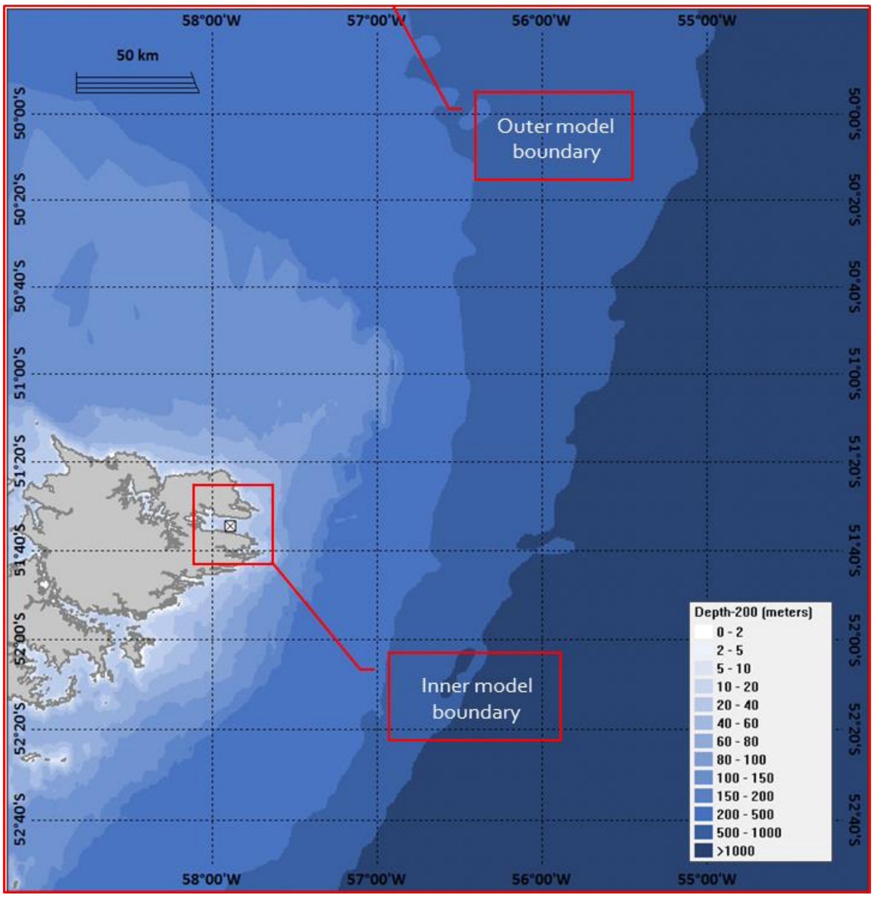


Figure 12.50: The two modelling grids used to predict the fate of oil from inshore oil spills

12.2.4.3.3 Release parameters and assumptions

As described in section 12.2.2.2, three worst case inshore fuel oil spill scenarios were modelled (release parameters specific summarised in Table 12.23).

Table 12.23: Summary of the release parameters and assumptions used in the model run for each scenario

Scenario	Fluids discharged	Release volume (m^3)	Release duration	Release location	Release temp. (°C)	Release type	Model run duration	Worst case assumptions
(1) MGO release during bunkering	MGO	10	10 mins[a]	LTV anchorage	10	Bulk release	5 days	Worst case shoreline oiling illustrated
(2) Total MGO inventory loss - collision	MGO	3,700	24 hours[b]	LTV anchorage	10	Bulk release	5 days	Worst case shoreline oiling illustrated
(3) Total IFO loss - drift grounding	IFO-380	1,526	48 hours[c]	Likely drift grounding point close to shore	10	Bulk release	10 days	Worst case shoreline oiling illustrated

a Estimated time to escape primary containment.

b Estimated time for large volume to be displaced from tanks by seawater.

c Estimated time for viscous oil to be displaced from tanks by seawater.

12.2.4.3.4 Thresholds of significance defined in the model

In order to give meaning to the models, it is necessary to define thresholds (based on industry-standards), below which the predicted levels of a contaminant can be considered to be of no concern.

The spill properties to which thresholds apply inshore include:

- Surface thickness / density of oil;
- Total water column concentration of oil; and
- Total sediment concentration of oil.

The thresholds for the surface thickness and the total water column concentrations of oil are the same as those used, and described, in the offshore oil spill modelling section (section 12.1.4.3). For ease, these are presented again in Table 12.24 below. Given that this chapter is modelling inshore oil spills, there is the greater potential for oil to reach the sediments and therefore it is necessary to also identify a threshold for sediment concentrations.

12.2.4.3.4.1 Sediment concentration threshold

Worldwide standards or thresholds for oil in sediments were used to define the thresholds used in the modelling work (Premier, 2017d). Typically, these are expressed as Total Petroleum Hydrocarbons (TPH), or just the PAH component.

Generally, thresholds for commonly occurring PAH concentrations are around one hundredth of those for TPH. In the model results, the chemical properties of the Sea Lion crude produce ratios of greater than one hundred between total oil in the sediment and total PAH concentrations (in fact a ratio of more than 1:1,000). In other words, a given concentration of oil corresponds to 1/1,000th concentration of PAH. This means that thresholds for total oil are conservative in respect of PAH toxicity. These conclusions are derived from running the model for five days after a 300 tonne spill has occurred, with <0.5 % of the oil entering the sediment (further oil entering the sediment is unlikely to change this ratio). Conclusions on toxicity using predicted total oil concentrations in the sediment are likely to hold true for PAH concentrations as well.

On a ‘balance of evidence’ approach, a threshold concentration of 10 mg/kg in sediments for TPH is considered a reasonable level below which concentrations would not be considered environmentally significant (Table 12.24). As context, North Sea TPH sediment concentrations have been reported as 10-120 mg/kg (Cefas, 2001) and up to 450 mg/kg in surveys very close to Oil and Gas (O&G) installations, with concentrations generally falling to background levels within a very short distance. The PAH component of the TPH concentrations range from 0.2 - 2.7 mg/kg, increasing to the highest reported value of 74.7 mg/kg near an O&G installation.

Table 12.24: Thresholds used in the Sea Lion Development oil spill modelling

Oil type discharged	Surface thickness threshold	Water column concentration threshold	Sediment
Sea Lion crude oil (Total Petroleum Hydrocarbons)	1 g/m^2 [a]	25 ppb [b]	10 mg/kg [c]
Poly-Aromatic Hydrocarbons (PAH)	n/a	2-3 ring: c. 0.1-1 ppb 4-6 ring: c. 0.2-23 ppt [d]	5.6 - 1,000 mg/kg [e]
Diesel	0.3 µm [f]	25 ppb [b]	50 mg/kg [g]

[a] For the Sea Lion crude oil type the properties of the wax components mean that a surface thickness parameter is not meaningful, and a scale has therefore been devised to reflect the density of wax droplets, on the sea surface. Here the chosen threshold is 1 g/m^2 and below this value the oil ceases to be recorded in the model (section 12.1.4.3.3).

[b] Water column concentrations are frequently split between TPH and PAH. This threshold reflects a worst case and it is noted that 50 pbb is the lowest predicted No Effect Concentration (NOEC) for acute toxicity of the oil components in the OSCAR database and is also the mid-range of the concentrations of crude oil found to give sub-lethal effects (Patin, 2004). As context, North Sea levels of TPH are quoted as 1 - 30 µg/l (i.e. *c.* 1 - 30 ppb) near O&G installations and around 2 µg/l (i.e. *c.* 2 ppb) at the coast (Cefas, 2001). PAH levels are quoted as 0.02 - 0.1 µg/l (c. 0.02 - 0.1 ppb).

[c] Stanislav Patin (2004)

[d] OSPAR Agreement 2014/05: OSPAR is a Regional Seas Convention set up to protect the environment of the North East Atlantic. The selection of Predicted No Effect Concentrations (PNEC) has been undertaken by a group of expert advisors to OSPAR including representatives from the UK, Norway, Netherlands, Germany and Denmark. The process has taken several years and has drawn on expert reviews of PNECs worldwide and has been reviewed and approved by representatives of all the OSPAR countries.

[e] Cefas/DEFRA (Fisher *et al.,* 2011).

[f] Advice from Alun Lewis, an oil specialist and member of the Bonn Agreement committee, is that 0.3 µm is a valid threshold for impact assessment and is the level given in BEIS Oil Pollution Emergency Plan Guidelines (2016).

[g] OSPAR recommendation (2006/05) Based on management of oily cuttings piles - 'diesel' base oil content guidelines.

12.2.4.3.5 Understanding the model

The oil spill modelling utilised two types of modelling approach described in section 12.2.4.3, as follows:

- **Stochastic modelling** - carried out by running individual discharge scenarios multiple times over different time periods (thereby utilising different wind and current conditions) and aggregating the results in order to report behaviour in some probabilistic or statistical manner. The aggregated stochastic modelling results present:
  - The seasonal distribution of:
    - Predicted worst case shoreline oiling (mass of oil onshore, te); and
    - Arrival time (days).
  - The probability (%) of hydrocarbons accumulating to levels above the stated thresholds in respect of:
    - Oil on the sea surface (above threshold of 0.3µm); and
    - Shoreline oiling;
  - The minimum times taken (days) for hydrocarbons to arrive at any location at levels above the stated thresholds in respect of:
    - Oil on the sea surface (above threshold of 0.3µm); and
    - Shoreline oiling;

- **Deterministic modelling** - conducted over a particular time frame which was selected based on the results of the stochastic model results. Deterministic modelling was used to highlight hydrocarbon behaviour over a specific time frame. The time period for each deterministic run was selected to highlight either the worst case scenario in terms of mass of oil arriving on shore, or the largest mass of oil on the sea surface, both of which are derived from the outputs of the stochastic modelling component. The deterministic modelling results present:
- The effectiveness of oil spill response measures as:
  - Average mass (%) of oil stranded onshore with and without Oil Spill Response (OSR); and
  - Average proportion of oil recovered with and without OSR.
- The effectiveness of OSR on the worst case oil onshore (g/m^2) presented as a 'Swept path' plot.

12.2.4.3.6 Air Quality Assessment

To assess the likely impacts on regional air quality, the relative evaporative properties of each oil type, as derived from the OSCAR modelling ouputs, were used to assess potential air quality impacts.

12.2.4.4 Modelling results - Scenario 1: 10 tonne MGO Bunkering Incident Marine Gas Oil (Fuel Oil) Spill (No response)

Figure 12.51 shows the stochastic model for the probability of oil on the sea surface above the threshold of 0.3 µm (a surface thickness threshold of 0.3 µm thickness corresponds to a rainbow sheen and surface oil thickness below this value becomes unlikely to be visible) over a five day period. After five days the oil is on longer visible and therefore no longer amenable to response techniques such as enhanced natural dispersion (i.e. where the bow wave, propeller, or firefighting systems of a response vessel are utilised to break up the oil into smaller fragments which are more susceptible to the effects of natural weathering).

As can be seen in generally the oil moves in an eastward direction out the mouth of the Berkeley Sound with a low probability of impacting the highly sensitive areas of Cochon and Kidney Islands. The results also show a relatively high probability (10 -20%) that the oil will migrate in a south easterly direction impacting the southern coastline of the Berkeley Sound. This corresponds with the probable shoreline oiling results shown in as it shows the highest probable location of shoreline oiling is the southern coastline of Berkeley sound. Coastline sensitivity mapping of the shoreline shows that the area of shoreline most likely to be impacted is characterised by rocky outcrops. Rocky out crops are recognised as high energy areas where weathering of spilt oil is increased due to the abrasive action of sea water against the rock face breaking up the oil and increasing the surface area suspectable to natural weathering process.

Minimum arrival times of the oil are shown spatially and shoreline arrival times are plotted in Figure 12.52 which suggest that an oil will impact the shoreline within 11 hours on average. In terms of seasonality, shows that in the months July - December there is a greater likelihood that the slick will pass straight out of Berkeley Sound without contacting the shore, although if it does reach the shore, the masses are consistently around seven tonnes.

12.2.4.5 Modelling results - Scenario 2: 3,700 Tonnes of MGO Due to Installation Vessel Collision with Jigger or Reefer (No response)

Figure 12.53 shows the stochastic model for the probability of oil on the sea surface above the threshold of 0.3 µm over a five day period.

As can been in Figure 12.53 the movement of the oil is similar to that in Scenario 1 however, in contrast to Scenario 1, with the higher volumes in the Scenario 2 release, there is a moderate to high probability of impacting the highly sensitive areas of Cochon and Kidney Islands which are known habitats for species of penguins and other vulnerable birds.

As with Scenario 1, the results also show a relatively high probability that the oil will migrate in a south easterly direction thus potentially impacting the southern coastline of the Berkeley Sound. This corresponds with the probable shoreline oiling results shown in Figure 12.53 which shows the highest probable location of shoreline oiling along the southern coastline of Berkeley sound with its rocky outcrops.

Minimum arrival times of the oil are shown spatially and shoreline arrival times and oil masses are plotted in Figure 12.54 which suggest that oil will impact the shoreline within 11 hours on average, and that the mass of oil onshore averages around 300 tonnes. In terms of seasonality, Figure 12.54 shows that seasonal variations have very little effect on the fate of the oil.

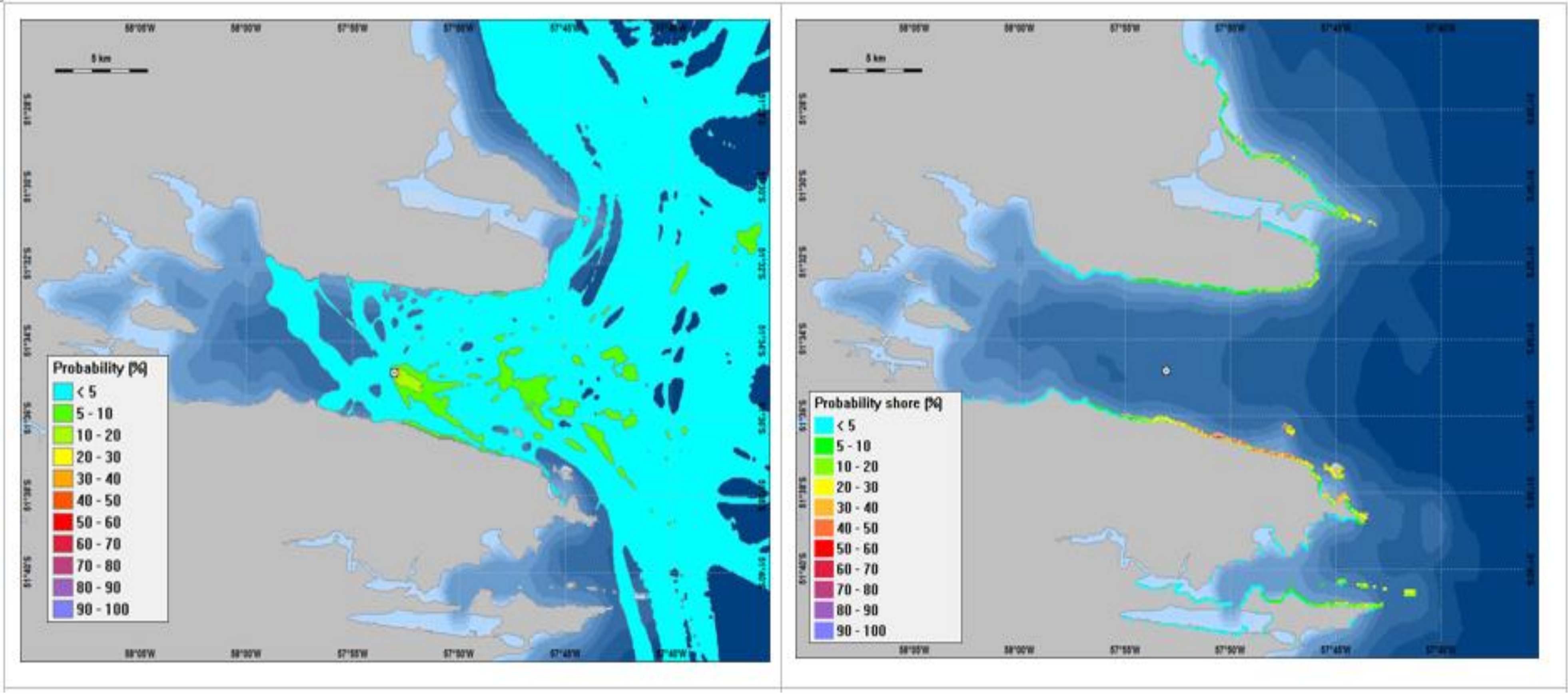


Figure 12.51: Probability of Surface Contamination and Shoreline Oiling – Scenario 1

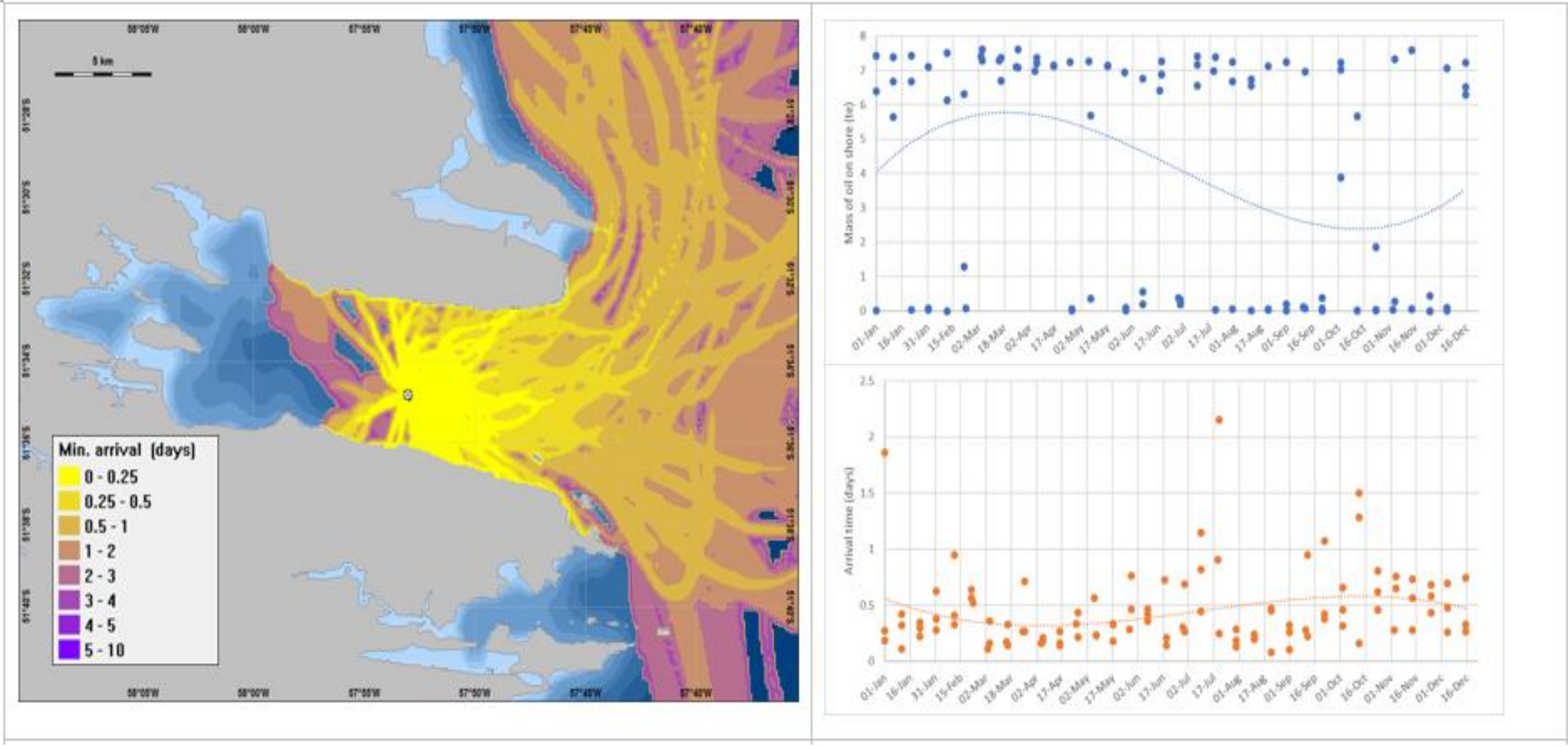


Figure 12.52: Minimum Arrival Time and Seasonal Distribution – Scenario 1

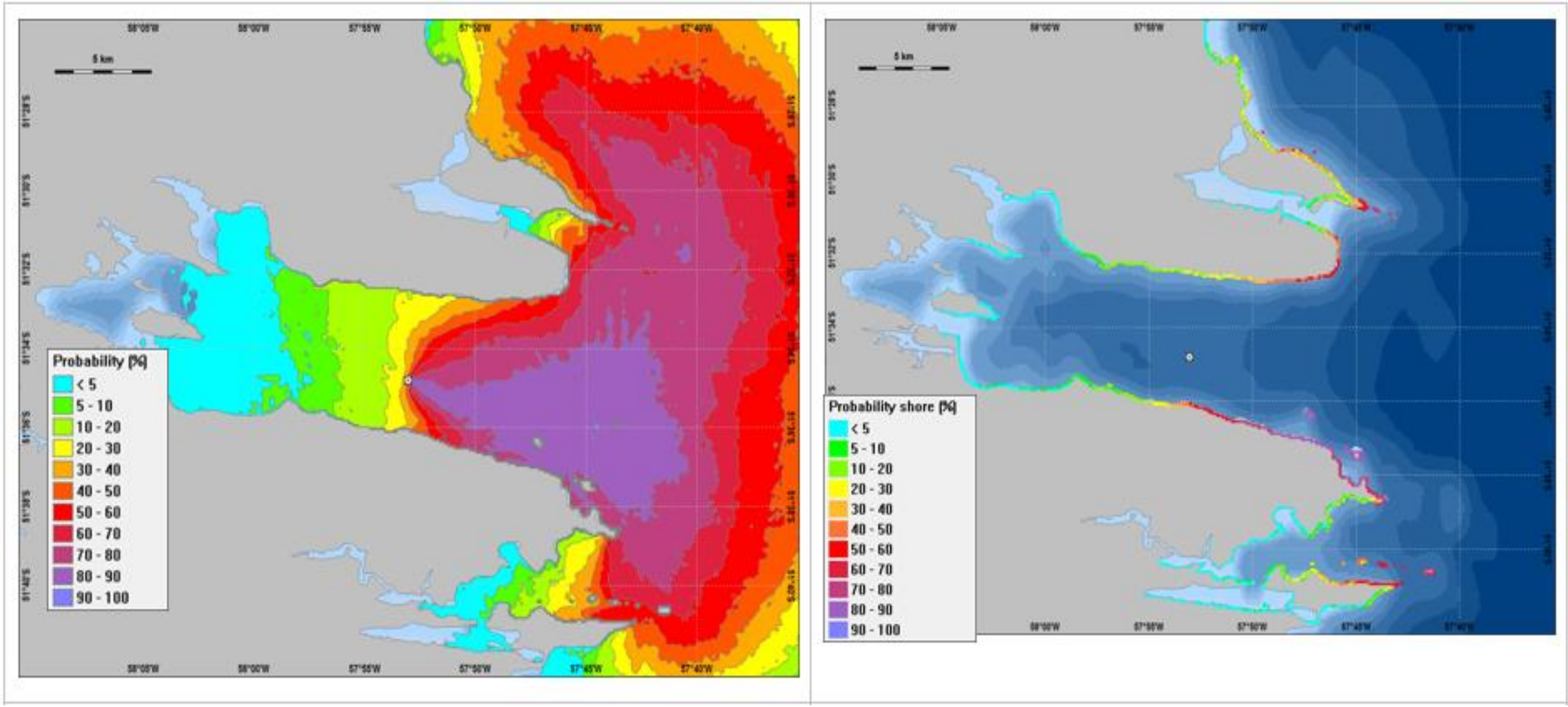


Figure 12.53: Probability of Surface Contamination and Shoreline Oiling – Scenario 2

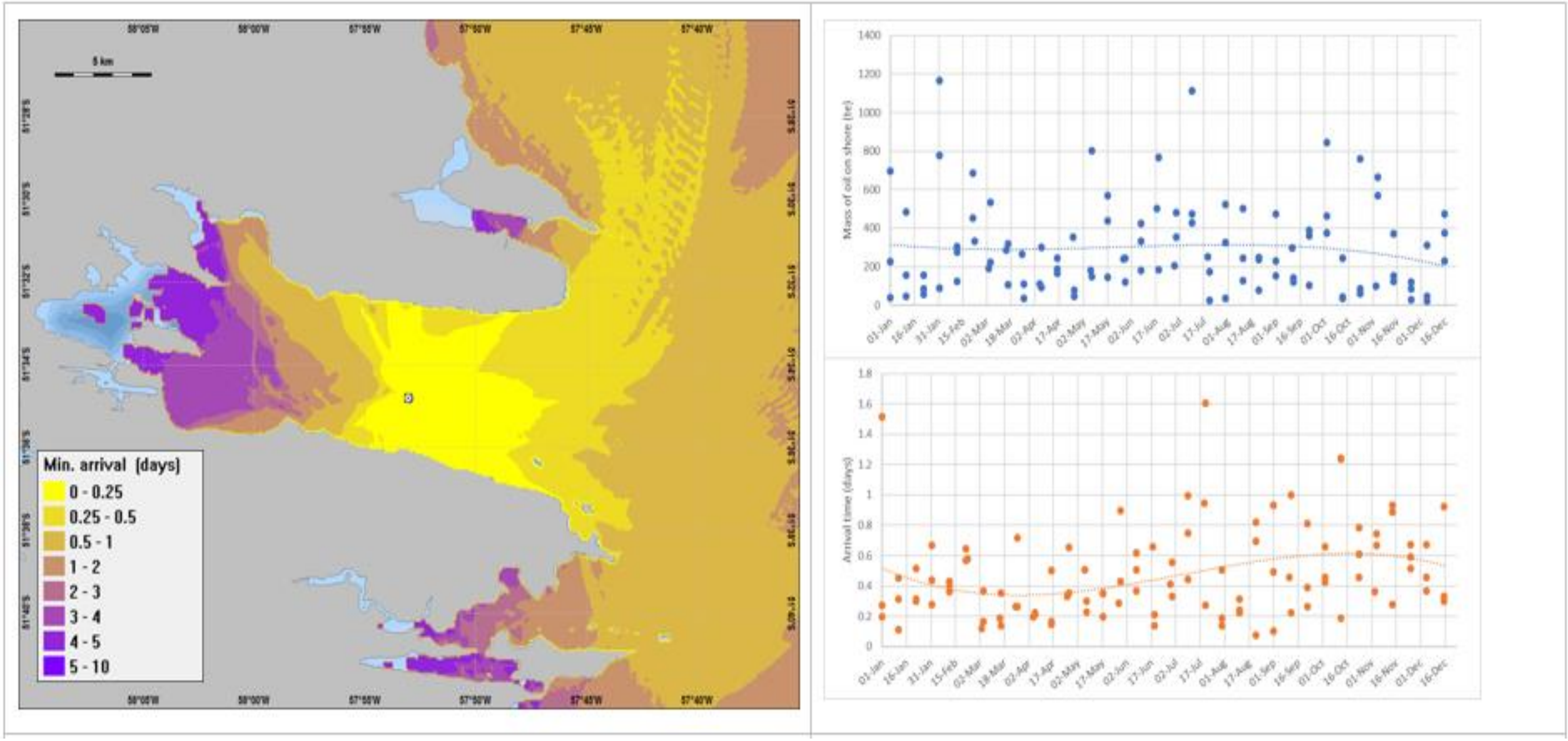


Figure 12.54: Minimum Arrival Time and Seasonal Distribution – Scenario 2

12.2.4.6 Modelling results – Scenario 3: 1,526 Tonnes IFO 380 Oil Spill Due to Drift Grounding (No response)

Figure 12.55 shows the stochastic model for the probability of oil on the sea surface above the threshold of 0.3 µm over a 10-day period. After 10 days the oil has left the modelling area or reached available coastlines and therefore no longer amenable to surface response techniques of recovery or dispersion.

As can been in Figure 12.55, the oil travels in the same way as it did in Scenarios 1 and 2 and similar to Scenario 2 there is a moderate to high probability of impacting the highly sensitive areas of Cochon and Kidney Islands and oiling the rocky shoreline along the southern coastline of Berkeley sound.

Minimum arrival times of the oil are shown spatially and shoreline arrival times and oil masses are plotted in Figure 12.56 which suggest that an oil will impact the shoreline within six hours on average although this is reduced to a few minutes for situations where a northerly wind is present, and that the mass of oil onshore averages around 500 tonnes up to a maximum of 1,350 tonnes. In terms of seasonality, Figure 12.56 shows that seasonal variations have very little effect on the fate of the oil.

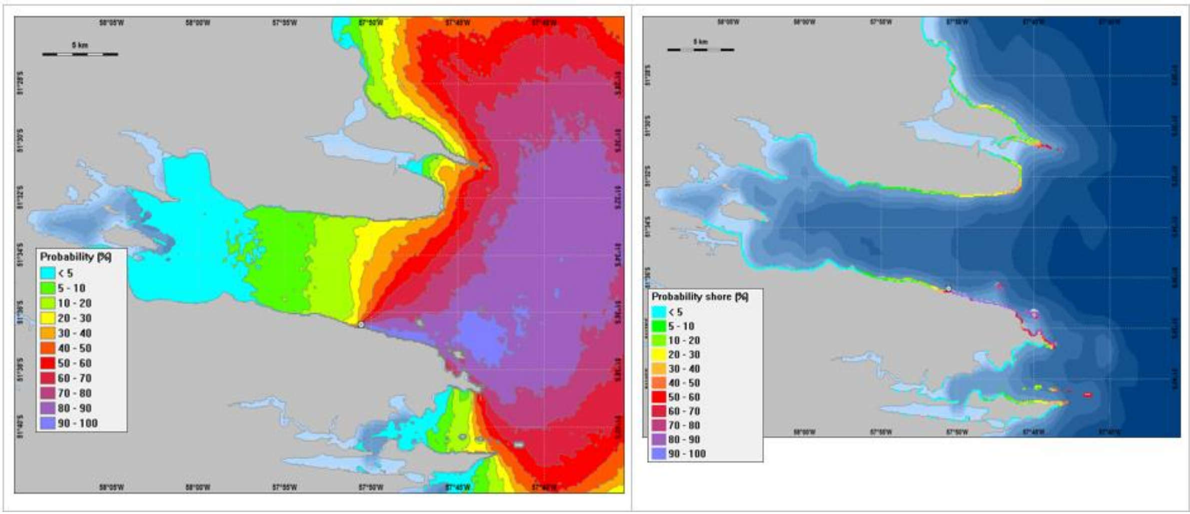


Figure 12.55: Scenario 3 – probability of surface contamincation above threshold of 0.3µm.

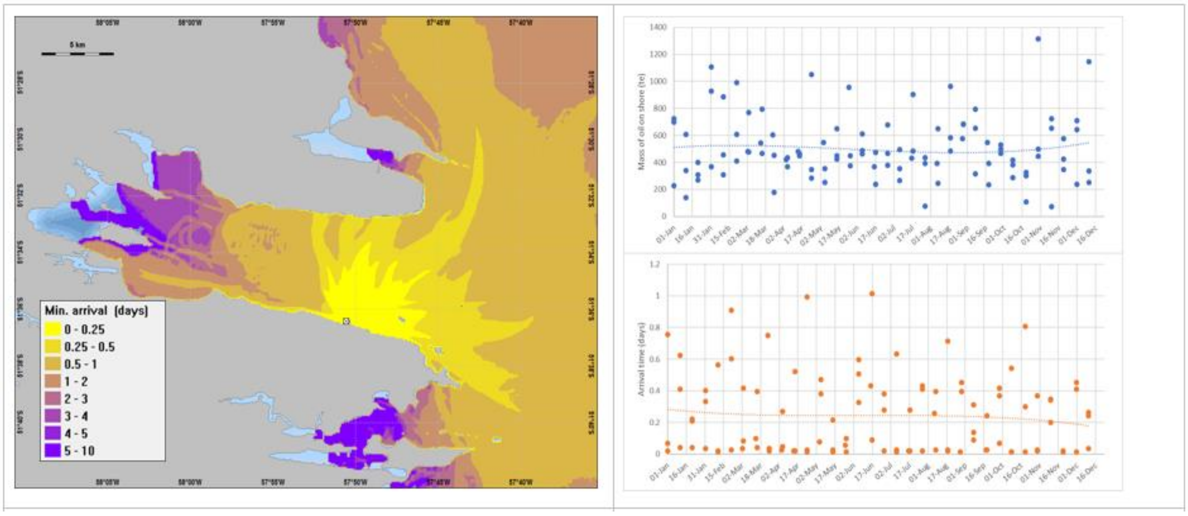


Figure 12.56: Minimum Arrival Time and Seasonal Distribution – Scenario 3

12.2.4.7 Regional air quality

Previous detailed OSCAR modelling (Premier 2017d) performed for the [now elimianted] Inshore Transfer option, provided modelling outputs to understand the impacts of a wide range of inshore spill sizes (300, 3,000 and 50,000 tonnes of Sea Lion crude) and oil types (Sea Lion crude, MGO and IFO). Given the selection of Direct Offtake as the oil export option, the previous modelling remains a useful reference source.

With respect to potential air quality impacts, the previous modelling runs of equal sized (e.g. 300 tonne) releases of IFO and MGO from a mid-point location in Berkeley Sound provide useful information concerning the relative evaporative properties of the different oil types. The model was run for five days to determine the fate of the different oil types which is summarised in Table 12.25 (as percentages of the released masses of oil). These figures allow the relative evaporative properties of the different oil types to be compared and used as input to the environmental risk assessment process for potential air quality impacts.

From Table 12.25, it can be seen that c. 30 % of the MGO spill had evaporated after the five day modelling run, compared with c. 11 % IFO. The previous modelling also indicated that, whilst relatively high proportions of hydrocarbon VOCs may be emitted from fuel oil spills in the first five days, thereafter much smaller rates of evaporation were anticipated.

Table 12.25: The fate of different oil types 5 days after 300 tonne Sea Lion crude and fuel oil spills, based on the 'worst case' metocean conditions

Fate of oil (%)	IFO	MGO
Surface	0.1	0.6
Atmosphere	10.6	30.2
Water column	0.5	5.4
Sediment	1.5	5.2

Fate of oil (%)	IFO	MGO
Ashore	85.4	48.5
Biodegraded	1.9	9.9
Outside grid	0.0	0.1

12.2.4.8 Summary of oil spill characteristics and modelling results

12.2.4.8.1 Oil spill characteristics

A comparison of some key attributes of the different oil types is provided in Table 12.26.

Table 12.26: Comparison of the relative properties of spilled hydrocarbons, including fuels

Hydrocarbon	Response	Surface oil risks	Adhesion risk	Sediment risks	Water column risks
IFO	Containment and recovery (belt skimmer) Dispersant possible	Significant, persistent sheen	High adhesion to shorelines and animals	Localised contamination	Longer term, low
MGO (Diesel)	Limited containment and recovery possible Dispersant ineffective	Significant, short-term sheen	Short-term	More extensive contamination inc. aromatics	Short-term, high

12.2.4.8.2 Oil fate predictions

The oil spill modelling predicts that:

- Surface oil remains closely grouped until it is acted on by stronger, more complex currents exiting Berkeley Sound;
- Oil leaving Berkeley Sound will tend to continue north-east out to sea. There is a small likelihood of some oil returning to the north coast of East Falkland, and very little likelihood of oil reaching the shore south of Cape Pembroke; and
- The local impacts of a marine diesel spill or an IFO spill are likely to be worse than a crude oil spill of the same size, and recovery may be less effective.

12.2.5 Industry-standard mitigation

In addition to the legislative requirements described in section 12.2.1.1 (including the project-specific OSCP), a number of industry-standard measures exist in order to reduce the likelihood of accidental events occurring during inshore operations. These requirements are factored into the Phase 1 base-case as follows:

- The use of a Vessel Traffic Management System;
- Clear manoeuvring and approach channel;
- Operational limits defined and implemented;

- Development and implementation of bunkering procedures with fuel supplier to ensure corporate standards of operational safety are maintained; and
- Bunkering conducted within the 500 m LTV exclusion zone, or other defined area.

12.2.6 Risk assessment

The following section draws on all the data described above to assess the risk of inshore oil spills. As with all risk assessments, it is necessary to consider first the potential impact of the event (i.e. 'Sensitivity of Receptor' x 'Severity of Effect') and *then* to consider the Likelihood of Occurrence of that event to establish the overall risk. The impact on each receptor is tabulated in each section below, and the likelihood of occurrence, which will be consistent within each scenario, is described as a whole.

The following assessments take account of all legislation and industry-standard and base case mitigations described in section 12.2.1.1 and section 12.2.5, respectively. A summary of all the risk assessment outcomes is tabulated in section 12.2.12 (Table 12.39 below), which shows the worst case impact / risk for each activity and receptor.

12.2.6.1 Scenario 1: 10 tonne MGO Bunkering Incident Marine Gas Oil (Fuel Oil) Spill (No response)

Diesel fuel is most often a light, refined petroleum product. Small diesel spills will usually evaporate and disperse naturally within a day or less. This is true for most spills even in cold water. However, 'marine diesel' (MGO) is a slightly heavier fuel oil that will persist longer when spilled. When spilled on water, MGO may form a thicker film of dull or dark colours (section 12.2.4.1).

MGO spreads rapidly and also evaporates and dissolves or mixes with water, which means that containment and recovery is rarely very successful. MGO forms a significant short-term surface sheen. Birds and other animals may be initially affected via contact although the window is confined to a few days and diminishes rapidly. Of the oil types modelled, MGO has the highest proportion (5 %) of oil that dissolves in the water column, resulting in a high but short-lived risk. In the longer-term, sediment toxicity is more likely than with the other oil types modelled in this assessment.

12.2.6.1.1 Likelihood of occurrence

A review of historic oil spill incidents suggests that the accidental release of MGO during a bunkering operation is the most likely incident to occur as a result of Premier's planned operations within Berkeley Sound.

The likelihood of accidents associated with fuel oil transfer was not analysed specifically in the QRA (DNV-GL, 2016). However, to take a precautionary approach, the rate of accidents is assumed to be similar to that for crude transfers. The frequency of crude transfer or bunkering spills is predicted to be 5.0E-03 per year which equates to a rate of one event every 200 years. Nonetheless, fuel oil transfer spills have occurred previously in the industry, and while failure of numerous operational controls would be required (e.g. procedural and engineering controls) on balance, the **likelihood of occurrence** is considered to be '**Unlikely**'.

To ensure this risk assessment considers the worst case, the higher likelihood (of 'Unlikely') is used for the risk assessment.

12.2.6.1.2 Overall significance of the risk

A summary of the risk assessment for a 10 tonne spill of MGO in Berkeley Sound is presented in Table 12.27. While the *impact* of such an event to some of the receptors would be 'High', owing to the likelihood of such an event occurring, the **significance of the *risk*** posed by a 10 tonne MGO spill, with the base case measures in place, is **Moderate** for fish and squid, Human population (fisheries), seabirds and marine mammals.

Table 12.27: Summary of the impact assessment for a 10 tonne Marine Gas Oil (MGO) spill at the LTV Mooring location, with base case mitigation in place

Receptor	Sensitivity of Receptor and Severity of Effect (Impact)	Likelihood of occurrence	Overall risk significance
Plankton	Plankton show high seasonal and spatial variation in abundance and productivity, and it is expected that any effects will be greatest during summer when productivity is highest (section 7.4.1). The planktonic lobster krill is known to be abundant within Berkeley Sound, and elsewhere in the Falklands, which attracts higher predators to feed on this resource. At other times, the area is less significant for zooplankton but is still considered highly productive. Therefore, the **sensitivity of plankton** is considered to be '**Moderate**'. An MGO spill would rapidly spread to cover a wide area. Although the volatile nature of MGO limits exposure time to receptors, MGO is highly toxic to marine organisms. As the impact would be local, temporary and reversible (due to immigration of planktonic organisms from unaffected areas), the **severity of the effect of a 10 tonne spill of MGO** on plankton has been assessed as '**Moderate**' Therefore the **significance of the impact** on plankton is assessed as '**Moderate (9)**'.	**Unlikely**	**'Low (6)'**
Marine flora	Kelp forest is a widespread habitat around the entire coast of the Falklands archipelago but is relatively sparse within Berkeley Sound (section 7.4.2.3). Kelp is a habitat forming species, and although undesignated this habitat is considered to be of national importance and therefore the sensitivity of the receptor is considered to be '**Moderate** Kelp is apparently reasonably tolerant of hydrocarbon pollution (section 12.2.4.2.1). Modelling indicates that there is a low probability of oil reaching large areas of kelp forest. Any impact will be localised, short-term and rapidly reversible leading to a barely detectable impact on kelp taxa. The severity of effect is therefore '**Minor**'. Therefore the significance of the impact is assessed as '**Moderate (6)**'.	**Unlikely**	**'Low (6)'**
Benthic communities	Berkeley Sound supports a diverse benthic fauna (section 7.4.3.3) and includes habitats that could be considered to be biogenic and geogenic reefs congruent with habitats listed in Annex I of the Habitats Directive (section 7.4.3.3.4). By nature, reef forming organisms are sessile and often filter feeders, and are therefore vulnerable to water borne pollutants. Additionally, recent testing of one benthic species indicated that relatively high concentrations of oil in sediments would impact benthic communities (section 12.1.4.1.1.1) Although benthic habitats are undesignated within the Falklands, those found within Berkeley Sound are considered to be of national or local importance. The **sensitivity of the benthic community** is therefore considered to be '**Moderate**'. Modelling predicts that a relatively high proportion of MGO will reach the sediments. Most of oil reaching the sediment does so in coastal waters. Although buoyant, MGO is more dispersible in water than other oil types. In addition, as it spreads into shallower waters the likelihood of adhering to fine grain particulate matter increases resulting in diesel deposits in the sediment. It is predicted that 5 % (0.5 tonnes) of the MGO will reach the sediments, a higher proportion than for other oil types. Once in the sediment, MGO will persist as a source of toxic aromatics, such as PAHs. Additionally, about 5% (0.5 tonnes) of MGO will dissolve, which will pose a locally high risk over the short-term, until the oil disperses. Contamination will be restricted to a local area and is temporary in nature. The **severity of effect** is considered to be '**Moderate**' due to the potential for localised reversible nature of the impact. The **significance of impact** on the benthic community is therefore assessed as '**Moderate (9)**'.	**Unlikely**	**'Low (6)'**

Receptor	Sensitivity of Receptor and Severity of Effect (Impact)	Likelihood of occurrence	Overall risk significance
Fish and squid	Loligo squid are known to spawn within Berkeley Sound although large aggregations of squid eggs have not been found to date. Overall, there is a great deal of uncertainty regarding where squid spawn and what areas should be considered as important spawning sites (section 7.4.4.3.2.1). However, it is known that eggs and larvae of fish and squid are regarded to be more susceptible to pollution events than adults due to their immobility (section 12.1.4.2.3.2). Given the uncertainty regarding the distribution of loligo spawning grounds, it is possible that a regionally important proportion of the population (1 % of biogeographic population) could fall within the zone of influence of the Phase 1 Development activity. Therefore, the **sensitivity of fish and squid** receptors to a 10 tonne MGO spill is considered to be '**High**'. Due to the properties of MGO (section 12.2.4.8), the impact of a 10 tonne MGO spill on the water column will be high but very short-lived. Contamination associated with sediments will be more persistent. It is unlikely that adult fish and squid will be impacted directly but they could consume toxins via food. Direct toxic effects on fish and squid eggs and larvae could occur but the impact will be locally high, but short-term, and therefore the **severity of the effect** on fish is considered to be '**Moderate**'. The **significance of the impact** of a 10 tonne MGO spill on fish and squid is assessed as '**Upper Moderate (12)**'.	**Unlikely**	**'Moderate (8)'**
Human population (fisheries)	The loligo trawl fishery is the second largest (in terms of catch) in the Falklands and is therefore an important part of the Islands economy. The squid are caught off the coast of East Falkland, including waters adjacent to Berkeley Sound and they are known to spawn inshore (section 7.4.4.3.2.1). Given the importance of these fisheries to the Falklands' economy, and the uncertainty over the extent of any impacts, a precautionary approach should be taken. Consequently, it is assumed that a 300 tonne spill would result in economic impacts for the fishing industry. Given that there have been spills of hydrocarbons within Berkeley Sound in the past and background levels of contamination are detectable (section 7.3.7.2.2), the fishery is believed to have a moderate capacity to absorb change on this scale. However, a spill of this size would be unacceptable to a majority of stakeholders and therefore the **sensitivity of the human population** is considered to be '**High**'. Berkeley Sound has experienced similar sized spills of MGO in the past with no impact on local fishing grounds. Nevertheless, taking the precautionary approach, there is a chance that a 10 tonne MGO spill could result in the localised temporary closure of the fishing grounds due to potential tainting and contamination and therefore, the **severity of the effect** of an uncontrolled release on fisheries is considered to be '**Moderate**' Therefore the **significance of the impact** on the human population via fisheries is assessed as '**Upper Moderate (12)**'.	**Unlikely**	**'Moderate (8)'**
Seabirds	At times, during the summer breeding seasons, more than 1 % of the biogeographic populations of several species (e.g. gentoo penguin and sooty shearwater) and species of IUCN 'Vulnerable' status (e.g. rockhopper penguin, white-chinned petrel) or species of local conservation concern (Falklands flightless steamer duck) will be present year-round (section 7.4.5.3.2). Therefore, the **sensitivity of seabirds** to the effects of a 10 tonne MGO spill, is considered to be '**High**'. A spill of 10 tonnes of MGO would rapidly spread to form a sheen throughout Berkeley Sound. Although the sheen will be short-lived due to natural break-down and evaporation, MGO has the potential to contaminate the feathers of any seabirds that come into contact with it. Further, diesel has greater potential than Sea Lion crude for impacts associated with toxicity (section 12.1.4.2.5.1). The highest probability is for the MGO to move south-eastwards towards the breeding sites of the species mentioned above. A large proportion of the Falklands populations of sooty shearwaters and white-chinned petrels breed on Kidney Island. During the breeding season, these birds form huge rafts close inshore before returning to nest	**Unlikely**	**'Moderate (10)'**

Receptor	Sensitivity of Receptor and Severity of Effect (Impact)	Likelihood of occurrence	Overall risk significance
	burrows at dusk. A 10 tonne MGO spill during the breeding season could impact a significant proportion of the regional population, which may have long-term implications for the populations of these species. The **severity of the effect** of a 10 tonne MGO spill on seabirds is therefore considered to be '**Serious'**. Therefore the **significance of the impact** on seabirds is assessed as '**High (16)**'.		
Marine mammals	Berkeley Sound experiences a seasonal presence of fin and sei whales (both species classified as IUCN 'Endangered') (section 7.4.6.3.1.2) and the presence of several other species of local conservation concern (Peale's and Commerson's dolphins, South American sea lions and fur seals), as prescribed in the Falklands biodiversity action plan (section 7.5.3). Although it is possible that oil from a spill of this size will not come into direct contact with any marine mammals, which occur in relatively low densities, this is not certain. Therefore, the **sensitivity of marine mammals** is assessed as '**High**'. Given the the volatile nature of MGO, marine mammals will be susceptible to inhaling hydrocarbons upon surfacing to breath. Further, the coats of fur seals and sea lions that come into contact with oily sheens will become contaminated. This will result in a loss of insulation and direct ingestion while grooming. The potential for exposure is short lived (measured in days). However, as a worst case the ingestion of MGO could have long-lasting implications for the individuals concerned and potentially the local populations. Therefore, taking a precautionary approach, the **severity of effect** of a 10 tonne MGO spill within Berkeley Sound on marine mammals is assessed as '**Serious**'. Therefore the **significance of the impact** on marine mammals is assessed as '**High (16)**'.	**Unlikely**	**'Moderate (10)'**
Coastal habitats (terrestrial)	The coast of Berkeley Sound contains a wide variety of coastal habitats. The probability plots (section 12.2.4.8.2) indicate that the north and south coasts of the outer Sound are more likely to be impacted than elsewhere. These shorelines are steep, rocky and subject to moderate wave action. Of great concern are the coasts of the inner Sound and Volunteer Lagoon, which have high Environmental Sensitivity Scores due to the fine grained sediments (section 7.6), where oil is more likely to form tarballs and persist longest. Probability plots indicate that it is likely that the oil will drift towards the National Nature Reserve of Cochon and Kidney Island (section 12.2.4.8.2). The coastal habitat of these islands is particularly important for Cobb's wren (IUCN 'Vulnerable'). These are nationally designated sites and therefore the **sensitivity of the receptor** is considered to be '**High**'. Modelling predicts that under the prevailing environmental conditions MGO will travel towards the coast where it becomes trapped and sedimentation takes place. While a large proportion of the Berkeley Sound coast could be impacted, the nature of the MGO is such that this will be short-term and the severity of effect is therefore assessed as '**Minor**'. Therefore the significance of the impact is assessed as '**Moderate (8)**'.	**Unlikely**	**'Low (6)'**
Human Population (tourism)	There are unlikely to be significant impacts on local tourism from an incident at the scale of a 10 tonne MGO spill (see assessments above). However, media publicity may influence the experience and perceptions of tourists, which may then impact upon their propensity to visit. Given that there would be moderate capacity to absorb change in the aftermath of a small inshore MGO spill, the **sensitivity of tourism** is considered to be '**Moderate**'. Any negative impact from adverse publicity associated with an incident of this size would be short lived but may have a small short-term impact on the number of visitors. The **severity of effect** of a 10 tonne MGO spill in Berkeley Sound on tourism has been assessed as '**Minor**'. Therefore the **significance of the impact** on tourism is assessed as '**Moderate (6)**'.	**Unlikely**	**'Low (6)'**

12.2.6.2 Scenario 2: 3,700 Tonnes of MGO Due to Installation Vessel Collision with Jigger and or Reefer (No response)

This scenario was identified as the potential worst case in terms of the quantity of hydrocarbon spilled into the Berkeley Sound. The only credible event that could cause such a release is from a collision with a vessel during a period of low visibility. To illustrate the outer envelope in terms of spill response, the modelling assumes that the inventory is lost over a 24hr period. This is presented as a worst case scenario.

12.2.6.2.1 Likelihood of occurrence

Of the measures described in section 12.2.7, the following preventative measures are intended to make such an incident extremely unlikely:

- The use of a Vessel Traffic Management System.
- Clear manoeuvring and approach channel;
- Use of exclusion zones around LTVs; and
- Operational limits defined and implemented.

As a result, on balance, the **likelihood of occurrence** is considered to be '**Unlikely**'.

To ensure this risk assessment considers the worst case, the higher likelihood (of 'Unlikely') is used for the risk assessment.

12.2.6.2.2 Overall significance of the risk

A summary of the risk assessment for a 3,700 tonne spill of MGO in Berkeley Sound is presented in Table 12.28. While the *impact* of such an event to some of the receptors would be 'High', owing to the likelihood of such an event occurring, the **significance of the *risk*** posed by a 3,700 tonne MGO spill, with the base case measures in place, is **Moderate** for fish and squid, Human population (fisheries), seabirds and marine mammals.

Table 12.28: Summary of the impact assessment for a 3,700 tonne Marine Gas Oil (MGO) spill at the LTV Mooring location, with base case mitigation in place

Receptor	Sensitivity of Receptor and Severity of Effect (Impact)	Likelihood of occurrence	Overall risk significance
Plankton	The **sensitivity of plankton** is as described in Table 12.27 above and is considered to be '**Moderate**'. An MGO spill would rapidly spread to cover a wide area. Although the volatile nature of MGO limits exposure time to receptors, MGO is highly toxic to marine organisms. As the impact would be local, temporary and reversible (due to immigration of planktonic organisms from unaffected areas), the **severity of the effect of a 3,700 tonne spill of MGO** on plankton has been assessed as '**Moderate**' Therefore the **significance of the impact** on plankton is assessed as '**Moderate (9)**'.	**Unlikely**	**'Low (6)'**
Marine flora	The **sensitivity of kelp** is as described in Table 12.27 above and is considered to be '**Moderate**'. Kelp is apparently reasonably tolerant of hydrocarbon pollution (section 12.2.4.2.1). Modelling indicates that there is a low probability of oil reaching large areas of kelp forest. Any impact will be localised, short-term and rapidly reversible leading to a barely detectable impact on kelp taxa. The severity of effect is therefore '**Minor**'. Therefore the significance of the impact is assessed as '**Moderate (6)**'.	**Unlikely**	**'Low (6)'**
Benthic communities	The **sensitivity of the benthic community** is as described in Table 12.27 and is considered to be '**Moderate**'. Modelling predicts that a relatively high proportion of MGO will reach the sediments. Most of oil reaching the sediment does so in coastal waters. Although buoyant, MGO is more dispersible in water than other oil types. In addition, as it spreads into shallower waters the likelihood of adhering to fine grain particulate matter increases resulting in diesel deposits in the sediment. It is predicted that 5 % (185 tonnes) of the MGO will reach the sediments, a higher proportion than for other oil types. Once in the sediment, MGO will persist as a source of toxic aromatics, such as PAHs. Additionally, about 5% (185 tonnes) of MGO will dissolve, which will pose a locally high risk over the short-term, until the oil disperses. Contamination will be restricted to a local area and is temporary in nature. The **severity of effect** is considered to be '**Moderate**' due to the potential for localised reversible nature of the impact. The **significance of impact** on the benthic community is therefore assessed as '**Moderate (9)**'.	**Unlikely**	**'Low (6)'**
Fish and squid	The **sensitivity of fish and squid** is as described in Table 12.27 above and is considered to be '**High**'. Due to the properties of MGO, the impact of a 3,700 tonne MGO spill on the water column will be high but short-lived. Contamination associated with sediments will be more persistent. It is unlikely that adult fish and squid will be impacted directly but they could consume toxins via food. Direct toxic effects on fish and squid eggs and larvae could occur but the impact will be locally high, but short-term, and therefore the **severity of the effect** on fish is considered to be '**Moderate**'. The **significance of the impact** of a subsea blow-out on fish and squid is assessed as '**Upper Moderate (12)**'.	**Unlikely**	**'Moderate (8)'**
Human population (fisheries)	The **sensitivity of the human population** is as described in Table 12.27 above and is considered to be considered to be '**High**'.	**Unlikely**	**'Moderate (8)'**

Receptor	Sensitivity of Receptor and Severity of Effect (Impact)	Likelihood of occurrence	Overall risk significance
	Berkeley Sound has experienced similar sized spills of MGO in the past with no impact on local fishing grounds. Nevertheless, taking the precautionary approach, there is a chance that a 3,700 tonne MGO spill could result in the localised temporary closure of the fishing grounds due to potential tainting and contamination and therefore, the **severity of the effect** of an uncontrolled release on fisheries is considered to be '**Moderate**' Therefore the **significance of the impact** on the human population via fisheries is assessed as '**Upper Moderate (12)**'.		
Seabirds	At times, during the summer breeding seasons, more than 1 % of the biogeographic populations of several species (e.g. gentoo penguin and sooty shearwater) and species of IUCN 'Vulnerable' status (e.g. rockhopper penguin, white-chinned petrel) or species of local conservation concern (Falklands flightless steamer duck) will be present year-round (section 7.4.5.3.2). Therefore, the **sensitivity of seabirds** to the effects of a 3,700 tonne MGO spill, is considered to be '**High**'. A spill of 3,700 tonnes of MGO would rapidly spread to form a sheen throughout Berkeley Sound. Although the sheen will be short-lived due to natural break-down, MGO has the potential to contaminate the feathers of any seabirds that come into contact with it. Further, diesel has greater potential than Sea Lion crude for impacts associated with toxicity (section 12.1.4.2.5.1). As in the crude oil modelling, the highest probability is for the MGO to move south-eastwards towards the breeding sites of the species mentioned above. A large proportion of the Falklands populations of sooty shearwaters and white-chinned petrels breed on Kidney Island. During the breeding season, these birds form huge rafts close inshore before returning to nest burrows at dusk. A 3,700 tonne MGO spill during the breeding season could impact a significant proportion of the regional population, which may have long-term implications for the populations of these species. The **severity of the effect** of a 3,700 tonne MGO spill on seabirds is therefore considered to be '**Serious'**. Therefore the **significance of the impact** on seabirds is assessed as '**High (16)**'.	**Unlikely**	**'Moderate (10)'**
Marine mammals	The **sensitivity of marine mammals** is as described in Table 12.27 above and is considered to be '**High**'. In addition to the effects of crude oil on marine mammals described in section 12.1.4.2.6, the volatile nature of MGO is such that marine mammals are susceptible to inhaling hydrocarbons upon surfacing to breath. Further, the coats of fur seals and sea lions that come into contact with oily sheens will become contaminated. This will result in a loss of insulation and direct ingestion while grooming. The potential for exposure is short lived (measured in days). However, as a worst case the ingestion of MGO could have long-lasting implications for the individuals concerned and potentially the local populations. Therefore, taking a precautionary approach, the **severity of effect** of a 3,700 tonne MGO spill within Berkeley Sound on marine mammals is assessed as '**Serious**'. Therefore the **significance of the impact** on marine mammals is assessed as '**High (16)**'.	**Unlikely**	**'Moderate (10)'**
Coastal habitats (terrestrial)	The **sensitivity of the receptor** is as described in Table 12.27 and is considered to be '**High**'. Modelling predicts that under the prevailing environmental conditions MGO will travel towards the coast where it becomes trapped and sedimentation takes place (*c.f.* Sea Lion crude, section 12.1.4.1.1.1). While a large proportion of the Berkeley Sound coast could be impacted, the nature of the MGO is such that this will be short-term and the severity of effect is therefore assessed as '**Minor**'.	**Unlikely**	**'Low (6)'**

Receptor	Sensitivity of Receptor and Severity of Effect (Impact)	Likelihood of occurrence	Overall risk significance
	Therefore the significance of the impact is assessed as '**Moderate (8)**'.		
Human Population (tourism)	There are unlikely to be significant impacts on local tourism from an incident at the scale of a 3,700 tonne MGO spill (see assessments above). However, media publicity may influence the experience and perceptions of tourists, which may then impact upon their propensity to visit. Given that there would be moderate capacity to absorb change in the aftermath of a small inshore MGO spill, the **sensitivity of tourism** is considered to be '**Moderate**'. Any negative impact from adverse publicity associated with an incident of this size would be short lived but may have a small short-term impact on the number of visitors. The **severity of effect** of a 3,700 tonne MGO spill in Berkeley Sound on tourism has been assessed as '**Minor**'. Therefore the **significance of the impact** on tourism is assessed as '**Moderate (6)**'.	**Unlikely**	**'Low (6)'**

12.2.6.3 Scenario 3: 1,526 Tonnes IFO 380 Oil Spill Due to Drift Grounding (No response)

IFO Fuel oil is a dense, viscous oil produced which tends to break up into discrete patches and tar balls when spilled, rather than forming slicks. Very little of this viscous oil is likely to disperse into the water column.

These oils can occasionally form an emulsion, but usually only slowly and after a period of days. Because of its high viscosity, beached oil tends to remain on the surface rather than penetrate sediments. Light accumulations usually form a 'bathtub ring' at the high-tide line; heavy accumulations can pool on the beach. IFO behaves in a similar way to Sea Lion crude but has a greater potential to form a surface sheen (and emulsion), which poses a risk of adhesion to animals and shorelines.

12.2.6.3.1 Likelihood of occurrence

The justification for the **likelihood of occurrence** of a 1,526 tonne IFO spill is the same as that given in section 12.2.6.1.1 (for a 3,700 tonne MGO spill) and is considered to be '**Unlikely**'.

12.2.6.3.2 Overall significance of the risk

A summary of the risk assessment outcomes for a 1,526 tonne IFO spill in Berkeley Sound is presented in Table 12.29. While the *impact* of such an event to some of the receptors would be 'High', owing to the likelihood ('**Unlikely'**) of such an event occurring, the **significance of the *risk*** posed by a 1,526 tonne IFO spill, with the base case measures in place, is **Moderate** for benthic communities, fish and squid, Human population (fisheries), seabirds, marine mammals and coastal habitats.

Table 12.29: Summary of the impact assessment for a 1,526 tonne Intermediate Fuel Oil (IFO) spill, with base case mitigation

Receptor	Sensitivity of Receptor and Severity of Effect (Impact)	Likelihood of occurrence	Overall risk significance
Plankton	The **sensitivity of plankton** is as described in Table 12.27 above and is considered to be '**Moderate**'. IFO would spread rapidly to form a thick slick. A surface sheen would persist longer than for a Sea Lion crude or MGO spill. IFO can form emulsions (referred to as 'chocolate mousse'), which increase the volume and persistence of the oil. The **severity of the effect** of a 1,526 tonne spill of IFO on plankton has been assessed as '**Moderate**' because the impact would be local, temporary and reversible (due to immigration of planktonic organisms from unaffected areas). Therefore the **significance of the impact** on plankton is assessed as '**Moderate (9)**'.	**Unlikely**	**'Low (6)'**
Marine flora	The **sensitivity of kelp** is as described in Table 12.27 above and is considered to be '**Moderate**'. A small percentage (5 – 10 % or 76 – 153 tonnes) of IFO will evaporate in the first few hours after a spill. The residual oil would be persistent and can spread over a large area. Kelp beds within Berkeley Sound are likely to be impacted, but oil leaving the Sound is likely to travel offshore away from the coastal kelp beds. Furthermore, kelp is apparently reasonably tolerant of hydrocarbon pollution (section 12.2.4.2.1). Any impacts will be localised, temporary and reversible. The severity of effect is therefore '**Moderate**'. Therefore the significance of the impact is assessed as '**Moderate (9)**'.	**Unlikely**	**'Low (6)'**
Benthic communities	The **sensitivity of the benthic community** is as described in Table 12.27 and is considered to be '**Moderate**'. Modelling predicts that a very small proportion of the oil will reach the sediments and most of oil reaching the sediment does so in coastal waters (section 12.1.4.1.1.1). IFO is buoyant, but as it spreads into shallower waters the likelihood of adhering to fine grain particulate matter increases resulting in oil deposits in the sediment. It is predicted that 1.5 % (4.5 tonnes) of the IFO will reach the sediments. Once in the sediment, IFO will persist as a source of toxic aromatics, such as PAHs. Contamination will be restricted to a local area but may take a long time to recover. The **severity of effect** is considered to be '**Serious**' due to the potential for localised impacts that should be reversible in nature. The **significance of impact** on the benthic community is therefore assessed as '**Upper Moderate (12)**'.	**Unlikely**	**'Moderate (8)'**
Fish and squid	The **sensitivity of fish and squid** is as described in Table 12.27 above and is considered to be considered to be '**High**'. Due to the properties of IFO, the impact of a 1,526 tonne spill on fish and squid will be locally high but short-lived and therefore the **severity of the effect** on fish is considered to be '**Moderate**'. The **significance of the impact** of a subsea blow-out on fish and squid is assessed as '**Upper Moderate (12)**'.	**Unlikely**	**'Moderate (8)'**
Human population (fisheries)	The **sensitivity of the human population** is as described in Table 12.27 above and is considered to be considered to be '**High**'. The main impact on fisheries is believed to be the risk of tainting of squid, due to the bioaccumulation of hydrocarbons in the tissues of these animals and the associated risks to human health (section 12.1.4.2.4.2). This could lead to possible closure of the fishery, and / or loss of confidence by consumers. The results of modelling indicate that under certain conditions a large proportion of the oil would be swept out of Berkeley Sound and traces of hydrocarbons,	**Unlikely**	**'Moderate (8)'**

PremierOil

Receptor	Sensitivity of Receptor and Severity of Effect (Impact)	Likelihood of occurrence	Overall risk significance
	including PAHs, could drift into the Loligo Box (section 12.2.3). Given the importance of these fisheries to the Falklands' economy, and the uncertainty over the extent of any impacts, a precautionary approach should be taken. Consequently, it is assumed that a 1,526 tonne IFO spill could result in economic impacts for the fishing industry. A 1,526 tonne IFO spill could result in the localised temporary closure of the fishing grounds due to potential tainting and contamination and therefore, the **severity of the effect** of an uncontrolled release on fisheries is considered to be '**Moderate**' Therefore the **significance of the impact** on the human population via fisheries is assessed as '**Upper Moderate (12)**'.		
Seabirds	The **sensitivity of seabirds** is as described in Table 12.27 above and is considered to be '**High**'. A spill of 1,526 tonnes of IFO would result in the formation of a persistent sheen, which has the potential to contaminate the feathers of any seabirds that come into contact with it. As in the crude oil modelling, the highest probability is for IFO to move south-eastwards towards the breeding sites of the species mentioned above. A large proportion of the Falklands populations of sooty shearwaters and white-chinned petrels breed on Kidney Island. During the breeding season, these birds form huge rafts close inshore before returning to nest burrows at dusk. A 1,526 tonne IFO spill during the breeding season could impact a significant proportion of the regional population, which may have long-term implications for the populations of these species. The **severity of the effect** of a 1,526 tonne IFO spill on seabirds is therefore considered to be '**Serious'**. Therefore the **significance of the impact** on seabirds is assessed as '**High (16)**'.	**Unlikely**	**'Moderate (10)'**
Marine mammals	The **sensitivity of marine mammals** is as described in Table 12.27 above and is considered to be '**High**' The **severity of effect** of a 1,526 tonne IFO spill on marine mammals is as described in 12.2.4 above and is considered to be '**Serious**' Therefore the **significance of the impact** on marine mammals is assessed as '**High (16)**'.	**Unlikely**	**'Moderate (10)'**
Coastal habitats (terrestrial)	The **sensitivity of the receptor** is as described in Table 12.27 and is considered to be '**High**'. Any IFO that reaches the shore will adhere to the substrate and persist, which may require dedicated clean-up operations. The impact may be long-lasting but reversible, and therefore the severity of effect is '**Serious**'. Therefore the significance of the impact is assessed as '**High (16)**'.	**Unlikely**	**'Moderate (10)'**
Human Population (tourism)	The potential for persistent shoreline contamination may have an effect on local tourism, depending on the area impacted. Media publicity may influence the perceptions of potential tourists, which may then impact upon their propensity to visit. An incident on this scale may stimulate significant attention from the media, depending on the impact of other receptors. Given that there would be moderate capacity to absorb change in the aftermath of a small inshore IFO spill, the **sensitivity of tourism** is considered to be '**Moderate**'. Any negative impact from adverse publicity associated with an incident of this size on the tourism industry as a whole would be short lived but may have a small short-term impact on the number of visitors. If a tourist visitor site was contaminated the impact on the landowner may be more significant. The **severity of effect** of a 1,526 tonne IFO spill in Berkeley Sound on tourism has been assessed as '**Moderate**'. Therefore the **significance of the impact** on tourism is assessed as '**Moderate (9)**'.	**Unlikely**	**'Low (6)'**

12.2.6.4 Regional air quality

The inshore hydrocarbon spill sceanrios that have been considered are 10 tonne of MGO (bunkering operations), 1,500 tonne IFO (LTV drift and grounding) and 3,700 tonne MGO (SS7 offshore installation vessel collision) as described in earlier sections

Given the relatively high evaporative rates of fuel oils (MGO and IFO), c, relatively higher proportions of hydrocarbon VOCs may be emitted from fuel oil in the first 5 days, thereafter much smaller rates of evaporation would be anticipated. Given the short duration of this potential air quality impact, it is anticipated that the human population (and by extrapolation marine mammals and seabirds) would undergo short-term disturbance (in the region of days) from a fuel oil spill in Berkeley Sound. The dominant wind direction would also likely facilitate dispersion of the VOCs and drive the evaporated components away from Berkeley Sound.

it is clearly not plausible that the exposure of people at large would be significant at these spill level (10 to 3,700 tonne scenarios. By extension, given the precautionary approach to human health, it is not plausible that animals would be significantly harmed in terms of inhalation, although the vapours would be discernible to many animals and may affect their behaviour. Workers involved in oil spill response are routinely equipped with gas monitoring devices and breathing protection should they be required to work inside those zones for long periods e.g. recovering oil.

12.2.6.4.1 Likelihood of occurrence

The likelihood of occurrence of 10 and 3,700 tonne MGO spills and a 1,526 tonne IFO spill are assessed in sections 12.2.6.1 to 12.2.6.3 respectively.

12.2.6.4.2 Overall significance of the risk

A summary of the risk assessment associated with a deterioration of regional air quality following a Sea Lion crude spill in Berkeley Sound is presented in Table 12.30. It is assessed that the impact on the Human Population (local residents and visitors) would be ‘**Low**’, while the impact on colonial seabirds is assessed as ‘**Moderate**’, following a 50,000 tonne spill. However, owing to the likelihood (‘**Very Unlikely**’) of such an event occurring, the **significance of the risk** posed to the Human Population and wildlife is ‘**Very Low**’.

The risks posed directly from the oil (see sections 12.2.6.1, 12.2.6.2 and 12.2.6.3) are more significant than the resulting risk due to deteriorating regional air quality.

Table 12.30: Summary of the assessment of the impact on the Human Population and wildlife of worst case 3,700 MGO fuel oil spill at the LTV Mooring location on regional air quality, with base case mitigation in place

Spill scenario	Sensitivity of Receptor and Severity of Effect (Impact)	Likelihood of occurrence	Overall risk significance
Fauna	Following a release of MGO fuel oil, a maximum of 1,117 tonnes of hydrocarbons is predicted to evaporate. The number of seabirds and marine mammals that could be exposed is negligible and therefore the **Sensitivity** of Receptor is '**Very Low**'. Any disturbance to the local fauna due to deterioration in regional air quality, would be very short-term and minor, therefore the **Severity of Effect** is considered to be '**Minor**'. Therefore, the significance of the impact is assessed as '**Very Low (2)**'.	Unlikely	Very Low (2)
Human Population	Following a release of MGO fuel oil, a maximum of 1,117 tonnes of hydrocarbons is predicted to evaporate. Under prevailing weather conditions, a human could remain within 240 m of the release for up to 8 hours before it would be considered unacceptable for routine work. The number of humans, other than those employed by Premier, or other receptors (seabirds and marine mammals) that could be exposed is negligible and therefore the **Sensitivity of Receptor** is '**Very Low**'. Following the *Braer* oil spill, public close downwind of the tanker complained of a strong smell of oil and irritation to eyes and nose. Monitoring following this event, concluded that no obvious ill health was recorded, beyond initial irritation, due to VOCs (i.ei.e. deterioration in regional air quality). Any disturbance to the local population dueand wildlife, due to deterioration in regional air quality, would be very short-term and minor, therefore the **Severity of Effect** is considered to be '**Minor**'. Therefore, the significance of the impact is assessed as '**Very Low (2)**'.	Unlikely	Very Low (2)

12.2.7 Project-specific mitigation measures

In addition to the industry-standard measures listed in section 12.2.5, a number of project-specific measures will be implemented to reduce the likelihood of accidental events occurring during inshore operations and to mitigate against any impacts should releases occur. To eliminate the risk of potential collisions due to human error or dynamic positioning control system faults (which could result in a powered collision), both the LTV and installation vessel will be at anchor prior to heavy lifts commencing. Further mitigations to be used include:

- Development of the Harbour Management Plan, with operational limits defined;
- Speed limitations to prevent inner hull penetration;
- Use of an exclusion zone around each LTV location;
- Watch keeping for errant vessels (in good weather) or radar monitoring (in bad visibility conditions);
- For every bunkering operation, there will be three differing containment systems to increase the likelihood of containing any accidental release of bunker fuel at source;
- Heavy Lift Vessel vetted for double skinned fuel tanks;
- Automatic tank level monitoring systems with alarms on receiving vessels;
- Auto pressure relief system on the manifold; and
- Enhanced crew bunkering competency.

The majority of the industry-standard (section 12.2.5) and project-specific (listed above) mitigation measures are aimed at the prevention (avoidance) of spills in line with the hierarchy of risk reduction. However, the initial impact assessment was used to inform the selection of the most appropriate OSR equipment, and how and where this should be applied to reduce the consequences of an inshore oil spill should it occur.

The following section provides details on the:

- Selection of OSR resources; and
- Comparative assessment of the selected OSR resources.

The Inshore Oil Spill Strategy (OSS) provides details and commitments for oil spill response capability which will be implemented within the framework an Oil Spill Contingency Plan (OSCP). The OSCP will be developed and submitted nearer to the time of execution, as described in section 12.1.1.1.3 of the offshore oil spill chapter. Additionally, details regarding wildlife response strategies and equipment can be found in the Inshore Oil Spill Strategy (OSS).

12.2.7.1 Selection of oil spill response resources

Based on the output of the OSCAR oil spill modelling and specialist input by oil spill response professionals, Premier has identified the OSR equipment that it will have available in the Falkland Islands. The OSR equipment will be sufficient to respond to Tier 1 and 2 inshore (and offshore) oil spill events and support a response until the arrival of Tier 3 response equipment, VOOs and a TOO.

Generic names for equipment are used herein as no equipment has been procured yet however, it is fully expected that Premier will consult with the supplier to ensure optimum operational potential of response equipment for responding to Sea Lion crude oil and operating in the Falkland Islands before purchase. A summary of the OSR resources that were selected for use in the event of an inshore oil spill is provided in Table 12.31.

Using this approach and taking into account the frequency of potential incidents, the adopted oil spill response strategy and resources are considered commensurate to the risk. Using worked examples for different Tiers of incident, the effectiveness of oil spill response has been presented and discussed in an Oil Spill On Paper exercise conducted in Stanley by Premier in 2017. Oil spill strategy and resources are described in more detail in the Inshore Oil Spill Strategy (Premier, 2016g)

Details describing how the OSR resources will be deployed can be found in Premier's Inshore Oil Spill Strategy Document (OSS; Premier, 2016g).

Table 12.31: OSR resources available in support of Inshore operations

Item	Description	Location
At Sea Containment and Recovery Equipment		
Oil recovery boom 	**300m (1,500 mm overall height) of heavy-duty oil containment boom:** constructed of robust material for example moulded rubber, neoprene or similar material, and formed of individual floatation chambers to provide additional resilience. The size of 1,500 mm was chosen due to the ease of handling using the guiding principles in the IMO, section IV, Combating Oil Spills 2nd edition, 2005. Can operate in conditions up to Beaufort scale force 4. The boom has a freeboard of 0.5m to contain the buoyant molasses which will be formed as a result of blowout scenario. The boom has an operational draft of 0.70m to prevent any recovered oil escaping under the boom.	Offshore Support Vessels (Excluding PSV)
Single Vessel System 	**1 single vessel recovery system bellowed with boom vane (1,500mm overall height).** constructed of robust material for example moulded rubber, neoprene or similar material. Can be deployed from one vessel utilising a boom vane. To enhance the recovery capability of the available 3 vessels and provide resilience and alternative response options based of the response priorities.	Offshore Support Vessels (Excluding PSV)

Item	Description	Location
Mechanical Skimming System 	**Large belt skimming system:** was selected due to the ability to recover the highly viscous crude oil. The belt will have two options being the spiked belt or oleophilic brush. Belt systems when operated correctly are proven to reduce water intake. The skimmer will have the ability provide steam and water injection to aid pumping. The skimming system will be accompanied with a heavy-duty multipurpose Archimedes screw pump with a minimum proven transfer rate of 30 m^3 per hour for highly viscous oils and with water injection to aid oil transfer. Both the skimmer and pump will be powered by a compatible, diesel driven, intrinsically safe, hydraulic power pack. Can operate in conditions up to Beaufort scale force 4.	Offshore Support Vessels (Excluding PSV)
Weir Skimming System 	**The large diameter free floating weir skimming** device has been chosen to respond to IFO and MGO spills within the sound. The weir skimming device is to be self-levelling with the ability to recover oil from the surface of the water. The pump attached to system will be an Archimedes screw pump with a minimum proven transfer rate of 30 m^3 per hour with water injection to aid pumping. This allows the pumps to be interchangeable between skimmers to increase the resilience of equipment during a response. Both the skimmer and pump will be powered by a compatible, diesel driven, intrinsically safe, hydraulic power pack which can also power mechanical belt skimmers. Can operate in conditions up to Beaufort scale force 4.	Support Vessels, (two on each vessel) Warehouse (10)
Fast Response Craft 	**Vessels fast response craft,** specification will depend on the vessel. to tow/work the boom.	Support Vessels, Heavy Lift Vessels
Waste Management		
100 Tonne Bladder 	**100-ton capacity free floating waste storage bladders:** The floating bladders are towable, and collapsible being stored in a small container on the deck of the vessel and when deployed can be towed at a maximum speed of 5 knots. The bladder is equipped with an integrated pump to assist in the transfer of recovered product. The bladders were elected as a method to contain recovered oil until the arrival of a conventional trade tanker. This method is in agreement with FIG.	Support Vessels, (two on each vessel) Warehouse (10 in warehouse)
200m^3 Heated Waste Storage	Heated waste storage on the vessel allows tanks allows the oil to remain in a liquid state once recovered. Thus, increasing the recovery capacity of the vessel and providing additional resilience throughout the response.	AHV

Item	Description	Location
Intermediate Bulk Containers (IBCs)	1m^3 portable storage containers which can be utilised for both liquid and solid waste storage. Can be utilised to store oil recovered at sea if temporary waste bladders are at full capacity.	20 located at the Warehouse
Flexible Intermediate Bulk Containers (IBCs)	1m^3 portable flexible storage bags which can be utilised for contaminated solid waste storage. Can be utilised in shoreline response for collecting contaminated detritus	
205 litre Drums	205 litre drums with clip top lids can be used for both solid and oily liquid wastes during a shoreline response.	
Fast Deployment Waste Storage Tanks 	Fast deployment waste tanks will be utilised as the storage for recovered liquids, or contaminated solid materials such as absorbents. If necessary one can be utilised for liquid wastes and the other for solid oil contaminated wastes.	2 Located at the Warehouse
Mixed ancillaries 	Oil sorbent boom, Oil sorbent pads, waste bags, cable ties, marker pens, labels, impermeable ground sheet, quick erect bunding. To be supplied to vessels for the decontamination of personnel and equipment at sea.	Warehouse
Surveillance		
Long Wave Infrared Surveillance equipment	An important step in oil spill response is being able to assess and detect oil on the water surface. Test results from CEDRE experiments suggest that infrared remote sensing tools will enhance the capability of Premier Falkland Islands resources to detect the location and movement of Sea Lion Crude Oil on the water's surface.	Vessels, Helicopters. Support vessels
Trained Observers	An important step in oil spill response is being able to assess the appearance and distribution of the oil. The information allows IMTs to prioritise response efforts. Specific personnel will be trained in aerial surveillance and how to utilise spill monitoring equipment such as infrared.	Crew Change Pilots, Vessel Crew, MODU Offshore Installation Manager.
Modelling Capability	The ability to model the fate and effects of a spill event is incremental to prioritising response efforts and predicting the potential impact of the incident. The Premier teams located in will have 24-hour access to modelling capability through OSRL.	Remote

Item	Description	Location
Tracking Buoy 	A tracking buoy will be stored on a vessel in the field and will be deployed on the leading edge of an oil slick to track the slicks movements. Assisting in the verification of deterministic modelling outputs and guiding response vessels to undertake containment and recovery operations.	Vessel in Field
Satellite 	Satellite imagery has the ability to support the response process from providing the initial detection and assessment throughout the response. It provides a wide coverage that can complement alternative surveillance methods. Premier have access to satellite surveillance through membership with OSRL who have a contract in with MacDonald, Dettwiler and Associates Ltd. This contract provides access to many of the world's highest resolution Synthetic Aperture Radar (SAR) and optical satellites.	Remote
Inshore/shoreline Response Equipment		
Inshore Fence Boom with ancillaries 	Inshore fence boom located at the TDF for rapid deployment around source of pollutant to contain spill, or corral oil to a localised area to recover oil with either absorbents or oil recovery device. Can be deployed around recovery bladders as provisional containment, or around vessels during any decontamination operations; However, it is envisaged there will be minor contamination to hulls of recovery vessels.	200m located at the TDF 750m located on HLV
Shore Sealing Boom 	Specialist oil containment booms where the skirts of the boom are replacing with water-filled chambers allowing the boom to settle on an exposed shoreline at low tide and therefore containing the movement of oil on shoreline environments. Can be used by Premier response teams in the unlikely event that oil impacts the shoreline environment.	100m located a Warehouse
Sea Sentinel Boom (Air Inflation) 	Oil containment booms with air filled chambers smaller in size than the offshore 20 boom constructed of less durable material. Can be utilised concurrently with shore sealing boom, or it can be deployed around recovery bladders as provisional containment, or around vessels during any decontamination operations; However, it is envisaged there will be minor contamination to hulls of recovery vessels.	200m Located at the warehouse
Steam Generator	High pressure, high temperature, steam cleaner available to clean oil contaminated surfaces on the decks of vessels, or equipment following deployment.	1 located at the warehouse

Item	Description	Location
	Ship to Ship self-regulating air inflated containment H boom system for deployment in-between fender 2 and 3. Constructed of double-faced neoprene or similar abrasion resistant material with a freeboard of 715mm and a draft of 90mm.	Located on HLV
	Oleophilic skimming system to recovery light oils corralled in boom at the TDF or within the bunkering containment systems. Oleophilic properties reduces the recovery of water and suitable in sheltered and coastal waters. Can recover up to 30m^3 per hour.	Located at the TDF

12.2.7.1.1 Limitations of the OSR resources not reflected in the model

Modelling was used to identify the most effective combination of OSR resources, and it is recognised that there are some practical limitations to these resources that cannot be accommodated in the model.

There is also an inherent uncertainty in the wave height limitation approach. The OSCAR model generates wave heights internally based on wind speed and fetch calculations. It does not include swell heights which can, at times, be a significant component of waves in Berkeley Sound, particularly when wind is from the east. The way this has been accommodated in this analysis is by limiting the model wave limit to one metre wind-driven waves, allowing a notional one metre for swell. In practice, the picture is more complex as swell waves are generally of a longer period than local wind-driven waves and may not have the same effect on containment and recovery performance. And when there is no significant swell (i.e. much of the time), this approach may underestimate the recovery performance. This is, however, the best approximation available at the moment. Looking ahead, it is expected that the OSCAR model will be enhanced to allow the incorporation of more sophisticated wave forecasts such as those already prepared by Premier for Berkeley Sound.

12.2.7.2 Comparative assessment of selected OSR resources

The OSCAR model has been used to predict the effectiveness of the response measures discussed throughout this document. Pessimistic assumptions have been used in all scenarios as in reality more resources may be made available by utilising national vessels of opportunity or sourcing additional vessels of opportunity.

For all scenarios, containment and recovery is the principal response strategy deployed concurrently with monitoring and evaluating measures (spill trajectory modelling and aerial surveillance). Dispersant application would most likely not be approved due to the sensitivities within Berkeley Sound, proximity to the shoreline and water depths within the Sound. The effectiveness of containment and recovery operation is limited by wave heights in excess of 2 m, although wave height monitoring has confirmed that waves are typically around 0.5 m in height and rarely exceed 1.5 m.

The following sections describe the OSR equipment and strategy proposed for each scenario. It also contains stochastic and deterministic modelling to demonstrate the effectiveness of the inshore OSR response measures for each scenario.

12.2.7.2.1 Scenario 1: 10 tonne MGO Bunkering Incident Marine Gas Oil (Fuel Oil) Spill

The response measures for this scenario would include the deployment of fast deployment boom around the vessels creating a tertiary containment area (H-boom primary, Yokohama Fenders secondary).

The effectiveness of response to a 10 tonne MGO release is based on experience. It is calculated that the three levels of containment readily available at the bunkering location would be enough to contain all the released oil. Containing the oil will enable sufficient concentrations of MGO to be recovered by skimming or by the use of absorbent materials.

If a small concentration of MGO is not contained it will disperse, and in doing so it rapidly spreads to a very thin layer and begins to mix and dissolve into the water column (particularly when waves are present, which is the majority of the time) and will evaporate. The use of prop wash from vessels is an established technique to reduce sheen density and thereby reduce risks to seabirds and to coastlines, although it increases concentrations in the water column.

Modelling of the larger MGO release (Scenario 2, see section 12.2.7.2.2) shows that response once in the wider environment is unlikely to offer significant benefit. The positioning of local booming does present the opportunity to protect vulnerable areas of coastline and would be beneficial, but it is unlikely to affect the length of shoreline affected or add measurably to MGO recovery.

Figure 12.61 shows the cumulative swept path of the release for the case of maximum oil on shore (Scenario 2, see section 12.2.7.2.2) assuming no response, it is anticipated that aided dispersion from prop wash will reduce the affected areas.

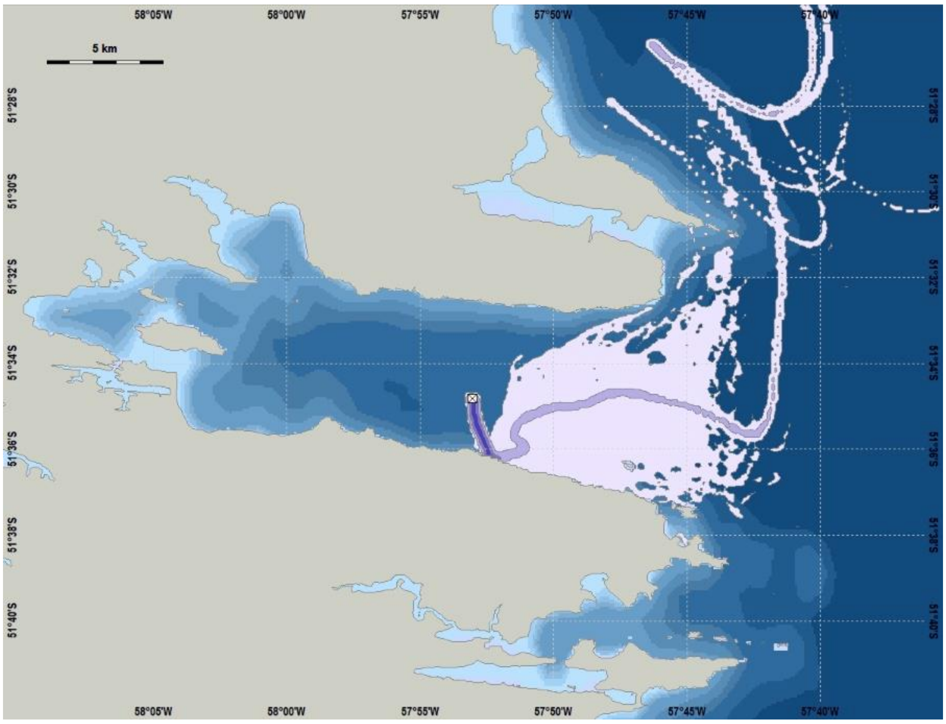


Figure 12.57 Scenario 2 Deterministic: Cumulative Swept Area of Oil on Surface no Response

12.2.7.2.2 Scenario 2: 3,700 Tonnes of MGO Due to Installation Vessel Collision with Jigger and/or Reefer

The response measures itemised below were used to assess the effectiveness of Premier's response to Scenario 2 (installation vessel collision):

- AHV and PSV deploy J configuration boom after 12 hours;
- AHV deploys single sweep system and mechanical belt skimmer after 12 hours;
- Each recovery unit is able to store 200m^3 of liquid waste storage. Once maximum capacity is reached, the vessels return to Stanley for offload then return to the field;

- Due to the weathering characteristics of MGO and the trajectory of the oil there is no requirement for Tier 3 at sea containment and recovery resources.

In reality efforts would be made to deploy containment boom at source to restrict the spread of oil into the wider areas of the Berkeley Sound and commensurate the risk to vulnerable receptors. To assess the outer envelope this has not been considered in the modelling the process.

Response teams in the Falkland Islands would be mobilised to complete SCAT surveys and determine the most appropriate method of shoreline clean-up. Concurrent oiled wildlife response measures such as surveys (at sea and shoreline), and hazing will be undertaken. Tier 3 resources would be mobilised to undertake oiled wildlife response and support any shoreline response options

12.2.7.2.2.1 Stochastic Model Results

Key comparisons for the assumed response and no response are shown in Table 12.32 with a geographical representation shown in Figure 12.62, Figure 12.59, Figure 12.60.

As can be seen, the response is modestly effective in terms of reducing the overall consequence of the incident with a recovery rate of 0.4%. This is due to the weathering characteristics of MGO in terms of spreading, evaporating and dispersing into the water column making corralling the oil into boom configurations problematic. In this situation enhanced natural weathering through prop washing, or aggravation through high pressure water application, may prove a more advantageous response technique. Figure 12.60 shows the localised effectiveness of the notional shoreline booms in mitigating in the impacts of the released oil. It is envisaged that the MGO that impacts the shoreline would leave a greasy film on the substrates which would most likely be left to natural weathering process such as abrasion, biodegradation, and oil mineral aggregation.

Statistically, the response measures of skimming using two vessels and in using a shoreline boom result in <1% reduction in coastline at >50 % risk of oiling; and <1 % reduction in coastline at >90 % risk of oiling. Overall, indiscriminate shoreline booming (as included in the response model) is not effective in mitigating the area downstream of the boom. However, when looking at individual model scenarios, the shoreline boom does significantly alter the path of the slick and could reduce the exposure of sensitive areas.

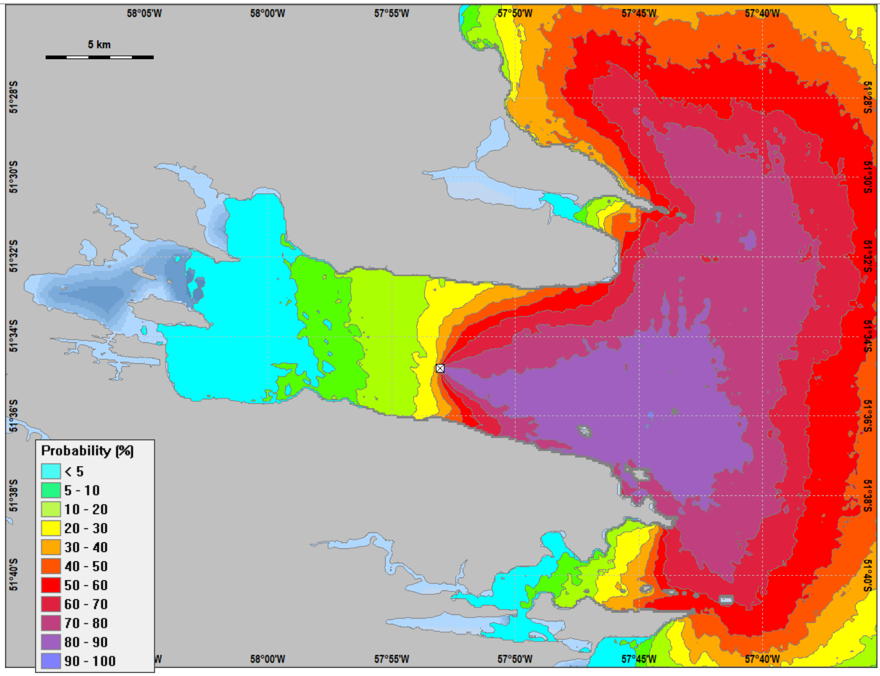
Table 12.32 Response Effectiveness - Stochastic model outputs summary

Scenario 1 Response Effectiveness - Stochastic Summary		
Parameters	No Response	With Response
Maximum mass of oil on shore	1,167	1,169 [a]
Average mass of oil on shore	9.1%	9.1%
Average proportion of oil recovered	0%	0.4%

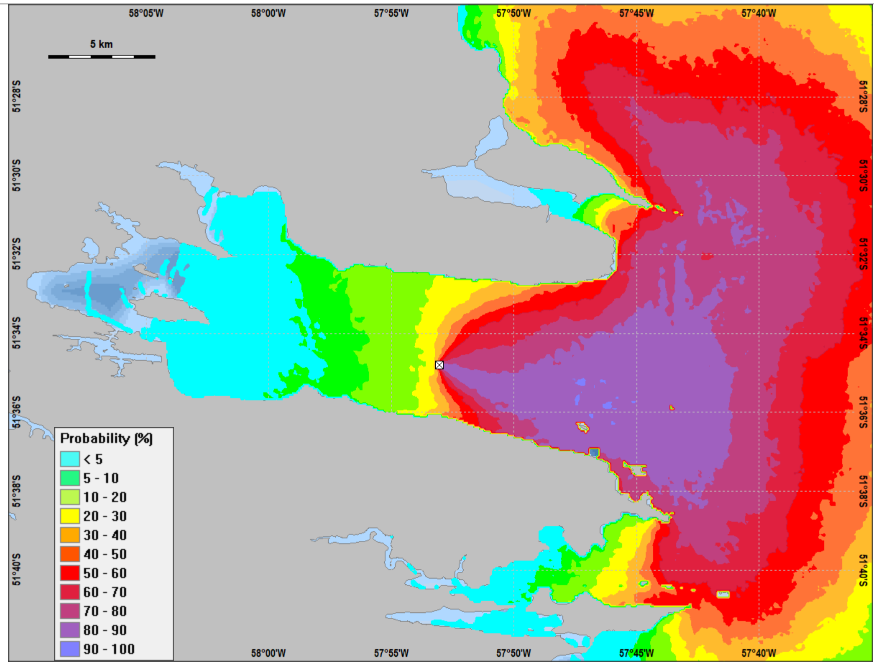
a This figure is effectively the same as the ‘no response’ figure - due to the random walk nature of the model there will be small changes in outputs with every run, and this result simply shows that response has had no discernible effect.

12.2.7.2.2.2 Deterministic Modelling Results

A deterministic simulation with the worst probability of shoreline oiling was used to assess the response measures. The results showed a modest improvement mostly in the reduced surface oiling at the mouth of the Sound by containing the trajectory of the release. Figure 12.61 shows the geographic representation of the decreased surface volumes due to response measures.

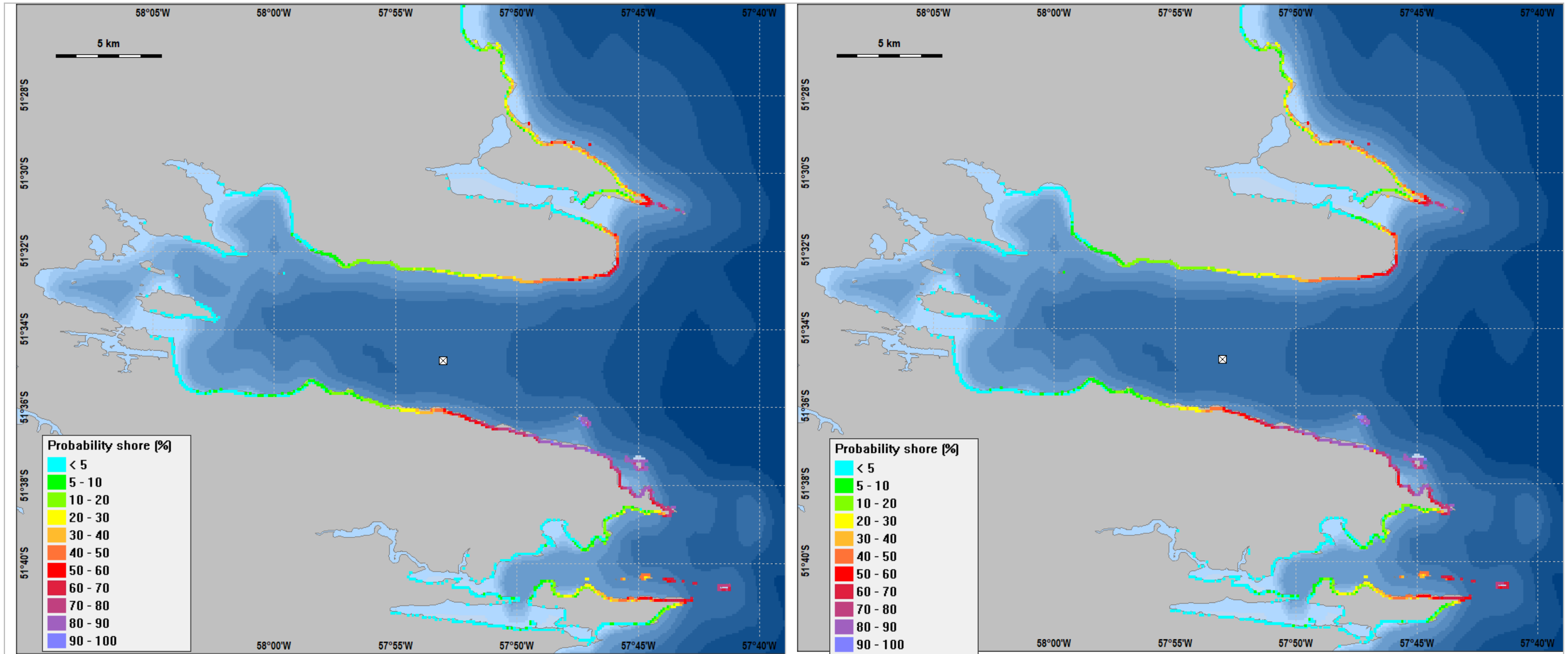


No Response - Probability of Surface Contamination Above Threshold of 0.3µm



Response - Probability of Surface Contamination Above Threshold of 0.3µm

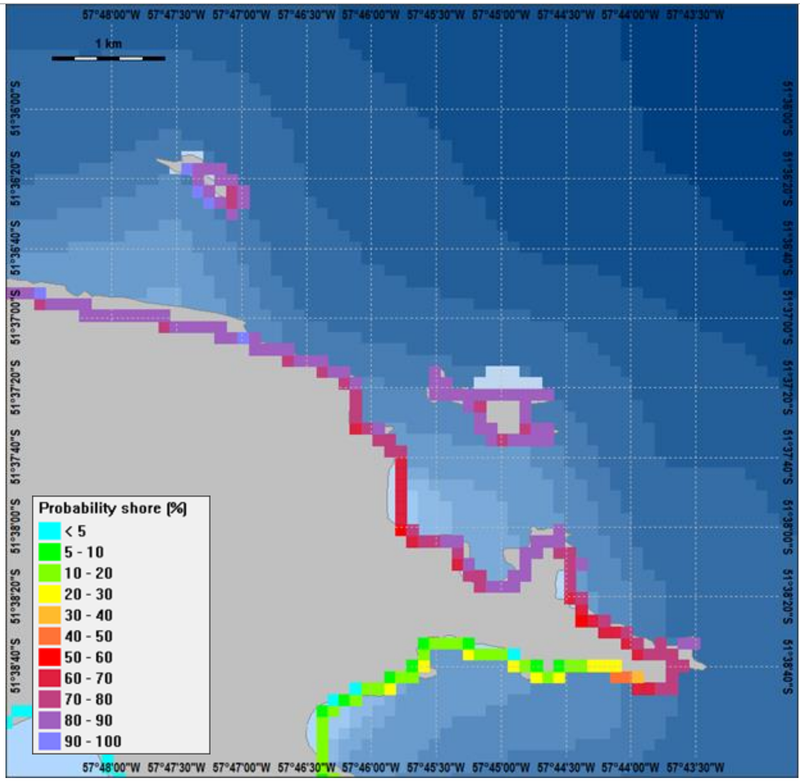
Figure 12.58 Scenario 2 Effectiveness of Response – Comparison of Surface Probability



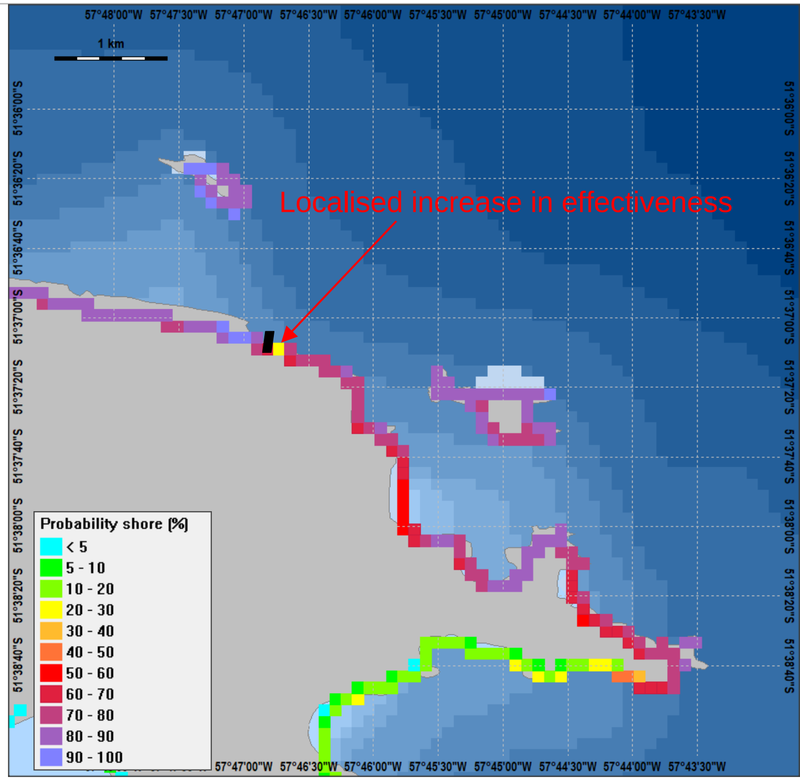
No Response Probability of Shoreline Oiling

Response - Probability of Shoreline Oiling

Figure 12.59 Scenario 2 Effectiveness of Response – Comparison of Shoreline Oiling Probability

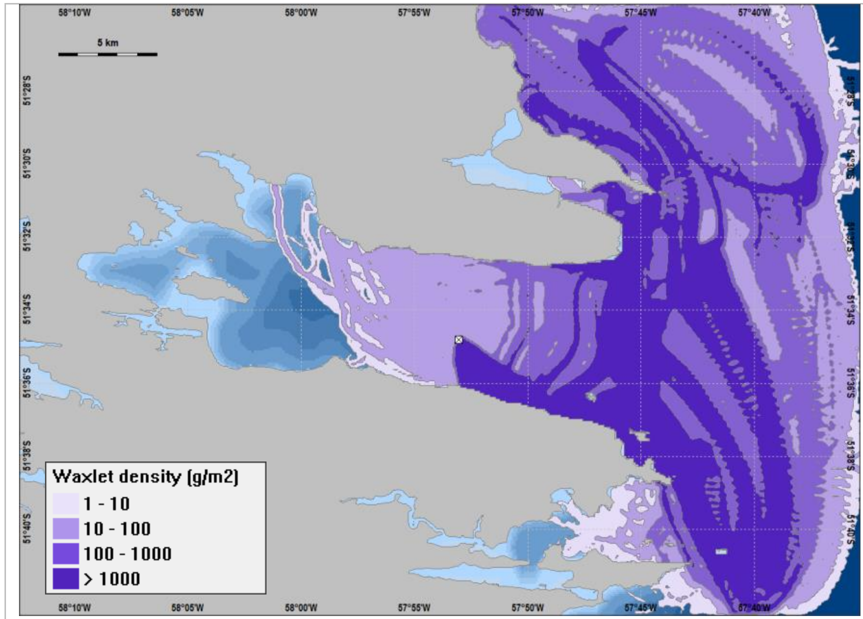


No Response - Probability of Shoreline Oiling

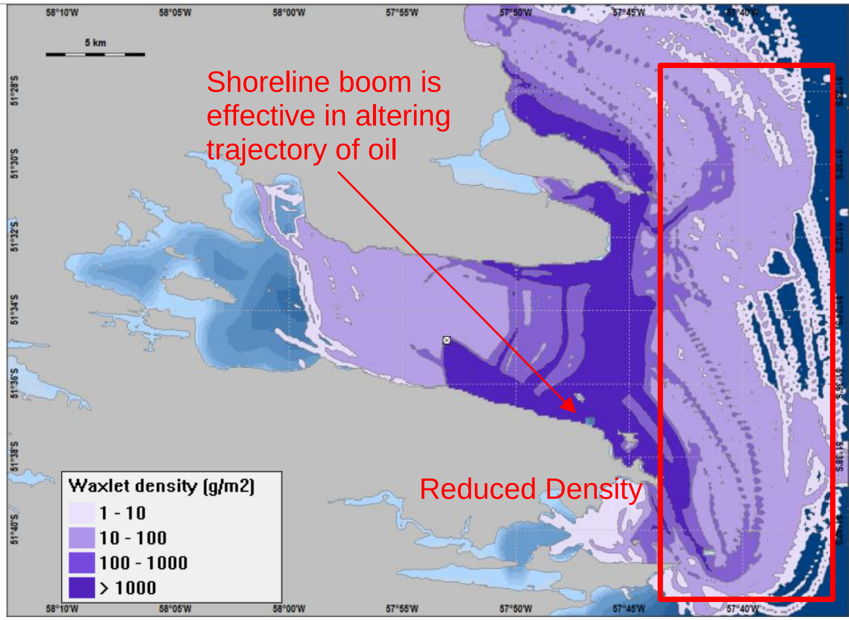


Response - Probability of Shoreline Oiling

Figure 12.60 Scenario 2 Effectiveness of Response – Close up Comparison of Shoreline Oiling Probability



No Response Deterministic ‘swept path’ plot for worst case oil on shore



Response - Deterministic ‘swept path’ plot for worst case oil on shore

Figure 12.61 Scenario 2 Deterministic: Cumulative Swept Area of Oil on Surface no Response and Response

12.2.7.2.3 Scenario 3: 1,500 Tonnes IFO 380 Oil Spill Due to Drift Grounding

The response measures itemised below were used to assess the effectiveness of Premier's response to Scenario 2 (drift grounding of HLV).

- AHV and PSV deploy J configuration boom after 12 hours;
- AHV deploys single sweep system and mechanical belt skimmer after 12 hours;
- Each recovery unit can store 200 m^3 of liquid waste storage. Once maximum capacity is reached, the vessels return to Stanley for offload then return to the field;
- Due to the weathering characteristics of IFO and the trajectory of the oil there is no requirement for Tier 3 at sea containment and recovery resources.

In reality efforts would be made to deploy containment boom at source to restrict the spread of oil into the wider areas of the Berkeley Sound and mitigate the risk to vulnerable receptors. To assess the outer envelope this has not been considered in the modelling the process.

Response teams in the Falkland Islands would be mobilised to complete SCAT surveys and determine the most appropriate method of shoreline clean-up. Concurrent oiled wildlife response measures such as surveys (at sea and shoreline), and hazing will be undertaken. Tier 3 resources would be mobilised to undertake oiled wildlife response and support shoreline response options, and waste management.

12.2.7.2.3.1 Stochastic Modelling

Key comparisons for the assumed response and no response are shown in Table 12.33 with a geographical representation shown in Figure 12.62, Figure 12.63 and Figure 12.64 . As can be seen, response efforts are successful in reducing the risk to vulnerable receptors with a reduction in the average mass of oil on shore. The model also predicts an oil recovery rate of 14.4 % which is above the industry standards of effectiveness for containment and recovery offshore of 12 %.

Figure 12.65 shows the localised effectiveness of the notional shoreline booms in mitigating in the impacts of the released oil. It is envisaged that the IFO that impacts the shoreline would leave gross contamination on shoreline substrates which would require the deployment of shoreline clean-up strategies to remove and recover the oil. This will be undertaken by Tier 3 response organisations and local workforce where possible. Any residual oil remaining on rocky outcrops would most like be left to natural weathering which will degrade over time to a stain. IPIECA guidance (IPIECA, 2011) suggests that over two to three seasonal cycles the oil will become less visible.

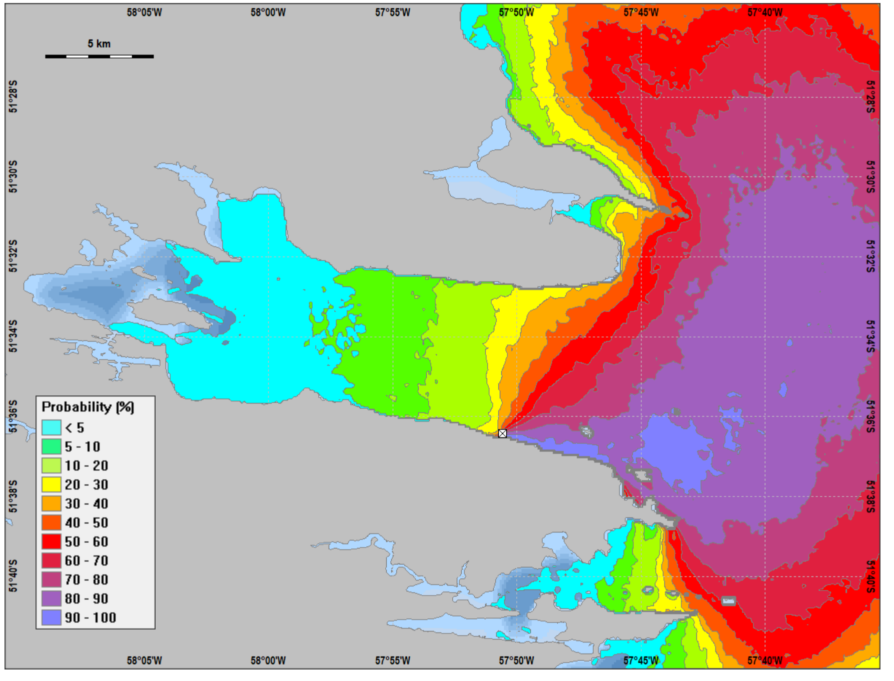
Statistically, the response measures of skimming using two vessels and in using a shoreline boom result in a 29 % reduction in coastline at >50 % risk of oiling; and a 29 % reduction in coastline at >90 % risk of oiling. Overall, indiscriminate shoreline booming (as included in the response model) does noticeably mitigate the area downstream of the boom. This is reinforced, when looking at individual model scenarios, the shoreline boom does significantly alter the path of the slick and could reduce the exposure of sensitive areas.

Table 12.33 Response Effectiveness - Stochastic model outputs summary

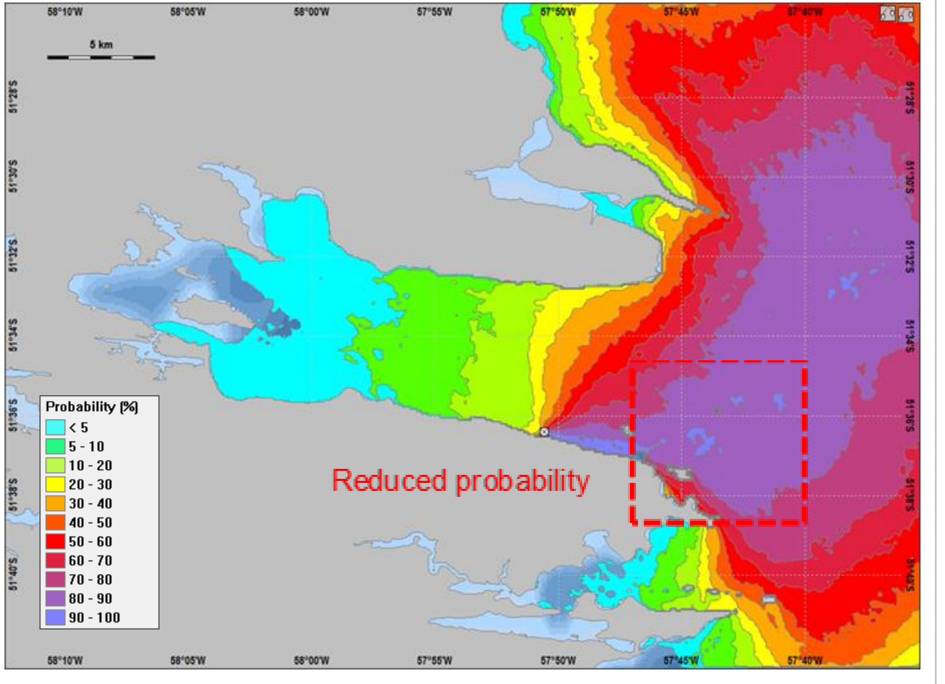
Scenario 1 Response Effectiveness - Stochastic Summary		
Parameters	No Response	With Response
Maximum mass of oil on shore	1,312	916
Average mass of oil on shore	34.8%	26.6 %
Average proportion of oil recovered	0%	19.0%

12.2.7.2.3.2 Deterministic Modelling Results

A deterministic simulation with the worst probability of shoreline oiling was used to assess the response measures. The results showed a modest improvement mostly in the reduced surface oiling at the mouth of the Sound by containing the trajectory of the release. Figure 12.65 shows the geographic representation of the decreased surface volumes due to response measures.

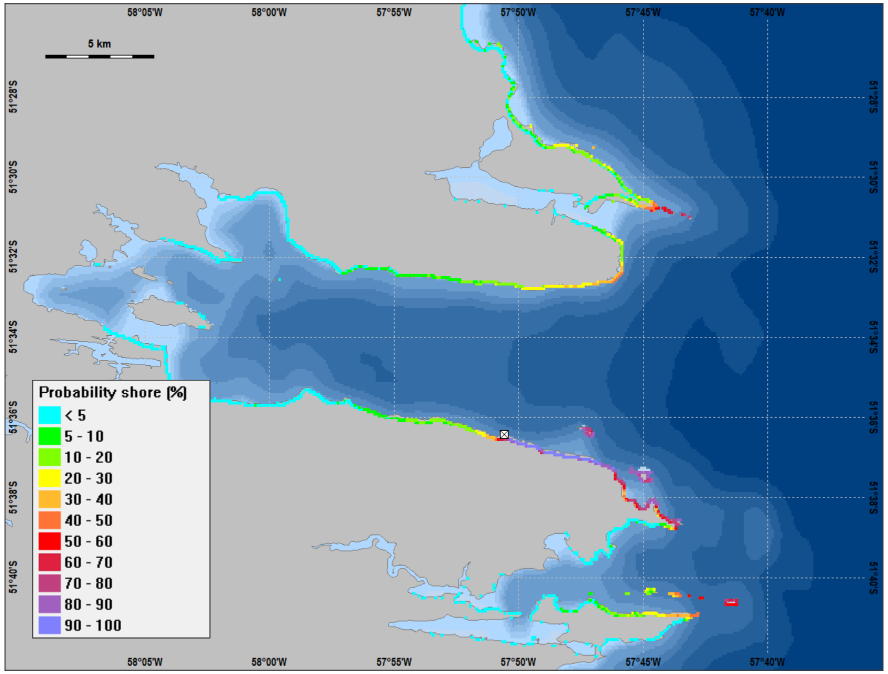


No Response - Probability of Surface Contamination Above Threshold of 0.3µm

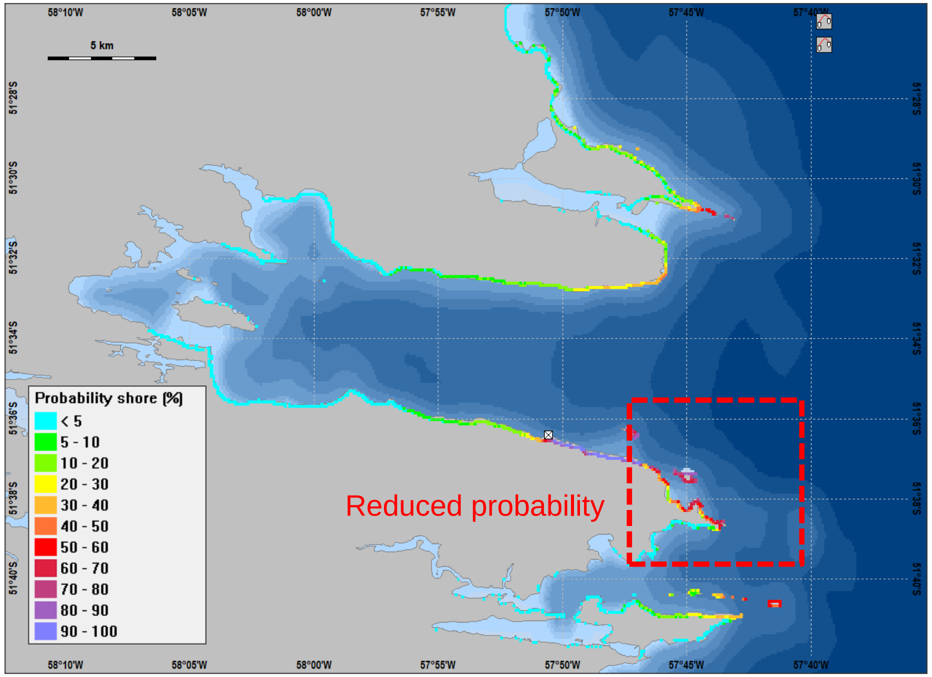


Response - Probability of Surface Contamination Above Threshold of 0.3µm

Figure 12.62 Scenario 3 Effectiveness of Response – Comparison of Surface Probability

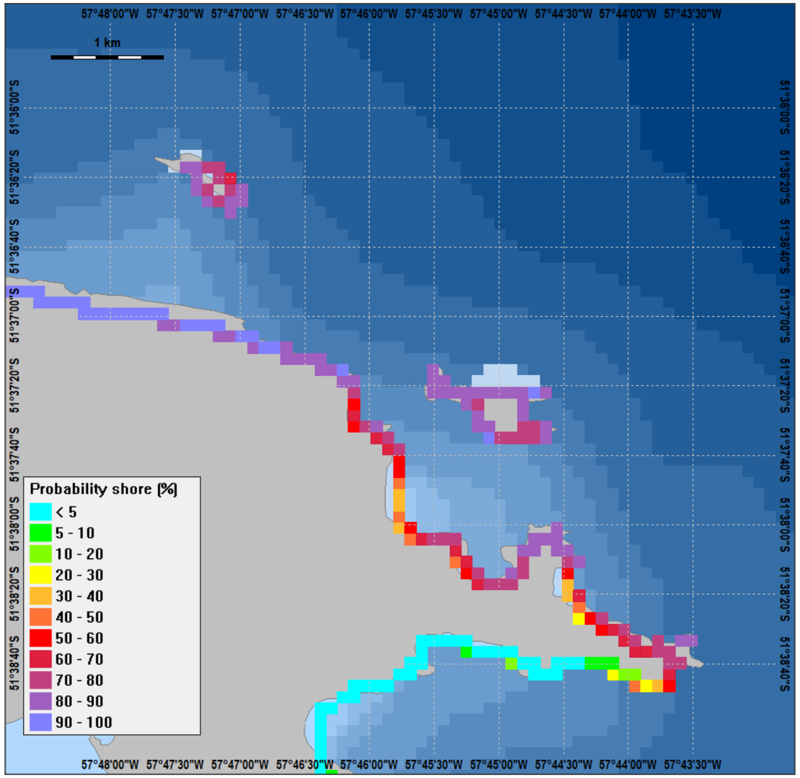


No Response Probability of Shoreline Oiling

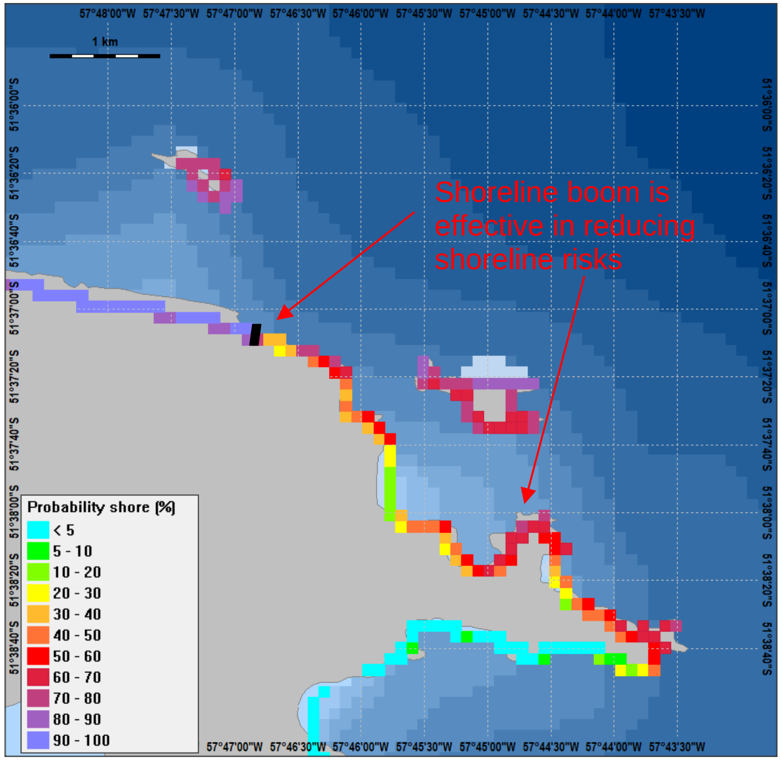


Response - Probability of Shoreline Oiling

Figure 12.63: Scenario 3 Effectiveness of Response – Comparison of Shoreline Oiling Probability

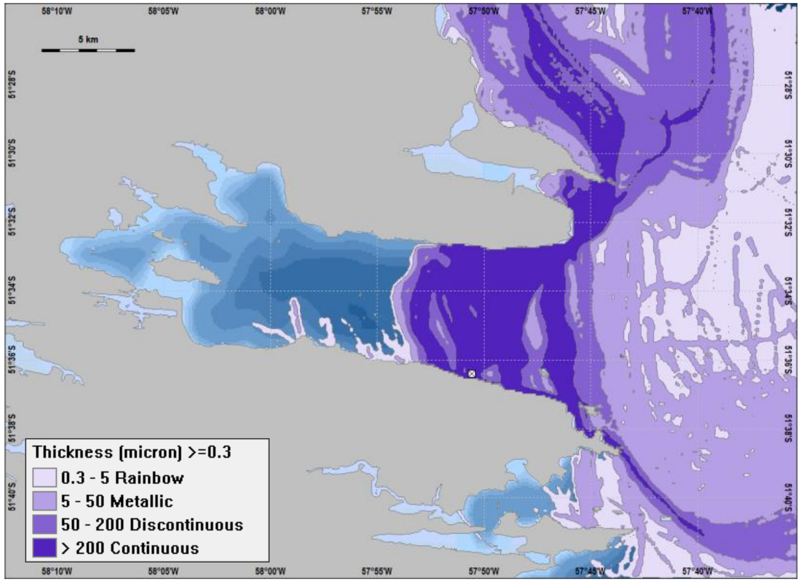


No Response - Probability of Shoreline Oiling

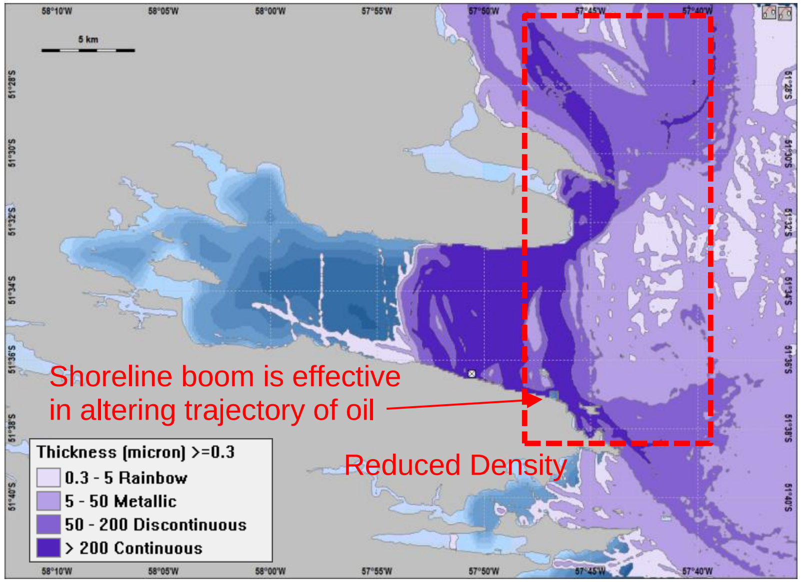


Response - Probability of Shoreline Oiling

Figure 12.64: Scenario 3 Effectiveness of Response – Close up Comparison of Shoreline Oiling Probability



No Response Deterministic ‘swept path’ plot for worst case oil on shore



Response - Deterministic ‘swept path’ plot for worst case oil on shore

Figure 12.65: Scenario 3 Deterministic: Cumulative Swept Area of Oil on Surface no Response and Response

12.2.8 Residual impacts and risks

While the initial risk assessment for the different oil spill scenarios indicates that the risks to many of the receptors are '**Low**' or '**Very Low**' (section 12.2.6), this was primarily because the likelihood of the incidents occurring in the first place is very low. It is acknowledged in the initial risk assessment sections above however that the *impacts* of the spill, should they actually occur, ranged from '**Moderate**' to '**High**'. The modelling carried out to inform the selection of the OSR equipment and resources indicate that the oil spill response and clean up interventions have the potential to reduce the 'Severity of Effect' of oil spills by reducing the number of receptors that are exposed, the concentration of oil that they are exposed to and the duration of that exposure.

Therefore, regardless of whether the initial risk assessment indicated that a risk was low, or less severe, the following section assesses the residual risks of all oil spill types against all receptors to accommodate the changes to the 'Severity of Effect' scores that result from deploying oil spill clean-up and response interventions.

12.2.8.1 Scenario 1: 10 tonne MGO Bunkering Incident Marine Gas Oil (Fuel Oil)

Project-specific OSR equipment and techniques (i.e. enhanced natural dispersion via prop wash) will be modestly effective in reducing sheen density and thereby reduce the risks to seabirds and to coastlines, although it increases water column concentrations.

12.2.8.1.1 Likelihood

The likelihood of occurrence of an oil spill is not affected by the project-specific response measures and remains unchanged from the initial assessment.

12.2.8.1.2 Residual risk significance

Given that the OSR measures are unlikely to make any substantial change to the behaviour of the MGO, and due to the difficulty of recovering MGO, the severity of the impact remains unchanged, therefore the residual impacts, and the overall risks remain the same as in the initial assessment.

Enhanced natural dispersion will serve to reduce the severity of effect to many of the receptors, thus reducing the overall *impact*. However, as is shown in Table 12.34, while the *impact* often decreases, this does not necessarily push the overall *risk* rating down and the **significance of the risk** posed by a 10 tonne MGO spill in Berkeley Sound remains '**Low' to 'Moderate'** for all receptors.

Table 12.34: Summary of the impact assessment for a 10 tonne Marine Gas Oil (MGO) spill at the LTV Mooring location, with project-specific mitigation

Receptor	Sensitivity of Receptor and Severity of Effect (Impact)	Likelihood of occurrence	Overall risk significance
Plankton	The residual **sensitivity of plankton** remains the same and is considered to be '**Moderate**'. The residual **severity of the effect** remains the same and is considered to be '**Moderate**' Therefore the residual **significance of the impact** on plankton is assessed as '**Moderate (9)**'.	**Unlikely**	**'Low (6)'**
Marine flora	The residual **sensitivity of kelp** remains the same and is considered to be '**Moderate**'. The residual **severity of the effect** remains the same and is considered to be '**Minor**' Therefore the residual **significance of the impact** on marine flora is assessed as '**Moderate (6)**'.	**Unlikely**	**'Low (6)'**
Benthic communities	The residual **sensitivity of the benthic community** remains the same and is considered to be '**Moderate**'. The residual **severity of the effect** remains the same and is considered to be '**Moderate**' Therefore the residual **significance of the impact** on benthic communities is assessed as '**Moderate (9)**'.	**Unlikely**	**'Low (6)'**
Fish and squid	The residual **sensitivity of fish and squid** remains the same and is considered to be '**High**'. The residual **severity of the effect** remains the same and is considered to be '**Moderate**' Therefore the residual **significance of the impact** on fish and squid is assessed as '**Upper Moderate (12)**'.	**Unlikely**	**'Moderate (8)'**
Human population (fisheries)	The residual **sensitivity of the human population** remains the same and is considered to be '**High**'. The residual **severity of the effect** remains the same and is considered to be '**Moderate**' Therefore the residual **significance of the impact** on the human population via fisheries is assessed as '**Upper Moderate (12)**'.	**Unlikely**	**'Moderate (8)'**
Seabirds	The residual **sensitivity of seabirds** remains the same and is considered to be '**High**'. The residual **severity of the effect** remains the same and is considered to be '**Serious**' Therefore the residual **significance of the impact** on seabirds is assessed as '**'High (16)**'.	**Unlikely**	**'Moderate (10)'**
Marine mammals	The residual **sensitivity of marine mammals** remains the same and is considered to be '**High**'. The residual **severity of the effect** remains the same and is considered to be '**Serious**' Therefore the residual **significance of the impact** on marine mammals is assessed as '**'High (16)**'.	**Unlikely**	**'Moderate (10)'**
Coastal habitats (terrestrial)	The residual **sensitivity of coastal habitats** remains the same and is considered to be '**High**'. The residual **severity of the effect** remains the same and is considered to be '**Minor**.' Therefore the residual **significance of the impact** on coastal habitats is assessed as '**'Moderate (8)**'.	**Unlikely**	**'Low (6)'**
Human Population (tourism)	The residual **sensitivity of the human population (tourism)** remains the same and is considered to be '**Moderate**'. The residual **severity of the effect** remains the same and is considered to be '**Minor**.' Therefore the residual **significance of the impact** on tourism is assessed as '**'Moderate (6)**'.	**Unlikely**	**'Low (6)'**

12.2.8.2 Scenario 2: 3,700 tonnes MGO spill following vessel collision or grounding

A spill of this size may initially overwhelm OSR equipment; however, the deployment of shore booms will help to contain oil and increase the rate of oil recovery. This means that the size of the area impacted will be reduced but the impact in areas that are oiled may be more acute. With OSR, it is predicted that on average 0.4 % (15 tonnes) of the oil will be recovered, over 95 % (3,515 tonnes) will be lost to sea and 9.1 % (337 tonnes) will strand on the shoreline (Table 12.32).

12.2.8.2.1 Likelihood

The likelihood of occurrence of an oil spill is not affected by the project-specific OSR and remains unchanged from the initial assessment.

12.2.8.2.2 Residual risk significance

While the OSR resources do reduce the severity of effect to many of the receptors, thus reducing the *impact*, the difference does not push the overall *risk* into a different category. As shown in Table 12.39, the highest **significance of the risk** posed by a 3,700 tonne MGO spill is to the following receptors: fish and squid; human population (fisheries); seabirds, marine mammals and coastal ecology, all of which remain '**Low' to 'Moderate'.**

Table 12.35: Summary of the impact assessment for a 3,700 tonnes MGO spill following vessel collision or grounding, with project-specific mitigation

Receptor	Sensitivity of Receptor and Severity of Effect (Impact)	Likelihood of occurrence	Overall risk significance
Plankton	The residual **sensitivity of plankton** remains the same and is considered to be '**Moderate**'. The residual **severity of the effect** remains the same and is considered to be '**Moderate**' Therefore the residual **significance of the impact** on plankton is assessed as '**Moderate (9)**'.	**Unlikely**	**'Low (6)'**
Marine flora	The residual **sensitivity of kelp** remains the same and is considered to be '**Moderate**'. The residual **severity of the effect** remains the same and is considered to be '**Minor**' Therefore the residual **significance of the impact** on marine flora is assessed as '**Moderate (6)**'.	**Unlikely**	**'Low (6)'**
Benthic communities	The residual **sensitivity of the benthic community** remains the same and is considered to be '**Moderate**'. The residual **severity of the effect** remains the same and is considered to be '**Moderate**' Therefore the residual **significance of the impact** on benthic communities is assessed as '**Moderate (9)**'.	**Unlikely**	**'Low (6)'**
Fish and squid	The residual **sensitivity of fish and squid** remains the same and is considered to be '**High**'. The residual **severity of the effect** remains the same and is considered to be '**Moderate**' Therefore the residual **significance of the impact** on fish and squid is assessed as '**Upper Moderate (12)**'.	**Unlikely**	**'Moderate (8)'**
Human population (fisheries)	The residual **sensitivity of the human population** remains the same and is considered to be '**High**'. The residual **severity of the effect** remains the same and is considered to be '**Moderate**' Therefore the residual **significance of the impact** on the human population via fisheries is assessed as '**Upper Moderate (12)**'.	**Unlikely**	**'Moderate (8)'**
Seabirds	The residual **sensitivity of seabirds** remains the same and is considered to be '**High**'. The residual **severity of the effect** remains the same and is considered to be '**Serious**' Therefore the residual **significance of the impact** on seabirds is assessed as '**'High (16)**'.	**Unlikely**	**'Moderate (10)'**
Marine mammals	The residual **sensitivity of marine mammals** remains the same and is considered to be '**High**'. The residual **severity of the effect** remains the same and is considered to be '**Serious**' Therefore the residual **significance of the impact** on marine mammals is assessed as '**'High (16)**'.	**Unlikely**	**'Moderate (10)'**
Coastal habitats (terrestrial)	The residual **sensitivity of coastal habitats** remains the same and is considered to be '**High**'. The residual **severity of the effect** remains the same and is considered to be '**Minor**.' Therefore the residual **significance of the impact** on coastal habitats is assessed as '**'Moderate (8)**'.	**Unlikely**	**'Low (6)'**
Human Population (tourism)	The residual **sensitivity of the human population (tourism)** remains the same and is considered to be '**Moderate**'. The residual **severity of the effect** remains the same and is considered to be '**Minor**.' Therefore the residual **significance of the impact** on tourism is assessed as '**'Moderate (6)**'.	**Unlikely**	**'Low (6)'**

12.2.8.3 Scenario 3: 1,526 tonne IFO spill at LTV location

Given the properties of IFO, containment and recovery would be possible with the equipment proposed, including by using weir skimmers instead of belt skimmers (section 12.2.7.1). The rapid response built into the strategy will allow oil to be recovered early on in the process. A rapid response will also mean that emulsions will have little chance to form, which otherwise could increase the volume of IFO through water entrainment from wave action and the inherent emulsion-forming properties of intrinsic asphaltenes.

The sheen-forming behaviour and propensity of IFO to adhere to feathers, fur and the shoreline means that overall the impacts of IFO are considered to be more severe than those associated with MGO spills of the same or larger size.

Shoreline clean-up operations therefore become more important because the oil remains fluid and adhesive (and hence causes impacts to coastal flora and fauna) for a considerable time. As indicated in Table 12.26, dispersants may work in moving oil off the surface into fine suspension in the water column and sediments although this course of action would require a Net Environmental Benefit Analysis as it would increase water column and sediment contamination and prevent ongoing evaporation. Any dispersant use would need to comply with the National Oil Spill Contingency Plan, and would require prior discussion with FIG and application via the PON8 (section 12.1.1.1).

12.2.8.3.1 Likelihood

The likelihood of occurrence of an oil spill is not affected by the project-specific OSR measures and remains unchanged from the initial assessment.

12.2.8.3.2 Residual significance of the risk

Although OSR will reduce the severity of effect on some receptors, the properties of IFO are such that the reduction is rarely sufficient to move the scoring down into a lower category (Table 12.36). For most receptors, the severity of effect, and therefore residual impact and risk, remains the same.

Therefore, the residual **significance of the risk** posed by a 1,526 tonne IFO spill with the project-specific measures in place is **Moderate** for fish and squid, human population (fisheries), seabirds, marine mammals and coastal habitats.

Table 12.36: Summary of the residual risk assessment for a 1,526 tonne IFO spill, with project-specific mitigation

Receptor	Sensitivity of Receptor and Severity of Effect (Impact)	Likelihood of occurrence	Residual risk significance
Plankton	The residual **sensitivity of plankton** remains the same and is considered to be '**Moderate**'. The residual **severity of the effect** remains the same and is considered to be '**Moderate**'. Therefore the residual **significance of the impact** on plankton remains the same and is assessed as '**Moderate (9)'**.	**Unlikely**	**'Low (6)'**
Marine flora	The residual **sensitivity of the marine flora** remains the same and is considered to be '**Moderate**'. The residual **severity of the effect** remains the same and is considered to be '**Moderate'**. Therefore the residual **significance of the impact** on marine flora remains the same and is assessed as '**Moderate (9)'**.	**Unlikely**	**'Low (6)'**
Benthic communities	The residual **sensitivity of the benthic communities** remains the same and is considered to be '**Moderate**'. The use of shore tethered booms will help to prevent the spread of IFO. Therefore the residual **severity of the effect** is reduced from '**Serious'** to '**Moderate**'. The residual **significance of impact** on the benthic community is reduced from '**Upper Moderate (12)**' to '**Moderate (9)**'.	**Unlikely**	**'Low (6)'**
Fish and squid	The residual **sensitivity of fish and squid** remains the same and is considered to be '**High**'. The residual **severity of the effect** remains the same and is considered to be '**Moderate**'. The residual **significance of the impact** on fish and squid remains the same and is assessed as '**Upper Moderate (12)'**.	**Unlikely**	**'Moderate (8)'**
Human population (fisheries)	The residual **sensitivity of the human population (fisheries)** remains the same and is considered to be '**High**'. The residual **severity of the effect** remains the same and is considered to be '**Moderate**'. Therefore the residual **significance of the impact** on the human population via fisheries remains the same and is assessed as '**Upper Moderate (12)**'.	**Unlikely**	**'Moderate (8)'**
Seabirds	The residual **sensitivity of seabirds** remains the same and is considered to be '**High**'. The residual **severity of the effect** remains the same and is considered to be '**Serious**'. Therefore the residual **significance of the impact** on seabirds remains the same and is assessed as '**High (16)'**.	**Unlikely**	**'Moderate (10)'**
Marine mammals	The residual **sensitivity of marine mammals** remains the same and is considered to be '**High**'. The residual **severity of the effect** on marine mammals remains the same and is considered to be '**Serious**'. Therefore the residual **significance of the impact** on marine mammals remains the same and is assessed as '**High (16)'**.	**Unlikely**	**'Moderate (10)'**

Receptor	Sensitivity of Receptor and Severity of Effect (Impact)	Likelihood of occurrence	Residual risk significance
Coastal habitats (terrestrial)	The residual **sensitivity of coastal habitats** remains the same and is considered to be '**High**'. Due to the properties of IFO, some oil will be recovered and shore anchored booms will be deployed to contain oil that reaches the shore, thus limiting along shore drift and reducing the extent of coastal contamination. The residual **severity of the effect** is reduced from '**Serious'** to '**Moderate**'. Therefore the residual **significance of the impact** on coastal habitats is reduced from '**High** (16)' to '**Upper Moderate (12)'**.	**Unlikely**	**'Moderate (8)'**
Human Population (tourism)	The residual **sensitivity of the human population (tourism)** remains the same and is considered to be '**Moderate**'. The residual **severity of the effect** remains the same and is considered to be '**Moderate**'. Therefore the residual **significance of the impact** on tourism remains the same and is assessed as '**Moderate (9)'**.	**Unlikely**	**'Low (6)'**

12.2.9 Cumulative impact

Fuel bunkers are undertaken within Berkeley Sound on a regular basis and all of these operations carry a risk of fuel oil spill. Therefore, there is the potential for cumulative impacts through 'increased concentration' of fuel from oil spills (section 8.10.1). There are several known spills of MGO in Berkeley Sound, the largest of these are associated with ships that sank or ran aground (Table 12.37), although many of these incidents have not been formally recorded.

Baseline Total Hydrocarbon Concentrations (THC) and PAH in Berkeley Sound have been sampled and reported by Benthic Solutions (BSL, 2015c). Background levels are interpreted as being a mixture of naturally occurring hydrocarbons and weathered diesel. These vary from 1.03 mg/kg THC up to 159.89 mg/kg, with typical levels of 10 mg/kg (section 7.3.7.2.2). It is noted that these baseline levels are already at or above potential levels of concern, starting at 10 mg/kg.

Baseline PAH levels are reported as <1 µg/kg up to 0.938 mg/kg (section 7.3.7.2.2.2). Again, these pre-existing levels are already within the range of common levels of concern.

The fuel bunkering operations within Berkeley Sound carry an environmental risk. However, with industry-standard, base case and project-specific mitigation measures in place, the risk is reduced to ALARP. Tighter regulation of activities within Berkeley Sound will help to reduce the risks of accidental events occurring with third-party vessels. Additionally, the availability of vessels with OSR capability and additional OSR equipment should reduce the potential for environmental impacts from any oil spill events that might occur.

Table 12.37: Anecdotal data on incidents that could lead to oil leaks involving vessels in Berkeley Sound [a]

Date	Vessel type	Type of incident	Outcome	Environmental impact
April 2005	Reefer	Grounding in Berkeley Sound (Cochon Island)	Refloated with damage to hull	Fuel oil leak
May 2008	Trawler	Fire in Berkeley Sound	Vessel eventually sank	Fuel oil leaks (c.137 Tonnes)
Unknown	Jigger	Struck a rock and sank	Vessel sank	Fuel oil leaks

[a] M. Jamieson *pers. comm*. and A. Black *pers. obs*.

12.2.10 Confidence

There are a number of uncertainties regarding the models used to predict the likelihood of oil spill events and the impact that Sea Lion crude would have, due to the oil's unusual properties. Recent lab tests (CEDRE, 2017) have helped improve our understanding of the behaviour and weathering of Sea Lion crude as well as its impact on seabird feathers, but its impact on fur remains a data gap (see section 12.2.10.1 below). Overall, confidence in the assessment of the impacts and risks due to oil spills associated with Inshore operations is therefore considered to be '**Uncertain**'.

12.2.10.1 Uncertainty Regarding the Impact of Oil Spills

Although the fate and impact of oil in the marine (including inshore) environment is well documented through a number of historic studies there remain specific uncertainties relating to this project and location that are listed in Table 12.38.

Table 12.38: Summary of uncertainties regarding impact of vessel fuel oil

Uncertainty	Description
The performance of containment and recovery equipment	*In situ* performance is uncertain and could affect residual impacts post-response (positively or negatively), particularly for larger spills. This can be further investigated by pursuing industry trials and potentially designing site-specific trials
Efficacy of dispersants (on IFO)	The use of dispersants on spills of IFO would probably be effective, but may not be desirable in terms of environmental protection. Advice within the National Oil Spill Contingency Plan would be referred to in this respect Tests have confirmed that dispersants would not be effective on a spill of Sea Lion crude

12.2.10.2 Monitoring required

For pre- and post-spill monitoring, it is beneficial to identify and monitor species that qualify as markers for anthropogenic oil pollution. In many studies, local amphipod species are used for this purpose and have proved effective, strongly correlating indicator species (e.g. USEPA, 1975; Law and Moffat, 1993; Gesteira and Dauvina, 2000). In the Falklands, loligo squid are key components of the inshore food chain and are also an important commercial species. They are fast growing and short-lived, and therefore the accumulation of pollutants in their tissues reflect the bioavailability in the immediate environment over a relatively short period of time.

During operations a real time inshore hydrodynamic model covering 3-day detailed current and wind forecasts will be run and available in the event of a spill.

12.2.11 Offsetting

For significant residual and impact and risks (Moderate or above), offsetting via an Environmental Fund is proposed, see section 8.9 for further details.

12.2.12 Findings summary

Table 12.39: Summary of the impact assessment for inshore oil spills

Activity	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
MGO Spill during bunkering of fuel oil	Scenario 1: 10 tonne MGO spill	Toxic effects on Plankton	Accidental	1 & 2	Moderate	Moderate	Unlikely	**Low (6)**	**Low (6) [b]**	**Uncertain**	**Industry-standard and base case:** The use of a Vessel Traffic Management System. Clear manoeuvring and approach channel; Operational limits defined and implemented; Development and implementation of bunkering procedures with fuel supplier to ensure corporate standards of operational safety are maintained; Bunkering conducted within the 500 m LTV exclusion zone, or other defined area; and
		Toxic effects on Marine flora (kelp)	Accidental	1 & 2	Moderate	Minor	Unlikely	**Low (6)**	**Low (6) [b]**	**Uncertain**	
		Toxic effects on Benthic communities	Accidental	1 & 2	Moderate	Moderate	Unlikely	**Low (6)**	**Low (6) [b]**	**Uncertain**	
		Toxic effects on Fish and squid	Accidental	1 & 2	High	Moderate	Unlikely	**Moderate (8)**	**Moderate (8)**	**Uncertain**	
		Impact on fisheries from tainting of fish and contamination of fishing grounds	Accidental	1 & 2	High	Moderate	Unlikely	**Moderate (8)**	**Moderate (8)**	**Uncertain**	
		Plumage contamination and oil ingestion by Seabirds	Accidental	1 & 2	High	Serious	Unlikely	**Moderate (10)**	**Moderate (10)**	**Uncertain**	
		Skin contamination and ingestion of toxins by marine mammals	Accidental	1 & 2	High	Serious	Unlikely	**Moderate (8)**	**Moderate (10)**	**Uncertain**	
		Coastal communities	Accidental	1 & 2	High	Minor	Unlikely	**Low (6)**	**Low (6) [b]**	**Uncertain**	

Activity	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
		Negative publicity impacting tourist numbers	Accidental	1 & 2	Moderate	Minor	Unlikely	**Low (6)**	**Low (6) [b]**	**Uncertain**	Development and implementation of the OSCP. **Project-specific:** On-site OSR capability
Vessel collision / grounding leading to MGO Spill in Berkeley Sound	Scenario 2: 3,700 tonne MGO spill	Toxic effects on Plankton	Accidental	1 & 2	Moderate	Moderate	Unlikely	**Low (6)**	**Low (6) [b]**	**Uncertain**	**Industry-standard and base case:** The use of a Vessel Traffic Management System. Clear manoeuvring and approach channel; Operational limits defined and implemented; Development and implementation of bunkering procedures with fuel supplier to ensure corporate standards of operational safety are maintained; Active monitoring of LTV exclusion zone, or other defined area; and Development and implementation of the OSCP.
		Toxic effects on Marine flora (kelp)	Accidental	1 & 2	Moderate	Minor	Unlikely	**Low (6)**	**Low (6) [b]**	**Uncertain**	
		Toxic effects on Benthic communities	Accidental	1 & 2	Moderate	Moderate	Unlikely	**Low (6)**	**Low (6) [b]**	**Uncertain**	
		Toxic effects on Fish and squid	Accidental	1 & 2	High	Moderate	Unlikely	**Moderate (8)**	**Moderate (8)**	**Uncertain**	
		Impact on fisheries from tainting of fish and contamination of fishing grounds	Accidental	1 & 2	High	Moderate	Unlikely	**Moderate (8)**	**Moderate (8)**	**Uncertain**	
		Plumage contamination and oil ingestion by Seabirds	Accidental	1 & 2	High	Serious	Unlikely	**Moderate (10)**	**Moderate (10)**	**Uncertain**	
		Pelage / skin contamination and ingestion of toxins by marine mammals	Accidental	1 & 2	High	Serious	Unlikely	**Moderate (10)**	**Moderate (10)**	**Uncertain**	

Activity	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a]		Confidence	Mitigation / Prevention / Control
								Initial	Residual		
		Coastal ecology	Accidental	1 & 2	High	Minor	Unlikely	**Low (6)**	**Low (6) [b]**	**Uncertain**	**Project-specific:** On-site OSR capability
		Negative publicity impacting tourist numbers (human population Tourism)	Accidental	1 & 2	Moderate	Minor	Unlikely	**Low (6)**	**Low (6) [b]**	**Uncertain**	
Vessel collision / grounding in Berkeley Sound leading to Intermediate Fuel Oil (IFO) spill in Berkeley Sound	Scenario 3: 1,576 tonne IFO spill	Toxic effects on Plankton	Accidental	1 & 2	Moderate	Moderate	Unlikely	**Low (6)**	**Low (6) [b]**	**Uncertain**	**Industry-standard and base case:** The use of a Vessel Traffic Management System. Clear manoeuvring and approach channel; Operational limits defined and implemented; Development and implementation of bunkering procedures with fuel supplier to ensure corporate standards of operational safety are maintained; Active monitoring of LTV exclusion zone, or other defined area; and
		Toxic effects on Marine flora (kelp)	Accidental	1 & 2	Moderate	Moderate	Unlikely	**Low (6)**	**Low (6) [b]**	**Uncertain**	
		Toxic effects on Benthic communities	Accidental	1 & 2	Moderate	Serious	Unlikely	**Moderate (8)**	**Low (6) [b]**	**Uncertain**	
		Toxic effects on Fish and squid	Accidental	1 & 2	High	Moderate	Unlikely	**Moderate (8)**	**Moderate (8)**	**Uncertain**	
		Impact on fisheries from tainting of fish and contamination of fishing grounds	Accidental	1 & 2	High	Moderate	Unlikely	**Moderate (8)**	**Moderate (8)**	**Uncertain**	
		Plumage contamination and oil ingestion by Seabirds	Accidental	1 & 2	High	Serious	Unlikely	**Moderate (10)**	**Moderate (10)**	**Uncertain**	
		Pelage / skin contamination and ingestion of toxins by marine mammals	Accidental	1 & 2	High	Serious	Unlikely	**Moderate (10)**	**Moderate (10)**	**Uncertain**	
		Coastal ecology	Accidental	1 & 2	High	Serious	Unlikely	**Moderate (10)**	**Moderate (8)**	**Uncertain**	

Activity	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance [a] Initial	Impact / Risk Significance [a] Residual	Confidence	Mitigation / Prevention / Control
		Negative publicity impacting tourist numbers (human population Tourism)	Accidental	1 & 2	Moderate	Moderate	Unlikely	**Low (6)**	**Low (6)** [b]	**Uncertain**	Development and implementation of the OSCP. **Project-specific:** On-site OSR capability
Release of MGO fuel oil	Impact to air quality	Impact of deteriorating air quality on local wildlife	Accidental	1 & 2	Very Low	Minor	Unlikely	**Very Low (2)**	**Very Low (2)**	**Uncertain**	
		Impact of deteriorating air quality on human population	Accidental	1 & 2	Very Low	Minor	Very Unlikely	**Very Low (2)**	**Very Low (2)**	**Uncertain**	

a See Chapter 8 for definitions of sensitivity, severity, likelihood and significance.

b While the initial risk assessment is Low or Very Low such that there is no need for a residual assessment, these risks are low primarily owing to the very low likelihood of spill events occurring and the impacts range from Very Low to High. It should be noted that the project-specific oil spill clean-up and response resources that will be in place will be used for all spills regardless of the outcome of this assessment and therefore, for clarity, the residual assessments are illustrated within this table also.

12.3 At-shore and onshore fuel oil and chemical spills

12.3.1 Introduction

The interface between the land-based storage of fuel and chemicals and their offshore use presents a risk in terms of the onshore storage and the 'at-shore' transfer of potentially hazardous liquid products, for example fuel oil and chemicals.

This chapter assesses the impacts and risks associated with:

- The transfer of fuel oil at the Temporary Dock Facility (TDF) and / or Falklands Interim Port And Storage System (FIPASS);
- The movement of chemicals at the TDF; and
- The storage of chemicals at the onshore supply base.

Under the Planning Ordinance 1991, an Environmental Impact Assessment (EIA) was conducted as part of the original planning application for the TDF to cover the construction and operational use of the facility (NEFL, 2013). In addition to the EIA, a TDF Oil Spill Response Plan (OSRP) to cover Premier activities within Stanley Harbour was produced (Premier, 2014f), which is compatible with the Falklands National Oil Spill Contingency Plan (NOSCP). The assessment below draws on the conclusions of the EIA and contents of the OSCP.

Note: the other impacts and risks associated with potential oil spills during offshore operations and inshore operations are described elsewhere in this document (Chapters 12.1 and 12.2 respectively).

12.3.1.1 Relevant legislation

The legislation relevant to all oil spills is described in section 12.1.1.1.

Additional legislation relevant to at-shore activities or to the selection, use and discharge of chemicals, and / or that which is directly relevant to chemical spills at the TDF and onshore supply base specifically include:

- International legislation:
  - International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78:
    - Annex III- Regulations for the Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form.
  - OSPAR Decision 2000/2 on a Harmonised Mandatory Control System (HMCS) for the Use and Reduction of the Discharge of Offshore Chemicals.
  - OSPAR Recommendation 2010/3 on a Harmonised Offshore Chemical Notification Format (HOCNF).
  - OSPAR Recommendation 2010/4 on a Harmonised Pre-Screening Scheme for Offshore Chemicals.
  - OSPAR Recommendation 2006/3 on Environmental Goals for the Discharge by the Offshore Industry of Chemicals that are, or which contain Substances Identified as Candidates for Substitution.

- EC Directive 2012/18/EU on control of major-accident hazards involving dangerous substances.

- UK legislation:
  - Offshore Chemical Regulations (OCR) 2002 (and all amendments).
  - The Control of Major Accident Hazards (COMAH) Regulations 2015.

12.3.1.1.1 Compliance with chemical selection legislation

Details on the compliance requirements relevant to chemical selection are provided in section 10.7.1.1.2 so are not repeated here.

12.3.1.1.2 Compliance with chemical use and discharge legislation

The offshore chemical regulations require that the use and discharge of all chemicals be permitted and reported and that all chemical releases be reported via the PON system to FIG.

12.3.1.1.3 COMAH regulations compliance

The aim of the COMAH Regulations is to prevent and mitigate the effects on people and the environment of major accidents involving dangerous substances. They are applicable to any establishment storing, or otherwise handling, large quantities of industrial chemicals of a hazardous nature. Types of establishments include chemical warehousing, chemical production facilities and some distributors. Whether or not a site qualifies as a COMAH site will depend upon the type and quantity of chemicals stored:

- Lower tier establishments are required to document a Corporate Major Accident Prevention Policy (CMAPP) which should be signed off by the managing director.
- A top tier COMAH establishment is required to produce a full safety report which demonstrates that all necessary measures have been taken to minimise risks posed by the site with regard to the environment and local populations.

The proposed storage of up to 300m^3 of methanol does not qualify the proposed operations base as the equivalent of a lower tier UK COMAH site however, Premier Oil's internall process will apply a COMAH methodology and require the following activities to be undertaken:

- Reduce risks to ALARP;
- Notify the Competent Authority;
- Prepare a Major Accident Prevention Policy (MAPP);
- Provide information for the public; and
- Consider the possible domino risks.

In addition to the above, Premier intend to produce a Safety Report covering the transportation and storage of chemicals at the proposed base. Full details are provided in the Major Accident Hazard Assessment completed for Premier by Risktec (Premier, 2018a).

Full guidance on the COMAH qualification and assessment process is provided by the Health and Safety Executive.

12.3.1.1.4 MARPOL Annex III

In 1973, IMO adopted the International Convention for the Prevention of Pollution from Ships, now known universally as MARPOL. The convention has been repeatedly amended and updated by the Marine Environmental Protection Committee (MEPC).

Annex III sets out regulations for the prevention of pollution by harmful substances in packaged form and includes general requirements for the issuing of detailed standards on packing, marking, labeling, documentation, stowage, quantity limitations, exceptions and notifications for preventing pollution by harmful substances. For the purpose of Annex III, 'harmful substances' are those identified as 'marine pollutants' in the International Maritime Dangerous Goods (IMDG) Code and compliance with Annex III will form part of Premier's contractor management and audit processes (section 3.2.16).

12.3.2 Sources of at-shore oil and chemical spills

It is the intention of Premier to apply to FIG to extend the operational life of the TDF. Further, Premier may propose future modifications to improve the Dock's functionality. As described in section 5.11.1.1.1, proposals to extend the life of the TDF and / or upgrade the facilities will have to go through the process of planning, which may be accompanied by a full separate EIA.

For the purposes of this EIA, it is assumed that proposed upgrades to the TDF will be approved.

Sources of at-shore oil and chemical spills / leaks during the Phase 1 Development include:

- The presence and use of equipment that involve fluid products. Such equipment includes (but may not be limited to):
  - Crane/s;
  - Forklifts;
  - Ballast pumps;
  - Diesel generator;
  - Oil storage tanks; and
  - Heavy goods vehicles and cars.
- Chemical transfer at the TDF (section 5.11.1.1.1);
- Diesel bunkering at the TDF and / or at FIPASS (section 5.11.1.1.2);
- Mud and chemical storage at the onshore supply base;
- Major accidents at the supply base; and
- Vessel collisions and groundings on approach to the port facilities

12.3.3 Potential receptors

The ENVironmental Impact and risk IDentification (ENVIID) workshop was used to identify those receptors upon which the impacts and / or risks of oil spills warranted further investigation (Chapter 9). These include:

- Marine benthic flora and fauna in Stanley Harbour and surrounding areas (section 7.4.3.4);
- Fish and squid in Stanley Harbour and surrounding areas (section 7.4.4.4);

- Seabirds in Stanley Harbour and surrounding areas (section 7.4.5.4);
- Marine mammals in Stanley Harbour and surrounding areas (section 7.4.6.4); and
- Coastal communities and habitats (section 7.5.1).

These receptors may be impacted upon as they either exist in, or spend time in, the area that might be influenced by fuel oils or chemicals accidentally discharged into the marine environment.

12.3.4 Characterising and quantifying the risk of at-shore and onshore oil and chemical spills

The influencing factors with regard to oil type and behaviour, and the nature of the impacts of oil spills on receptors have already been described in section 12.1 above. However, when characterising and quantifying the impacts of at-shore oil and chemical spills specifically, it is also necessary to consider the following:

- Port facility and onshore supply base use and the scenarios which could lead to spills:
  - Day-to-day operations;
  - Bulk transfer of substances;
  - Chemical storage; and
  - Vessel approaches.
- Quantification of the potential oil spill volumes; and
- The fate of chemicals in the marine environment.

12.3.4.1 Port facility and onshore supply base use and the scenarios which could lead to spills

Given the known activities occurring at the TDF, FIPASS and the onshore supply base, a spill scenario identification exercise was conducted in 2014 by Premier to identify the credible emergency scenarios that could result in a spill of hydrocarbon and / or chemicals (Premier, 2014f). These scenarios are identified below and will be included within the scope of Premier's Phase 1 Development Atshore OSCP.

12.3.4.1.1 Day-to-day operations

Small scale spills and leaks may occur through the presence and / or the day-to-day use of equipment (as listed in section 12.3.2 above). Specifically, spills and leaks that may result from the presence and / or use of equipment include losses of:

- Fuel oils;
- Hydraulic oils;
- Oily bilges from machinery spaces;
- Oil fouled water from ballast tanks;
- Leaks from propeller shaft or drive-shaft oil seals; and
- Leakage of hydraulic or lubricating oils from various moving parts such as hydraulic ramp and deck moving / lifting mechanisms.

Leaks most commonly occur due to incorrect maintenance or neglect of maintenance schedules and most can be avoided in the first instance through procedural control. However, where leaks do occur, they can be a significant source of discharged fluids, particularly if they go undetected for significant periods of time.

At the TDF, very small leaks or spills of diesel from vehicles or machinery are likely to be contained on the superstructure of the Dock where they will rapidly evaporate and are amenable to clean-up. However, larger spills may reach the water which could occur through drains or direct runoff from quayside surfaces.

In water, diesel readily spreads to form a sheen, which evaporates rapidly (section 12.1.4.1.1.2). Heavier oils, such as hydraulic oil, behave differently and some fractions of these oils will transfer to the bottom and stay there. Eventually, the ingredients of hydraulic fluids are degraded in the environment, but complete degradation may take more than a year (ATSDR, 1997). Little is known about how some of the ingredients in hydraulic fluids breakdown in the environment, but almost nothing is known about how toxic these breakdown products are. However, there are biodegradable hydraulic oils on the market, the use of which would greatly reduce the risk of environmental impact. Over recent years, the industry has progressively replaced many more harmful fluids that were once oil-based and has transitioned to less harmful oils or non-oil systems. For example, hydraulic fluids planned for the subsea control system on the FPSO, for the operation of the BOP on the MODU and for the operation of tensioning systems on the MODU are biodegradable products based on the PLONOR chemical monoethylene glycol (MEG).

Any unintentional at-shore release which reaches the water, however small, will contribute to chronic pollution of the marine environment.

12.3.4.1.2 Bulk transfer of substances

Bulk transfers involve the use of unbunded flexible bulk hoses which can be considered a weak link in terms of the potential for accidental spills and leaks.

12.3.4.1.2.1 Diesel bunkering at the TDF and / or FIPASS

There is a potential risk that during bunkering operations, marine diesel could be spilled to sea, due to:

- Equipment failure / malfunction e.g. dry-break valve failure, perishing of hoses, failure of level gauge, level alarms; tank failure and / or
- Operator error e.g. poor bulk hose storage, neglect of hose inspections / change-out schedules, neglect of watchman during operations.

In the past ten years there have been several small Marine Gas Oil (MGO) spills in Stanley Harbour, with the largest amounting to about 100 litres (ITOPF, 2012). However, there have been larger spills recorded within the Islands' territorial waters in the last 20 years, resulting from groundings (see section 12.2).

The likelihood of unintentional releases of diesel is greatest during transfer operations, when diesel is moved from one secure holding tank to another via bulk hoses. Detailed spill statistics are not available for the Falkland Islands, but as dry-break couplings will be used on the bulk hoses alongside shut-down valves and observations, it is assumed that the worst case maximum volume of any spill would comprise only the volume of diesel contained in the mains pipe before the valve is manually shut down. This is estimated to be approximately one tonne (Table 12.40). This scenario could only occur if the automated emergency shut down valves failed *and* the quayside watchman was unaware of the incident and pumps remain on for a time before being shut-off.

As detailed in section 12.1.4.1.1.2, diesel contains a high percentage of low molecular weight hydrocarbon compounds, known as 'light ends' and hence tends to disperse very rapidly upon release to the marine environment (mainly via evaporation), usually within a matter of hours on the surface. Further, diesel oil is biodegraded by naturally occurring microbes in the sediment, under time frame of months. However, if a large volume of diesel fuel were to be released in the vicinity of the TDF, it could spread and pose a significant risk of possible impact to wildlife throughout Stanley Harbour, even if only for a brief period of time. Small diesel spills can affect marine birds due to ingestion during preening as well as by hypothermia from matted feathers, though the number of birds affected is usually small because of the short time the diesel is on the water's surface (section 12.1.4.1.1.2).

When small fuel oil spills do strand on the shoreline, the fuel oil tends to penetrate porous sediments rapidly but also tends to be washed off quickly by waves and tidal flushing. Thus, shoreline clean-up following diesel spills is usually not needed.

12.3.4.1.2.2 Chemical transfer operations

For the purpose of this assessment, it is assumed that all chemical cargo (and other supplies needed to support offshore operations) will be delivered to the TDF and stored at the onshore supply base (section 5.11.1).

Throughout the Development, all chemicals will be selected to minimise environmental impacts as much as possible, in compliance with legislation. However, although chemicals may be rated as Posing Little Or NO Risk (PLONOR) when used in-Field due to the concentrations and application type, they are transported as undiluted chemicals and in this state, pose a greater environmental risk.

Well chemicals

Details on the specific chemicals that will be used during the Phase 1 Development drilling operations are not yet known. However, the well chemical function groups required are as described in section 5.9.1.

Vessels will be loading and offloading a number of chemicals that will be used in the drilling operation. The majority of chemicals required are dry 'bulk' chemicals used in the make-up of drilling mud. However, Oil Based Mud (OBM) may be pumped across the TDF and onto the supply vessels (subject to approval of proposed upgrades to the TDF). Other chemicals that will be transferred at the TDF might include: cementing chemicals, rig cleaning chemicals, and pipe dope (drill pipe connector thread lubricant and sealing compound). During transfer of chemicals to and from the TDF, there is a potential risk that the chemicals could be spilled to sea. The worst case scenario for chemicals being released to sea at the TDF would be an entire batch of cementing chemical, which would be transferred in 1.5 tonne batches, being lost to sea. Liquid chemicals will be transported in various sizes of drum, IBCs and tote tanks, and as such a loss of a load during transfer would not immediately result in a loss of chemical to sea; the container would have to be breached in some way during the incident for this to occur.

Production chemicals

Details on the specific chemicals which will be used during the Phase 1 Development production operations are not yet known. However, the production chemical function groups required are as described in section 5.9.1.

Of the chemical function groups required, two chemicals which are required to ensure flow assurance (namely wax inhibitor and methanol) are required in significant volumes, while the other chemicals are required in lesser quantities (section 5.9.1.1). While the quantities of the different production chemicals will change as oil production rates decline, the wax inhibitor and methanol make up 70 % of the total first year production chemical volume requirements. These bulk chemicals will be transported from their place of manufacture (which is likely to be the UK) to the Falklands in 24,000 litre (20') ISO frame tanks.

The base case assumption is that the 20' ISO tanks will be transported to the Falkland Islands via Large Transport Vessel (LTV) in the first instance and by coaster supply ships thereafter. The tanks will be unloaded at the TDF and moved onshore to be stored in the production chemical laydown yard until they are ready to be taken offshore to Sea Lion. When required offshore, the bulk chemicals will be shipped to the Sea Lion Field, by transporting the 20' ISO frame containers to the TDF and pumping the contents into the hull tanks of the supply vessels (MRSVs). These hull tanks will be used only for these chemicals such that there will be no cross-contamination. The maximum possible spillage that could occur is the full volume of a single tank (Table 12.40). The empty containers will then be returned to the production chemical laydown yard for storage and subsequent back loading (section 10.10). The MRSV will then transport the chemicals to Sea Lion where they will be offloaded via bulk hoses into the storage tanks in the FPSO.

The worst case scenarios which could lead to the loss of the content of an ISO frame tank to sea during transfer include:

- Offload of the frame tanks from the LTV / Coaster vessel to a vehicle on the TDF via crane-lift; and
- Pumping of the tank content into the MRSV from the TDF.

The smaller volume chemicals will be decanted into Tote Tanks in the production chemical laydown yard. These will then be transported to the TDF on trucks and lifted by crane onto the back deck space of a supply vessel. They will then be transported out to Sea Lion, where they will be lifted by crane into metal framed bins on the deck of the FPSO.

12.3.4.1.3 Chemical storage

Once offloaded from the LTV / Coaster supply vessel:

- Drilling chemicals will be stored in a dedicated OBM and Bulks facility; and
- Production chemicals will be stored in a dedicated production chemical laydown yard (section 5.11.1.2).

The worst case scenarios which could lead to the loss of containment of chemical to ground during transfer include:

- Offload of the frame tanks from the vehicle to the chemical laydown yard; and
- Loading of the frame tanks onto a vehicle at the laydown yard for transportation to the TDF.

12.3.4.1.3.1 History of chemical spills during exploration campaigns

There were two incidents of chemical spills at the onshore supply base during the 2015 exploration campaign. Neither incident resulted in significant release of chemicals or resulted in environmental damage.

The first incident occurred as Intermediate Bulk Containers (IBCs), containing approx. 1,000 litres each, were being moved from one laydown yard to another. As the forks of the forklift truck were entered into the lifting pockets of the IBC, the metal plate at the base was caught and scraped by the right-hand fork, resulting in the plate being dented and pushed upwards, thereby puncturing the IBC. When reversing, the forklift operator noticed a puddle of liquid on the ground. The chemical spilled was Halliburton CFS - 476 (Oxygen Scavenger) which is a Cefas Gold chemical (see section 12.3.1.1.2). The spill was estimated to be in the region of 400 litres. Action was taken to prevent further spillage and the incident was reported to FIG.

The second incident concerned small leaks from several IBCs that had been stored at the laydown yard for over a year. The IBC's had been placed on chipboard boards, which, when lifted, were discovered to be damp, with the screed floor underneath also damp. There was no other obvious source of the dampness other than from the IBC's. The IBC's contain Mono Ethylene Glycol (MEG) which is an OCNS E rated chemical (see section 12.3.1.1.2).

It was noticed that some of the caps at the bottom of the IBC were not fully finger tight, so the decision was made to re-locate all IBC's containing MEG and manually tighten their caps. All IBC's were accessible in the hold of the vessel and in the warehouse, and three were found to have minor leaks from the cap. They were tightened and spill pads were secured around the cap to prevent any further leakage. It is estimated that 1 litre had leaked over a 12 month period.

12.3.4.1.4 Major accidents at the supply base

In the event of a major incident at the supply base, such as an explosion, whilst safety of personnel is of greatest concern, there can be the risk of an associated spill to ground or sea. The UK COMAH regulations, which Premier will adhere to, are designed to prevent any impacts of major accidents, to both the human population through separation distances, and to surrounding environment via the implementation of appropriately designed site bunding and drainage, see section 12.3.5.2.

The inventories identified as having the potential to cause a major accident are the methanol and the explosives, which are used in drilling. The explosives will be stored at a dedicated separate location, such that any explosions instigated by them will not cause an associated spill.

Any fire / explosion in the methanol storage area, which has the potential to cause an associated spill, will be firstly contained within the bund (see section 12.3.5.2 below), and, due to the highly flammable nature of methanol, is likely to be burnt up in the explosion.

Premier will apply mitigations to the methanol storage to ensure other flammable material or oils are not stored in proximity to the methanol to prevent event escalation.

12.3.4.1.5 Vessel approaches

The increase in the number of vessels utilising Stanley Harbour during the Phase 1 Development increases the potential risk of vessel collision particularly if vessels working on behalf of the Phase 1 Development are not familiar with the location.

However, by international standards, the Harbour is not regarded as a busy port and collisions and groundings should be readily avoidable by following standard navigational procedures (e.g. ColRegs).

Assuming a worst case-scenario, a fully laden supply vessel would contain approximately 800 m^3 of diesel fuel. This would be spread between numerous different tanks and therefore it is extremely unlikely that all of this could be lost in a single event. A more credible worst case scenario is the loss of fuel from two fuel tanks, which is predicted to be around 320 m^3, based on a typical MRSV. Nevertheless, a breach of a fuel tank could result in a sizable spill in sheltered inshore waters, where dispersal by wind and waves would be limited.

Table 12.40: Summary of the credible worst case spill quantities for each at-shore scenario

Scenario	Cause	Spill type	Credible worst case volume (m^3)
Day to Day operations	Leaks, seeps and weeps	Fuel and hydraulic oils to sea	<1 m^3
Diesel bunkering	Equipment failure (e.g. hose rupture) / human error	Diesel to sea	1 m^3
Chemical bunkering	Equipment failure (e.g. hose rupture) / human error	Drilling mud	1 m^3
	Equipment failure (e.g. crane failure) / human error	Wax inhibitor or methanol to sea	24 m^3
Chemical storage	Equipment failure (e.g. failure of forklift truck) / human error	Drilling / production chemical to land	1 m^3
	Major accident with associated spill	Chemical / oil to sea or land	0 m^3
Vessel approach	Collision or grounding due to equipment failure / human error	Fuel to sea	320 m^3
		Chemical to sea	10 m^3

12.3.4.1.5.1 History of collisions in Stanley Harbour

Fishing vessel *Pesca Vaqueiro* ran into the FIPASS dock whilst on approach 5th September 2019. Otherwise there are no formal records of collisions in Stanley Harbour although there have been a number of collisions between local vessels, or vessels running aground, in Stanley Harbour and Port William in recent years (A Black pers. obs.). None of these events involved vessels associated with the Oil and Gas (O&G) industry and none resulted in a major pollution incident.

12.3.4.2 Fate of chemicals in the marine environment

The fate of chemicals in the environment will vary enormously depending upon the substances concerned; however, the following properties of each chemical used will be considered:

- Relative biodegradation;
- Persistence and toxicity; and
- Potential to bioaccumulate.

The varying combinations of the above will affect the impact each chemical may have in the event that it is spilled.

For example, the behaviour of a methanol spill would be similar to that of a diesel spill (i.e. relatively rapid evaporation); however, as methanol is soluble in water it would disperse more rapidly to non-toxic levels (<1 %) (dependent on water mixing due to tide or wind) and would biodegrade. Although biodegradation of a large spill in enclosed waters could lead to localised deoxygenation of surface waters, this is unlikely where water is well mixed.

12.3.5 Industry-standard mitigation

12.3.5.1 Day-to-day operations and bulk transfers at the TDF

The industry-standard mitigation measures used by Premier to prevent and mitigate against leaks and spills at the quayside are as follows:

- Use of Management Maintenance System (MMS) to ensure all equipment remains in good working order and fit for the purpose intended:
  - The MMS will provide alerts for regular Preventative Maintenance Routines, with priority given to equipment listed in the Safety and Environmentally Critical Elements (SECE) Register (section 3.2.8).
  - A Locked Open / Locked Closed (LO / LC) Register will be used at the TDF to ensure that all safety and environmentally critical valves will be left in the appropriate position.
  - Critical spares will be identified and in place.
  - Hose management processes in line with NWEA good practice guidelines (Chamber of Shipping, 2009). Bulk hose and flexible hose management procedures which will ensure that:
    - All hoses are stored correctly, inspected and changed-out regularly, colour coded appropriately, listed in hose registers, utilise swivel joints to minimise kinking etc.
- Use of standard operating procedures, building upon any lessons learned during the exploration drilling campaigns, including, for example:
  - Diesel bunkering procedures which will ensure that:
    - Bunkering operations will be monitored throughout by trained personnel under Premier supervision; and
    - A team utilised to hook up, and following commencement of pumping, to monitor from the quayside.
  - Chemical handling and loading procedures.
- Use of task specific planning, toolbox talks, risk assessments and pre-use checks;
- Use of emergency response plans e.g.:
  - Facility Emergency Response Plan (ERP) and Oil Spill Response Plan OSCP) for the TDF will align with the existing NOSCP in place for FIPASS;
  - Use of a Hazardous Chemical Management Plan (HCMP) to manage the handling of chemicals; and
  - Phase 1 Atshore Development Oil Spill Contingency Plan (OSCP).
- Use of engineering controls e.g. dry-break coupling on bulk hoses, emergency shut-down valves;
- Training of all personnel in spill prevention and response; and
- Use of spill kits which will be located on the TDF and at FIPASS

12.3.5.2 Chemical storage at the onshore supply base and major accident prevention

The industry-standard mitigation measures used by Premier to prevent and mitigate against leaks and spills at the supply base are as follows:

- All onshore storage operations involving the production chemicals will take place in a bunded facility to ensure that any spills can be contained:
  - In line with COMAH (2015), the normal design specifications for bunding require a holding capacity of 110% of the largest tank contained within the bunding and 25% of the total capacity of all the tanks within the bund (whichever is the greatest volume).
- A 'double drainage' system will be required for surface water in hazardous areas, which will allow the recovery and appropriate disposal of surface water that has become contaminated by any spilt production chemicals.
- Tote Tanks will be inspected and maintained within the production chemical laydown yard in the Falkland Islands in compliance with the inspection and certification regime.
- Tote Tanks will be returned to the UK for in depth inspections and certification, if it is not possible to complete this within the islands.
- All personnel will be adequately trained in spill prevention and response and in the use of spill kits which will be located around the supply base.

Based on the maximum volume of methanol that will be stored at the onshore facility (i.e. up to 600 m^3 at any one time) it is anticipated the location will fall under the definition of a lower tier COMAH site. As such, Premier will adopt chemical management standards in line with the COMAH regime in the UK. This will include, amongst other safety precautions, adhering to safe separation distances of flammable chemicals to local houses and roads, which has been calculated to be between 80 and 136 m (Premier, 2017a).

12.3.5.3 Vessel approaches

It is anticipated that Premier will co-operate in a Harbour Management Plan, designed and implemented in close collaboration with the Harbour Master to include the following:

- Pre-notification protocols associated with the entry of vessels into Stanley Harbour during operation;
- Procedures associated with vessel collision and emergency response;
- Marine night-time lighting requirements; and
- VHF Radio communication protocols.

The system of reporting within the Harbour and Port William will inform all users of vessel movements. The crews of O&G related vessels are highly trained and the vessels (e.g. MRSVs) are extremely manoeuverable. All users of Stanley Harbour will continue to be made aware of the position of the TDF and the structure will be lit at night.

Pre-mobilisation audits will be undertaken on all vessels. Vessels will be selected which comply with all IMO codes for the prevention of pollution from both oil and chemicals.

All vessels will have a Shipboard Oil Pollution Emergency plan (SOPEP) in place to enable fast and effective response to any potential pollution incident.

12.3.6 Risk assessment for at-shore oil and chemical spills

The following section draws upon all the information provided above to assess the 'Sensitivity of the Receptor' and the 'Severity of Effect' in order to determine the overall 'Impact' of any spills followed by an assessment of the 'Likelihood of Occurrence' to determine the overall 'Risk'.

A summary of the risk assessment outcomes for this Development is tabulated in section 12.3.12 (Table 12.41), which shows the worst case risk for each activity and receptor and details are provided below.

12.3.6.1 Day-to-day operations

The nature of the impact of diesel, or chemical spills, on birds and marine mammals is different (see section 12.1.4.2) and is likely to be greater on birds due to feather fouling and loss of insulation than on marine mammals, which are generally more impacted by ingestion. Therefore, birds are considered to be the more sensitive receptor. As described in sections 7.4.5.4 and 7.4.6.4, Stanley Harbour supports a population of Falkland flightless steamer ducks, and is utilised by Commerson's and Peale's dolphins and South American sea lions. Although the number of animals present is not significant in terms of the Falklands populations, all of these are included in the list of priority conservation species (section 7.5.3) and therefore the **sensitivity of receptors** is considered to be '**High**'.

Although there is some uncertainty regarding the potential impacts of some of the fluids used during operations on the TDF (section 12.3.4.2), the environmental impact of any small leak or spill will be localised, short-term and fully reversible once activity ceases. Considering the range of other activity that could result in leaks or small spills of hydrocarbons that is currently undertaken around the Harbour, the impact from Phase 1 Development activity is considered to pose a barely detectable impact on species, habitats or the ecosystem. Therefore, the **severity of effect** is considered to be '**Minor**'.

Therefore, the overall **significance of impact** is '**Moderate (8)**'.

Accidental release of small volumes of fluids associated with day-to-day operation of the TDF represents the most likely source of unintentional releases. During the 2015 exploration campaign, there were two incidents of small chemical spills and leaks in the laydown yard. There was no risk of the chemicals escaping into the marine environment but it highlights the potential for accidental events and undetected leaks. These events may occur less than once per year but could occur more than once over 10 years in the event that operational controls failed; therefore, the **likelihood** of small scale spills or leaks occurring and contaminating the environment is '**Possible**'.

Therefore, the **overall risk associated** with day-to-day small spills is assessed as '**Moderate (9)**'.

12.3.6.2 Bulk transfer of substances

12.3.6.2.1 Diesel fuel transfer spills at TDF and / or FIPASS

The most sensitive potential receptors are the same as those described in section 12.3.6.1. Therefore, the **sensitivity of receptors** is considered to be '**High'**.

The environmental effect of small diesel spills (i.e. <1 tonne) would be localised short-term, and fully reversible. The impact would be barely detectable on species, habitats or the ecosystem as a whole and therefore, the **severity of effect** is considered to be '**Minor**'.

Therefore, the overall **significance of impact** is '**Moderate (8)**'.

The zone affected by any spill will vary according to weather conditions, but overall the volume impacted will remain similar. In severe weather, for example, any pollution will be moved a greater distance but will be diluted more quickly at the same time by increased turbulence. Although small spills have occurred infrequently during fuel transfer operations at FIPASS in the past, no spills occurred during the Premier exploration drilling campaign. The base case mitigations applied by Premier vessels represents a higher standard than that applied generally within the shipping industry, such that the **likelihood** of diesel spills during bunkering operations is considered to be '**Unlikely**'.

Therefore, the **overall risk associated** with diesel spills during bunkering is '**Low (6)**'.

12.3.6.2.2 Chemical transfer spills at TDF

The most sensitive potential receptors are the same as those described in section 12.3.6.1. Therefore, the **sensitivity of receptors** is considered to be '**High**'.

The nature and severity of the impact of a chemical spill will depend on the chemicals involved. For instance, in terms of volume transferred, methanol will be one of the most significant chemicals used during the Phase 1 Development but will rapidly disperse causing only localised deoxygenation (section 12.3.4.2). In contrast, another chemical may be spilled in lower volumes but may, for example, be more toxic (section 12.3.4.2). On balance, however, and given that the bulk chemicals intended for use are expected to be Cefas Gold or OCNS E (see section 12.3.1.1.2), the overall **severity of the impact** of a methanol spill is considered to be '**Minor**'.

Therefore, the overall significance of the impact is '**Moderate (8)**'.

As above, the zone affected by any spill will vary according to weather conditions, but overall the volume impacted will remain similar. Small chemical spills have occurred previously in the global O&G industry, however, no spills occurred during the Premier exploration drilling campaigns and failure of numerous operational controls would be required. The likelihood of all mitigation measures described above failing is such that the **likelihood** of chemical spills is considered to be '**Unlikely**'.

Therefore, the **overall risk associated** with the transfer of liquid chemicals is '**Low (6)**'.

12.3.6.3 Chemical storage spills at onshore supply base

Given the use of the mitigation measures described in section 12.3.5.2, it is not considered possible for spills at the supply base to reach any potential receptors. Therefore, as there is 'no potential to transmit contaminants to nearby sensitive receptors' the **sensitivity of soil as a receptor** is considered to be '**Very Low**'.

With no receptors impacted by any spill which will be contained within the bunds and double drainage system, **the severity of effect** is considered to be '**Slight**'.

Therefore, the overall **significance of impact** is '**Very Low (1)**'.

Spills and leaks at onshore supply bases have been known to occur within the industry and the majority of operational controls require implementation by humans e.g. correct storage / segregation / local bunding checks etc. rather than reliance on, and maintenance of, engineering controls. Therefore, the **likelihood** of chemical spills at the onshore is considered to be '**Possible**'.

Therefore, the overall risk associated with storage spills at the supply base is '**Very Low (3)**'.

12.3.6.4 Spills associated with major accidents at the supply base

Given the use of the mitigation measures described in section 12.3.5.2, it is not considered possible for spills associated with major accidents at the supply base to reach any potential receptors. Therefore, as there is 'no potential to transmit contaminants to nearby sensitive receptors', the **sensitivity of soil and sea as receptors** is considered to be '**Very Low**'.

With no receptors impacted by any spill, which will be contained within the bunds and double drainage system, the severity of effect is considered to be '**Slight'**.

Therefore, the overall **significance of impact** is '**Very Low (1)**'.

Major spills at onshore supply bases breaching bunding limits have been known to occur within the industry but are rare. The majority of controls to prevent this happening are appropriate design of the bunding and drainage system, maintenance of bunds and linings and engineering controls. Therefore, the **likelihood** of chemical spills at the onshore is considered to be '**Unlikely**'.

Therefore, the overall risk of spills associated with major accidents is '**Very Low (2)**'.

12.3.6.5 Vessel approaches

The most sensitive potential receptors are the same as those described in section 12.3.6.1. Therefore, the **sensitivity of receptors** is considered to be '**High**'.

Small spills such as those that may result from collisions of vessels using Stanley Harbour are likely to have a short-term, rapidly reversible impact on the local ecosystem and species. Nonetheless, the loss of up to 320 m^3 of fuel would warrant an immediate local oil spill response and therefore the severity of a collision between vessels that resulted in a significant oil spill is considered to be '**Serious**'.

Therefore, the overall **significance of impact** is '**High (16)**'.

As described in section 12.3.5.3, numerous barriers will be in place to prevent collisions between vessels within Stanley Harbour such that the likelihood of collisions involving vessels supporting the Phase 1 Development will be minimised as far as reasonably practicable. Failure of nearly all these operational controls would be required for a collision to occur and therefore the **likelihood** of a collision involving vessels associated with the Phase 1 Development that resulted in a significant oil spill is considered to be '**Very Unlikely**'.

Therefore, the **overall risk associated** with the major diesel spills resulting from a collision involving one or more vessels associated with Premier's operations is '**Low (5)**'.

12.3.7 Project-specific mitigation measures

With the exception of the presence and use of spill kits, the majority of in the industry-standard mitigation measures are based around the prevention of spills occurring. There is not a great deal more which could be put in place to prevent the occurrence of incidents. However, as part of the overall spill risk assessment for the Phase 1 Development, and in particular the inshore oil export operation, numerous spill response measures will be in place to minimise the consequence of a spill should it occur. This equipment will be stored in Stanley and will be available for use, where appropriate, in the event of at-shore incidents.

12.3.7.1 Response options available for all at-shore oil and chemical spills

In the unlikely event of a spill in Stanley Harbour, the main response to spilled diesel or chemicals would be to use absorbent materials to contain and collect the spill.

In the event of a larger spill, booms will be deployed to contain the spill to allow recovery and prevent contamination of the shore. Once corralled, sorbents will be used to soak up the hydrocarbons. It may also be possible to use an oil skimmer to recover the spill from the sea's surface. Dispersants are not included here as they would not be considered an appropriate response for chemical or diesel spills in shallow water, such as around Stanley Harbour.

Shorelines may also be boomed, but if the spill impacts the shoreline, personnel may be required to physically remove diesel / chemical deposits from the shoreline using hand tools. However, it should be noted that this is only a viable response option if the safety of personnel is assured and the response will be more effective than allowing the spill to breakdown naturally.

It will always be necessary to monitor the extent of the spill as far as possible from the shore and using boats in the area, and to inform the local authorities of the spill (PON 8) and the planned response.

12.3.7.1.1 Equipment List

The following spill response equipment will be available in Stanley Harbour:

- Oil skimmer with diesel pump and hoses;
- 400 m inshore boom;
- One x 10 m^3 oil water storage tank with groundsheet and cover;
- Seven fish totes containing 2,000 pads and heavy duty waste bags;
- Chemical Sorbent spill kits (stored in wheeled totes);
- Sealed plastic fish tote with spare hand tools, basic Personal Protective Equipment (PPE) and signage;
- 10 flexible IBCs;
- Pressure washer;
- Oil snare and oil snare on rope;
- Steam generator;
- Two trailers;

- A fast response rigid inflatable bost (RIB) which will have oil recovery equipment on board for boom deployment and support will be based in Stanley;
- FIPASS spill response equipment (mobilised and managed by FIG).

12.3.8 Residual impacts and risks

With industry-standard mitigations in place, the significance of the risk associated with at-shore and onshore oil and chemical spills is generally '**Low**' or '**Very Low'**. The exception is:

- The risk of small spills and leaks during day-to-day operations which is considered to be '**Moderate**' as this is the most likely source of oil or chemicals escaping into the environment.

The project-specific spill response options described above will not make any difference to the potential for chronic impacts from small spills or leaks as they would not warrant the deployment of OSR equipment. However, the equipment may serve to reduce the consequence of at-shore chemical spills from the TDF, due to enhanced clean-up capability, thus reducing the severity of the impact should they occur. When the impact assessment of the latter is carried out taking the project-specific mitigation measures into account, the severity of effect of spills from day-to-day operations can be reduced to '**Slight**' such that the residual impact and the overall risk is reduced to '**Low (6)**'.

12.3.9 Cumulative impact

Although the TDF is reserved for O&G activities, throughout the life of the Phase 1 Development many other users of the sea will be operating within Stanley Harbour. Many of these vessels will also be taking on fuel at FIPASS and will be required to safely navigate through inshore waters.

The presence of O&G vessels and activity will increase the number of fuel transfers within the Harbour (Increased concentration, section 8.9.2). Premier's activity will add to the potential sources of fuel and chemical spills occupying the same 'space' consecutively or soon after each other. This may increase the 'duration' of exposure for the same receptors and / or the 'extent and proportion' (section 8.10.1) of the local or regional population at risk. However, the O&G industry will also bring many benefits in terms of harbour management and response capability and therefore the cumulative impact of Premier's activities within Stanley Harbour is likely to be beneficial.

12.3.10 Confidence

Stanley Harbour has been the focus of vessel activity for many years. Although there isn't an official record of incidents involving fuel spills or vessel collisions / groundings, collective memory indicates that these are rare events that have not resulted in significant environmental impact over the past 20 years or so. Additionally, the use of the TDF during the 2015 exploration campaign means that procedures have been developed and implemented and will be refined to meet the requirements of the Phase 1 Development. The history of O&G activity within the Harbour is such that confidence in the assessment of at-shore oil spills is considered to be '**Certain**'.

In contrast, while there have been no chemical spills to sea to date during the O&G activities (as is reflected in the likelihood of chemical spills (section 12.3.6.2.2), the current uncertainty over the specific chemicals which will be used is such that the severity of effect of chemical spills is based on assumptions. Therefore, the confidence in the assessment of at-shore chemical spills is considered to be '**Probable**'.

12.3.10.1 Monitoring required

Monitoring will be carried out in the event of any oil or chemical spill. All monitoring requirements agreed by Premier and FIG will be recorded and managed via the project-specific Phase 1 Environmental Monitoring and Management Plan (EMMP) (Chapter 15).

12.3.11 Offsetting

As no residual impacts or risks identified in this section are considered significant, i.e. Moderate or above, offsetting is not considered (see section 8.9).

12.3.12 Findings summary

Table 12.41: Summary of the risk assessment of leaks and spills at the TDF, FIPASS and the onshore supply base

Activity / Event	Aspect	Potential Impact	Type of Activity	Stage of operation	Sensitivity [a]	Severity [a]	Likelihood [a]	Impact / Risk Significance[a] Initial	Impact / Risk Significance[a] Residual	Confidence	Mitigation / Prevention / Control
At-shore spills of liquid fuel and chemicals	Small leak / spill during day-to-day operations	Pollution of Stanley Harbour through spills and leaks with the potential to impact several species of local conservation concern	Unplanned	1, 2 & 3	High	Minor	Possible	**Moderate (9)**	**Low (6)**	**Certain**	**Industry-standard:** Use of MMS; Use of standard operating procedures; Task specific planning, risk assessments etc.; Use of all emergency response plans e.g. FEPRP, OSCP, NOSCP, HCMP; Use of engineering controls e.g. dry-break couplings; Training and spill kits; and Management of vessel movements. **Project-specific:** On site OSR equipment.
	Spill or diesel fuel during bulk transfer at the TDF and / or FIPASS		Accidental		High	Minor	Unlikely	**Low (6)**	n/a	**Certain**	
	Spill of chemical during bulk transfer at the TDF				High	Minor	Unlikely	**Low (6)**	n/a	**Probable**	
	Spill of diesel fuel due to collision or grounding during vessel approach				High	Serious	Very unlikely	**Low (5)**	n/a	**Certain**	
Spill of chemical at onshore	Spill of chemicals to soil	Potential for impact to soil quality and / or	Accidental		Very Low	Slight	Possible	**Very Low (3)**	n/a	**Certain**	**Industry-standard:** Bunded storage sites;

supply base	Spill of chemical to soil or sea associated with a major accident	pollution of Stanley Harbour			Very Low	Slight	Unlikely	**Very Low (2)**	n/a	**Certain**	Double drainage in hazardous areas; Tank inspection; and Training and use of spill kits. **Project-specific:** None proposed.

a See Chapter 8 for definitions of sensitivity, severity, likelihood and significance.

13 IMPACT INTERACTIONS

Table of Contents

13.1 Introduction

Within each impact and risk assessment chapter, consideration was given to the potential for the cumulative effects of each aspect of the Development. These qualitative assessments explored the cumulative impacts that may result if a similar activity was to occur at the same time in the same place, nearby, or just before or after the Premier Development activities, as described in section 8.10.1. For example, the assessment of the cumulative impact of underwater noise on marine mammals takes account of the noise generated by Premier vessels along with that generated by other vessels.

As is detailed in section 8.10.2 however, impact interactions can also occur. Impact interactions refer to the potential for one impact upon one receptor to be 'additive or synergistic' or 'cancelling or ameliorative' to the impact upon another.

For example, interactions which may exacerbate the impacts of different activities could include the following:

- Where artificial lights on the FPSO / MODU attract plankton, and therefore fish and cephalopods (section 10.1), these may in turn attract marine mammals to feed. Increased proximity to the FPSO / MODU may then make the marine mammal more vulnerable to the impact of underwater noise (section 10.4); or
- Where macerated food waste (section 10.7) and / or artificial light (section 10.1) attract birds to the MODU / FPSO / vessels, the birds may be more susceptible to collision with the vessel / or to oiling should this coincide with a time when an unplanned process upset means that the Produced Water Re-Injection (PWRI) system is down and produced water is being discharged (section 10.7) or a small spill has occurred (section 12.1).

Impact interactions of any kind are very difficult to quantify and assess, particularly when factoring in the potential for unplanned or accidental events. The number of variables, the extent of the unknowns and the inevitable 'what if' element, ultimately make it difficult to carry out an assessment.

Therefore, this chapter aims only to provide an indication of the potential for impact interactions with a view to informing the Environmental Monitoring and Management Plan (EMMP) as described in Chapter 15.

13.2 Indication of impact interactions

Table 13.1 provides a basic indication of the number of impact interactions that may occur throughout the Sea Lion Development, including both planned, and unplanned events. Each 'receptor' row indicates all the aspects which may be impacted by it. For example, seabirds may be impacted in various ways by six aspects associated with planned activities, and by four aspects associated with unplanned activities, giving a total of ten ways this receptor could be impacted. This highlights both the number of ways in which the receptor, e.g. seabirds, could be impacted and gives an indication of where impact interactions may occur i.e. by a combination of any of these factors. Table 13.1 illustrates that there is the greatest potential for planned and unplanned impact interactions to the human population, fish / cephalopods, seabirds, marine mammals and the seabed.

PremierOil

Table 13.1: The number of ways receptors could be impacted and impact interactions that may occur for each receptor

Receptor	Aspects associated with planned activities														Aspects associated with unplanned and accidental events							Total number of ways receptor could be impacted
	Environmental									Social				Number of ways receptor could be impacted	Environmental and social						Number of ways receptor could be impacted	
	Use of artificial light	Onshore disturbance from helicopters	Disturbance to seabed / placement of objects	Underwater noise	Drilling mud and cuttings	Operational discharges to sea	Thermal discharges to sea	Atmospheric emissions (climatic factors)	Management of solid waste	Increased vessel presence, subsea presence, exclusion zones	Competition for onshore resources	Nuisance factors to humans	Localised emissions		Loss of containment of solid waste	Unplanned venting of gas	Collision with marine mammals	Non-natives - marine	Non-natives - terrestrial	Loss of containment of crude, fuel oil, or chemicals		
Human population								Y	Y	Y	Y	Y	Y	**6**	Y	Y		Y	Y	Y	**5**	**11**
Other users of the sea										Y				**1**						Y	**1**	**2**
Commercial fisheries						Y		Y		Y				**3**	Y	Y		Y		Y	**4**	**7**
Plankton	Y		Y			Y	Y	Y						**5**				Y		Y	**2**	**7**
Benthos			Y		Y	Y	Y	Y						**5**				Y		Y	**2**	**7**
Fish / cephalopods	Y		Y	Y	Y	Y	Y	Y						**7**				Y		Y	**2**	**9**
Seabirds	Y	Y		Y		Y		Y	Y					**6**	Y	Y		Y		Y	**4**	**10**
Marine mammals	Y	Y		Y		Y		Y	Y					**6**	Y		Y	Y		Y	**4**	**10**
Terrestrial flora and fauna	Y	Y						Y	Y					**4**	Y				Y		**2**	**6**
Designated sites	Y	Y						Y	Y				Y	**5**	Y				Y	Y	**3**	**8**
Biosecurity							Y			Y				**2**	Y			Y	Y		**3**	**5**

Receptor	Aspects associated with planned activities														Aspects associated with unplanned and accidental events							Total number of ways receptor could be impacted
	Environmental									Social				Number of ways receptor could be impacted	Environmental and social						Number of ways receptor could be impacted	
	Use of artificial light	Onshore disturbance from helicopters	Disturbance to seabed / placement of objects	Underwater noise	Drilling mud and cuttings	Operational discharges to sea	Thermal discharges to sea	Atmospheric emissions (climatic factors)	Management of solid waste	Increased vessel presence, subsea presence, exclusion zones	Competition for onshore resources	Nuisance factors to humans	Localised emissions		Loss of containment of solid waste	Unplanned venting of gas	Collision with marine mammals	Non-natives - marine	Non-natives - terrestrial	Loss of containment of crude, fuel oil, or chemicals		
Seabed (including soil)			Y		Y	Y		Y					Y	**5**	Y			Y	Y	Y	**4**	**9**
Water quality			Y		Y	Y	Y	Y					Y	**6**		Y				Y	**2**	**8**
Regional air quality								Y	Y	Y			Y	**4**		Y					**1**	**5**
Global atmosphere								Y	Y				Y	**3**		Y					**1**	**4**
Landscape / seascape	Y								Y	Y				**3**	Y				Y	Y	**3**	**6**
Tangible property, including livestock		Y							Y	Y	Y	Y		**5**	Y				Y	Y	**3**	**8**

14 OVERALL SUMMARY OF EIS FINDINGS

Table 14.1 presents a summary of all the impact and risk assessments above.

Table 14.1: Overall summary of EIA findings (note that, for summary purposes, the 'residual assessment' column indicates the final outcome for all impacts and risks, whether project-specific mitigations and a residual assessment were required or not)

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance	Project-specific mitigation	Residual impact / risk	Confidence
Chapter 10.1: Artificial light							
Presence of all vessels / MODU / FPSO offshore	Deck and accommodation lights, flare pilot light, and flaring during shutdowns	Planned	The use of blackout blinds in accomodation block.	Attraction of plankton, invertebrates and fish Sensitivity | Severity | Significance Very Low | Slight | Very Low (1)	Reduce light pollution by: Design (where possible and limited by safety) and auditing; Dousing of unrequired lights.	Very Low (1)	Probable
		Planned		Attraction and disorientation of seabirds Sensitivity | Severity | Significance Low | Slight | Very Low (2)		Very Low (2)	Probable
Presence of all vessels inshore		Planned		Attraction / disorientation of seabirds inshore Sensitivity | Severity | Significance High | Slight | Low (4)		Low (4)	Probable
Small scale bird-strike with vessel / MODU / FPSO or flare		Unplanned		Injury or fatality to single / handful of birds Impact | Likelihood | Significance Very low (2) | Likely | Low (4)		Low (4)	Probable
Large scale bird-strike with vessel / MODU / FPSO or flare		Unplanned		Injury or fatality to multiple (dozens) birds Impact | Likelihood | Significance Moderate (6) | Possible | Moderate (9)		Moderate (9)	Probable
Small scale bird collision inshore		Unplanned		Injury or fatality to single / handful of birds Impact | Likelihood | Significance Low (4) | Likely | Moderate (8)		Moderate (8)	Probable
		Unplanned		Injury or fatality to multiple (dozens) birds		Moderate (9)	Probable

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance			Project-specific mitigation	Residual impact / risk	Confidence
Large scale bird collision inshore				Impact	Likelihood	Significance			
				Moderate (8)	Possible	Moderate (9)			
Chapter 10.2: Onshore disturbance to wildlife from helicopter operations									
Helicopter use	Noise disturbance to wildlife	Planned	FILFH	Impacts to breeding and moulting seabirds and marine mammals			None proposed	Low (4)	Certain
				Sensitivity	Severity	Significance			
				Low	Minor	Low (4)			
Chapter 10.3: Disturbance to the seabed / placement of objects									
Placement of objects on the seabed	Installation of mooring systems, SPS and SURF at Sea Lion Field	Planned	Good operational practise to minimise anchor scarring; Marine growth removal; Inspection of marine growth during seabed surveys / inspections; and Reporting and retrieval of dropped objects.	Disturbance to the benthos and habitats			None proposed	Very Low (1)	Probable
				Sensitivity	Severity	Significance			
				Very Low	Slight	Very Low (1)			
		Planned		Habitat modification and marine growth on articial substrate				Low (3)	Probable
				Sensitivity	Severity	Significance			
				Very Low	Moderate	Low (3)			
	Installation of oil spill response equipment and floating logistics vessel anchors in Berkeley Sound	Planned		Disturbance to the benthos and habitats				Very Low (3)	Probable
				Sensitivity	Severity	Significance			
				Moderate	Slight	Very Low (3)			
		Planned		Habitat modification and marine growth on articial substrate				Very Low (3)	Probable
				Sensitivity	Severity	Significance			
				Moderate	Slight	Very Low (3)			
		Unplanned		Disturbance to the seabed and benthos				Very Low (2)	Probable

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance			Project-specific mitigation	Residual impact / risk	Confidence
Dropped objects	Loss of equipment or infrastructure			Impact	Likelihood	Significance			
				Very Low (1)	Unlikely	Very Low (2)			
Chapter 10.4: Underwater noise offshore									
Underwater piling noise	Impulse high intensity noise	Planned	JNCC guidelines will be followed, including: Dedicated Marine Mammal Observers (MMO); Soft-start to piling operations; Passive Acoustic Monitoring (PAM) in low visibility; and Acoustic Deterrent Devices (ADD).	Injury to invertebrates and fish			None proposed	Low (4)	Probable
				Sensitivity	Severity	Significance			
				Low	Minor	Low (4)			
		Planned		Injury to seabirds				Low (4)	Probable
				Sensitivity	Severity	Significance			
				High	Slight	Low (4)			
		Planned		Injury to marine mammals				Low (4)	Probable
				Sensitivity	Severity	Significance			
				High	Slight	Low (4)			
		Planned		Behavioural disturbance to marine mammals				Low (4)	Probable
				Sensitivity	Severity	Significance			
				High	Slight	Low (4)			
Underwater vessel noise	Continuous moderate intensity noise	Planned	No	Injury to invertebrates and fish			None proposed	Very Low (2)	Uncertain
				Sensitivity	Severity	Significance			
				Low	Slight	Very Low (2)			
		Planned		Injury to seabirds				Low (4)	Uncertain
				Sensitivity	Severity	Significance			
				High	Slight	Low (4)			
		Planned		Behavioural disturbance to marine mammals				Moderate (8)	Uncertain

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance			Project-specific mitigation	Residual impact / risk	Confidence
				Sensitivity	Severity	Significance			
				High	Minor	Moderate (8)			
Chapter 10.5: Underwater noise inshore									
Vessel operations within Berkeley Sound	Intermittent moderate intensity noise during LTV operations	Planned	None	Behavioural disturbance to invertebrates and fish			None proposed	Very Low (2)	Uncertain
				Sensitivity	Severity	Significance			
				Low	Slight	Very Low (2)			
		Planned		Behavioural disturbance to seabirds				Low (4)	Uncertain
				Sensitivity	Severity	Significance			
				High	Slight	Low (4)			
		Planned		Behavioural disturbance to marine mammals				Low (4)	Uncertain
				Sensitivity	Severity	Significance			
				High	Slight	Low (4)			

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance			Project-specific mitigation	Residual impact / risk	Confidence
Chapter 10.6: Discharge of drilling mud and cuttings									
Drilling operations	Discharge of seawater and bentonite sweeps, tophole drill cuttings and thermally	Planned	Compliance with Drilling discharges to be minimised as far as possible in line with BAT;	Water quality: Suspension of particles leading to increased turbidity			None proposed	Very Low (1)	Probable
				Sensitivity	Severity	Significance			
				Very Low	Slight	Very Low (1)			

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance	Project-specific mitigation	Residual impact / risk	Confidence
	treated OBM drill cuttings	Planned	Selection of benign chemicals where possible; OBM cuttings returned to the rig and thermally treated treated to minimise oil on cuttings (aiming to exceed compliance requirements); and Post-drilling monitoring of seabed recovery.	Plankton: Reduction in the ambient light, barite particles may affect zooplankton Sensitivity: Very Low Severity: Slight Significance: Very Low (1)		Very Low (1)	Probable
		Planned		Seabed sediment: Deposition of drill cuttings modifying sediment particle size Sensitivity: Very Low Severity: Minor Significance: Very Low (2)		Very Low (2)	Probable
		Planned		Benthic fauna: Burial of benthic fauna, modification of habitat, toxicity and oxygen depletion Sensitivity: Low Severity: Moderate Significance: Moderate (6)	Continual improvement so that oil on cuttings will be minimised, as far as is possible, during drilling campaign to below a 0.5 % average	Moderate (6)	Probable
		Planned		Fish and shellfish: Suspended barite particle may affect gill structures Sensitivity: Low Severity: Minor Significance: Low (4)	None proposed	Low (4)	Probable
Chapter 10.7: Operational discharges							
Chemical discharges	Discharge of hydrotesting water, wellbore clean-up fluid,	Planned	Selection of benign chemicals where possible;	Impacts on water quality and marine organisms	None proposed	Very Low (1)	Probable

PremierOil

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance			Project-specific mitigation	Residual impact / risk	Confidence
	cooling water and hydraulic fluids		OiW target of 10-15 mg/l; RBA of PW; EI (2016) Guidance; Maintenance Management System; HSES-MS; Off spec tank; and O&G UK Well Clean-up Guidelines	Sensitivity	Severity	Significance			
				Very Low	Slight	Very Low (1)			
	PW discharge-commissioning of PWRI units	Planned		Toxic impacts on marine organisms				Low (3)	Probable
				Sensitivity	Severity	Significance			
				Very Low	Moderate	Low (3)			
PWRI malfunction / unavailability	Discharge of PW	Unplanned		Acute and chronic impacts on marine fauna				Very Low (2)	Uncertain
				Impact	Likelihood	Significance			
				Very Low (2)	Unlikely	Very Low (2)			
All MODU, FPSO and vessel activity	Discharge of waste water / food	Planned		Impacts to water quality and plankton				Very Low (1)	Certain
				Sensitivity	Severity	Significance			
				Very Low	Slight	Very Low (1)			
	Discharge of drainage / bilge water	Planned		Impacts to water quality				Very Low (1)	Certain
				Sensitivity	Severity	Significance			
				Very Low	Slight	Very Low (1)			
	Discharge of hypersaline water	Planned		Impact to benthos, flora and fauna				Very Low (1)	Certain
				Sensitivity	Severity	Significance			
				Very Low	Slight	Very Low (1)			
Off-spec discharges of bilge and drainage	Formation of a sheen	Unplanned		Contamination of seabirds				Low (4)	Probable
				Impact	Likelihood	Significance			
				Upper Moderate (15)	Very Unlikely	Low (4)			

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance			Project-specific mitigation	Residual impact / risk	Confidence
Chapter 10.8: Thermal discharges									
Heated subsea infrastructure	Radiation of heat	Planned	None	Potential impact of heat on benthic fauna			None proposed	Very Low (1)	Probable
				Sensitivity	Severity	Significance			
				Very Low	Slight	Very Low (1)			
Topside cooling process	Discharge of heated water	Planned		Potential for impacts on flora and fauna				Very Low (1)	Probable
				Sensitivity	Severity	Significance			
				Very Low	Slight	Very Low (1)			
Production from the FPSO	PW discharge (90°C) - PWRI commissioning	Planned		Potential for impacts on flora and fauna				Very Low (1)	Probable
				Sensitivity	Severity	Significance			
				Very Low	Slight	Very Low (1)			
PWRI unavailability	Discharge of PW overboard	Unplanned		Potential for impacts on flora and fauna				Very Low (3)	Certain
				Impact	Likelihood	Significance			
				Very Low (1)	Possible	Very Low (2)			
Chapter 10.9: Atmospheric emissions (climatic factors)									
Fuel combustion throughout Development	Generation of atmospheric emissions (CO_2, CH_4, N_2O, indirect NOx, SO_2, CO, VOCs)	Planned	Use of BAT in project design; Monitoring and measuring of emissions; Selection and pre-mobilisation auditing; Optimisation of operations;	Contribution to global warming			Use of EEOI in developing tanker KPIs; and Investigation of pilot-free flare design using automatic ignition systems.	Moderate (10)	Certain
				Sensitivity	Severity	Significance			
				Very High	Minor	Moderate (10)			
		Planned		Contribution to ocean acidification				Moderate (8)	Certain
				Sensitivity	Severity	Significance			
				High	Minor	Moderate (8)			
		Planned		Direct impact from acid deposition				Low (4)	Uncertain

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance			Project-specific mitigation	Residual impact / risk	Confidence
Emissions in Berkeley Sound			Management Maintenance System; SMART objectives and targets; and Ongoing ALARP reviews.	Sensitivity	Severity	Significance			
				High	Slight	Low (4)			
Fuel combustion by diesel generators at supply base	Emissions of NOx and SO_2	Planned		Direct impact from acid deposition				Low (4)	Uncertain
				Sensitivity	Severity	Significance			
				High	Slight	Low (4)			
Emergency blowdown / Venting of full HC gas blanket	Emissions of NOx, SO_2, CO, VOCs and/or CH_4	Unplanned		Incremental increase in emissions				Low (6)	Certain
				Impact	Likelihood	Significance			
				Low (5)	Possible	Low (6)			
Malfunction of HVAC and fire-fighting equipment	Venting, flaring, release of F-Gas	Unplanned		Incremental increase in emissions				Low (6)	Certain
				Impact	Likelihood	Significance			
				Low (5)	Possible	Low (6)			
Chapter 10.10: Waste generation and management									
Waste from drilling, installation and production	Use of landfill	Planned	Compliance with the Premier HSES-MS with regard to contractor management, auditing, performance monitoring and the setting of waste objectives and targets; E-Reps scheme, waste awareness training; segregated bins, signage, netting, dedicated waste laydown areas.	Use of landfill resource			Collaboration with FIG.	Moderate (8)	Probable
				Sensitivity	Severity	Significance			
				High	Minor	Moderate (8)			
Improper waste containment	Loss of containment of solid and liquid waste	Unplanned		Potential impact to landscape / seascape and human population				Low (6)	Certain
				Impact	Likelihood	Significance			
				Moderate (8)	Unlikely	Low (6)			
		Unplanned		Potential impact to wildlife				Low (6)	Certain
				Impact	Likelihood	Significance			
				Moderate (10)	Unlikely	Low (6)			

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance				Project-specific mitigation	Residual impact / risk	Confidence
					Impact	Likelihood	Significance			
Improper waste segregation	Cross-contamination of waste	Unplanned		Increased use of landfill	Low (5)	Possible	Low (6)	None proposed	Low (6)	Certain
Chapter 10.11: Collisions between vessels and marine mammals										
Presence of project vessels	Collisions en route between field and Stanley	Unplanned	None	Potential for fatal injury	Upper Moderate (12)	Unlikely	Moderate (8)	Premise of NOAA (2009) guidelines will be followed.	Low (6)	Uncertain
	Collisions inshore Berkeley Sound	Unplanned		Potential for fatal injury	Upper Moderate (12)	Unlikely	Moderate (8)		Moderate (8)	Uncertain
Chapter 10.12: Introduction of marine non-native species										
Premier in-field vessels	Introduction of non-native species by project vessels, via ballast water and biofouling Potential to have irreversible impact on biodiversity	Unplanned	Pre-selection and pre-mobilisation audits.	Potential impact on marine biodiversity	High (20)	Unlikely	Moderate (10)	Oil Companies International Marine Forum (OCIMF) Ship Inspection Report Programme (SIRE) will be applied to audit BWMP and the BFMP and all associated records ; Ballast water modelling; LTVs used as floating logistics vessels will have their hulls	Moderate (10)	Uncertain
Premier chartered coaster vessels		Unplanned		Potential impact on marine biodiversity	High (20)	Unlikely	Moderate (10)		Moderate (10)	Uncertain
Presence of Large Transport Vessels (LTV)		Unplanned		Potential impact on marine biodiversity	High (20)	Possible	Upper Moderate (15)		Moderate (10)	Uncertain

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance			Project-specific mitigation	Residual impact / risk	Confidence
Presence of third party Conventional Trading Tanker (CTT)		Unplanned		Potential impact on marine biodiversity			inspected prior to departure for the Falklands; Non-natives species monitoring programme and ballast sampling.	Upper Moderate (15)	Uncertain
				Impact	Likelihood	Significance			
				High (20)	Possible	Upper Moderate (15)			
Chapter 10.13: Introduction of terrestrial non-native species with cargo imports									
Freight arriving in the Falklands	Introduction of terrestrial non-native species	Unplanned	None	Potential impact on terrestrial biodiversity			Implementation of Project-specific Biosecurity Plan.	Upper Moderate (12)	Probable
				Impact	Likelihood	Significance			
				Upper moderate (12)	Possible	Upper Moderate (12)			
Food products arriving in the Falklands	Introduction of pathogens in Food of Animal Origin (FOAO)	Unplanned		Potential impact on agricultural livestock			Source food of animal origin from UK / EU certified sources and from within the UK / EU	Low (4)	Probable
				Impact	Likelihood	Significance			
				High (20)	Very Unlikely	Low (4)			
Chapter 11.1: Disturbance to other users of the sea offshore									
Presence of offshore development	Offshore 500 m radius Safety Zone	Planned	Exclusion zones added to admiralty charts and status issued in 'Notes to Mariners' and on radio.	Exclusion of fishing vessels and loss of catch			None proposed	Very Low (1)	Certain
				Sensitivity	Severity	Significance			
				Very Low	Slight	Very Low (1)			

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance			Project-specific mitigation	Residual impact / risk	Confidence
Interference between fishing gear and subsea infrastructure	Snagging of fishing gear	Unplanned	500 m exclusion zone; Permanent presence of ERRV; Amended Admiralty charts, AIS and radio broadcasts; and Collision risk management procedures.	Loss of fishing gear / subsea damage			None proposed	Low (6)	Probable
				Impact	Likelihood	Significance			
				Moderate (9)	Unlikely	Low (6)			
Offshore vessel collision	Third party vessel collision	Unplanned		Damage to vessel and FPSO / MODU				Low (5)	Probable
				Impact	Likelihood	Significance			
				High (20)	Very Unlikely	Low (5)			
	Infield vessel collision	Unplanned		Damage to project vessels and MODU / FPSO				Low (5)	Probable
				Impact	Likelihood	Significance			
				High (20)	Very Unlikely	Low (5)			
Chapter 11.2: Disturbance to other users of the sea inshore									
Presence of vessels	Use of amenities in Stanley Harbour	Planned	Adherence to the Stanley Harbour Management Plan.	Disruption to other users of Stanley Harbour			None proposed	Low (4)	Certain
				Sensitivity	Severity	Significance			
				Low	Minor	Low (4)			
Berkeley Sound exclusion zones	Reduction in the area available to navigating and anchoring vessels	Planned	Use of local pilots on Premier managed	Loss of potential anchorage			Briefing documents issued in the language of the Captain.	Low (4)	Probable
				Sensitivity	Severity	Significance			
				Low	Minor	Low (4)			

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance	Project-specific mitigation	Residual impact / risk	Confidence
Inshore collisions due to reduction in sea room	Temporary exclusion zone	Unplanned	vessels in Berkeley Sound; Use of exclusion zones; Amended Admiralty charts and 'notes to mariners'; Collision risk management procedures; and	Damage to vessels Impact: Moderate (12) – Likelihood: Unlikely – Significance: Low (6)		Low (6)	Probable
Collision of vessels due to addition of Phase 1 vessels	Collision in Stanley Harbour	Unplanned		Damage to vessels Impact: Moderate (6) – Likelihood: Unlikely – Significance: Low (6)		Low (6)	Probable
	Collision between third-party vessels and offshore construction vessels	Unplanned		Damage to vessels Impact: Moderate (8) – Likelihood: Unlikely – Significance: Low (6)		Low (6)	Probable
Chapter 11.3: Resource competition - Accommodation							
Need to accommodate transitory personnel	Competition with domestic housing needs	Planned	None	Reduction of available accommodation Sensitivity: Low – Severity: Slight – Significance: Very Low (2)	None proposed	Very Low (2)	Probable
Need to accommodate permanent personnel		Planned		Reduction of available accommodation Sensitivity: Low – Severity: Minor – Significance: Low (4)		Low (4)	Probable
Chapter 11.4: Resource competition - Fresh potable water							
Water use for MODU drilling and vessel top-up and for onshore yards and accomm.	Competition for water resources	Planned	End user prioritisation; Buffer tank capacity and voluntary restrictions;	Restriction of water supply and / or quality Sensitivity: Very High – Severity: Serious – Significance: High (20)	Sustainable design; and Offshore planning.	Upper Moderate (15)	Uncertain

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance			Project-specific mitigation	Residual impact / risk	Confidence
Water use for offshore vessel top-up and onshore yards and accomm.		Planned	Offshore desalination;	Restriction of water supply and / or quality				Upper Moderate (15)	Uncertain
				Sensitivity	Severity	Significance			
				Very High	Moderate	Upper Moderate (15)			
Supplementary impact assessment of freshwater use assuming use of FIG 'workarounds'									
Water use for MODU drilling & vessel top-up and onshore yards and accomm.	Competition for water resources	Planned	End user prioritisation.	Restriction of water supply and / or quality			Mitigations outwith Premier's control: Capacity increase (FIG); and Mains upgrade (FIG/Premier).	Moderate (8)	Uncertain
				Sensitivity	Severity	Significance			
				HIgh	Minor	Moderate (8)			
Chapter 11.5: Resource competition - Electricity									
Daytime electricity use by TDF, yards, accomm. and heli ops	Competition with domestic energy needs	Planned	None	Overloading of current capacity and need for use of stand-by generators			Sustainable design; and Off-peak power utilisation.	Upper Moderate (12)	Uncertain
				Sensitivity	Severity	Significance			
				High	Major	High (20)			
Night-time use of above plus shore-power hook-up of vessels at TDF		Planned		Overloading of current capacity and need for use of stand-by generators			Monitoring of noise levels to determine need for shore-power hook-up by vessels.	Low (3)	Uncertain
				Sensitivity	Severity	Significance			
				Moderate	Minor	Moderate (6)			
Chapter 11.6: Resource competition - Air links									
International movement of personnel to and from the Falkland Islands	Air-link resource competition for seat availability	Planned	None	Lack of seat availability of seats			The base case dedicated regular charter flight will be sufficient to meet all personnel travel requirements.	Low (4)	Certain
				Sensitivity	Severity	Significance			
				High	Slight	Low (4)			
		Planned		Potential for extra seat availability				Beneficial	Uncertain

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance	Sensitivity	Severity	Significance	Project-specific mitigation	Residual impact / risk	Confidence
	Additional air-link to the Falkland Islands				n/a	n/a	Beneficial			
Chapter 11.7 Resource competition - Road Network										
Use of existing road network	Increased number of vehicles and use of infrastructure	Planned	Adherence to vehicle and road statutory requirements. Specific applications for abnormal road movements including signage and warning devices. Strict HSE driving policy, risk assessment and local training. All non-critical activities coordinated to avoid peak periods.	Potential for nuisance to human population	Moderate	Minor	Moderate (6)	Traffic Management Plan. Accommodation with off-street parking will be a preference.	Moderate (6)	Probable
Use of existing road network	Increased number of vehicles and use of infrastructure	Planned	(as above)	Degradation of road surfaces	Low	Minor	Low (4)	(as above)	Low (4)	Probable
Chapter 11.8: Disturbance to the human population - Light										
Operations at the TDF and supply base	Vessel, TDF and yard lighting	Planned	Good working practice and design; and Black-out blinds for the vessel accommodation sections.	Annoyance, sleep disturbance	Moderate	Minor	Moderate (6)	Deck lights and yard lights will face inwards; Vessel lights to be turned off when not required, particularly deck lighting, TDF offices and yard offices;	Moderate (6)	Probable
Inshore operations	Deck and accommodation lights	Planned	(as above)	Annoyance, sleep disturbance, impairment of dark skies	Moderate	Minor	Moderate (6)	(as above)	Moderate (6)	Probable
Chapter 11.9: Disturbance to the human population - Noise										

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance			Project-specific mitigation	Residual impact / risk	Confidence
Helicopter use for crew changes and SAR test flights	Disturbance to human population	Planned	Use of specific flight plan in line with the flight avoidance map as the basis for flight planning, following the Falkland Islands Low Flying Handbook Guidance (FILFH, 2015).	Annoyance, sleep disturbance			Optimising design and management to minimise noise; Equipment specific noise mitigations; Activity restrictions; and Potential vessels hook-up to TDF at night.	Low (4)	Probable
				Sensitivity	Severity	Significance			
				Low	Minor	Low (4)			
	Noise disturbance to livestock	Planned		Stress, reduced lambing success				Low (4)	Certain
				Sensitivity	Severity	Significance			
				Low	Minor	Low (4)			
Operations at the TDF and supply base	Noise at the TDF, reversing alarms and yard activities	Planned	Compliance with noise guidelines.	Annoyance, sleep disturbance				Very Low (3)	Probable
				Sensitivity	Severity	Significance			
				Moderate	Minor	Moderate (6)			
Inshore operations	Noise from pumps, vessel engines and vessel loading	Planned		Annoyance, sleep disturbance				Moderate (9)	Probable
				Sensitivity	Severity	Significance			
				Moderate	Moderate	Moderate (9)			
				Sensitivity	Severity	Significance			
				Low	Slight	Very Low (2)			
Chapter 11.11: Disturbance to the human population – Visual impact									
Inshore operations	Visual disturbance, annoyance	Planned	None	Visual disturbance, annoyance			None proposed	Very Low (2)	Probable
				Sensitivity	Severity	Significance			
				Low	Slight	Very Low (2)			
Chapter 11.12: Regional and local air quality									
	Emissions of CO_2, O2, N2,	Planned		Degradation of local air quality			None proposed	Very Low (3)	Probable

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance			Project-specific mitigation	Residual impact / risk	Confidence
Use of diesel generators at supply base	water, dioxins and furans, NOx, SOx, CO and PM in the form of dust		Use of BAT in project design; Monitoring and measuring of emissions; Selection and pre-mobilisation auditing; Optimisation of operations; Management Maintenance System; SMART objectives and targets; and Ongoing ALARP reviews.	Sensitivity	Severity	Significance			
				Moderate	Slight	Very Low (3)			
Combustion by vessels during inshore operations	Emissions of NOx, SOx, CO and PM	Planned		Degradation of local air quality				Very Low (2)	Certain
				Sensitivity	Severity	Significance			
				Very Low	Minor	Very Low (2)			
Use of MPC road	Emissions of Particulate Matter	Planned		Degradation of local air quality with PM				Very Low (1)	Certain
				Sensitivity	Severity	Significance			
				Very Low	Slight	Very Low (1)			

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance			Project-specific mitigation	Residual impact / risk	Confidence
Chapter 12.1: Offshore accidental and chronic discharges of crude oil and diesel									
Well drilling and production	Scenario 1: Subsea well blow-out	Accidental	Use of standard operating procedures; Compliance with HSE MS and Drilling Management System; SECE Register and performance standards; Primary and secondary well control; Development and implementation of the OSCP; Use of a well capping device.	Toxic effects on Plankton			Additional oil spill recovery equipment on support vessels.	Low (6)	Uncertain
				Impact	Likelihood	Significance			
				Moderate (9)	Unlikely	Low (6)			
		Accidental		Toxic effects on Benthos				Low (6)	Uncertain
				Impact	Likelihood	Significance			
				Moderate (4)	Unlikely	Low (6)			
		Accidental		Toxic effects on Fish and squid				Low (6)	Uncertain
				Impact	Likelihood	Significance			
				Moderate (9)	Unlikely	Low (6)			
		Accidental		Tainting of fish / contamination of fishing grounds				Moderate (10)	Uncertain
				Impact	Likelihood	Significance			
				High (20)	Unlikely	Moderate (10)			
		Accidental		Contamination / oil ingestion by seabirds				Moderate (10)	Uncertain
				Impact	Likelihood	Moderate (10)			
				High (20)	Unlikely	Moderate (10)			
		Accidental		Contamination / oil ingestion by marine mammals				Moderate (8)	Uncertain
				Impact	Likelihood	Significance			
				Upper Moderate (12)	Unlikely	Moderate (8)			

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance			Project-specific mitigation	Residual impact / risk	Confidence
		Accidental		Impact on coastal ecology				Moderate (8)	Uncertain
				Impact	Likelihood	Significance			
				Upper Moderate (12)	Unlikely	Moderate (8)			
		Accidental		Negative publicity impacting on tourism				Moderate (10)	Uncertain
				Impact	Likelihood	Significance			
				High (16)	Unlikely	Moderate (10)			
Catastrophic loss of the FPSO	Scenario 2: loss of the full FPSO crude oil inventory	Accidental	SECE Register, HSE MS and performance standards; A 500 m radius Safety Zone; A ERRV vessel; AIS and Radar surveillance; Radio broadcasts; and Development and implementation of the OSCP.	Toxic effects on Plankton			Additional oil spill recovery equipment on support vessels.	Very Low (3)	Uncertain
				Impact	Likelihood	Significance			
				Moderate (9)	Very Unlikely	Very Low (3)			
		Accidental		Toxic effects on Benthos				Very Low (3)	Uncertain
				Impact	Likelihood	Significance			
				Moderate (4)	Very Unlikely	Very Low (3)			
		Accidental		Toxic effects on Fish and squid				Very Low (3)	Uncertain
				Impact	Likelihood	Significance			
				Moderate (9)	Very Unlikely	Very Low (3)			
		Accidental		Tainting of fish / contamination of fishing grounds				Low (5)	Uncertain
				Impact	Likelihood	Significance			
				High (20)	Very Unlikely	Low (5)			

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance			Project-specific mitigation	Residual impact / risk	Confidence
		Accidental		Contamination / oil ingestion by seabirds				Low (5)	Uncertain
				Impact	Likelihood	Significance			
				High (20)	Very Unlikely	Low (5)			
		Accidental		Contamination / oil ingestion by marine mammals				Low (4)	Uncertain
				Impact	Likelihood	Significance			
				Upper Moderate (12)	Very Unlikely	Low (4)			
		Accidental		Impact on coastal ecology				Low (4)	Uncertain
				Impact	Likelihood	Significance			
				Upper Moderate (12)	Very Unlikely	Low (4)			
		Accidental		Negative publicity impacting on tourism				Low (5)	Uncertain
				Impact	Likelihood	Significance			
				High (16)	Very Unlikely	Low (5)			
Offshore transfer of crude from the FPSO to the CTT	Scenario 3: Crude oil transfer spill	Accidental	SECE Register, HSE MS and performance standards; Pipelines will be protected by pressure alarms; A leak detection system will be fitted; Dry break couplings;	Toxic effects on Plankton			Additional oil spill recovery equipment on support vessels.	Very Low (3)	Uncertain
				Impact	Likelihood	Significance			
				Very Low (2)	Possible	Very Low (3)			
		Accidental		Toxic effects on Fish and squid				Very Low (3)	Uncertain
				Impact	Likelihood	Significance			
				Very Low (3)	Possible	Very Low (3)			

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance	Impact	Likelihood	Significance	Project-specific mitigation	Residual impact / risk	Confidence
		Accidental	Development and implementation of the OSCP.	Tainting of fish / contamination of fishing grounds	Low (4)	Possible	Low (6)		Low (6)	Uncertain
		Accidental		Contamination / oil ingestion by seabirds	Moderate (10)	Possible	Moderate (9)		Moderate (9)	Uncertain
		Accidental		Contamination / oil ingestion by marine mammals	Very Low (3)	Possible	Very Low (3)		Very Low (3)	Uncertain
		Accidental		Negative publicity impacting on tourist numbers	Moderate	Possible	Moderate (9)		Moderate (9)	Uncertain
Catastrophic event leading to the loss of the MODU or FPSO	Scenario 4: Loss of MODU / FPSO full diesel inventory	Accidental	SECE Register, HSE MS and performance standards; A 500 m radius Safety Zone; A ERRV vessel; AIS and Radar surveillance;	Toxic effects on Plankton	Low (4)	Unlikely	Very Low (4)	Additional oil spill response equipment on support vessels.	Very Low (4)	Probable
		Accidental		Toxic effects on Fish and squid					Very Low (4)	Probable

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance			Project-specific mitigation	Residual impact / risk	Confidence
			Radio broadcasts; and	Low (4)	Unlikely	Very Low (4)			
		Accidental	Development and implementation of the OSCP.	Tainting of fish / contamination of fishing grounds				Low (6)	Probable
				Impact	Likelihood	Significance			
				Moderate (6)	Unlikely	Low (6)			
		Accidental		Contamination / oil ingestion by seabirds				Moderate (8)	Probable
				Impact	Likelihood	Significance			
				Upper Moderate (15)	Unlikely	Moderate (8)			
		Accidental		Contamination / oil ingestion by marine mammals				Low (6)	Probable
				Impact	Likelihood	Significance			
				Moderate (8)	Unlikely	Low (6)			
		Accidental		Negative publicity impacting on tourism				Moderate (8)	Probable
				Impact	Likelihood	Significance			
				Upper Moderate (12)	Unlikely	Moderate (8)			
Offshore transfer of diesel fuel	Scenario 5: Diesel bunkering spill	Accidental	SECE Register, HSE MS and performance standards; Maintenance Management System (MMS);	Toxic effects on Plankton			Additional oil spill response equipment on support vessels.	Very Low (3)	Probable
				Impact	Likelihood	Significance			
				Very Low (2)	Possible	Very Low (3)			
		Accidental		Toxic effects on Fish and squid				Very Low (3)	Probable
				Impact	Likelihood	Significance			

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance			Project-specific mitigation	Residual impact / risk	Confidence
			Use of spill kits for spills to deck; Development and implementation of the OSCP; Bunding of all liquid containing equipment and chemicals; Open deck drains to catch and collect spills to a dedicated slop tank; and High level tank filling alarm and emergency shutdown of the process.	Very Low (2)	Possible	Very Low (3)			
		Accidental		Tainting of fish / contamination of fishing grounds				Very Low (3)	Probable
				Impact	Likelihood	Significance			
				Very Low (2)	Possible	Very Low (3)			
		Accidental		Contamination / oil ingestion by seabirds				Moderate (9)	Probable
				Impact	Likelihood	Significance			
				Moderate (10)	Possible	Moderate (9)			
		Accidental		Contamination /oil ingestion by marine mammals				Low (6)	Probable
				Impact	Likelihood	Significance			
				Low (4)	Possible	Low (6)			
		Accidental		Negative publicity impacting on tourist numbers				Low (6)	Probable
				Impact	Likelihood	Significance			
				Low (4)	Possible	Low (6)			
Small scale spills and releases	Development of an oily sheen on the water	Unplanned		Potential for the formation of oily sheens, which can lead to the oiling of seabirds				Moderate (9)	Probable
				Impact	Likelihood	Significance			
				Moderate (10)	Possible	Moderate (9)			
Riser disconnect	Loss of riser contents to sea	Unplanned	Compliance with HSE MS and Premier Drilling Management System.	Smothering and toxic effects on benthos and seabed			Additional oil spill response equipment on support vessels	Low (6)	Probable
				Impact	Likelihood	Significance			

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance			Project-specific mitigation	Residual impact / risk	Confidence
				Moderate (6)	Unlikely	Low (6)			
Chapter 12.2: Inshore oil spill									
MGO Spill during fuel bunkering	Scenario 1: 10 tonne MGO spill	Accidental	Limiting operational criteria; Standard operational procedures; Development and implementation of the OSCP. Tug assist during manoeuvring	Toxic effects on Plankton			Clear manoeuvring and approach channel; Operational limits defined and implemented; Development and implementation of bunkering procedures with fuel supplier to ensure corporate standards of operational safety are maintained; Bunkering conducted within the 500 m LTV exclusion zone, or other defined area; Development and implementation of the OSCP; and On-site OSR capability.	Low (6)	Uncertain
				Impact	Likelihood	Significance			
				Moderate	Unlikely	Low (6)			
		Accidental		Toxic effects on Marine flora (kelp)				Low (6)	Uncertain
				Impact	Likelihood	Significance			
				Moderate	Unlikely	Low (6)			
		Accidental		Toxic effects on Benthic communities				Low (6)	Uncertain
				Impact	Likelihood	Significance			
				Moderate	Unlikely	Low (6)			
		Accidental		Toxic effects on Fish and squid				Moderate (8)	Uncertain
				Impact	Likelihood	Significance			
				High	Unlikely	Moderate (8)			
		Accidental		Tainting of fish / contamination of fishing grounds				Moderate (8)	Uncertain
				Impact	Likelihood	Significance			
				High	Unlikely	Moderate (8)			
		Accidental		Contamination / oil ingestion by seabirds				Moderate (10)	Uncertain
				Impact	Likelihood	Significance			
				High	Unlikley	Moderate (10)			
		Accidental		Contamination / oil ingestion by marine mammals				Moderate (10)	Uncertain

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance			Project-specific mitigation	Residual impact / risk	Confidence
				Impact	Likelihood	Significance			
				High	Unlikely	Moderate (10)			
		Accidental		Coastal communities				Low (6)	Uncertain
				Impact	Likelihood	Significance			
				High	Unlikely	Low (6)			
		Accidental		Negative publicity impacting tourist numbers				Low (6)	Uncertain
				Impact	Likelihood	Significance			
				Moderate	Unlikely	Low (6)			
Vessel collision / grounding leading to MGO Spill in Berkeley Sound	Scenario 2: 3,700 tonne MGO spill	Accidental	Limiting operational criteria; Standard operational procedures; Development and implementation of the OSCP.	Toxic effects on Plankton			Clear manoeuvring and approach channel; Operational limits defined and implemented; Development and implementation of bunkering procedures with fuel supplier to ensure corporate standards of operational safety are maintained; Bunkering conducted within the 500 m LTV exclusion zone, or other defined area; Development and implementation of the OSCP; and	Low (6)	Uncertain
				Impact	Likelihood	Significance			
				Moderate	Unlikely	Low (6)			
		Accidental		Toxic effects on Marine flora (kelp)				Low (6)	Uncertain
				Impact	Likelihood	Significance			
				Moderate	Unlikely	Low (6)			
		Accidental		Toxic effects on Benthic communities				Low (6)	Uncertain
				Impact	Likelihood	Significance			
				Moderate	Unlikely	Low (6)			
		Accidental		Toxic effects on Fish and squid				Moderate (8)	Uncertain
				Impact	Likelihood	Significance			
				High	Unlikely	Moderate (8)			
		Accidental		Tainting of fish / contamination of fishing grounds				Moderate (8)	Uncertain
				Impact	Likelihood	Significance			

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance			Project-specific mitigation	Residual impact / risk	Confidence
				High	Unlikely	Moderate (8)	On-site OSR capability.		
		Accidental		Contamination / oil ingestion by seabirds				Moderate (10)	Uncertain
				Impact	Likelihood	Significance			
				High	Unlikley	Moderate (10)			
		Accidental		Contamination / oil ingestion by marine mammals				Moderate (10)	Uncertain
				Impact	Likelihood	Significance			
				High	Unlikely	Moderate (10)			
		Accidental		Coastal communities				Low (6)	Uncertain
				Impact	Likelihood	Significance			
				High	Unlikely	Low (6)			
		Accidental		Negative publicity impacting tourist numbers				Low (6)	Uncertain
				Impact	Likelihood	Significance			
				Moderate	Unlikely	Low (6)			
Intermediate Fuel Oil (IFO) spill during fuel bunkering in Berkeley Sound	Scenario 3: 1,576 tonne IFO spill	Accidental	Limiting operational criteria; Standard operational procedures; Development and implementation of the OSCP; and Tug assist during manoeuvring.	Toxic effects on Plankton			Clear manoeuvring and approach channel; Operational limits defined and implemented; Development and implementation of bunkering procedures with fuel supplier to ensure corporate standards of	Low (6)	Uncertain
				Impact	Likelihood	Significance			
				Moderate	Unlikely	Low (6)			
		Accidental		Toxic effects on Marine flora (kelp)				Low (6)	Uncertain
				Impact	Likelihood	Significance			
				Moderate	Unlikely	Low (6)			
		Accidental		Toxic effects on Benthic communities				Low (6)	Uncertain
				Impact	Likelihood	Significance			
				Moderate	Unlikely	Moderate (8)			

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance			Project-specific mitigation	Residual impact / risk	Confidence
		Accidental		Toxic effects on Fish and squid			operational safety are maintained; Bunkering conducted within the 500 m LTV exclusion zone, or other defined area; Development and implementation of the OSCP; and On-site OSR capability.	Moderate (8)	Uncertain
				Impact	Likelihood	Significance			
				High	Unlikely	Moderate (8)			
		Accidental		Tainting of fish / fishing grounds				Moderate (8)	Uncertain
				Impact	Likelihood	Significance			
				High	Unlikely	Moderate (8)			
		Accidental		Contamination / oil ingestion by seabirds				Moderate (10)	Uncertain
				Impact	Likelihood	Significance			
				High	Unlikely	Moderate (10)			
		Accidental		Contamination / oil ingestion by marine mammals				Moderate (10)	Uncertain
				Impact	Likelihood	Significance			
				High	Unlikely	Moderate (10)			
		Accidental		Coastal communities				Moderate (8)	Uncertain
				Impact	Likelihood	Significance			
				High	Unlikely	Moderate (10)			
		Accidental		Negative publicity impacting tourist numbers				Low (6)	Uncertain
				Impact	Likelihood	Significance			
				Moderate	Unlikely	Low (6)			
Chapter 12.3: At-shore and onshore fuel oil and chemical spills									
At-shore spills of liquid fuel and chemicals	Small leak / spill during day-to-day operations	Unplanned	Compliance with legislation and Premier HSES-MS;	Pollution of Stanley Harbour			On site OSR equipment.	Low (6)	Certain
				Impact	Likelihood	Significance			

Activity / Event	Aspect	Type of activity	Industry-standard mitigation	Initial impact / risk and significance	Project-specific mitigation	Residual impact / risk	Confidence
			Compliance with MMS; Use of standard operating procedures; Task specific planning, risk assessments etc; Use of all emergency response plans e.g. FEPRP, OSCP, NOSCP, HCMP; Use of engineering controls e.g. dry-break couplings; and Use of OSR training and spill kits manage vessel movements in Stanley Harbour.	Moderate (8) | Possible | Moderate (9)			
	Spill of diesel fuel transfer at FIPASS	Accidental		Pollution of Stanley Harbour Impact | Likelihood | Significance Moderate (8) | Unlikley | Low (6)		Low (6)	Certain
	Spill of chemical transfer at the TDF	Accidental		Pollution of Stanley Harbour Impact | Likelihood | Significance Moderate (8) | Unlikley | Low (6)		Low (6)	Probable
	Spill of diesel fuel due to vessel collision or grounding during approach	Accidental		Pollution of Stanley Harbour Impact | Likelihood | Significance High (16) | Very Unlikely | Low (5)		Low (5)	Certain
Spill of chemical at onshore supply base	Spill of chemicals to soil	Accidental	Bunded storage sites; Double drainage; Tank inspection;and Training and use of spill kits.	Potential for impact to soil quality Impact | Likelihood | Significance Very Low (1) | Possible | Very Low (3)	None proposed	Very Low (3)	Certain
	Spill of chemical to soil or sea assocaited with a major accident	Accidental		Potential for impact to soil quality and / or pollution of Stanley Harbour Impact | Likelihood | Significance Very Low | Unlikely | Very Low (2)		Very Low (2)	Certain

15 OUTLINE ENVIRONMENTAL MONITORING & MANAGEMENT PLAN (EMMP)

Table of Contents

15.1 Introduction

The Environmental Management and Monitoring Plan (EMMP), has the purpose of detailing the actions / plans required to:

- Measure and monitor the impacts (primarily the 'Severity of Effect') of the Development;
- Check the efficacy of the project-specific mitigations in place; and
- Address uncertainties, such as spatial / temporal data gaps, to increase the level of confidence in the impact / risk assessment.

Should the monitoring of impacts indicate that the significance of the impacts and risks predicted in the EIS are not appropriate, and / or that mitigation is not effective, a revised mitigation measure and / or monitoring regime will be required.

The EMMP will framework specific monitoring and management plans for those issues where:

- the initial impact was assessed as 'Significant' *and* the confidence in the assessment was assessed as either 'Probable' or 'Uncertain', or when
- the sensitivity of a receptor was assessed as 'High' or 'Very High' *and* the confidence in the assessment was assessed as either 'Probable' or 'Uncertain'.

These monitoring, mitigation, survey and research actions are noted in each assessment chapter and are collated below in sections 15.4, 15.5 and 15.7;

Premier has developed an EMMP strategy and will collaboratively work with FIG to identify how the EMMP may be jointly best managed. An integral part of the EMMP development process was an EMMP workshop (see below).

Once the FDP has been approved and the project has been sanctioned, the EMMP will be transferred into a live document which will provide detail on:

- Specific roles and responsibilities;
- Timelines, deadlines and 'frequency of execution' for actions identified; and
- Progress and completion for use throughout the life of the field.

Premier oil will continue the following studies in addition to the EMMP:

- Bird surveys and intertidal mapping within Berkeley Sound;
- Testing adherence of Sea Lion crude to feathers and fur;
- Invasive species monitoring in Berkeley Sound; and
- Squid (loligo) spawning investigation.

15.2 EMMP Workshop

A workshop to consider the contents of an Environmental Monitoring and Management Plan (EMMP) to accompany the Sea Lion oil field Environmental Impact Statement (EIS) was held in Stanley, Falkland Islands on 23-25 April 2019. It was attended by 25 interested stakeholders, comprising FIG, PMO, industry bodies and NGOs. Consideration was given to eleven environmental impacts from the Sea Lion development where there was potentially a need for further certainty as to the actual impact. Summary EMMP tables were prepared, and reproduced herein, for seven of these impacts, namely:

- Effects on offshore benthos;
- Seabird attraction to light;
- Seabird risk from offshore oil spills;
- Effects of underwater noise on marine mammals,
- Risk of ship collision with marine mammals,
- Invasive species; and,
- Nuisance effects on humans.

Due to the change in planned nearshore activities (the elimination of inshore ship-to-ship crude oil transfers from the Field Development Plan (FDP)), the following further four impacts were considered by the workshop to be no longer be within the scope of the EMMP:

- Oil spill effects on inshore seabirds;
- Effects of underwater noise on marine mammals inshore;
- Effects on squid spawning grounds; and,
- Effects on intertidal/nearshore benthic habitats.

15.3 Scope

The EMMP will cover the activities to be undertaken as part of the construction, drilling and operational phases of the Sea Lion development project and look to manage and monitor the performance of the mitigations proposed within the EIS on the key project activities following an assessment of each aspect and impact / risk.

Where the proposed EMMP programme indicates that the mitigations/management actions proposed have not been appropriate or do not deliver the level or value expected in the impact / risk assessment, or are unnecessary, the EMMP Steering Group may assess whether a revised mitigation or measure is needed or a particular measure is no longer required.

The Monitoring and Management Programme can be split into three types of work:

- Legislative and corporate monitoring activities (section 15.4);
- Baseline data and survey work (section 15.5); and /or
- Research and studies (section 15.7).

The EMMP will also, where possible, identify the thresholds and the associated adaptive management actions.

Legislative and corporate monitoring requirements are determined by FIG or UK legislation and Premier's corporate requirements, themselves driven by:

- Premier's HSES MS being certified to ISO14001; and
- Premier's environmental reporting commitments both to the GRI and as a member of IOGP.

15.3.1 Screening

To determine whether actions over and above those stipulated by legislation or corporate governance were required, the EIS assessment results were screened for impacts and risks where:

8) The initial impact was assessed as 'Moderate', 'Upper Moderate' or 'High' *and* the confidence in the assessment was assessed as either 'Probable' or 'Uncertain'; and / or
9) The sensitivity of a receptor was assessed as 'High' or 'Very High' *and* the confidence in the assessment was assessed as either 'Probable' or 'Uncertain'.

A worked example of the screening process is provided below in Table 15.1.

Table 15.1: Example: collisions between cetaceans and an inshore vessel

Impact assessment results					
Sensitivity	**Severity**	**Likelihood**	**Initial impact assessment**	**Residual impact assessment**	**Confidence**
High	Moderate	Unlikely	Moderate (8)	Moderate (8)	Uncertain
Screening					
Is an EMMP action required for this impact /risk?					
Is initial impact / risk 'Moderate', 'Upper Moderate' or 'High' and is confidence 'Probable' or 'Uncertain'?				Yes, therefore EMMP action is required.	
Is sensitivity of receptor 'High' or 'Very High' and is confidence 'Probable' or 'Uncertain'?				Yes, therefore EMMP action is required.	

If an action is required it could lead to either further gathering of baseline data and survey effort, a requirement for further research or studies, or a management action.

All 'screened in' impacts and risks are presented below in Table 15.2 and their corresponding EMMP action referenced.

Table 15.2: Screened impacts and risks from the assessment that require EMMP action

EIS chapter	Impact / risk	Screening rationale	EMMP action
10.1 Artificial light	Risk of bird strikes offshore and inshore	Large and small scale bird collisions offshore Initial impact '**Moderate**', Confidence '**Probable**' Large and small scale bird collisions inshore: Initial impact '**Moderate**', Confidence '**Probable**'	See sections 15.6.1.1, 15.7.2.1.
10.4 Underwater noise offshore	Impact of vessel and piling noise on receptors offshore	Injury to seabirds and marine mammals and behavioural disturbance to marine mammals from piling noise Sensitivity '**High**', Confidence '**Probable**' Injury to seabirds from underwater vessel noise Sensitivity '**High**', Confidence '**Uncertain**' Behavioural disturbance to marine mammals from vessel noise Initial impact '**Moderate**', Confidence '**Uncertain**'	See sections 15.6.1.3, 15.7.3.2

EIS chapter	Impact / risk	Screening rationale	EMMP action
10.5 Underwater noise inshore	Impact of vessel noise on receptors inshore	Displacement and behavioural disturbance to seabirds and marine mammals in Berkeley Sound Sensitivity '**High**', Confidence '**Uncertain**'	See sections 15.7.3.2
10.6 Drill muds and cuttings	Impact to benthic fauna	Impact to benthic fauna Initial impact '**Moderate**', Confidence '**Probable**'	See Table 15.4 and section 15.5
10.7 Operational discharges	Risk of sheens impacting seabirds offshore	Impact of oil sheens on seabirds Sensitivity '**Very High**', Confidence '**Uncertain**'	See Table 15.4 and sections 15.6.1.5,15.7.1.1, 15.7.3.1
10.11 Marine mammal collisions	Risk of Premier vessels colliding with marine mammals offshore and inshore	Risk of vessels colliding with marine mammals Initial impact '**Moderate**', Confidence '**Uncertain**'	See sections 15.6.1.4, 15.7.3.2
10.12 Marine invasives	Risk of introducing invasives by vessels associated with the development	Introduction of invasives by Sea Lion in-field vessels and coaster vessels Initial impact '**Moderate**', Confidence '**Uncertain**' Introduction of invasives by LTVs and OSV in Berkeley Sound Initial impact '**Upper Moderate**', Confidence '**Uncertain**'	See Table 15.4 and sections 15.6.2.1, 15.7.2.2
10.13 Terrestrial non-natives	Risk of introducing invasives by air freight associated with the development	Introduction of invasives by air freight Initial impact '**Upper Moderate**', confidence '**Probable**' Introduction of pathogen species in FOAO Sensitivity '**Very High**', confidence '**Probable**'	See Table 15.4 [a]
11.4 Competition for water resources	Restriction of water supply and / or quality	Risk of restriction of water supply to the community and/or Project Initial impact '**High**' / '**Upper Moderate**', Confidence '**Uncertain**'	See Table 15.5
11.5 Competition for energy resources	Competition with domestic energy needs	Risk of overloading of current capacity and need for stand-by generators at power station Initial impact '**High**' / '**Moderate**', Confidence '**Uncertain**'	See Table 15.5
11.7 Competition for roads network	Increased number of vehicles and use of infrastructure	Potential for nuisance to human population, e.g. congestion Initial impact '**Moderate**', Confidence '**Probable**'	See Table 15.5
11.8 Disturbance to the human pop from light	Annoyance, sleep disturbance	Annoyance, sleep disturbance to Stanley residents Initial impact '**Moderate**', confidence '**Probable**' Annoyance, sleep disturbance and impairment of dark skies Initial impact '**Moderate**', confidence '**Probable**'	See Table 15.5 and section 15.6.3.1
11.9 Disturbance to the	Noise disturbance to residents and stress to livestock	Stress, reduced lambing success to livestock Initial impact '**Upper Moderate**', confidence '**Probable**'	See Table 15.5 and section 15.6.3.1

EIS chapter	Impact / risk	Screening rationale	EMMP action
human pop from noise		Annoyance, sleep disturbance to residents Initial impact '**Moderate**', confidence '**Probable**'	
12.1, 12.2 and 12.3 Oil spills	Risk of oil spills offshore, inshore or at-shore	See sections 12.1.12, 12.2.12 and 12.3.12	See Table 15.5 and sections 15.7.1.1, 15.7.1.2, 15.7.3.4

[a] Currently there are no additional monitoring measure proposed over and above that already required by legislation and / or Premier's corporate requirements as there are no other feasible measures expected to be effective in monitoring these impacts / risks

It should be noted that for some impacts / risks that were screened out, monitoring will still be required. This is either to comply with Premier's corporate reporting standards, for example, in the case of the monitoring of day-to-day energy and water usage. There are also some aspects that will be monitored to ensure Premier is following its social commitments as a responsible operator, such as monitoring for noise nuisance and tracking usage of local accommodation and use of seats on the Airbridge. These monitoring requirements are included in Table 15.5 below.

15.3.2 Periodic review of scope

At least every five years, the scope of the EMMP will be formally reviewed.

If, through acquisition of data out-with the EMMP or through third party source or observations, an impact that is initially screened out appears to have unexpected significance, this will be raised at the Steering Group and a course of action agreed.

Equally, if sufficient evidence is present to demonstrate that the issue no longer reasonably meets the screening criteria, the issue will be removed from scope.

Changes to the EMMP scope may occur within the five-year period if agreed at the EMMP Governance Board.

15.4 Legislative and corporate monitoring

Legislative monitoring requirements cover those that are defined by FIG or, where none currently exist, the equivalent UK requirement. The EMMP must also cover Premier's corporate environmental reporting requirements which are defined in CP-BA-PMO-HS-SE-ST-0004 Environmental Performance Reporting Standard, which is designed to meet the company's environmental reporting commitments both as a member of the International Association of Oil and Gas Producers (IOGP) and to report to the standards of the Global Reporting Initiative (GRI).

As a minimum, Premier monitor against their seven Key Performance Indicators (KPI's, see Table 15.3).

Table 15.3: Premier's environmental performance data reporting

Area	Sub Area	Data Requirements	Frequency	Units	Comment / Basis
GHG Emissions	Direct Emissions (Scope 1)	Gross Production	Monthly	Tonnes	Collected by Corporate from CHESS (Corporate Health, Environment and Safety Statistics, a purpose built Premier database for HSE statistics)
		Flared Gas	Monthly	Tonnes	Collected by Corporate from CHESS
		Fuel Gas Use	Monthly	Tonnes	Collected by Corporate from CHESS
		Diesel Consumption	Monthly	Tonnes	To include diesel used on platforms and in vessels (standby and supply vessels), and to be reported by Business Units (BUs)
		Helicopter Fuel Use	Monthly	Tonnes	Reported by BUs
		Vented Gas	Monthly	Tonnes	Estimated from information on point source vents and quantity vented, provided by the BUs.
		Fugitive Emissions	Monthly	Tonnes	Calculated using production figures and information on each facility from BUs
	Indirect Emissions (Scope 2)	Office Energy Consumption	Annually	kW-h	Reported by BUs. Also include the percentage of electricity consumption (if any) from renewable energy
	Indirect Emissions (Scope 3)	Global Business Travel	Annually	Tonnes CO_2e	Collected by corporate from Grosvenor Travel
Pollution Prevention	Planned Discharges	Produced Water	Quarterly	Tonnes	Reported by BUs
		Oil in Produced Water	Quarterly	Tonnes	Reported by BUs
		Drainage Water	Quarterly	Tonnes	Reported by BUs (if available)
		Oil in Drainage Water	Quarterly	Tonnes	Reported by BUs (if available)
		Black Water	Quarterly	Tonnes	Reported by BUs
		Grey Water	Quarterly	Tonnes	Reported by BUs
		Discharges to Air	Annually	Tonnes	Estimated by corporate, to include NOx, SOx, VOC and CO emissions
	Unplanned Discharges	Hydrocarbon Spills	Monthly	Tonnes	BU to register Synergi (Premier's incident reporting system) cases and update as new information becomes available. Corporate to collect number of spills and quantity spilled from CHESS

Area	Sub Area	Data Requirements	Frequency	Units	Comment / Basis
		Chemical Spills	Monthly	Tonnes	BU to register Synergi cases and update as new information becomes available. Corporate to collect number of spills and quantity spilled from CHESS
	Waste	Hazardous Waste	Quarterly	Tonnes	Reported by BUs, to include quantity of waste recycled
		Non Hazardous Waste	Quarterly	Tonnes	Reported by BUs, to include quantity of waste recycled
Natural resources	Energy Use	Fuel Gas and Diesel	Annual	GJ	Calculated by Corporate based on fuel use figures provided by BUs
	Water Use	Drilling water; potable water offshore	Quarterly	Tonnes	Reported by BUs
	Biodiversity impacts	As identified in ESIAs	Annual	-	To be covered in annual meeting/phone call for qualitative data collection

All Premier's environmental data systems are included in independent audits as part of Premier's ISO 14001 certification and as part of Premier's annual reporting to the standards of the Global Reporting Initiative (GRI).

Currently understood activities related to legislative and corporate environmental and social monitoring are shown in Table 15.4 and Table 15.5 respectively.

Any additional legislative requirements that may develop as FIG legislation is enacted will updated in the EMMP as required.

Table 15.4: Legislative and corporate environmental monitoring requirements

Relevant Chapter	Impact	Relevant legislation	Legal Monitoring & Measurement requirements	Project Specific commitments	Premier KPI	When monitored	Regularity of monitoring
10.6 Drill muds and cuttings	Discharge of treated OBM cuttings	FIG PON 10: <1 % oil on discharged cuttings	Monitor % oil on discharged cuttings	Premier targeting 0.5 % oil on cuttings	No	Drilling	Representative (multiple) samples per well section
10.6 Drill muds and cuttings	Discharge of drill muds	UK OCNS: only approved chemicals may be discharged (application via Chemical Permit)	Select OCNS approved chemicals and monitor use and discharge		No	Drilling	Daily
10.7 Operational discharges	Discharge of chemicals during commissioning (hydrotest water)	UK OCNS: only approved chemicals may be discharged (application via Chemical Permit)	Select OCNS approved chemicals and monitor use and discharge		No	Commissioning and hook up	Weekly
10.7 Operational discharges	Discharge of chemicals during operations (cooling water, prod water)	UK OCNS: only approved chemicals may be discharged (application via Chemical Permit)	Select OCNS approved chemicals and monitor use and discharge		No	Operations	Monthly
10.7 Operational discharges	Discharge of OBM % in completion fluids	UK OCNS: an appropriate limit of 200 mg/l is usually applied	Monitor OBM % in completion discharges; only visibly oil-free water discharged		No	Drilling	Representative (multiple) samples during each wellbore clean-up
10.7 Operational discharges	Discharge of drainage water from MODU, FPSO and vessels	MARPOL (Annex 1): No discharges >15 ppm in transit	Monitor drainage discharges	No discharges > 15 ppm in transit *and* on station	No	Throughout field life	Daily
10.7 Operational discharges	Discharge of produced water (not normal operation)	FIG PON8: 40 mg/l averaged over the month, and that no single discharge exceed 100 mg/l. 30 mg/l monthly average during periods of	Monitor any produced water discharge for oil in water content;	Averaged monthly discharge target 10-15 mg/l.	Yes (OIW content and PWRI uptime)	Production (if PWRI offline)	Twice daily samples if over-boarding;

Relevant Chapter	Impact	Relevant legislation	Legal Monitoring & Measurement requirements	Project Specific commitments	Premier KPI	When monitored	Regularity of monitoring
		discharge has been advised by DMR verbally.	Volume injected; Volume discharged; Monitoring of dissolved components	Target 93% produced water reinjection uptime			Volumes taken daily; Dissolved components twice a year
10.9 Atmospheric emissions	Combustion equipment and fuel use	N/a	Meter fuel gas; Monitor all diesel, helifuel, IFO and MGO use; Calculate and reports all emissions from MODU and FPSO; Monitor fuel gas composition Monitor NOx and SOx emissions	Use of MGO instead of IFO inshore; Auditing of third party vessels during pre-mobilisation process	Yes (energy use, GHG intensity and Gas Production / Injection (GPI) uptime)	Throughout field life	Monthly. For fuel gas composition, quarterly. For NOx emissions, occasionally during field life Annually: Other releases e.g. fugitive emissions, MODU emissions
10.9 Atmospheric emissions	Flaring	UK Petroleum Act 1998 UK Petroleum Licensing (Production) (Seaward Areas) Regulations 2008	Meter all flaring; Monitor flare gas composition	No routine flaring except pilot; Flare recovery system on FPSO and gas reinjection; see also studies in section 147515.7.2.1	Yes (energy use)	Throughout field life	Daily. For flare gas composition, quarterly.
10.9 Atmospheric emissions	Venting	UK Energy Act 1976 UK Petroleum Act 1998	Monitor all unplanned venting	Vapour recovery package on cargo tanks	Yes	Production	As required

Relevant Chapter	Impact	Relevant legislation	Legal Monitoring & Measurement requirements	Project Specific commitments	Premier KPI	When monitored	Regularity of monitoring
10.9 Atmospheric emissions	F-Gases	The Fluorinated Greenhouse Gases Regulations 2015	Monitor all unplanned F-gas releases	Log all F gas inventories on the facility, maintain via specialist contractors	No	Drilling and Production	As required
10.9 Atmospheric emissions	Fugitive emissions	n/a	Minimise all fugitive emissions	Minimisation of releases via good practices including STEP Change Hydrocarbon Release Reduction Toolkit	No	Drilling and Production	Ongoing leak detection and repair programme including use of FLIR (Forward looking Infra-Red) Camera
10.10 Waste	Waste production	UK Waste Regulations	Monitor all waste generated on the MODU, FPSO, vessels, TDF and onshore bases	Education of offshore and onshore personnel on waste management and consequences of mis-management. To be included in all FIBU personnel inductions; E-Reps programme; Pursue discussions with FIG and relevant stakeholders on solutions to waste management in the Islands	Yes	Throughout field life	Monthly

Relevant Chapter	Impact	Relevant legislation	Legal Monitoring & Measurement requirements	Project Specific commitments	Premier KPI	When monitored	Regularity of monitoring
10.12 Marine non-natives	Introduction of marine non-native species	n/a	Adhere to IMO BWMC (no monitoring actions required)	Adherence to ballast water and biofouling requirements included in pre-selection and pre-mob audits; Sampling of ballast water discharges from Subsea Installation Vessels and LTVs in Berkeley Sound. LTVs hull inspection requirement included in vetting; Sampling of shoreline, benthos, settlement plates and structures for presence of non-native species	No	Transport (LTVs) and Subsea Installation Vessels	As required for vessels. Seasonally or less frequently for presence of non-native species in the environment.
10.13 Terrestrial invasives	Introduction of terrestrial non-native species	n/a	Adhere to FIG Biosecurity Guidelines – FIG monitor of incoming cargoes	Biosecurity Management Plan implemented Training and awareness for yard/TDF personnel accepting cargoes;	No	Throughout field life	As required

Relevant Chapter	Impact	Relevant legislation	Legal Monitoring & Measurement requirements	Project Specific commitments	Premier KPI	When monitored	Regularity of monitoring
				E-Reps programme; Visual inspection of all cargoes on arrival			
12.1 & 12.3 Oil spill offshore and atshore	Impact to various flora and fauna	FIG PON8: Reporting spills and sheens FIG OSCP requirements: An OSCP must be submitted to FIG	Monitor all spills and sheens and report to FIG	Regular oil spill response exercises to be conducted	Yes	Throughout field life	As required
12.2 Inshore Oil spills	Impact to various flora and fauna	FIG PON8: Reporting spills and sheens FIG OSCP requirements: An OSCP must be submitted to FIG	Monitor all spills and sheens and report to FIG	As above	Yes	Throughout field life	As required
Other	n/a	n/a	n/a	Development of a voluntary Environmental representative (E-Rep) role (a representative on the MODU / FPSO to promote environmental awareness, similar to a Safety Rep)	No	Throughout field life	n/a

Table 15.5: Legislative and corporate social monitoring requirements

Relevant Chapter	Impact	Relevant legislation	Legal Monitoring & Measurement requirements	Project Specific commitments	Premier KPI	When monitored	Regularity of monitoring
11.3 – 11.7 Competition for Resources	Impact to local residents from competition for accommodation, water, power, air links	n/a	n/a	All complaints will be monitored. All use of local accommodation and Airbridge monitored; Water and power use monitored.	Water use and power use	Throughout field life	As required
11.8-11.12 Nuisance to the human population	Impact to local residents from light, noise, odour, visual impact and air quality			All complaints will be monitored. Routine sampling and tests of air quality will be undertaken on all fuel supplies as part of the procurement process and audits; Monitoring of air quality parameters will be conducted over the seasons to establish baseline levels; Air quality monitoring during operations will be undertaken to validate predictions and inform ongoing practices; Confirm background noise levels.			
11.1 and 11.2 Disturbance to other users of the sea	Impact to other users of the sea due to additional vessels present and exclusion zones offshore and inshore	n/a	n/a	All complaints will be monitored, reviewed and responded to.	No	Throughout field life	Reporting of all vessel incursions into the exclusion zones

15.5 Baseline data and survey work

Where uncertainties in the EIS arise from lack of baseline data, Premier propose to develop a number of key surveys and data collection programmes related to the key phases of the project:

- Pre-sanction;
- Post-sanction and pre-first oil; and
- Post-first oil and throughout production.

Table 15.6 below shows the three main phases of the project timeline. This is included for each EMMP activity to show when it will occur and for how long the programme will continue.

Table 15.6: Project timeline

Pre-sanction			Post-sanction and pre-first oil				Post-first oil and throughout production		
Now	EIS submission	Public consultation	Sanction / FIG approval	Construction of FPSO etc.	Development drilling	Offshore construction and Commissioning	First oil	Production	End of field life

Based on the uncertainties noted in the EIS, the proposed surveys include:

- Intertidal baseline studies in Berkeley Sound, to ground truth satellite data;
- Seabird monitoring - species distribution prior to operations and throughout field life; offshore and coastal birds around Berkeley Sound;
- Invasive species monitoring of shorelines, benthos, settlement plates and structures;
- Marine mammal observations prior to and during operations in Berkeley Sound, at the Sea Lion location and on transits;
- Baseline measurements of underwater noise in Berkeley Sound;
- Measurements of underwater noise during construction operations at Sea Lion;
- Underwater noise monitoring during Large Transport Vessels (LTV) and OCV operations in Berkeley Sound;
- Seabed surveys of benthos and sediment chemistry at Sea Lion ongoing throughout field life;
- Cooperation with surveys relating to Loligo spawning grounds within Berkeley Sound environs prior to operations; and,
- Operational monitoring and measurements ongoing throughout field life.

The EMMP activities presented below are an outline only and the final scope of environmental baseline data collection, surveys, monitoring, thresholds and potential management actions will be discussed and agreed with input from technical advisors and the Governance Board.

Table 15.7 below presents an overview of EMMP activities throughout field life. They are followed by individual workscope activities (see sections 15.6.1, 15.6.2 and 15.6.3 below) which provide further details, as guided by the EIS assessment. These proposed activities are set out in each chapter of the EIS but these workscopes describe the proposed scope of the task and any concurrent surveys or monitoring (outwith Premier activities), which may feed into the Premier scope of work. Indications of timing and regularity are provided as well as any reporting requirements.

15.6 Governance

The following governance framework for the EMMP was discussed at the EMMP Workshop. A governance board consisting of representatives of FIG and of Premier was suggested. This would be supported by an advisory forum including both non-technical stakeholders and relevant individuals with expertise in the subjects being monitored (offshore benthos, seabirds, marine mammals, invasive species) and managed. The advisory forum would help draw up the specifications in any scope of work used in contracting particular monitoring work, and would also be able to comment upon the results of the monitoring or performance/success of management actions – this to include giving advice as to whether any threshold had been passed, any further management that might be needed and reviewing whether monitoring efforts should be increased or could be reduced. Decision-taking on the whole EMMP lies ultimately at FIG level, but the above suggestion would provide support to such decisions, while also ensuring that stakeholders would be able to be involved at all relevant stages.

Throughout field life, information arising from the EMMP process will be reported to the EMMP Governance Board on a regular basis, likely biannually, and relevant actions discussed and the programme of work updated as necessary. Meetings of the Governance Group will include FIG, technical advisors, and invited or statutory stakeholders, with outputs reported publicly.

Table 15.7: Overview of proposed EMMP activities throughout Sea Lion Field life

					Year	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20
Stage[a]	**Pre-sanction**	**Post-sanction and pre-first oil**				**Post-first oil and throughout production**																			
	EIS submission, consultation	**Sanction / FIG approval**	**Construction of FPSO etc.**	**Development drilling**	**Offshore construction**	**First oil**	**Production**																		
Offshore																									
Benthic sediments																									
Seabirds - light																									
Seabirds - oil spill																									
Marine mammals - noise																									
Offshore and Inshore																									
Marine mammals - collision																									
Inshore																									
Invasives																									
Squid																									
Onshore																									
Disturbance to humans																									

Baseline	
Ongoing Monitoring	
Ongoing Monitoring, frequency to be reviewed	

[a] Decommissioning (including any associated monitoring) will be subject to a separate EIA

15.6.1 Offshore

<table>
<tr><td colspan="11"><h3>15.6.1.1 Seabirds</h3></td></tr>
<tr><td colspan="11">EIS Chapter Ref: 10.1 Artificial light</td></tr>
<tr><td colspan="11">Reason for inclusion: Potentially significant impacts resulting from artificial light</td></tr>
<tr><td colspan="11">Management Objective: Confirm that impacts are within the envelope of predictions in the EIS, and feedback data to review the significance of impacts and the measures to mitigate any significant impacts</td></tr>
<tr><td colspan="11">Scope of work: Post-sanction, pre-first oil and post-first oil</td></tr>
<tr><td colspan="11"><u>Monitoring</u>
Observers (SMMOs) for bird strikes based offshore during any periods of flaring on the drilling platform and during commissioning flaring.
Encourage crew on all vessels to record and report any onboard seabird occurrence.</td></tr>
<tr><td>Inputs to task</td><td colspan="10">Bird Strike Management Plan</td></tr>
<tr><td rowspan="2">Timing</td><td colspan="3">Pre-sanction</td><td colspan="4">Post-sanction and pre-first oil</td><td colspan="3">Post-first oil and throughout production</td></tr>
<tr><td>Now</td><td>EIS submission</td><td>Public consultation</td><td>Sanction / FIG approval</td><td>Construction of FPSO etc.</td><td>Development drilling</td><td>Offshore construction</td><td>First oil</td><td>Production</td><td>End of field life</td></tr>
<tr><td>Frequency</td><td colspan="10">Seasonal deployments in all seasons, 2-3 weeks for each deployment; focussed if suitable sensitive period can be determined.</td></tr>
<tr><td>Notes</td><td colspan="10">Thresholds could be tuned by use of e.g. protected status of bird species. A species with a higher protected status would have lower thresholds for response.</td></tr>
<tr><td>Reporting</td><td colspan="10">Report all bird strikes to FIG.</td></tr>
<tr><td>Adaptive Management Thresholds</td><td colspan="10">Resample n/a
Review - any fatal bird strike.
Investigate - multiple fatal bird strikes, more than 4 incidents in 4 months.
React - Repeat multiple bird fatalities at < monthly intervals. Reaction to lower-levels of fatality would also be evaluated in the review/investigate stages and would depend on the specific nature of the incidents.
Adapt - Chronic fatalities sustained over period of 1 year.</td></tr>
<tr><td>Potential Management Actions</td><td colspan="10">Reaction - Manually alter lighting operations, flare practices in daylight only or restrictions on dusk/dawn operations.
Adaptation - Trial and replace light fittings, change cladding/ coatings, install deterrent devices.</td></tr>
</table>

15.6.1.2 Benthic Sediments

<table>
<tr><td colspan="11">EIS Chapter Ref: 10.6 Discharge of drilling muds and cuttings</td></tr>
<tr><td colspan="11">Reason for inclusion: Potentially significant impacts resulting from deposition of treated drill cuttings</td></tr>
<tr><td colspan="11">Management Objective: Confirm that impacts and recovery are within the envelope of predictions in the EIS, and feedback data to review the significance of impacts and the measures to mitigate any significant impacts</td></tr>
<tr><td colspan="11">Scope of work: Post-first oil</td></tr>
<tr><td colspan="11"><u>Ongoing monitoring</u>
Seabed grabs for sediment characterisation, benthos, chemistry and heavy metal analysis.
Video at each monitoring station.
Cuttings pile sampling.
Analysis of PAH content of treated cuttings.</td></tr>
<tr><td>Inputs to task</td><td colspan="10">Approach GAP Team for advice on number of samples and methodology following GAP I report recommendations.</td></tr>
<tr><td rowspan="2">Timing</td><td colspan="3">Pre-sanction</td><td colspan="4">Post-sanction and pre-first oil</td><td colspan="3">Post-first oil and throughout production</td></tr>
<tr><td>Now</td><td>EIS submission</td><td>Public consultation</td><td>Sanction / FIG approval</td><td>Construction of FPSO etc.</td><td>Development drilling</td><td>Offshore construction</td><td>First oil</td><td>Production</td><td>End of field life</td></tr>
<tr><td>Frequency</td><td colspan="10">Repeat survey will be done post-drilling and risk-based follow up surveys will be assessed periodically. Exact scope of each survey will be dependent on any changes identified throughout field life and will be determined nearer the time.
Post-drilling, changes to the seabed will be slow and monitoring requirements are expected to diminish in scope and frequency over time.</td></tr>
<tr><td>Notes</td><td colspan="10">Chevron’s Gorgon LNG project (Western Australia) modelling of impacts can be used to inform survey scope.</td></tr>
<tr><td>Reporting</td><td colspan="10">Reports to FIG.</td></tr>
<tr><td>Adaptive Management Thresholds</td><td colspan="10">Resample - a significant fraction of the samples are outwith 1 S.D. of expected results.
Review - review of seabed monitoring results within 3 months of each survey.
Investigate - significant differences to expected seabed quality / recovery.
React - Impacted areas >100% greater than expected.
Adapt - Impacted areas >30% greater than expected.</td></tr>
</table>

Potential Management Actions	Reaction - Change operation of cuttings cleaning unit for higher residence time, change discharge parameters. Adaptation - Examine chemical components for substitution, time discharges with sea currents to change dispersion pattern.

15.6.1.3 Marine Mammals – Underwater Noise

EIA Chapter Ref: 10.4 Offshore underwater noise & 10.5 Inshore Underwater Noise

Reason for inclusion: Sensitive receptor with uncertain impacts

Management Objective: Confirm that impacts are within the envelope of predictions in the EIS, and feedback data to review the significance of impacts and the measures to mitigate any significant impacts

Scope of work: Post-sanction, pre-first oil

<u>Baseline and ongoing monitoring</u>

Offshore Passive Acoustic Monitoring (PAM) and hydrophone to detect presence of mammals as part of pre-start controls for piling

PAM and observers present on the piling vessel/rig during pilling

Independent SMMOs on MRSVs for ongoing monitoring

Scope of work: Post-first oil

<u>Ongoing monitoring</u>

Monitoring of day-to-day operational noise including during activation of thrusters as well as various vessel scenarios to understand baseline noise levels during operations

Independent SMMOs on vessels (MRSVs) for ongoing monitoring

Inputs to task	Observation protocols to be developed Determine if JNCC pile driving Guidelines need to be adapted for Falkland Islands waters e.g. depth and different mammal dive times

Timing	Pre-sanction			Post-sanction and pre-first oil				Post-first oil and throughout production		
	Now	EIS submission	Public consultation	Sanction / FIG approval	Construction of FPSO etc.	Development drilling	Offshore construction	First oil	Production	End of field life

Frequency	PAM installed at set intervals over the course of construction, drilling, Simultaneous Operations and normal production SMMOs on board during piling (approximately one month) Complete for first three years of the project then review and revise strategy as required (depending on other ongoing work)

Notes	SMMOs will make observations at site as well as during transits between the Falkland Islands and Sea Lion Align with any concurrent marine mammal monitoring programmes Seabird observers will also contribute to marine mammal survey as well as collecting seabird data Two SMMOs on MRSVs transiting between field and Stanley. Systematic programme and protocols to be developed
Reporting	SMMO and noise reports to FIG
Adaptive Management Thresholds	Resample n/a Review - Review observation data every 6 months initially Investigate - Any adverse noise-related behaviour of marine mammals React - Any mass noise-related behaviour Adapt - Chronic noise-related behaviour change
Potential Management Actions	Reaction - Scale back noisy activity Adaptation - Adjust timing of operations

15.6.1.4 Marine Mammals – Collision

EIA Chapter Ref: 10.11 Marine mammal collisions			
Reason for inclusion: Sensitive receptor with potentially significant impact			
Management Objective: Confirm that impacts are within the envelope of predictions in the EIS, and feedback data to review the significance of impacts and the measures to mitigate any significant impacts			
Scope of work: Post-sanction, pre-first oil, post-first oil			
Baseline and ongoing monitoring Independent SMMOs on MRSVs for ongoing monitoring and mitigation			
Inputs to task	Observation protocols to be developed Falkland Islands have a protocol for vessel behaviour near marine mammals – this may need to be adapted		
Timing	Pre-sanction	Post-sanction and pre-first oil	Post-first oil and throughout production

<table>
<tr><th></th><th>Now</th><th>EIS submission</th><th>Public consultation</th><th>Sanction / FIG approval</th><th>Construction of FPSO etc.</th><th>Development drilling</th><th>Offshore construction</th><th>First oil</th><th>Production</th><th>End of field life</th></tr>
<tr><td>Frequency</td><td colspan="10">SMMOs on board vessels periodically covering all seasons with particular focus at the time of year when animals are concentrated in the area of ship movements
Complete for first three years of the project then review and revise strategy as required (depending on other ongoing work)</td></tr>
<tr><td>Notes</td><td colspan="10">SMMOs will make observations at site as well as during transits between Sea Lion and the Falkland Islands
Align with any concurrent marine mammal monitoring programmes
Seabird observers will also contribute to marine mammal survey as well as collecting seabird data
Two SMMOs on MRSVs transiting between field and Stanley.
Systematic programme and protocols to be developed</td></tr>
<tr><td>Reporting</td><td colspan="10">SMMO reports to FIG, real time reports between vessels if aggregations of marine mammals observed.</td></tr>
<tr><td>Adaptive Management Thresholds</td><td colspan="10">Resample n/a
Review - Review observation data every 6 months initially
Investigate - Any near miss situations with marine mammals
React - Any collision or suspected collision
Adapt - Occasional but repeated interactions at risk of collision</td></tr>
<tr><td>Potential Management Actions</td><td colspan="10">Reaction - Reduce vessel speed near marine mammals not attracted to the vessel
Adaptation - Add marine mammal detection systems (e.g. infra-red camera systems); adjust timing of operations; consider use of deterrents</td></tr>
</table>

<table>
<tr><th colspan="11">15.6.1.5 Oil Spill</th></tr>
<tr><td colspan="11">EIA Chapter Ref: 12.1 Offshore oil spill</td></tr>
<tr><td colspan="11">Reason for inclusion: Potentially significant impacts resulting from unplanned oil releases</td></tr>
<tr><td colspan="11">Management Objective: Confirm that impacts are within the envelope of predictions in the EIS, and feedback data to review the significance of impacts and the measures to mitigate any significant impacts</td></tr>
<tr><td colspan="11">Scope of work: Post-sanction, pre- and post first oil</td></tr>
<tr><td colspan="11"><u>Baseline data collection</u>
Use of Independent Seabird and Marine Mammal Observers (SMMOs) on Premier support vessels infield and on transit to and from the field (most likely the two MRSVs) to detect oiled birds (and help in wider data collection)
Sampling of oil from plumage of oiled birds to determine if it is Sea Lion crude</td></tr>
<tr><td>Inputs to task</td><td colspan="10">Review GAP modelling work, which may augment the Seabird at Sea Team data
Methods to be agreed</td></tr>
<tr><td rowspan="2">Timing</td><td colspan="3">Pre-sanction</td><td colspan="4">Post-sanction and pre-first oil</td><td colspan="3">Post-first oil and throughout production</td></tr>
<tr><td>Now</td><td>EIS submission</td><td>Public consultation</td><td>Sanction / FIG approval</td><td>Construction of FPSO etc.</td><td>Development drilling</td><td>Offshore construction</td><td>First oil</td><td>Production</td><td>End of field life</td></tr>
<tr><td>Frequency</td><td colspan="10">Seasonal deployments in all seasons, 2-3 weeks for each deployment</td></tr>
<tr><td>Notes</td><td colspan="10">University of Highlands and Islands are conducting a review of the Oil Vulnerability Indices for oil and gas activities in the sub-Arctic. An Oil Vulnerability Index has been updated to Seabird Oil Sensitivity Index in the UK Continental Shelf
The Sea Lion oil spill strategies and statutory reporting of all oil spills are relevant.</td></tr>
<tr><td>Reporting</td><td colspan="10">Data to be reported to FIG.</td></tr>
<tr><td>Adaptive Management Thresholds</td><td colspan="10">Resample n/a
Review - any oiled seabird
Investigate - multiple fatal oiled bird finds, more than 4 incidents in 4 months.
React - Repeat multiple oiled bird fatalities at < monthly intervals with indication of oil deriving from Sea Lion development.
Adapt - Chronic oiled fatalities sustained over period of 1 year with indication of oil deriving from Sea Lion development.</td></tr>
</table>

Potential Management Actions	Reaction - Cease oily discharges or apply more stringent discharge standard (rely on reinjection) Adaptation - Analyse process operations and oil monitoring results; apply further laboratory tests to potentially oily discharges and manage critical factors; amend normal operating philosophy to decrease oily discharges if possible.

15.6.2 Inshore

<table>
<tr><th colspan="11">15.6.2.1 Marine invasive species</th></tr>
<tr><td colspan="11">Impact Chapter Ref: 10.12 Marine non-natives</td></tr>
<tr><td colspan="11">Reason for inclusion: Potentially significant impact resulting from introduction of invasive species</td></tr>
<tr><td colspan="11">Management Objective: Confirm that presence of non-native species is not increased beyond levels of background change. Feedback observations into management of the issue.</td></tr>
<tr><td>Scope of work</td><td colspan="10">Settlement plates will be positioned in Berkeley Sound prior to and during the construction phase of the project. Plates will also be positioned at the Temporary Docki Facility for sampling throughout the duration of the project.
In the event that a new marine invasive species is discovered, a pathway analysis will be conducted to attempt to determine where / how the species had been brought in to the Islands.</td></tr>
<tr><td>Inputs to task</td><td colspan="10">Discussion with FIG Biosecurity Officer</td></tr>
<tr><td rowspan="2">Timing</td><td colspan="3">Pre-sanction</td><td colspan="4">Post-sanction and pre-first oil</td><td colspan="3">Post-first oil and throughout production</td></tr>
<tr><td>Now</td><td>EIS submission</td><td>Public consultation</td><td>Sanction / FIG approval</td><td>Construction of FPSO etc.</td><td>Development drilling</td><td>Offshore construction</td><td>First oil</td><td>Production</td><td>End of field life</td></tr>
<tr><td>Notes</td><td colspan="10">Ballast water management in line with IMO standards will be undertaken regardless of any further actions. Pre-charter inspection of hulls for fouling will also be undertaken</td></tr>
<tr><td>Reporting</td><td colspan="10">Results shared with FIG</td></tr>
<tr><td>Adaptive Management Thresholds</td><td colspan="10">Resample - If obvious failure or contamination of a monitoring site or inconclusive tests of settlement plates
Review - Annual review of results
Investigate - Analysis shows a new or significantly changed species within a list of high-risk species; employ pathway analysis to determine most likely causes
React - Obvious infestation or release or gross contamination of equipment/cargo.
Adapt - Presence of high risk species or adverse change in species composition outwith background variation</td></tr>
<tr><td>Potential Management Actions</td><td colspan="10">Reaction - Minimise ballast water discharge inshore, refuse mooring to contaminated vessels, backload contaminated cargo
Adaptation - Change vessel logistics, additional treatment or exchange of ballast water</td></tr>
</table>

15.6.3 Social

15.6.3.1 Disturbance to Humans

Impact Chapter Ref: 11.8 and 11.9 Disturbance to the human population from light and noise

Reason for inclusion: Potentially significant impact from light and noise emissions

Management Objective: Confirm that impacts are within the envelope of predictions in the EIS and feedback observations into management of the issue

Scope of work: Post-sanction, pre-first oil

<u>Baseline data collection and ongoing monitoring</u>
Light and noise monitoring in Stanley
Light and noise monitoring and photographs taken from relevant receptors to establish baseline
Further monitoring and photographs during operations to verify EIS predictions and monitor any changes
Ongoing monitoring and recording of all complaints received

Inputs to task	Helicopter, FIGAS and onshore baseline noise recordings Any synergistic outcomes from the joint Premier/FIG Social Effects Monitoring Programme. BS EN 12464-2:2007 for lighting intrusion BS 4142 for industry noise BS 8233 for community noise									
Timing	Pre-sanction			Post-sanction and pre-first oil				Post-first oil and throughout production		
	Now	EIS submission	Public consultation	Sanction / FIG approval	Construction of FPSO etc.	Development drilling	Offshore construction	First oil	Production	End of field life
Frequency	Frequency and continued monitoring dependent on impacts recorded and complaints received									
Notes	-									
Reporting	Reports to FIG									

Adaptive Management Thresholds	Resample - If surveys are compromised by weather Review - Review survey findings within 6 months Investigate - If noise levels are >5 dBA above those predicted and there are reasonable grounds to link this to the project activities; any incident of complaint. React - If noise levels are >10 dBA above those predicted and there are reasonable grounds to link this to the project activities; multiple related complaints. Adapt - Continued regular complaints over period of 1 year
Potential Management Actions	React - Change operational practices e.g. timing of activities; switch off idle equipment Adapt - Replace, muffle or shield equipment; provide additional physical barriers; look at alternative logistics arrangements or equipment

15.7 Research and studies

15.7.1 Pre-sanction

<table>
<tr><th colspan="11">15.7.1.1 Operational discharges</th></tr>
<tr><td colspan="11">Impact Chapter Ref: 10.7 Operational discharges</td></tr>
<tr><td>Scope of work</td><td colspan="10">Identification of oiled or dead birds offshore using marine observers on vessels of opportunity with cause of death identification, as part of MMO scope</td></tr>
<tr><td>Inputs to task</td><td colspan="10">Crude properties tests to assess likelihood of sheens forming with Sea Lion crude
Sheen impact to seabirds investigated as part of oil tests, see section 15.7.1.2 below
Standard test methods and protocols to be used wherever possible. Otherwise to be developed by CEDRE, in conjunction with Premier and stakeholders
Fingerprinting of Sea Lion crude from CEDRE tests</td></tr>
<tr><td rowspan="2">Timing</td><td colspan="3">Pre-sanction</td><td colspan="4">Post-sanction and pre-first oil</td><td colspan="3">Post-first oil and throughout production</td></tr>
<tr><td>Now</td><td>EIS submission</td><td>Public consultation</td><td>Sanction / FIG approval</td><td>Construction of FPSO etc.</td><td>Development drilling</td><td>Offshore construction</td><td>First oil</td><td>Production</td><td>End of field life</td></tr>
<tr><td>Notes</td><td colspan="10">-</td></tr>
<tr><td>Reporting</td><td colspan="10">Results shared with FIG and informs EIS impact assessment chapters</td></tr>
</table>

<table>
<tr><th colspan="2">15.7.1.2 Oil spills</th></tr>
<tr><td colspan="2">Impact Chapter Ref: 12.2, 12.2 and 12.3 Oil spills</td></tr>
<tr><td>Scope of work</td><td>Fur and additional feather tests incl. adhesion and cleaning
Toxicity: Egg toxicity
Interaction with suspended solids
Interaction with kelp
Total response test incl. in situ booming and recovery</td></tr>
</table>

<table>
<tr><td colspan="12">15.7.1.2 Oil spills</td></tr>
<tr><td>Inputs to task</td><td colspan="11">Expertise from CEFAS, SANCOB, SINTEF, OSRL, SpillConsult, NOFO, and local stakeholders
Oil Spill Contingency Plan & Vulnerability Mapping
CEDRE results:
Stage 1
• Feather dip tests on a number of local at risk species
• Toxicity: OCNS test, as per CEFAS
• Meso-scale (Droplet Size and PAH)
• Shoreline adhesion and tarballs: meso scale tests
• Surface oil visibility
• Sheen measurement

Stages 2 and 3
• Comparator tests on other oils
• Feather and fur pelt tests
• Outdoor basin shoreline adhesion test
• Booming and skimming performance (tank test)
• Loligo eggs toxicity
• Pre-operations spill response tests</td></tr>
<tr><td rowspan="2">Timing</td><td colspan="3">Pre-sanction</td><td colspan="4">Post-sanction and pre-first oil</td><td colspan="3">Post-first oil and throughout production</td></tr>
<tr><td>Now</td><td>EIS submission</td><td>Public consultation</td><td>Sanction / FIG approval</td><td>Construction of FPSO etc.</td><td>Development drilling</td><td>Offshore construction</td><td>First oil</td><td>Production</td><td>End of field life</td></tr>
<tr><td>Notes</td><td colspan="11">-</td></tr>
<tr><td>Reporting</td><td colspan="11">Results shared with FIG and will inform EIS impact assessment chapters and OSR planning</td></tr>
</table>

15.7.2 Post sanction and pre-first oil

15.7.2.1 Offshore seabirds
Impact Chapter Ref: 10.1 Artificial light

Scope of work	Investigate the use of alternative spectrum lighting; Investigate pilot-free flare design using an automated ignition system									
Inputs to task	FEED / Detailed Design contractor studies									
Timing	Pre-sanction			Post-sanction and pre-first oil				Post-first oil and throughout production		
	Now	EIS submission	Public consultation	Sanction / FIG approval	Construction of FPSO etc.	Development drilling	Offshore construction	First oil	Production	End of field life
Notes	Desk top studies conducted during FEED									
Reporting	Results shared with FIG									

15.7.2.2 Marine invasives

Impact Chapter Ref: 10.12 Marine non-natives										
Scope of work	In the event marine invasives are discovered in the course of normal monitoring, pathways analysis will be conducted to determine where / how invasives are being brought in to the Islands This will be done in conjunction with genomics whereby water samples are taken at various points and analysed to identify the individual DNA AIS data gathered from vessels in Berkeley Sound will be analysed and compared with marine invasives data									
Inputs to task	Discussion with FIG Biosecurity Officer(DoA) AIS data from Berkeley Sound vessels									
Timing	Pre-sanction			Post-sanction and pre-first oil				Post-first oil and throughout production		
	Now	EIS submission	Public consultation	Sanction / FIG approval	Construction of FPSO etc.	Development drilling	Offshore construction	First oil	Production	End of field life
Notes	-									
Reporting	Results shared with FIG									

15.7.2.3 Underwater vessel noise										
Impact Chapter Ref: 10.4 Underwater noise offshore, 10.5 Underwater noise inshore										
Scope of work	Investigate low noise thrusters and propellers on any Premier operated and newly constructed / re-fitted vessels, i.e. MRSVs and inshore support vessels									
Inputs to task	Vessel specifications									
Timing	Pre-sanction			Post-sanction and pre-first oil				Post-first oil and throughout production		
	Now	EIS submission	Public consultation	Sanction / FIG approval	Construction of FPSO etc.	Development drilling	Offshore construction	First oil	Production	End of field life
Notes	Premier is aware this technology is used by local fishing companies									
Reporting	Results shared with FIG and informs EIS impact assessment chapters									

15.7.3 Post-first oil and throughout field life

15.7.3.1 Offshore seabirds / seawater quality										
Impact Chapter Ref: 10.7 Operational discharges										
Scope of work	Risk Based Approach (RBA) to ascertain composition of produced water; and DREAM modelling of produced water once samples taken and composition known to confirm impact zone, impact assessment in EIS and test model									
Inputs to task	Produced water samples: Whole Effluent Testing in line with the laboratory analysis requirements of the UK RBA Implementation Programme									
Timing	Pre-sanction			Post-sanction and pre-first oil				Post-first oil and throughout production		
	Now	EIS submission	Public consultation	Sanction / FIG approval	Construction of FPSO etc.	Development drilling	Offshore construction	First oil	Production	End of field life
Notes	After produced water breakthrough in Sea Lion reservoir									

15.7.3.1 Offshore seabirds / seawater quality

Reporting	Results shared with FIG

15.7.3.2 Offshore and inshore marine mammals

Impact Chapter Ref: 10.4 & 10.5 Underwater noise offshore and inshore
10.11 Vessel collisions with marine mammals

Scope of work	Information gathered from MMOs will be used to verify the accuracy of the EIS assessment and refine procedures MMO reports used to improve knowledge of locations and behaviour of marine mammals Review of MMO reports conducted after 5 years, as per JNNC (Carolyn Stone's work in the North Sea)									
Inputs to task	MMO reports									
Timing	Pre-sanction			Post-sanction and pre-first oil				Post-first oil and throughout production		
	Now	EIS submission	Public consultation	Sanction / FIG approval	Construction of FPSO etc.	Development drilling	Offshore construction	First oil	Production	End of field life
Notes	After 5 years of data recording									
Reporting	Results shared with FIG									

15.7.3.3 Vessel collisions (disturbance to human population)

Impact Chapter Ref: 11.1 Disturbance to other users of the sea

Scope of work	An AIS based survey will be carried out at the location of the Sea Lion Development to confirm the shipping traffic pattern in the area once the FPSO Safety Zone is in place		
Inputs to task	AIS data		
	Pre-sanction	Post-sanction and pre-first oil	Post-first oil and throughout production

Timing	Now	EIS submission	Public consultation	Sanction / FIG approval	Construction of FPSO etc.	Development drilling	Offshore construction	First oil	Production	End of field life
Notes	Once FPSO safety zone is established									
Reporting	Results shared with FIG									

15.7.3.4 Oil spills

Impact Chapter Ref: 12.1, 12.2 & 12.3 Oil spills										
Scope of work	Maintain continuous and live hydrodynamic model for use in the event of any spills. Once into production compare spill rates and compare with modelled flow rates, if actual flow rates are higher than predicted, modelling will be re-run. Use the spill modelling and hydrodynamic data to develop a means of forecasting spill trajectories pre-operation to enable rapid and targeted response in the event of a spill.									
Inputs to task	Well flowrates. Weather data. Hydrodynamic data from buoy in Berkeley Sound.									
Timing	Pre-sanction			Post-sanction and pre-first oil				Post-first oil and throughout production		
	Now		Public consultation	Sanction / FIG approval	Construction of FPSO etc.	Development drilling	Offshore construction	First oil	Production	End of field life
Notes	Hydrodynamic data will be collected to develop and improve the model									
Reporting	Results shared with FIG									

16 FINAL REVIEW & CONCLUSION

Table of Contents

16.1 Introduction

Sea Lion Field Phase 1 is the first proposed oil and gas (O&G) production development in the waters of the Falkland Islands. Therefore, a precautionary approach was taken with respect to all assessments carried out within this EIS. Nonetheless, the majority of the residual impacts and risks associated with the Phase 1 Development were considered to be of '**Low**' or '**Very Low**' significance and are not considered to warrant further reduction to meet Premier's Policy of doing all that is 'reasonably practicable' to minimise environmental impacts. These will, however, be periodically reviewed to ensure that the controls remain in place.

No residual impacts or risks were considered to be '**High**'.

However, while all residual impacts and risks have been reduced to ALARP, some were still considered to be of potentially '**Moderate**' or '**Upper Moderate**' significance and shall be subject to continuous improvement where opportunities exist.

16.2 Significant impacts and risks of planned activities and unplanned events

Significant residual impacts from planned activities and unplanned events associated with planned activities are:

- Artificial light - risk of bird-strikes **- Moderate** (section 10.1);
- Vessel noise offshore – potential for behavioural disturbance impacts to marine mammals - **Moderate**' (section 10.4);
- Discharge of drill cuttings – Impacts on benthos including burial of benthic fauna, modification of habitat, toxicity and oxygen depletion – **Moderate** (section 10.6);
- Emissions - greenhouse gas contribution to global warming - **Moderate** (section 10.9);
- Emissions - CO_2 contribution to ocean acidification - **Moderate** (section 10.9);
- Waste - impact of waste upon unsustainable resources with regards to export and the use of UK landfill – **Moderate** (section 10.10);
- Collisions between vessels and marine mammals at LTV site – **Moderate** (section 10.11.6.2);
- Marine invasive species - risk of introducing marine non-native species from Premier in field vessels, coaster vessels and LTVs **- Moderate** (section 10.12).
- Marine invasive species - risk of introducing marine non-native species from the purchaser's CTTs **- Upper Moderate** (section 10.12);
- Terrestrial invasive species - non-native species arriving on air freight – **Upper Moderate** (section 10.13);
- Competition for freshwater – water use for MODU drilling, vessel top-up, onshore yards and accommodation - **Upper Moderate** (section 11.4):
  - **Note:** a supplementary impact assessment was conducted assuming use of FIG 'work arounds', which still resulted in a residual impact of **Moderate;**
- Competition for daytime electrical energy use – **Upper Moderate** (section 11.5);

- Nuisance to human population from the use of roads – **Moderate** (section 11.7).
- Disturbance to the human population from light - Operations at TDF, supply base and LTV operations – **Moderate** (section 11.8); and

These remain significant, despite all mitigations, primarily because:

- A precautionary approach was taken owing to data gaps with regard to the above e.g. data gaps in whale species distribution and the long-term impact of vessel noise on hearing;
- Of the potential consequences with regard to:
  - The sensitivity of the receptors e.g. the protected status of whale / bird species or the unsustainability of the resource such as regulated landfill; and / or
  - The irreversible nature of some of the impacts e.g. the longevity of GHGs in the atmosphere or the difficulty in detecting whether a species has become invasive and in reversing the potential impacts to biodiversity.

As described in this EIS, technologies to reduce the impacts and risks have been built-in to the Phase 1 basis of design, where possible, and into the Premier HSES-MS. These, and the project-specific mitigation measures, include:

- Use of Best Available Technologies;
- Application of all industry-standard safeguards;
- Implementation of the:
  - Bird-strike Management Plan; and
  - Waste Management Plan.
- Awareness of the Premier Carbon Strategy;
- Application of Emissions, discharge and waste ALARP studies carried out during the Execution Phase of the project and verified through Premier Project Safety Reviews; and
- The use of SMART environmental targets and Key Performance Indicators (KPIs) throughout the field life to ensure continual optimisation of emissions, discharges and waste.

Moreover, monitoring and reporting will be carried out over the lifetime of the Development to ensure verification and comparison with the predictions made in this EIS.

16.3 Significant risks associated with accidental events

Significant residual risks associated with accidental events are:

- The risk of minor or major unplanned releases of hydrocarbon or diesel offshore **- Moderate** (section 12.1); and
- The risk of minor or major unplanned releases of hydrocarbon or diesel inshore - **Moderate** (section 12.2).

These remain significant, despite all reasonably practicable preventative measures designed to minimise the likelihood of accidental events occurring, primarily because:

- A precautionary approach was used in the assessments; and / or

- Of the potential consequences with regard to:
  - The sensitivity of the receptors to impacts e.g. the fragility of the Falkland Islands ecosystems and tourism industries and the globally important number of protected species (particularly seabirds); and / or
  - The severity of effect e.g. the potentially long-term impacts upon bird populations or public perception and therefore, potentially tourism.

All reasonably practicable efforts will be made to eliminate and prevent accidental events occurring and to Detect, Control, Mitigate, Respond and Remediate any consequences in the event that they do so, such that risks are reduced to ALARP. These measures include:

- Application of all industry-standard safeguards;
- Implementation of the:
  - Oil Spill Contingency Plan and Strategy.
- ALARP reviews during the Premier Process Safety Reviews; and
- Preparation of robust operations procedures during the Execution Phase of the project which will be verified through the Premier Project Safety Reviews.

16.4 Overall conclusion

In summary fourteen aspects remain of significance:

- Artificial light offshore and inshore - **Moderate;**
- Underwater vessel noise offshore - **Moderate**;
- Drill cuttings discharges – **Moderate;**
- Atmospheric emissions - **Moderate**;
- Waste management (landfill); – **Moderate**;
- Collisions with marine mammals inshore – **Moderate**;
- Marine species invasion - **Upper Moderate**;
- Terrestrial species invasion – **Upper Moderate**;
- Competition for freshwater resources – **Upper Moderate**;
- Competition for energy resources – **Upper Moderate**;
- Degradation of road surfaces from supply base operations – **Moderate**;
- Disturbance to the human population from light inshore and onshore – **Moderate**; and
- Oil spill offshore and fuel spill inshore - **Moderate**.

The use of vessels and fossil fuels is necessary to carry out any operation and the generation of some waste which cannot be re-used or recycled is unavoidable. Similarly, the use of third party vessels from elsewhere in the world will always carry some risk of non-native species introduction and all oil production can carry the risk of oil spill.

Premier believes that all impacts and risks have been identified, that those of low significance are sufficiently controlled and those that remain significant have been reduced to ALARP.

Therefore, Premier is satisfied that its Policy of doing all that is reasonably practicable to minimise environmental impacts has been met. Premier will ensure that all impacts and risks are periodically reviewed to ensure that the controls remain in place and that potentially '**Moderate**' and '**Upper Moderate**' impacts and risks are subject to continual improvement where opportunities exist.

17 POST-SUBMISSION CONSULTATION OUTCOMES

Table 17.1 provides a summary of the representations made during the formal statutory and public consultation process required under the FIG Offshore Minerals Ordinance (section 3.1.6.3.1).

Table 17.1: Summary of the representations made during the formal consultation process

Consultee	Representation	Premier response	Details in
[HOLD]	[HOLD]	[HOLD]	[HOLD]

18 ABBREVIATIONS

Abbreviation	Definition
ACAP	Agreement on the Conservation of Albatrosses and Petrels
ACC	Antarctic Circumpolar Current
AFS	Anti-Fouling Systems
AHT	Anchor Handling Tugs
AHV	Anchor Handling Vessels
AIS	Automatic Identification System
AIW	Antarctic Intermediate Water
ALARP	As Low As Reasonably Practicable
AMAR	Autonomous Multichannel Acoustic Recorder
API	American Petroleum Institute
ASD	Azimuth Stern Drive
AVS	Area Vulnerability Score
BAS	British Antarctic Survey
BAT	Best Available Techniques
bbl	Barrel
bbl/d	Barrels per day
BCF	Bio-Concentration Factor
BFMP	Biofouling Management Plan
BGS	British Geological Survey
BOP	Blow-out Preventor
BRB	Biofouling Record Book
BMP	Biosecurity Management Plan
BSL	Benthic Solutions Ltd
BSMP	Bird Strike Management Plan
BTEX	Benzine, Toluene, Ethylene and Xylene
BWMP	Ballast Water Management Plan
BWRB	Ballast Water Record Book
CBD	Convention on Biological Diversity
CBFSAI	Commander of the British Forces South Atlantic Islands
CCR	Central Control Room
CFSR	Climate Forecast Systems Reanalysis
CHARM	Chemical Hazard And Risk Management
chl-a	Chlorophyll-a
CITES	Convention on the International Trade in Endangered Species
CLC	International Convention on Civil Liability for Oil Pollution Damage
CMS	Convention on Migratory Species
CO	Carbon Monoxide

Abbreviation	Definition
CO_2	Carbon Dioxide
COLREGs	International Regulations for Preventing Collisions at Sea (1972)
COSHH	UK Control of substances Hazardous to Health
COW	Crude Oil Washing
CPA	Closest Point of Approach
CRMS	Craft Risk Management Standard
CTD	Conductivity, Temperature and Depth
CTT	Conventional Trading Tanker
DC	Drill Centre
dB	Decibel
DBEIS	Department of Business, Energy and Industrial Strategy (formerly DECC)
DECC	Department of Energy and Climate Change
DEFRA	Department of Environment, Fisheries and Rural Affairs
DMR	Department of Mineral Resources
DNR	Department of Natural Resources
DoA	Department of Agriculture
DOSRV	Dedicated Oil Spill Response Vessel
DPR	Dairy Paddock Reservoir
DREAM	Dose-Related Risk and Effects Assessment Model
DS	Deep Slope
DWT	Dead Weight Tonnes
EAC	Environmental Audit Committee
EC	European Community
ECMP	East Cove Military Port
EEDI	Energy Efficiency Design Index
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMMP	Environmental Monitoring and Management Plan
ENVIID	ENVironmental Impact IDentification
EnvSys	Environmental Systems
EOWR	End of Well Reports
EPD	Environmental Planning Department
EPB	East Plateau Basin
EPS	European Protected Species
ERA	Environmental Risk Assessment
ERL	Effect Range Low
ERM	Effect Range Median
ERP	Emergency Response Plan

Abbreviation	Definition
ERRV	Emergency Response and Rescue Vessel
ESI	Environmental Sensitivity Index
ESP	Electrical Submersible Pumps
ExCo	Falkland Islands Government Executive Council
FC	Falklands Conservation
FCO	Foreign and Commonwealth Office
FEED	Front End Engineering Design
FIBU	Premier Oil Falkland Islands Business Unit
FICAD	Falkland Islands Civil Aviation Department
FICZ	Falkland Islands Interim Conservation and management Zone
FIFCA	Falkland Islands Fishing Company Association
FIFD	Falkland Islands Fisheries Department
FIG	Falkland Islands Government
FIGAS	Falkland Islands Government Air Service
FILFH	Falkland Islands Low Flying Handbook
FIOHEF	Falkland Islands Offshore Hydrocarbons Environmental Forum
FIMBAr	Falkland Islands Marine Biological Archive
FIMSP	Falkland Islands Marine Spatial Plan
FIPASS	Falklands Interim Port And Storage System
FIRS	Falkland Islands Resupply Service
FITB	Falkland Islands Tourist Board
FMCF	Falkland / Malvinas Current Front
FOAO	Food of Animal Origin
FOCZ	Falklands Outer Conservation Zone
FOSA	Falklands Offshore Share Agreement
FPB	Falkland Plateau Basin
FPSO	Floating Production Storage and Offloading
FPV	Fisheries Patrol Vessel
FSO	Floating, Storage and Offloading Vessel
FTC	Fast Transit Carriers
GAP	Gap Analysis Programme
GC	Gas Chromatography
GC-FID	Gas Chromatography with Flame Ionisation Detections
GEBCO	General Bathymetric Chart of the Oceans
GHG	Greenhouse Gases
GIS	Geographic Information System
GOR	Gas Oil Ratio
GPI	Gas Production / Injection
GRE	Glass Reinforced Epoxy

Abbreviation	Definition
GWP	Global Warming Potential
HAB	Harmful Algal Bloom
HC	Hydrocarbon
HLCV	Heavy Lift Cargo Vessels
HLV	Heavy Lift Vehicles
HMCS	Harmonised Mandatory Control Scheme
HMP	Harbour Management Plan
HP	High Pressure
NADF	High Performance Oil Based Mud
HSE	Health and Safety Executive
HSES-MS	Health, Safety, Environmental and Security Management System
HSP	Hydraulic Submersible Pumps
HUC	Hook-Up and Commissioning
HVAC	Heating, Ventilation and Air Conditioning
Hz	Hertz
IACS	International Association of Classification Sociteies
IAPP	International Air Pollution Prevention
IBA	Important Bird Area
ICAO	International Civil Aviation Organisation
ICSS	Integrated Control and Safety System
ID	Inner Diametre
IFC	International Finance Corporation
IMO	International Maritime Organisation
IMP	Iceberg Management Plan
IOR	Improved Oil Recovery
IPA	Important Plant Area
IPMS	Integrated Production Management System
IPU	Integrated Production Umbilical
IS	Inner Shelf
ISV	Inshore Support Vessel
IUCN	International Union for the Conservation of Nature
IWC	International Whaling Commission
JNCC	Joint Nature Conservation Committee
KEMH	King Edward VII Memorial Hospital
km	kilometres
KPI	Key Performance Indicator
lb	Pounds
LOA	Length Over All
LP	Low Pressure

Abbreviation	Definition
LTOBM	Low toxicity Oil Based Mud
LTV	Large Transport Vessel
m	metres
MARPOL	International Convention for the Prevention of Pollution from Ships (1973)
MEPC	Marine Environment Protection Committee
MGO	Marine Gas Oil
MLA	Member of the Legislative Assembly
MMbls	Million barrels
MMO	Marine Mammal Observer
MMPA	Marine Mammal Protection Act
mmscfd	Million standard cubic feet per day
MoD	Ministry of Defence
MODU	Mobile Offshore Drilling Unit
MPA	Marine Protected Area
MPC	Mount Pleasant Complex
MPN	Mount Pleasant International Airport
MPFM	Multiphase Flow Meters
MRM	Mercury Removal Materials
MRSV	Multi-Role Support Vessels
MSL	Mean Sea Level
MSP	Marine Spatial Planning
MTTR	Mean Time To Repair
MWth	Mega Watts Thermal
NADF	Non Aqueous Drilling Fluid
NCEP	National Centers for Environmental Prediction
NEF	North East Front
NEMO	Nucleus for European Modelling of the Ocean
NFB	North Falkland Basin
nm	nautical mile
NNR	National Nature Reserve
NORM	Naturally Occurring Radioactive Material
NOSCP	National Oil Spill Contingency Plan
NPD	Naphthalene, Phenanthrene and Dibenzothiophene
NPR	Non-Permanent Residents
NRB	Northern Rift Basin
NS	Northern Slope
NWOS	North Western Outer Slope
O&G	Oil and Gas
OBM	Oil Based Mud

Abbreviation	Definition
OBO	Oil / Bulk Ore
OCNS	Offshore Chemical Notification Scheme
OCV	Offshore Construction Vessel
OD	Outer Diametre
ODS	Ozone Depleting Substances
OHEF	Offshore Hydrocarbon Environmental Forum
OPF	Organic Phase Drilling Fluids
OPRC	Oil Pollution Preparedness, Response and Co-operation
OSCAR	Oil Spill Contingency And Response
OSPRAG	Oil Spill Prevention and Response Advisory Group
OSR	Oil Spill Response
OSCP	Oil Spill Contingency Plan
OSV	Offshore Support Vessel
OVI	Oil Vulnerability Index
P&D	Production and Development
PAF	Potentially Affected Fraction
PAH	Polycyclic Aromatic Hydrocarbons
PAM	Passive Acoustic Monitoring
PCS	Production Control System
PHCB	Patagonia High Chlorophyll Band
PLANC	Permits, Licences, Authorisations, Notification and Consents
PLONOR	Pose Little Or NO Risk
PMO	Premier Oil
PON	Petroleum Operations Notices
ppb	Parts per billion
PPD	Pour Point Depressant
ppm	Parts per million
psia	Pounds per square inch absolute
PSR	Project Safety Review
psu	Practical Salinity Unit
PTS	Permanent Threshold Shift
PW	Produced Water
PWD	Public Works Department
PWRI	Produced Water Reinjection
RIDDOR	Reporting Of Injuries, Disease and Dangerous Occurrences
Rockhopper	Rockhopper Exploration PLC
Ro-Ro	Roll On- Roll Off
ROV	Remotely Operated Vehicle
SAAS	South American Atlantic Service

Abbreviation	Definition
SAERI	South Atlantic Environmental Research Institute
SAR	Search And Rescue
SAST	Seabirds At Sea Team
SASW	South Atlantic Surface Water
scf	Standard cubic feet
SD	Standard Deviation
SDU	Subsea Distribution Units
SECE	Safety and Environmentally Critical Equipment
SEEMP	Ship Energy Efficiency Management Plan
SEL	Sound Exposure Level
SEMP	Social Effects Monitoring Programme
SEOS	South Eastern Outer Slope
SF	Southern Front
SFB	South Falkland Basin
SG	Specific Gravity
SIA	Socio-economic Impact Assessment
SIMOPs	Simultaneous Operations
SINTEF	Stiftelsen for industriell og teknisk forskning
SIRE	Ship Inspection Report Programme
SIS	Safety Instrumented System
SLOES	Sea Lion Oil Export Selection
SMSG	Shallow Marine Surveys Group
SOLAS	Safety Of Life At Sea
SOPEP	Shipboard Oil Pollution Emergency Plan
SPL	Sound Pressure Level
SPS	Subsea Production Systems
SRB	Southern Rift Basin
SS	Southern Slope
SSL	Stanley Services Limited
ST	Shuttle Tanker
stb	Stock tank barrels
SURF	Subsea / Umbilical / Riser / Flowline
SWL	Safe Working Load
SWOS	South Western Outer Slope
TCC	Thermo-mechanical Cuttings Cleaner
TDF	Temporary Dock Facility
TEG	Triethylene glycol
TEMPSC	Totally Enclosed Motor Propelled Survival Craft
THC	Total Hydrocarbon Concentration

Abbreviation	Definition
TIC	Total Inorganic Carbon
TLP	Tension Leg Platform
TOC	Total Organic Carbon
TOM	Total Organic Matter
TSS	Total Suspended Solids
TTS	Temporary Threshold Shift
TVD	Total Vertical Depth
TZ	Transient Zone
UCM	Unresolved Complex Mixture
UEL	Upper Exposure Limit
UKCS	United Kingdom Continental Shelf
UKOT	United Kingdom Overseas Territory
UPS	Uninterruptable Power Supply
UVR	Ultra Violet Radiation
VIT	Vacuum Insulated Tubing
VMS	Vessel Monitoring System
VOC	Volatile Organic Compounds
VPQ	Vessel Particulars Questionnaire
VRP	Vapour Recovery Package
VTMS	Vessel Traffic Management System
W	Watts
WAT	Wax Appearance Temperature
WHRU	Waste Heat Recovery Units
WIF	Western Inshore Front
WBM	Water Based Mud
WMP	Waste Management Plan
WOF	Western Offshore Front
WRF	Weather Research and Forecasting
WRP	Wildlife Response Plan

19 GLOSSARY

Acronym / Term	Definition
Anthropogenic	Relating to human activities, or man-made
As Low As Reasonably Practicable (ALARP)	Often used in reference to mitigation measures where the benefit of the mitigation is weighed up against the relative cost and effort required to achieve that benefit.
At-shore	The shoreline and edge of the water.
Base-case	The design of the field before any project specific mitigations are added to avoid, limit or ameliorate environmental impacts and risks.
Barrel	One barrel, equivalent to 159 litres (0.159 m^3) or approximately 35 imperial gallons
Bathymetry	The measurement of water depth in oceans, seas and lakes
Benthic fauna	Organisms that live on, associated with or in the seabed sediments.
Berthing pocket	Area of seabed at a berth that is deeper than the surrounding seabed to allow vessels to berth. Created by dredging material or by stirring up the sediment with the vessels' props.
Best Available Techniques (BAT)	The latest stage of development (state of the art) of processes, facilities or methods of operation, which indicate the practical suitability of a particular measure for limiting discharges, emissions or waste. Definition of 'available' includes demonstrated techniques, timescales as well as economic considerations. 'Techniques' include both the technology used and the way in which the field is designed, built, maintained, operated and dismantled.
Best Practical Environmental Option	The option that offers most benefits and least damage to the environment within technical means, at acceptable cost in the long and short-term.
Biodiversity	The diversity of plant and animal life. Diversity is the measure of the variety of species contained within a habitat.
Biogenic	Produced by a living organism.
Bioturbation	The mixing of sediments or particles by fauna.
Black water	Sewage.
Block	Division of the FICZ / FOCZ into units. A Block is a subdivision of a Quadrant. There are 30 Blocks within one Quadrant. Block 14/05 is the 5th Block in Quadrant 14.
Blow-out	When the subsurface pressure in a well is greater than the pressure being applied from the rig or platform and there is an uncontrolled release of oil or gas into the wellbore and sometimes to the surface, wellbore or casing.
Blow-out preventer (BOP)	Hydraulically operated device placed on top of each well at the seabed to prevent uncontrolled releases of reservoir fluids from a well.
Casing	Large-diameter pipe lowered into the well and cemented into place to protect the well structure.
Clean-up	After a well has been drilled the drilling chemicals and rock in the hole will be flowed back to the rig or FPSO, this is known as cleaning up the well.
Completion	Preparing the well for production, including the assembly of downhole tubulars and equipment required to enable safe and efficient production from the well.

Acronym / Term	Definition
Conductor	The conductor extends from the drilling deck to the seabed and provides a guide and access to the well. It is sealed to enable circulation of drilling fluids.
Cuttings pile	A pile formed on the seabed as a result of the deposition of cuttings, which are produced whilst drilling the well.
Decommissioning	Shutdown of the development including system cleaning and dismantling of facilities.
Define (FEED)	The process of developing the design of the project to the point where it can be passed onto a yard to start building.
Demersal	Living or occurring in the water at the bottom of a water body.
Demulsifier	A chemical used to break down crude-oil water emulsions. The chemical reduces the surface tension of the film of oil surrounding the droplets of water. The water then settles to the bottom of the tank.
Development well	Any well drilled in the course of extraction of reservoir hydrocarbons, whether specifically a production well or injection well.
Displace (a well)	The act of removing one fluid (usually liquid) from a wellbore and replacing it with another.
Drilling	The mechanical process where a wellbore is drilled from an offshore rig into the seabed to access the underground reservoir below.
Drill cuttings	Chips and small fragments of rock generated while drilling a well, which are brought to the surface by the flow of the drilling mud being circulated.
Drilling mud	Special clay, water and chemical additives pumped downhole through the drill pipe and drill bit. The mud cools the rapidly rotating bit, lubricates the drill pipe as it turns in the well bore, carries rock cuttings to the surface and serves as a plaster to prevent the wall of the borehole from collapsing.
Drill string	Lengths of steel tubing roughly 10 m long screwed together to form a pipe connecting the drill bit to the rig. It is rotated to drill the hole and delivers the drilling fluids to the cutting edge of the drill bit.
Duty of Care	This is a requirement that a person / organisation act towards others and the public with watchfulness, attention, caution and prudence that a reasonable person / organisation in the circumstances would. If a person’s / organisation’s actions do not meet this standard of care then the acts are considered negligent and any damages resulting may be claimed in a lawsuit for negligence.
Dynamic positioning	Use of thrusters, instead of anchors, to maintain the position of a vessel.
Echolocation	The locating of objects using reflected sound.
Ecosystem	Consists of all the organisms living, including non-living physical components of the environment, with which they interact – a biological community and its environment.
Endemic	Native to or confirmed to a particular reason.
Environmental Impact Assessment	Process to identify and assess the impacts associated with a particular activity or plan.
Environmental Impact Statement	Document detailing the environmental impact assessment process.
Environmental Monitoring and Management Plan (EMMP)	Based on the findings of the EIS, this document, or set of documents sets out how the company will manage and monitor their environmental impacts. It includes, for example, surveys, research and monitoring of emissions.

Acronym / Term	Definition
Epifauna	Benthic organisms that inhabit the surface of the seabed.
E-Rep	Voluntary environmental representative who works offshore, responsibilities include checking waste consignments, performing audits on, for example, environmentally critical valves to ensure they are in the correct position.
First oil	First production of hydrocarbons from the reservoir to the FPSO
Flare	On the MODU and FPSO, a vent for burning unwanted gases or to burn off hydrocarbons which, due to temporary malfunction of maintenance of process plant, cannot be safely stored or retained in the process vessels.
Floating Production, Storage and Offloading vessel (FPSO)	The ship-shaped vessel used to produce the oil from the field, remaining in place offshore for the full field life.
Flow assurance	The various methods (heating, chemicals) used to keep the oil flowing through the flowlines offshore.
Flowline	Pipe laid on the seabed for the transportation of production or injection fluids. It links the subsea structures together or to the FPSO. Its length can range from a few hundred metres to a few kilometres.
Gas blanket	Inert gas used to cover liquid hydrocarbons in a tank to prevent ignition by removing oxygen from the atmosphere
Gas production / injection well	A well that can either produce gas from the reservoir to the FPSO or inject gas from the FPSO into the reservoir.
Gas lift	Adding reservoir gas into the well at the seabed to mix with the oil that is flowing to the surface to help move the oil from the seabed to the FPSO.
GIIP	Gas Initially In Place, the volume of gas in a reservoir before production.
Graben	Depressed block of land bordered by parallel faults.
Greenhouse gas	Gases in the atmosphere that absorbs and emit radiation within the thermal infrared range.
Grey water	Waste water from kitchens, showers and sinks.
Hawser	A thick rope tied between two vessels used to moor or tow a vessel
Hook up and commissioning	The process of connecting up all the offshore pipelines, FPSO, wells etc. before production can commence. This also includes testing all the connections to make sure they are sound.
Hydrates	Crystalline solids composed of gas molecules trapped inside water molecules. They are stable at low temperatures and relatively high pressures. Once hydrocarbon hydrates are formed they can plug pipelines, which can affect production.
Hydrotest	A pressure test using water, sometimes dosed with chemicals.
Inert gas	A non-reactive gas.
Inshore transfer	The process to transferring oil from one vessel to another in an enclosed bay.
Intervention	The down-hole re-entry of a well inside the existing completion equipment.
Jumper	A short flexible or rigid pipe used to connect a flowline to a subsea structure or two subsea structures close to each other.
Manifold	An area that contains all the valves for controlling the incoming and outgoing streams.

Acronym / Term	Definition
Mattress	A structure to support and protect subsea structures during installation and pre-commissioning activities and to provide dropped object protection to flowlines.
Migration	Any regular animal journey along well-defined routes, particularly those involving a return to breeding grounds.
Mitigation	Process, activity or piece of equipment that would make a consequence less severe.
Mobile Offshore Drilling Unit (MODU)	Also called a 'rig'. The MODU is only in field to drill the wells, it will then move to another job elsewhere.
Mud	This is generally synonymous with drilling fluid and encompasses most fluids used in hydrocarbon drilling operations, especially fluids that contain significant amounts of suspended solids, emulsified water or oil.
P50 reserves	Probable reserves for recovery.
Pelagic	Referring to the water column and the organisms living therein.
Petrogenic	Of hydrocarbon origin.
Photic zone	The upper water column which receives enough light for photosynthesis to occur.
Physio-chemical	Parameters such as temperature, nutrients or chemicals.
Phytoplankton	Microscopic planktonic plants such as diatoms and dinoflagellates.
Piling	Tubular steel shafts driven into the seabed to anchor a structure.
Plankton	Tiny plants and animals that drift in the surface water of seas and lakes. Of great economic and ecological importance as they are a major component of the marine food chain.
Polychaete	Bristle worms. Segmented worms, generally marine.
Produced water	Water that is produced from the reservoir along with oil and gas.
Production packer	A device used to isolate the annulus of the well and anchor or secure the bottom of the production tubing string.
Production well	A well drilled to produce hydrocarbons from the reservoir back to the FPSO.
Project sanction	When Premier decide to commit spending to start building the infrastructure for the project. 'Project sanction' may also refer to a decision by FIG to approve the project. The two are often simultaneous.
Project specific mitigation	Mitigations that are over and above the standard mitigations used by the Oil and Gas industry
Pyrogenic	Produced under conditions involving intense heat.
Ramsar site	Statutory areas designated under the Ramsar convention (the Convention on Wetlands of International Importance), especially as waterfowl habitat.
Recruitment	Young fish joining the main adult fish population.
Reservoir	A porous, permeable sedimentary rock formation containing oil and / or gas enclosed or surrounded by layers of less permeable or impervious rock – a structural trap.
Riser	Also known as a 'marine riser'. A pipe that goes from the seabed to the surface and is used to transfer produced fluids (oil, water and gas). Risers may be flexible or rigid.

Acronym / Term	Definition
Seawater sweeps	Drilling fluid which uses seawater as the bulk fluid for drilling the top sections of a well.
Separator	A pressure vessel used to separate reservoir fluids into gas and liquid components with the aid of chemicals and heat.
Sessile	An organism that is attached to another structure by its base and is unable to move freely.
Sidetrack	A directional hole drilled in a well to bypass an obstruction in the well that cannot be removed or damage, such as collapsed casing that cannot be repaired. Sidetracking may also be done to deepen a well or relocate the bottom of the well to a more productive zone.
Simultaneous Operations (SIMOPS)	The time when the rig is drilling wells whilst the FPSO is producing oil from the reservoir.
Social Impact Assessment	A impact of the social impact the project may have on the community. This looks at things like access to healthcare and schools. This is submitted separately to the EIS.
Spud / spudding	Starting to drill a well.
Stakeholder	Any individual or groups of people who are affected by or have interest in, the activities and / or outcome of the development.
Stock-Tank Oil Initially in Place (STOIIP)	The volume of oil in a reservoir prior to production.
Suction anchor	Anchor that is partly hollow inside. When installed the hollow part of the suction anchor sinks into the seabed. The suction anchor is then closed, creating a vacuum inside the anchor.
Suezmax	A large tanker which, historically, was able to fit through the Suez canal. Now defined by the size range: max. beam 77.5m, max. height 68m, max. draft 20.1 m, unlimited length.
Topsides	The equipment situated on a platform (such as an FPSO) including the oil production plant and accommodation block.
Trophic	Relates to feeding.
Tubing hanger	A device attached to the topmost tubing joint in the wellhead to support the tubing string.
Umbilical	Any of various lines transmitting electricity or fluids to one portion of a system or between systems subsea.
Vapour recovery / vapour balancing	When vapour (fumes) is prevented from release to the atmosphere (recovery) often by transferring it to another vessel (vapour balancing).
Venting	Discharge of unwanted, un-burnt gases or hydrocarbons which, due to temporary malfunction or maintenance of process plant, cannot be safely stored or retained in process vessels.
Viscosity	The resistance of flow of a liquid.
Water injection well	A well for flowing water into the reservoir to provide support to the reservoir and to 'push' the oil in the rock towards the oil producing wells.
Wellhead	A top of casing and the attached control and flow valves. The wellhead is where the control valves, testing equipment and take-off pipe are located.
Workover	A maintenance job on a well, usually to replace equipment or stimulate production.
X-mas tree	The assembly of valves and fittings on the seabed at each well to control and monitor the flow from the reservoir.

Acronym / Term	Definition
Zooplankton	Animals that drift in the plankton, mostly microscopic.
Anthropogenic	Relating to human activities, or man-made

20 REFERENCES

Aarts G, MacKenzie M, McConnell B, Fedak, M. & Matthiopoulos, J. 2008. Estimating space-use and habitat preference from wildlife telemetry data. Ecography (Cop) 31:140–160. doi: 10.1111/j.2007.0906-7590.05236.x.

ACAP. 2014. Agreement on the Conservation of Albatrosses and Petrels. Species Assessment: Grey-headed Albatross Thalassarche chrysostoma. http://www.acap.aq (Accessed 1 October 2010).

ACAP. 2016. Agreement on the Conservation of Albatrosses and Petrels. Species assessments. http://www.acap.aq/en/acap-species.

Acha, E.M., Mianzan, H.W., Guerrero, R.A., Favero, M. & Bava, J. 2004. Marine fronts at the continental shelves of austral South America: Physical and ecological processes. Journal of Marine Systems. 44, 83-105.

Agnew, D.J. 2002. Critical aspects of the Falkland Islands pelagic ecosystem: distribution, spawning and migration of pelagic animals in relation to oil exploration. Aquatic Conservation. 12, 39-50.

AGR Petroleum Services. 2012. Falkland Islands Fisheries and risk to subsea infrastructure. Report to Premier Oil, 18 February 2012.

AGR. 2012. Petroleum Services screening study - Falkland Islands fisheries and risk to subsea infrastructure.

Aguayo-Lobo, A., Acevedo, J., Brito, J.L., Acuna, P. & Bassoi, M. 2011. Presence of the leopard seal Hydrurga leptonyx (De Blainville, 1820), on the coast of Chile: an example of the Antarctica – South America connection in the marine environment. Oecologia Australis. 15, 69-85.

Airberlin. 2014. Airbus A330-200 Fuel Consumption. https://www.airberlin.com/site/seatplan.php?seatTyp=A330_200_1 (Accessed August 2014).

Alemany, D., Acha, E.M. & Iribarne, O. 2009. The relationship between marine fronts and fish diversity in the Patagonian Shelf large marine ecosystem. Journal of Biogeography. 36, 2111-2124.

Alloy, M., Baxter, D., Stieglitz, J., Mager, E., Hoenig, R., Benetti, D., Grosell, M., Oris, J., & Roberts, A. Ultraviolet Radiation Enhances the Toxicity of Deepwater Horizon Oil to Mahi-mahi (Coryphaena hippurus) Embryos. Environmental Science Technology. 50, 2011−2017.

Almeda, R., Baca, S., Hyatt, C., Buskey, E.J. 2014. Ingestion and sublethal effects of physically and chemically dispersed crude oil on marine planktonic copepods. Ecotoxicology. 23, 988-1003.

Almeda, R., Harvey, T.E., Connelly, T.L., Sarah Baca, S. & Buskey, E.J. 2016. Influence of UVB radiation on the lethal and sublethal toxicity of dispersed crude oil to planktonic copepod nauplii. Chemospere. 152, 446-458.

Almeda, R., Wambaugh, Z., Wang, Z., Hyatt, C., Liu, Z., & Buskey, E.J. 2013. Interactions between Zooplankton and Crude Oil: Toxic Effects and Bioaccumulation of Polycyclic Aromatic Hydrocarbons. PLoS ONE. 8(6): e67212.

Altwegg, R., Crawford, R.J., Underhill, L.G. & Williams, A.T.J. 2008. Long-term survival of de-oiled Cape gannets Morus capensis after the Castillo de Bellver oil spill of 1983. Biological Conservation. 141, 1924-1929.

Anatec. 2013. Collision Risk Assessment Sea Lion FPSO (Technical Note). Ref: A3140-PRE-RA-1. Report for Argos Ltd/Noble Energy.

Andreassen, I. & Sørheim, K.R. 2013. Fram crude oil-properties and behaviour at sea. SINTEF: Norway.

Andriashev, A.P. 1964. On the composition and origin of the Antarctic pelagic fish fauna. Biologie Antarctique. (Carrick, R. Holdgate, M. & Prevost, J., eds), 271-272. Paris: Hermann.

Aquateam COWI. 2014. Characterising Thermal Treated OBM Drill Cuttings. Sampling, characterisation, environmental analysis and risk assessment of offshore discharges. Report No. 14-028.

Arata, J. & Xavier, J.C. 2003. The diet of black-browed albatrosses at the Diego Ramirez Islands, Chile. Polar Biology. 145, 593-610.

Arcos, J.M., Oro, D. 2002. Significance of nocturnal purse seine fisheries for seabirds: a case study off the Ebro Delta (NW Mediterranean). Marine Biology, 141, 277-286.

Arctic Council. 2009. Guidelines and Strategies for Oily Waste Management in the Arctic Region. https://arctic-council.org/eppr/completed-work/oil-and-gas-products/.

Arkhipkin, A. & Laptikhovsky, V. 2013. From gelatinous to muscle food chain: rock cod Patagonotothen ramsayi recycles coelenterate and tunicate resources on the Patagonian Shelf. Journal of Fish Biology. 83, 1210-1220.

Arkhipkin, A.I. & Middleton, D.A.J. 2002a. Inverse patterns in abundance of Illex argentinus and Loligo gahi in Falkland waters: possible interspecific competition between squid? Fisheries Research. 51, 181-196.

Arkhipkin, A.I. & Middleton, D.A.J. 2002b. Sexual segregation in ontogenetic migrations by the squid Loligo gahi around the Falkland Islands. Bulletin of Marine Science. 71, 109-127.

Arkhipkin, A.I., Baumgartner, N., Brickle, P., Laptikhovsky, V.V., Pompert, J.H.W. & Shcherbich, Z. N. 2008. Biology of the skates Bathyraja brachyurops and B. griseocauda in waters around the Falkland Islands, Southwest Atlantic. ICES Journal of Marine Science. 65, 560-570.

Arkhipkin, A.I., Brickle, P. & Laptikhovsky, V.V. 2010. Usage of the island water dynamics by spawning red cod, Salilota australis (Pisces: Moridae) on the Falkland Islands shelf (Southwest Atlantic). Fisheries Research. 105, 156-162.

Arkhipkin, A., Brickle, P. & Laptikhovsky, V. 2013. Links between marine fauna and oceanic fronts on the Patagonian Shelf and Slope. Arquipelago. Life and Marine Sciences. 30, 19-37.

Arkhipkin, A., Brickle, P., Laptihovsky, V., Butcher, L., Jones, E., Potter, M. & Poulding, D. 2001. Variation in the diet of the red cod, Salilota australis (Pisces: Moridae), with size and season at the Falkland Islands (south-west Atlantic). Journal of the Marine Biological Association of the United Kingdom. 81, 1035-1040.

Arkhipkin, A., Brickle, P., Laptikhovsky, V.V., Pompert, J. & Winter, A. 2012a. Skate assemblage on the eastern Patagonian shelf and slope: structure, diversity and abundance. Journal of Fish Biology. 80, 1704-1726.

Arkhipkin, A., Brickle, P., Laptikhovsky, V.V. & Winter, A. 2012b. Dining hall at sea: feeding migrations of nektonic predators to the eastern Patagonian Shelf. Journal of Fish Biology. 81, 882-902.

Arkhipkin, A., Gras, M. & Blake, A. 2015. Water density pathways for shelf/slope migrations of squid Illex argentinus in the Southwest Atlantic. Fisheries Research. 127, 234-242.

Arkhipkin, A., Grzebielec, R., Sirota, A.M., Remeslo, A.V., Polishchuk, I.A. & Middleton, D.A.J. 2004a. The influence of seasonal environmental changes on ontogenetic migrations of the squid Loligo gahi on the Falkland shelf. Fisheries Oceanography. 13, 1-9.

Arkhipkin, A.I., Laptikhovsky V.V. & Middleton D.A.J. 2000. Adaptations for the cold water spawning in squid of the family Loliginidae: Loligo gahi around the Falkland Islands. Journal of Molluscan Studies, 66, 551-564.

Arkhipkin, A.I., Laptikhovsky, V.V., Sirota, A.M., & Grzebielec, R 2006. The role of the Falkland Current in the dispersal of the squid Loligo gahi along the Patagonian Shelf. Estuarine Coastal and Shelf Science, 67: 198-204.

Arkhipkin, A.I., Middleton, D.A.J., Portela, J.M. & Bellido, J,M. 2003. Alternative usage of common feeding grounds by large predators: the case of two hakes (Merluccius hubbsi and M. australis) in the southwest Atlantic. Aquatic Living Resources. 16, 487-500.

Arkhipkin, A.I., Middleton, D.A.J., Sirota, A.M. & Grzebielec, R. 2004b. The effect of Falkland Current inflows on offshore ontogenetic migrations of the squid Loligo gahi on the southern shelf of the Falkland Islands. Estuarine, Coastal and Shelf Science. 60, 11-22.

Arnbom, T., Fedak, M.A. & Boyd, I.L. 1997. Factors affecting maternal expenditure in southern elephant seals during lactation. Ecology. 78, 1772-1781.

Arthur B., Hindell M., Bester M., De Bruyn N., Trathan, P., Goebel, M. & Lea, M.A. 2017. Winter habitat predictions of a key Southern Ocean predator, the Antarctic fur seal (Arctocephalus gazella). Deep Res Part II Top Stud Oceanogr 140:171–181. doi: 10.1016/j.dsr2.2016.10.009

Atlantic, O.C.S. 1988. Synthesis of effects of oil on marine mammals. Geraci, J.R. & Aubin, D.J.S. (Eds.). Department of the Interior, Minerals Management Service, Atlantic OCS Region.

ATSDR, 1997. Agency for Toxic Substances and Disease Registry, Public Health Statement: Hydraulic fluids. www.atsdr.cdc.gov/

Augé, A. A., Otley, H., Rendell, N. & Frans, V. 2016. Spatial distribution of cetacean strandings in the Falkland Islands to define monitoring opportunities. Journal of Cetacean Research Management. 19, 1-17.

Augé, A.A. 2016a. Marine Spacial Planning for the Falkland Islands: 'Framing' workshop report. South Atlantic Environmental Research Institute, Stanley, Falkland Islands.

Augé, A.A. 2016b. Anthropogenic debris in the diet of turkey vultures (Cathartes aura) in a remote and low-populated South Atlantic island. Polar Biology.

Baird, P.H. 1990. Concentrations of seabirds at oil-drilling rigs. Condor, 92, 768-771.

Balushkin, A. V. 1992.. Classification, phylogenetic relationships, and origins of the families of the suborder Notothenioidei (Perciformes). Journal of Ichthyology. 32, 90–110.

Balushkin A. V. (1994). A fossil notothenioid, but not gadiform, fish Proeleginops grandeastmanorum gen. et sp. nov. (Perciformes, Notothenioidei, Eleginopsidae) from Late Eocene of Seymour Island, Antarctica. Voprosy Ikhthyologii 34, 298–307, (In Russian).

Banner, A. and Hyatt, M. 1973. Effects of Noise on Eggs and Larvae of Two Estuarine Fishes. Trans. Amer. Fish Soc., 1973, No. 1.

Bargelloni, L., Marcato, S, Zane, L. & Patarnello, T. 2000. Mitochondrial phylogeny of Notothenioids: a molecular approach to Antarctic fish evolution and biogeography. Systematic Biology. 49,114–129.

Barlow, M.J. & Kingston, P.F. 2001. Observations on the Effects of Barite on the Gill Tissues of the Suspension Feeder Cerastoderma edule (Linne) and the Deposit Feeder Macoma balthica (Linne). Marine Pollution Bulletin. 42, 71-76.

Barón, P.D. 2001. First description and survey of the egg masses of Loligo gahi (D'Orbigny, 1835) and Loligo sanpaulensis (Brakoniecki, 1984) from coastal waters of Patagonia. Journal of Shellfish Research, 20: 289-295.

Barratt, I. & Allcock, L. 2014a. Onykia ingens. The IUCN Red List of Threatened Species 2014: e.T163131A975198. http://dx.doi.org/10.2305/IUCN.UK.2014-1.RLTS.T163131A975198.en. Downloaded on 02 December 2018.

Barratt, I. & Allcock, L. 2014b. Illex argentinus. The IUCN Red List of Threatened Species 2014: e.T163246A989453. http://dx.doi.org/10.2305/IUCN.UK.2014-1.RLTS.T163246A989453.en. Downloaded on 02 December 2018.

Barrett, R.T. 1979. Small oil spill kills 10-20,000 seabirds in North Norway. Marine Pollution Bulletin. 10, 253-255.

BAS. 2014. Sea Lion marine growth study investigation of probable marine growth types, thickness, mass, density, roughness and drag on the Sea Lion Field Development, South Atlantic.

BAS. 2015. Research Ships. https://www.bas.ac.uk/polar-operations/sites-and-facilities/ship/ [Accessed November 2015]

Baumgartner, M.F., Van Parijs, S.M., Wenzel, F.W., Tremblay, C.J., Esch, H.C. & Warde, A.M. 2008. Low frequency vocalizations attributed to sei whales (Balaenoptera borealis). Journal of the Acoustical Society of America. 124, 1339-1349.

Baylis, A.M.M. 2012. 2010 archipelago-wide census gentoo and rockhopper penguins Falklands Conservation. Unpublished Report.

Baylis, A.M.M., Crofts, S. & Wolfaardt, A.C. 2013a. The world's largest Gentoo Penguin population? The current status of the population breeding at the Falkland Islands. Marine Ornithology. 41, 1-5.

Baylis, A.M.M., Orben, R.A., Arnould, J.P.Y., Peters, K., Knox, T., Costa, D.P. & Stanilands, I.J. 2015. Diving deeper into individual foraging specializations of a large marine predator, the southern sea lion. Oecologia. 179, 1053-1065.

Baylis, A.M.M., Orben, R.A., Pistorius, P., Brickle, P., Staniland, I. & Ratcliffe, N. 2014. Winter foraging site fidelity of king penguins breeding at the Falkland Islands. Marine Biology. 162, 99-110.

Baylis, A.M.M., Wolfaardt, A.C., Crofts, S., Pistorius, P.A. & Ratcliffe, N. 2013b. Increasing trend in the number of Southern rockhopper penguins breeding at the Flakland Islands. Polar Biology. 36, 1007-1018.

Baylis, A.M.M., Tierney, M., Orben, R.A., Warwick-Evans, V., Wakefield, E., Grecian, W. J., Trathan, P., Reisinger, R., Ratcliffe, N., Croxall, J., Campioni, L., Catry, P., Crofts, S., Boersma, P. D., Galimberti, F., Granadeiro, J., Handley, J., Hayes, S., Hedd, A., Masello, J.F., Montevecchi, W.A., Pütz, K., Quillfeldt, P., Rebstock, G.A., Sanvito, S., Staniland, I.J. ; Brickle, P. 2019. Important at-sea areas of colonial breeding marine predators on the Southern Patagonian Shelf. In: Scientific Reports. 2019 ; Vol. 9, No. 1.

Becker, A., Whitfield, A.K., Cowley, P.D., Jarnegren, J. & Naesje, T.F. 2013. Potential effects of artificial light associated with anthropogenic infrastructure on the abundance and foraging behaviour of estuary-associated fishes. Journal of Applied Ecology. 50, 43-50.

Behrens, H.L., Leppäkoski, E., Olenin, S. 2005. Ballast Water Risk Assessment Guidelines for the North Sea and Baltic Sea, Nordic Innovation Centre NT Techn. Report 587, Approved 12. Oslo, Norway, www.nordicinnovation.net (Accessed September 2016)

BEIS (Department for Business, Energy and Industrial Strategy). 2017. Updated Energy and Emissions Projections 2016. https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2016 (Accessed September 2017).

Belkin, I.M., Cornillon, P.C. & Sherman, K. 2009. Fronts in large marine ecosystems. Progress in Oceanography. 81, 223-236.

Berman-Kowalewski, M., Gulland, F.M.D., Wilkin, S., Calambokidis, J., Mate, B., Cordaro, J., Rotstein, D., St. Leger, J., Collins, P., Fahy, K. & Dover, S. 2010. Association Between Blue Whale (Balaenoptera musculus) Mortality and Ship Strikes Along the California Coast. Aquatic Mammals. 36, 59-66.

Berrow, S.D., Wood, A.G. & Prince, P.A. 2000 Foraging location and range of white-chinned petrels Procellaria aequinoctialis breeding in the South Atlantic. Journal of Avian Biology. 31, 303-311.

Beylot, A. and Villeneuve, J. 2013. Environmental impacts of reisidual Municipal Solid Waste incineration: A comparison of 110 French incinerators using a life cycle approach. https://www.researchgate.net/publication/255175439_Environmental_impacts_of_residual_Municipal_Solid_Waste_incineration_A_comparison_of_110_French_incinerators_using_a_life_cycle_approach [Accessed September 2017].

Bianchi, A., Massonneau, M. & Olevera, R.M. 1982. Analisis estatistico de las caracteristicas T–S del sector austral de la Plataforma Continental Argentina. Acta Oceanologica Argentina. 3, 93-118.

BirdLife International. 2004. Tracking ocean wanderers: the global distribution of albatrosses and petrels. Results from the Global Procellariiform Tracking Workshop, 1-5 September, 2003, Gordon's Bay, South Africa. Cambridge, UK. Birdlife International.

BirdLife International. 2008. Seabirds suffer from eating 'junk'. Presented as part of the BirdLife State of the world's birds website. http://www.birdlife.org/datazone/sowb/casestudy/159. (Accessed October 2015).

BirdLife International. 2014a. Country profile: Falkland Islands (Malvinas). http://www.birdlife.org/datazone/country/falkland-islands-malvinas. (Accessed October 2014).

BirdLife International. 2014b. IUCN Red List for birds. http://www.birdlife.org (Accessed July 2014).

BirdLife International. 2015. IUCN Red List for birds. http://www.birdlife.org on (Accessed July 2015).

BirdLife International. 2016. Species factsheet: Ardenna gravis. http://www.birdlife.org on 12/01/2016. Recommended citation for factsheets for more than one species: BirdLife International (2016) IUCN Red List for birds. http://www.birdlife.org. (Accessed January 2016).

BirdLife International. 2019. Country profile: Falkland Islands (Malvinas). Available from http://www.birdlife.org/datazone/country/falkland-islands-malvinas. Checked: 2019-09-08.

Birkett, D.A., Maggs, C.A., Dring M.J. & Boaden P.J.S. 1998. Infralittoral reef biotopes with kelp species. An overview of dynamic and sensitivity characteristics for conservation management of marine SACs. Queen's University of Belfast Marine Laboratory.

Black, A. 2005a. Light induced seabird mortality on vessels operating in the Southern Ocean: incidents and mitigation measures. Antarctic Science. 17, 67-68.

Black, A.D. 2005b. The distribution of seabirds and marine mammals in South Georgian waters. Unpublished report by Falklands Conservation to the Government of South Georgia and the South Sandwich Islands.

Black, A.D., Parker, G., Rexer-Huber, K., Sommer, E. & Cuthbert, R.J. 2012. Kerguelen petrel (Lugensa brevirostris): a 'new' breeding species for South Georgia. Antarctic Science. 25, 69-70.

Black, K.P., Brand, G.W., Grynberg, H., Gwyther, D., Hammond, L.S., Mourtikas, S., Richardson, B.J., Wardrop, J.A., 1994a. Environmental Implications of Offshore Oil and Gas Development in Australia Production Activities. Australian Petroleum Exploration Association (APEA), Energy Research and Development Corporation (ERDC), pp. 344–385.

Black, K.P., Brand, G.W., Gwyther, D., Hammond, L.S., Mourtikas, S., Noyes-Fitzsimmons, R.L., Smith, J.M., Richardson, B.J., 1994b. Environmental Implications of Offshore Oil and Gas Development in Australia Coastal Facilities. Australian Petroleum Exploration Association (APEA), Energy Research and Development Corporation (ERDC). pp. 460–492.

Blockley, D. and Tierney, M. 2017. Addressing priority gaps in understanding ecosystem functioning for the developing Falkland Islands offshore hydrocarbon industry – the 'Gap Project'. Final Report. SAERI 2017.

BMT. 2000. Murray Fenton Edon Liddiard Vince Limited: Study on the economic, legal, environmental and practical implications of a European Union system to reduce ship emissions of SO_2 and NOx. No. 3623. Final Report for European Commission 3040/98/000839/MAR/B1.

BMT, 2005. EIA study for heliport at Yung Shue Wan Lamma Island.

BMT Argoss. 2015. Sea Lion Hydrodynamic Modelling – Final Report. Reference Number: A14043_Final_Report_r1. Prepared for Premier Oil Exploration and Production Limited.

Boltovskoy, D. (ed). 2000. South Atlantic zooplankton. Backhuys Publishers, Leiden.

Bonn Agreement. 2009. Bonn Agreement Aerial Operations Handbook.

Boulenger, G.A. 1900. A list of fishes collected by Mr. Rupert Vallentin in the Falkland Islands. Annals and Magazine of Natural History (Ser. 7). 6, 52-54.

Bowmer, C.T., Gimeno, S., Foekema, E.M. and Kaag, N.H.B.M. 1996. An environmental evaluation of cleaned drill cuttings using a long term model bioassay. The Physical and Biological Effects of Processed Oily Drill Cuttings. E&P Forum Report.

Boyd, J.N., Kucklick, J.H., Scholz, D.K., Walker, A.H., Pond, R.G. & Bostrom, A. 2001. Effects of oil and chemically dispersed oil in the environment. Health and Environmental Sciences Department, Scientific and Environmental Associates, inc. Cape Charles, Virginia, Publication number 4693.

Breeding, J.E,Jr., Pflug, L.A., Bradley, M., Walrod, M.H. & McBride, W. 1996. Research Ambient Noise Directionality (RANDI) 3.1 Physics description. Naval Research Laboratory. NRL/FR/7176--95-9628.

Breuer, E., Howe, J.A., Shimmield G.B., Cummings, D. & Carroll, J. 1999. Contaminant Leaching from Drill Cuttings Piles of the Northern and Central North Sea: A Review. SAMS (Scottish Association for Marine Science) and Centre for Coastal and Marine Sciences, Dunstaffnage Marine Laboratory.

Brickle, P., Arkhipkin, A., & Shcherbich, Z. 2005a. Age and growth in a euryhaline notothenioid, Eleginops maclovinus (Cuv., & Val., 1830). Journal of Marine Biological Association of the United Kingdom. 85, 1217-1221.

Brickle, P. Arkhipkin, A., Laptikhovsky, V., Stocks, A.F. & Talyor, A. 2009. Resource partitioning in two large planktivorous fishes Micromesistius australis and Macruronus magellanicus in the Southwest Atlantic. Estuarine, Coastal and Shelf Science. 84, 91-98.

Brickle, P., Laptikhovski, V. & Arkhipkin, A. 2005b. Reproductive strategy of a primitive temperate Eleginops maclovinus (Cuv., & Val., 1830) (Notothenioidea: Eleginopidae). Journal of Fish Biology. 66, 1044-1059.

Brickle, P. Laptikhovsky, V. & Arkhipkin, A. 2011. The reproductive biology of a shallow water morid (Salilota australis Gunther, 1878), around the Falkland Islands. Estuarine, Coastal and Shelf Science. 94, 102-110.

Brickle P., Laptikhovsky, V., MacKenzie K., & Arkhipkin, A. 2003. Scientific report, The Falkland Mullet Eleginops maclovinus: Biology and Fishery in Falkland Islands' waters. Stanley, Falkland Islands Government Fisheries Department.

Brickle, P., & MacKenzie, K. 2007. Parasites as biological tags for Eleginops maclovinus (Teleostei: Eleginopidae) around the Falkland Islands. Journal of Helminthology. 81, 147- 153.

Brickle, P., Schuchert, P.C., Arkhipkin, A.I., Reid, M.R. & Randhawa, H.S. 2016. Otolith Trace Elemental Analyses of South American Austral Hake, Merluccius australis (Hutton, 1872) Indicates Complex Salinity Structuring on their Spawning/Larval Grounds. PLoS ONE 11(1): 0145479

Brickle, P., Shcherbich, Z., Laptikhovsky, V., & Arkhipkin, A. 2005. Scientific Report. Aspects of the biology of the Falkland Islands' rockcod Patagonotothenramsayi (Regan, 1913) on the southern Patagonian Shelf.

Brodie, J. and Mrowicki, R. 2019. A draft check-list of the seaweeds of the Falkland Islands. Natural History Museum, London. 31 July, 2019.

Brooks, S. & Waldock, M. 2009. The use of copper as a biocide in marine antifouling paints. In: Advances in Marine Antifouling Coatings and Technologies, (eds C. Hellio & D. Yebra) pp.492-521, Woodhead Publishing.

Brown, J. Laptikovsky, V. & Dimmlich, W. 2010. Solitary spawning revealed – an in situ observation of spawning behaviour of Doryteuthis (Amerigo) gahi (d'Orbigny, 1835 in 1834–1847) (Cephalopoda: Loliginidae) in the Falkland Islands. Journal of Natural History. 44, 2041-2047.

BS7445, 2003. British Standards Institution BS7445-1:2003. Description and measurement of environmental noise. Guide to quantities and procedures.

BS4142, 2014. British Standards Institution BS4142:2014 Method for rating industrial and commercial sound.

BSL. 2008a. Regional Benthic Environmental Survey of the Southern North Falklands Basin. Report for Desire Petroleum Plc. Rockhopper Exploration Plc. Arcadia Petroleum Plc.

BSL. 2008b. Burdwood Bank, South Falklands Basin. Regional Benthic Environmental Survey. Report for Borders and Southern.

BSL. 2015a: Geophysical and Environmental Programme Berkeley Sound. 1506 Volume 3: Geophysical survey. Unpublished report by Benthic Solutions Limited to Premier Oil Exploration and Production Limited.

BSL. 2015b: Geophysical and Environmental Programme Berkeley Sound; 1506 Volume 4: Habitat Assessment Report. Unpublished report by Benthic Solutions Limited to Premier Oil Exploration and Production Limited.

BSL. 2015c: Geophysical and Environmental Programme Berkeley Sound; 1506 Volume 5: Environmental Baseline Survey Report. Unpublished report by Benthic Solutions Limited to Premier Oil Exploration and Production Limited.

Buehler, D., Oestman, R., Reyff, J., Pommerenck, K. and Mitchell, B. 2015. Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish.

Burger, A. E. 1993. Estimating the mortality of seabirds following oil spills: effects of spill volume. Marine Pollution Bulletin. 26, 140-143.

Burger, A., & Fry, D., 1993. Effects of oil pollution on seabirds in the northeast Pacific. In: The Status, Ecology, and Conservation of Marine Birds of the North Pacific (Eds: Vermeer, K., Briggs, K., Morgan, K., Siegel-Causey, D). Canadian Wildlife Service Special Publication, Ottawa.

Burke, C.M., Davoren, G.K., Montevecchi, W.A. & Wiese, F.K. 2005. Seasonal and spatial trends of marine birds along offshore support vessel transects and at oil platforms on the Grand Banks. In: Offshore oil and gas environmental effects monitoring: approaches and technologies (Eds: Armsworthy, S.l.; Cranford, P.J.; Lee, K.), pp. 587-614. Battelle Press, Columbus, Ohio, USA.

Burkhardt, E. & Lanfredi, C. 2012. Fall feeding aggregations of fin whales off Elephant Island (Antarctica). Paper SC/64/SH9 presented to the IWC Scientific Committee (unpublished).

Bustos, C.A., Balbontín, F. & Landaeta, M. 2007. Spawning of the southern hake Merluccius australis (Pisces: Merlucciidae) in Chilean fjords. Fisheries Research. 83, 23-32.

Butler, R.G., Harfenist, A., Leighton, F.A. & Peakall, D.B. 1988. Impact of sublethal oil and emulsion exposure on the reproductive success of Leach’s Storm-Petrels: short and long- term effects. Journal of Applied Ecology, 25, 125–143.

CAA. 2013. CAP 437 Standards for Offshore Helicopter Landing Areas. https://publicapps.caa.co.uk/docs/33/CAP437.pdf

CABI. 2013. Biological control of the European earwig (Forficula auricularia) – a severe threat to horticulture and health & safety on the Falkland Islands. Centre for Agriculture and Bioscience International (CABI) report to Falkland Islands Government.

CABI. 2014. Invasive Species Compendium, Datasheet-Carcinus meanus.
http://www.cabi.org/isc/datasheetreport?dsid=90475 [Accessed 14 September 2014].

Caldeira, K. & Wickett, M.E. 2003. Anthropogenic carbon and ocean pH. Nature. 425, 365.

Carlmark J.W. 1971. Penetration of free-falling objects into deep-sea sediments. United States Naval Postgraduate School. http://calhoun.nps.edu/bitstream/handle/10945/15850/penetrationoffre00carl.pdf?sequence=1 [Accessed July 2017].

Campagna, C. 2008. Arctocephalus australis. In: The IUCN Red List of Threatened Species. Version 2014.2. (IUCN SSC Pinniped Specialist Group). http://www.iucnredlist.org [Accessed 16 September 2014].

Camphuysen, C.J. 1989. Beached bird surveys in the Netherlands 1915-1988: seabird mortality in the southern North Sea since the early days of oil pollution. Werkgroep Noordzee, Amsterdam.

Camphuysen, C.J. 2005. North Sea Pilot Project on Ecological Quality Objectives, Issue 4. Seabirds, EcoQO element (f): Oiled-guillemot-EcoQO. Final version, January 2005. CSR Consultancy, Oosterend, Texel.

Camphuysen C.J., Chardine, J., Frederiksen, M. & Nunes, M. 2005. Review of the impacts of recent major oil spills on seabirds. In: Report of the Working Group on Seabird Ecology, Texel, 29 March to 1 April 2005 (Eds: Anonymous). Oceanography Committee, ICES CM 2005/C:05, Ref. ACME+E, International Council for the Exploration of the Sea, Copenhagen, Denmark.

Carreto, J.I., Lutz, V.A., Carignan, M.O., Cucchi Colleoni, A.D. & De Marco, S.G. 1995. Hydrography and chlorophyll a in a transect from the coast to the shelf-break in the Argentine Sea. Continental Shelf Research. 15, 315-336.

Carroll, M., Pearson, T., Dragsund, E. and Gabrielsen, K.L. 2000. Environmental Status of the Norwegian Offshore Sector Based on the Petroleum Regional Monitoring Programme, 1996-1998. Prepared for the Norwegian Oil industry Association (OLF).

Catry, P., Campos, A., Segurado, P., Silva, M. & Strange, I. 2003 Population census and nesting habitat selection of thin-billed prion Pachyptila belcheri on New Island, Falkland Islands. Polar Biology. 26, 202-207.

Catry, P., Lemos, R., Brickle, P., Phillips, R.A., Matias, R. & Granadeiro, J.P. 2013. Predicting the distribution of a threatened albatross: the importance of competition, fisheries and annual variability. Progress in Oceanography. 110, 1-10.

CEDRE (Centre de documentation, de recherche et d’experimentations sur les pollutions accidentelles des eaux). 2017. Premier Oil: Study of the Weathering, Behaviour and Potential Impacts of a Crude Oil at the Laboratory and Pilot Scale in Simulated Local Weather Conditions. R.17.50.C/5227

CEFAS. 2001. Contaminant Status of the North Sea, DTI Strategic Environmental Assessment Technical Report TR_004.

CERC. 2012a. Cambridge Environmental Research Consultants Ltd: ADMS 5. Interface version: 5.0.0, build: 2.26. Release date: 16 November 2012.

Chamber of Shipping, Danish Shipowners' Association, Netherlands Oil and Gas Exploration and Production Association, Norwegian Oil Industry Association (OLF),Norwegian Shipowners' Association & Oil and Gas UK 2009. NWEA Guidelines For The Safe Management of Offshore Supply And Rig Moving Operations Version 2.

https://www.snspool.com/marine/library/manuals/offshore_guidelines.pdf

Cherel, Y., Pütz, K. & Hobson, K. 2002. Summer diet of king penguins (Aptenodytes patagonicus) at the Falkland Islands, southern Atlantic Ocean. Polar Biology. 25, 898-906.

CIRES. 2016. Co-operative Institute for Research in Environmental Sciences: The New World Atlas of Artificial Sky Brightness. http://cires.colorado.edu/artificial-sky [Accessed September 2016].

CIWEM. 2012. Chartered Institute of Water and Environmental Management Policy Position Statement: Control of Odour. CIWEM: London.

Clark, T. J., Matthiopoulos, T., Bonnet-Lebrun, A-S., Campioni, L., Catry, P., Marengo, I., & Poncet, S. 2019. Integrating habitat and partial survey data to estimate the regional population of a globally declining seabird species, the sooty shearwater. Global Ecology and Conservation. 17: doi.org/10.1016/j.gecco.2019.e00554.

Clarke, M.R. 1980. Cephalopoda in the diet of sperm whales of the southern hemisphere and their bearing on sperm whale biology. Discovery Reports. 37, 1-324.

Clausen, A.P. & Pütz, K. 2003. Winter diet and foraging range of gentoo penguins (Pygoscelis papua) from Kidney Cove, Falkland Islands. Polar Biology. 26, 32-40.

Clausen, A.P., Arkhipkin, A.I., Laptikhovsky, V.V. & Huin, N. 2005. What is out there: diversity in feeding of gentoo penguins (Pygoscelis papua) around the Falkland Islands (Southwest Atlantic). Polar Biology. 28, 653-662.

Clyne, H. & Leaper, R. 1999. Modelling collisions between whales and ships. Assessing the potential for vessels to take avoiding action in response to sightings of whales. SC/56/BC6.

C-NOPB. 2002. (Canada–Newfoundland Offshore Petroleum Board), Offshore waste treatment guidelines. St. John’s, NL: National Energy Board, Canada–Newfoundland Offshore Petroleum Board & Canada–Nova Scotia Offshore Petroleum Board. 21 pp.

Cohen, D.M., Inada, T., Iwamoto, T. & Scialabba, N. 1990. FAO species catalogue. Vol. 10. Gadiform fishes of the world (Order Gadiformes). An annotated and illustrated catalogue of cods, hakes, grenadiers and other gadiform fishes known to date. FAO Fisheries Synopsis, v. 10. FAO, Rome.

Cole, S., Codling, I.D., Parr, W. & Zabel, T. 1999. Guidelines for managing water quality impacts with European marine sites. Report prepared for the UK Marine SACs project. Swindon WRC.

Collette, B., Amorim, A.F., Boustany, A., Carpenter, K.E., de Oliveira Leite Jr., N., Di Natale, A., Fox, W., Fredou, F.L., Graves, J., Viera Hazin, F.H., Juan Jorda, M., Minte Vera, C., Miyabe, N., Nelson, R., Oxenford, H., Sun, C., Teixeira Lessa, R.P., Pires Ferreira Travassos, P.E. & Uozumi, Y. 2011. Allothunnus fallai. The IUCN Red List of Threatened Species 2011:

e.T170349A6761139. http://dx.doi.org/10.2305/IUCN.UK.2011-2.RLTS.T170349A6761139.en. Downloaded on 02 December 2018.

Committee on oil in the sea. 2003. Committee on oil in the sea: inputs, fates and effects. National Research Council of the National Academies. Washington, D.C.: The National Academies Press.

Coolen, J. W. P., Lindeboom, H., Cuperus J., van der Wiede, B. and van der Stap, T. 2015. Benthic communities on old gas platforms as predictors for new offshore wind farms. Conference on Wind energy and Wildlife impacts 2015, Berlin. https://www.researchgate.net/publication/279202168_Benthic_communities_on_old_gas_platforms_as_predictors_for_new_offshore_wind_farms [Accessed October 2016].

Cooper, J. 1982. Methods of reducing mortality of seabirds caused by underwater blasting. Cormorant, 10, 109-114.

Cooper, J., Avenant, N.L. & Lafite, P.W. 1994. Airdrops and penguins: a potential conservation problem at sub-Antarctic Marion Island. Polar Record. 30, 277-282.

Costa D.P., Robinson P.W., Arnould J.P.Y., Harrison A-L, Simmons SE, Hassrick J.L., Hoskins, A.J., Kirkman, S.P., Oosthuizen, H., Villegas-Amtmann, S. & Crocker, D.E. 2010. Accuracy of ARGOS Locations of Pinnipeds at-Sea Estimated Using Fastloc GPS. PLoS ONE 5(1): e8677. https://doi.org/10.1371/journal.pone.0008677.

Costa, M. and Cazzola, M. (2018) Dolphins of the kelp: Data priorities for Falkland's inshore cetaceans. Darwin Plus: Final Report. Pp. 74. Downloaded 04/09/2019 from: Website: www.south-atlantic-research.org/research/current-research/166-dolphins-of-the-kelp-data-priorities-for-falkland-s-inshore-cetaceans.

Cranford, P.J. & Gordon, D.C. 1992. The Influence of Dilute Clay Suspensions on Sea Scallop (Placopecten magellanicus) Feeding Activity and Tissue Growth. Netherlands Journal of Sea Research. 30, 107-200.

Cranford, P.J., Gordon, K.L., Jr, Lee, K., Armsworthy, S.L. & Tremblay, G.H. 1999. Chronic Toxicity and Physical Disturbance Effects of Water and Oil-based Drilling Fluids and Some Major Constituents of Adult Sea Scallops (Placopecten magellanicus). Marine Environmental Research. 48, 225-256.

Cranford, P., Querbach, K., Maillet, G., Lee, K., Grant, J. & Taggart, C. 1998. Sensitivity of Larvae to Drilling Wastes (Part A): Effects of water-based drilling mud on early life stages of haddock, lobster and sea scallop. Report to the Georges Bank Review Panel, Halifax, NS. http://www.dfo-mpo.gc.ca/Library/334183parta.pdf [Accessed September 2014].

Cranford, P.J., Emerson, C.W., Hargrave, B.T. &. Milligan, T.G. 1998. In situ feeding and absorption responses of sea scallops Placopecten magellanicus (Gmelin) to storm-induced changes in the quantity and composition of the seston. Journal of Experimental Marine Biology and Ecology. 219, 45-70.

Crofts, S. 2014. Action Plan for the southern rockhopper penguin Eudyptes chrysocome chrysocome at the Falkland Islands: Review of potential threats, progress of work and prioritised action for 2014 – 2020. A report to Falklands Islands Government. Falklands Conservation, Stanley.

Crofts, S. and Stanworth, A. 2017. Falkland Islands Seabird Monitoring Programme Annual Report 2016/2017 (SMP24), Falklands Conservation, Stanley.

Crofts, S. and Stanworth, A. 2018. Falkland Islands Seabird Monitoring Programme Annual Report 2017/2018 (SMP25). Falklands Conservation, Stanley.

Croxall, J.P., Black, A.D. & Woods, A.G. 1999. Age, sex and status of wandering albatrosses Diomedea exulans in Falkland Island waters. Antarctic Science. 11, 150-156.

Croxall, J.P., Butchart, S.H.M., Lascelles, B., Stattersfield, A.J., Sullivan, B., Symes, A. & Taylor, P. 2012. Seabird conservation status, threats and priority actions: a global assessment. Bird Conservation International. 22, 1-34.

Croxall, J.P., McInnes, S.J. & Prince, P.A. 1984. The status and conservation of seabirds at the Falkland Islands. In: Status and Conservation of the Worlds Seabirds. (Croxall, J.P, Evans, P.G.H, and Schreiber, R.W., eds), pp 271-293. ICBP Publication No 2 Cambridge.

Croxall, J.P. & Woods, A.G. 2002. The importance of the Patagonian Shelf for top predator species breeding at South Georgia. Aquatic Conservation: Marine and Freshwater Ecosystems. 12, 101-118.

Crum, L. & Mao, Y. 1996. Acoustically enhanced bubble growth at low frequencies and its implications for human diver and marine mammal safety. Journal of the Acoustical Society of America. 99, 2898-2908

Culik, B., Adelung, D. & Woakes, A.J. 1990. The effect of disturbance on the heart rate and behaviour of Adelie Penguins (Pygoscelis adeliae) during the breeding season. In: Antarctic ecosystems: ecological change and conservation. (Kerry KR, Hempel G., eds), pp 177–182.Springer, Berlin.

Cunningham, A.P., Howe, J.A. & Barker, P.F. 2002. Contourite sedimentation in the Falkland Trough, western South Atlantic Ocean. In: Deep-water contourite systems: modern drifts and ancient series, seismic and sedimentary characteristics. (Stow, D.A.V., Pudsey, C.J., Howe, J.A., Fauge`res, J.- C., and Viana, A.R., eds), pp 337-352. Geological Society of London Memoir. 22.

Danish Ministry for the Environment 2010. Noise from ships in ports. Possibilities for noise reduction. Lloyd's Register ODS Environmental Project No. 1330 2010.

Dauvin, J.C. and Gentil, F. 1990. Conditions of the peracarid populations of subtidal communities in Northern Brittany ten years after the Amoco Cadiz oil spill. Marine Pollution Bulletin, 21, 123–130.

Davidson, D., Lear, D. & Parr, J. 2013. Falkland Island Marine Biodiversity Archive. Darwin Initiative Report.

Davidson, D. 2016. Inshore Fisheries Research Project Berkeley Sound – West (Port Louis) Trip Report.

Davies, T.W., Duffy, J.P., Bennie, J. & Gaston, K.J. 2014. The nature, extent and ecological implications of marine light pollution. Frontiers in Ecology and the Environment. 12, 347-355.

Davies, J.M. & Topping, G. (editors) 1997. The impact of an oil spill in turbulent waters: The *Braer*. Proceedings of a symposium held at the Royal Society of Edinburgh, 7-8 September 1995.

DECC. 2008. Department of Energy and Climate Change, EEMS-Atmospheric Emissions Calculations (Issue 1.810a). https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/136461/atmos-calcs.pdf.

DECC. 2011. Department of Energy and Climate Change, Decommissioning guidelines V6.

DECC. 2012. Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting.

DECC. 2014a. Methodology for the Sampling and Analysis of Produced Water and Other Hydrocarbon Discharges.

DECC. 2014b. The United Kingdom Risk Based Approach Implementation Programme. Version 2. July 2014.

DECC. 2014c. UK Greenhouse Gas Emissions Final Figures Data Tables. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/295958/20140327_2012_UK_Greenhouse_Gas_Emissions_Final_Figures_data_tables.xlsx [Accessed September 2014].

DEFRA. 2007. The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. Volume 1.

DEFRA. 2010a. Odour Guidance for Local Authorities. DEFRA: London.

DEFRA. 2010b. Noise Policy Statement for England (NPSE). DEFRA: London.

DEFRA. 2012. UK Plan for Shipments of Waste. https://www.gov.uk/government/publications/uk-plan-for-shipments-of-waste [Accessed 10.11.16]

DEFRA. 2013. Effects of air pollution. https://uk-air.defra.gov.uk/air-pollution/effects.

DEFRA. 2015a. Governmental Statistical Services, UK Statistics on Waste – 2010 to 2012.

DEFRA. 2015b. Guidance: Artificial Light Nuisances, How Councils Deal with Complaints. https://www.gov.uk/guidance/artificial-light-nuisances-how-councils-deal-with-complaints [Accessed August 2016].

DEFRA. 2016. Part IV The Environment Act 1995 Local Air Quality Management Review and Assessment Technical Guidance.

Demaze, M.T. 2013. The obscure future of the Kyoto protocol. L'espace g´eographique (english edition), 41 (4), pp.346-351.

Derraik, J.G.B. 2002. The pollution of the marine environment by plastic debris: a review. Marine Pollution Bulletin. 44, 842-852.

DeWitt, H.H., Heemstra, P.C. & Gon, O. 1990. Nototheniidae. In: Fishes of the Southern Ocean (Eds: Gon O. & Heemstra P. C.), 279–331. Grahamstown: J. L. B. Smith Institute of Ichthyology.

Dick, M.H. & Donaldson, W. 1978. Fishing vessel endangered by Crested Auklet landings. Condor. 80, 235-236.

Doney, S.C., Fabry, V.J, Feely, R.A., & Kleypas, J.A. 2009. Ocean Acidification: The Other CO_2 Problem. Annual Review of Marine Science. 1, 169-192.

Doney, S. C., Mahowald, N., Lima, I., Feely, R. A., Mackenzie, F. T., Lamarque, J.F., Rasch, P.J. 2007. Impact of anthropogenic atmospheric nitrogen and sulfur deposition on ocean acidificationand the inorganic carbon system. Proceedings of the National Academt of Sciences. Vol 104 no 37.

DNV. 2010 Technical Data Report: Marine shipping quantitative risk analysis, Enbridge Northern Gateway Project, Det Norske Veritas Oslo, Norway

DNV-GL. 2016. Sea Lion Development oil export via inshore transfer - Quantitative Risk Assessment of oil export via inshore transfer. Report No.: 10016828/4, Rev. 1. Document No.: 1ZUAQWZ-2.

Drewery, H. and Wolfaardt, A. 2017. Output of a review of ingestion pathways for oil with particular regard for the size range of solid particles. A report to Premier Oil (not published).

DTI. 2011. Department for Trade and Industry: Technical Report TR_004. Technical report produced for Strategic Environmental Assessment – SEA2 Contaminant Status Of The North Sea, Produced by Cefas.

Durban, J.W. & Pitman, R.L. 2012. Antarctic killer whales make rapid, round-trip movements to subtropical waters: Evidence for physiological maintenance migrations? Biology Letters. 8, 274-277.

EA. 2007. Environment Agency: Review of odour character and thresholds. Science Report: SC030170/SR2. Bristol: Environment Agency.

EA. 2011. Environment Agency: Additional Guidance for H4 Odour Management: How to Comply with your Environmental Permit. Bristol: Environment Agency.

EA. 2012. Environment Agency: Waste Management 2012 - England and Wales. http://webarchive.nationalarchives.gov.uk/20140328084622/http://cdn.environment-agency.gov.uk/LIT8765_794dfc.pdf [Accessed 18.10.16]

EA. 2016. Environment Agency: Air emissions risk assessment for your environmental permit. https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit.

EAC. 2014. Environmental Audit Committee - Tenth Report. Sustainability in the UK Overseas Territories.

http://www.publications.parliament.uk/pa/cm201314/cmselect/cmenvaud/332/33205.htm#n27 (Accessed November 2015).

Eastman, J.T. 1993. Antarctic Fish Biology: Evolution in a Unique Environment. London: Academic Press Limited.

EC Regulation No 1013 / 2006 on the Shipment of Waste, Annex 1a.

EC. 2003. Technical Guidance Document on Risk Assessment in support of Commission Directive 93/67/EEC on Risk Assessment for new notified substances Commission Regulation (EC) No 1488/94 on Risk Assessment for existing substances Directive 98/8/EC of the European Parliament and of the Council concerning the placing of biocidal products on the market. European Commission Joint Research Centre. EUR 20418 EN/2.

EEA. 2012 Air quality in Europe — 2012 report. EEA Report, No. 4/2012. www.eea.europa.eu/publications/air-quality-in-europe-2012/download [Accessed September 2014].

Eglinton, G., Gonzalez, A.G., Hamilton, R.J. & Raphael, R.A. 1962. Hydrocarbon constituents of the wax coatings of plant leaves; a taxonomic survey. Phytochemistry. 1, 89-102.

Ekau, W. 1982. Biological investigations on Notothenia ramsayi Regan 1913 (Pisces, Notothenioidei, Nototheniidae). Archiv für Fischereiwissenschaft. 33, 43-68.

Ellenberg, U., Mattern, T., Seddon, P.J. & Jorquera, G.L. 2006. Physiological and reproductive consequences of human disturbance in Humboldt penguins: The need for species specific visitor management. Biological Conservation. 133, 95-106.

Ellenberg, U., Setiawan, A.N., Cree, A., Houston, D.M. & Seddon, P.J. 2007. Elevated hormonal stress response and reduced reproductive output in yellow-eyed penguins exposed to unregulated tourism. General and Comparative Endocrinology. 152, 54-63.

EMSA. 2016. European Maritime Safety Agency.

http://www.emsa.europa.eu/main/air-pollution/emission-abatement-methods.html

Energy Institute. 2016. Guidance on the management of subsea hydraulic fluids.

EnvSys. 2016. Terrestrial and marine habitat mapping from satellite imagery of Berkeley Sound, Falkland Islands. Environment Systems unpublished report to Premier Oil.

Erbe, C., McCauley, R., McPherson, C. & Gavrilov, A. 2013. Underwater noise from offshore oil production vessels. The Journal of the Acoustical Society of America. 133, 65-70.

Erin Consulting Ltd. & OCL Services Ltd. 2003. Sheens associated with produced water effluents—review of causes and mitigation options. Report No.142. Calgary: Environmental Studies Research Funds. 46 pp.

ESA, 2012. Overseas options: the importance of exports to UK recycling. Environmental Services Association.

http://www.esauk.org/reports_press_releases/esa_reports/Overseas_options.pdf [Accessed 28.10.16]

Exova Catalyst. 2017. Stack Emissions Testing Report Commissioned by Inciner8 Ltd. Stack Reference: I8 – 1000.

Falchi, F., Cinzano, P., Elvidge, C.D., Keith, D.M. & Haim, A. 2011. Limiting the Impact of Light Pollution on Human Health, Environmental and Stellar Visibility. Journal of Environmental Management. 92, 2714-2722.

Falklands Conservation. 2006. Important bird areas of the Falkland Islands.

Falklands Conservation, 2015. Welcome to Falklands Conservation.

http://www.falklandsconservation.com/

Falkland Islands Tourist Board, 2016a, Falkland Islands Tourism Development Strategy 2016-2023, 2016

Falkland Islands Tourist Board, 2018a, International Tourism Statistics Report, 2018

FAO. 2014. Fishing Techniques. Industrial squid jigging. Technology Fact Sheets. In: Food and Agriculture Organization of the United Nations, FAO Fisheries and Aquaculture Department [online]. Rome. Updated 1 January 2001. http://www.fao.org/fishery/fishtech/1114/en [Accesssed August 2014].

Farrington, J. W. and Tripp, B. W. 1977. Hydrocarbons in western North Atlantic surface sediments. Geochiica et Cosmochimica Acta. Vol 41, Issue 11. Pages 1627-1641.

FICoC, 2016. Falkland Islands Chamber of Commerce.

http://falklandislandschamberofcommerce.com/

FIFCA. 2015. Falkland Islands Fishing Companies Association (FIFCA); http://fifca.falklands.info/index.php/about

FIG. 2007. Seabird mortality. Fisheries Department, Falkland Islands Government.

FIG. 2008a. Falkland Islands Government, Environmental Planning Department; Falkland Islands State of the Environment Report 2008. Falkland Islands Government and Falklands Conservation, Stanley. Otley, H., Munro, G., Clausen, A. & Ingham, B.

FIG, 2008b. Falkland Islands Species Action Plan for Cetaceans 2008-2018. The Environmental Planning Department, Stanley, Falkland Islands.

FIG, 2008c. Falkland Islands Species Action Plan for Cobb's wren 2008-2018. The Environmental Planning Department, Stanley, Falkland Islands.

FIG. 2010a. Economic Development Strategy 2011/12, Falkland Islands Economic Development, Developing a sustainable economic future for the Falkland Islands, Strategic Direction.

FIG. 2010b. Falkland Islands Government, Fisheries Department Fisheries Statistics, Volume 14, 2009: Stanley, FIG Fisheries Department

FIG. 2011. UK Overseas Territories - Falkland Islands Biodiversity Snapshot. N. Rendell editor.

FIG. 2012a. Falkland Islands Government, Fisheries Department Fisheries Statistics, Volume 16, 2011: Stanley, FIG Fisheries Department

FIG. 2012b. Falkland Islands Government, Department of Public Works; Priorities for roads maintenance, increased funding for grading, capping and for surfacing the MPA road. ExCo paper 39/12, April 2012.

FIG, 2013a. Draft Stanley Tussac Islands Management Plan 2013-2018, Kidney Island, Cochon Island, Top Island and Bottom Island. Environmental Planning Department, Falkland Islands Government.

FIG. 2013b. Guidance note on approvals for offshore operations. Department of Mineral Resources, Falkland Islands Government.

FIG. 2013c. Falkland Islands Government, Fisheries Department Fisheries Statistics, Volume 17, 2012.

FIG. 2014a. Falkland Islands Government Policy Unit. Statistical Year Book.

FIG. 2014b. Falkland Islands Government, Fisheries Department Fisheries Statistics, Volume 18, 2013.

FIG. 2014c. Environmental Planning Department, Falkland Islands emissions database.

FIG. 2014d. Department of Mineral Resources; Field Development Plan guidelines. (withdrawn)

FIG. 2014e. Self-Sufficiency – The Economy. http://www.falklands.gov.fk/self-sufficiency/the-economy/ (Accessed January 2014).

FIG. 2014f. Waste Management Action Plan (2015-2017).

FIG. 2015a. Falkland Islands Biodiversity Framework 2016-2030. The Environmental Planning Department, Stanley, Falkland Islands.

FIG. 2015b. FIG Self-governance. http://www.falklands.gov.fk/self-governance/ (Accessed November 2015).

FIG. 2015c. FIG The Constitution. http://www.falklands.gov.fk/self-governance/the-constitution/ (Accessed November 2015).

FIG. 2015d. FIG The Environmental Charter. http://www.falklands.gov.fk/our-home/conservation/ (Accessed November 2015).

FIG. 2015e. FIG Fisheries Department. http://fis.com/falklandfish/html/harbour.html (Accessed November 2015).

FIG. 2015f. FIG Local Content.

http://www.fig.gov.fk/minerals/index.php/regulatory/local-content

(Accessed December 2015).

FIG. 2015g. FIG DMR. http://www.fig.gov.fk/minerals [Accessed December 2015).

FIG. 2015h. FIG EPD. http://www.fig.gov.fk/epd [Accessed December 2015].

FIG. 2015i. FIG Policy Unit. http://www.fig.gov.fk/policy[Accessed December 2015].

FIG. 2015j. FIG Fisheries Department. http://fis.com/falklandfish/index.html [Accessed December 2015].

FIG. 2015k. FIG Agriculture Department. http://www.falklands.gov.fk/self-sufficiency/commercial-sectors/agriculture [Updated for 2018].

FIG. 2015l. Falkland Islands Tourism Board. http://www.falklands.gov.fk/self-sufficiency/commercial-sectors/tourism [Updated for 2018].

FIG. 2015m. Falkland Islands Government, Environmental Planning Department; Environmental Impact Assessment guidance notes.

FIG. 2015n. An assessment of seabird by-catch in Falkland Islands trawl fisheries, July 2013 to June 2014. Quintin, M.J. Falkland Islands Government, Fisheries Department;

FIG. 2015o. Falkland Islands Fisheries Department; Vessel movements database.

FIG. 2015q. Falkland Islands Government, Environmental Planning Department; Falkland Islands Development Plan, Adopted August 2015.

FIG. 2015r. Falkland Islands Government, Department of Agriculture; 'Falkland Islands biosecurity: protecting our home, environment and economy. A guide to importing goods'

FIG. 2015s. Falkland Islands Government, Policy Unit, Socio-Economic Monitoring Plan report.

FIG. 2015t. Falkland Islands Civil Aviation Department; http://www.fig.gov.fk/aviation/index.php/desig/roles-and-responsibility

FIG. 2015u. Falkland Islands Government, Environmental Planning Department; Falkland Islands Town Plan.

FIG, 2015v. Fisheries Department Fisheries Statistics, Volume 19. 2014.

FIG, 2015w. Falkland Islands Government: Energy Strategy. 198/15. 11th November, 2015.

FIG. 2016a.; Falkland Islands Biodiversity Framework 2016-2030. Falkland Islands Government, Environmental Planning Department

FIG. 2016b. An assessment of seabird by-catch in Falkland Islands trawl fisheries, July 2014 to June 2015. Kuepfer, A. Falkland Islands Government, Fisheries Department

FIG. 2016c. Fisheries Department Fisheries Statistics, Volume 20, 2006-2015.

FIG. 2016d. Executive Council Paper: Developing Offsetting Guidance for the Falklands Islands. Paper No: 124/16, 29th June 2016, Director of Mineral Resources.

FIG. 2017. Falkland Islands Government Policy Unit, Falkland Islands census 2016, Statistics and Data Tables. Falkland Islands Government., Policy Unit.

FIG, 2017b. Falkland Islands ports and harbours information 2017, 23rd edition. www.falklandislands.com/shopimages/2017 Harbour Info Booklet.pdf

FIG. 2018a. FIG ExCo 30-18 Waste Management Strategy, 2018

FIG. 2018b. FIG ExCo 81-18 to the References. 'Implementation of Maritime Harbours and Ports Ordinances and development of a maritime administration, 2018

FIG. 2019a. Fisheries Department Fisheries Statistics, Volume 23, 2018: 102pp.

FIG. 2019b. ExCo 99-19 'Investment in Improved Waste Management', 2019

FILFH. 2015. Falkland Islands Low Flying Handbook, March 2015.

Filkin & Co. 2017. Premier Oil Waste Strategy. Document Reference FK-SL-PMO-EV-0003.

FIOHEF. 2013. Offshore Hydrocarbons Gap Analysis – Seabirds. Report to the FIOHEF.

Fish, F.E. and Hui, C.A. 1991. Dolphin swimming – a review. Mammal Review. 21: 181-195.

Fisher, T.T., Law, R.J., Rumney, H.S., Kirby, M.F. & Kelly, C. 2011. Towards a scheme of toxic equivalency factors (TEFs) for the acute toxicity of PAHs in sediment. Ecotoxicology and Environmental Safety, 74, 2245-2251.

Fisk, A.T., Stern, G.A., Hobson, K.A., Strachan, W.J., Loewen, M.D., & Norstrom, R.J. 2001. Persistent Organic Pollutants (POPs) in a Small, Herbivorous, Arctic Marine Zooplankton (Calanus hyperboreus): Trends from April to July and the Influence of Lipids and Trophic Transfer. Marine Pollution Bulletin. 43, 93-101.

Fjogstad, A. Saasen, A., Hagen, R., Tanche-Larsen, P.B., Ree, R., Melgren. H., Rostad, E. and Hoset, H. 2000. Field Trial of Alternative Weight Material with Improved Occupational Hygiene and Environmental Performance: SPE61042

Folk, R.L. 1954. The distinction between grain size and mineral composition in sedimentary rock nomenclature. Journal of Geology, 62 (4), 344-359.

Fordham, S., Fowler, S.L., Coelho, R.P., Goldman, K. & Francis, M.P. 2016. Squalus acanthias. The IUCN Red List of Threatened Species 2016: e.T91209505A2898271. http://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T91209505A2898271.en. Downloaded on 02 December 2018.

Fortreath, G.N.R., Picken, G.B., Ralph. R., & Williams, J. 1982. Marine Growth Studies on the North Sea Oil Platform Monstrose Alpha. Marine Ecology - Progress Series. 8: 61-68.

Foster, M., Neushul, M. & Zingmark, R. 1971. The Santa Barbara oil spill Part 2: Initial effects on intertidal and kelp bed organisms. Environmental Pollution 2, 115-134.

Fowler, C.W. 1987. Marine debris and northern fur seals: a case study. Marine Pollution Bulletin. 18, 326-335.

Franco, B.C., Piola, A.R., Rivas, A.L., Baldoni A. & Pisoni, J.P. 2008. Multiple thermal fronts near the Patagonian Shelf break. Geophysical Research Letters. 35, 1-6.

Frans, V.F. & Augé, A.A. 2016. Use of local ecological knowledge to investigate endangered baleen whale recovery in the Falkland Islands. Biological Conservation, 202, 127-137.

Fraser, G.S., Russell, J. & von Zharen, W.M. 2006. Produced water from offshore oil and gas installations on the Grand Banks, Newfoundland and Labrador: are the potential effects to seabirds sufficiently known? Marine Ornithology. 34, 147–156.

French, S.S., González-Suárez, M., Young, J.K., Durham, S. & Gerber, L.R. 2011. Human Disturbance Influences Reproductive Success and Growth Rate in California Sea Lions (Zalophus californianus). PLoS ONE. 6: e17686. doi:10.1371/journal.pone.0017686

FUGRO. 1999. North Falklands Metocean Survey Final Report - Volume 1 19. June-97 to 30-Sep-98. C10317/1762.

Galimberti, F. & Sanvito, S. 2012. Tracking at sea the elephant seals of Sea Lion Island, 2011 report. Ensenada, BC, Mexico, 28/01/2012

García-Borboroglu, P., Boersma, D., Ruoppolo, V., Pinho-da-Silva-Filho, R., Corrado-Adornes, A., Conte-Sena, D. & Velozo, R. 2010. Magellanic penguin mortality in 2008 along the SW Atlantic coast. Marine Pollution Bulletin. 60, 1652-1657.

García-Borboroglu, P., Boersma, P.D., Reyes, L. & Skewgar, E. 2008. Petroleum Pollution and Penguins: Marine Conservation Tools to Reduce the Problem. In: Marine Pollution: New Research (Ed: Hofer, T.N.), pp. 339-356. Nova Science Publishers Inc., New York, USA.

García-Borboroglu, P., Boersma, P.D., Ruoppolo, V., Reyes, L., Rebstock, G.A., Griot, K., Heredia, S.R., Adornes, A.C. & da Silva, R.P. 2006. Chronic oil pollution harms Magellanic Penguins in the Southwest Atlantic. Marine Pollution Bulletin. 52, 193-198.

Gardline. 1998a. Benthic Environmental Baseline Survey of the Sediments around the exploration "Little Blue-A" Well (February 1998). Gardline Surveys Limited.

Gardline. 1998b. Benthic Environmental Baseline Survey of the Sediments around the exploration "B1" Well (February 1998). Gardline Surveys Limited.

Gardline. 1998c. Benthic Environmental Baseline Survey of the Sediments around the exploration "14/14- A" Well, 1998d. Gardline Surveys Limited.

Gardline. 1998d. Benthic Environmental Baseline Survey of the Sediments around the exploration " Well 14/23-A (February 1998). Gardline Surveys Limited.

Gardline. 1998e. Benthic Environmental Baseline Survey of the Sediments around the exploration "FI 14/19-A" Well (March 1998). Gardline Surveys Limited.

Gardline. 1998f. Benthic Environmental Baseline Survey of the Sediments around the exploration FI 14/24 "Braela" Well (March 1998). Gardline Surveys Limited.

Gardline. 1998g. Benthic Environmental Baseline Survey of the Sediments around the exploration "Minke" 14/13-B Well (June 1998). Gardline Surveys Limited.

Gardline. 1998h. Post-Drill Environmental Survey of the Sediments around the Exploration Well "Little Blue- A" - Final report October 1998. Gardline Surveys Limited.

Gardline. 2012. Sea Lion Field Development. North Falklands Licence Areas. PL032, PL033 and PL04. March and April 2012. Environmental Baseline Survey Report. Prepared for Rockhopper Exploration Plc. Reference: 9030.1.

Gardline. 2013a. Sea Lion Field Development North Falkland Licence Areas PL032, PL033 AND PL04, March and April 2012 Environmental Baseline Survey Report. Ref. 9030.1.

Gardline. 2013b. Sea Lion Post Drill Environmental Survey North Falkland Licence Areas PL032, PL033 and PL04, March and April 2012 Environmental Report. Ref. 9030.2.

Gass, S. E. & Roberts, J. M. 2006. The occurrence of the cold-water coral Lophelia pertusa (Scleractinia) on oil and gas platforms in the North Sea: Colony growth, recruitment and environmental controls on distribution. Marine Pollution Bulletin. 52(5) 549-59.

Genesis. 2011. Review and Assessment of Underwater Sound Produced from Oil and Gas Sound Activities and Potential Reporting Requirements under the Marine Strategy Framework Directive. Report to the Department of Energy and Climate Change.

Genesis. 2013. Premier Oil UK Limited – Sea Lion Pre FEED concept engineering study. File name: J20230B-Y-TN-24004 B1 Environmental Road Map, Genesis June 2013

Genesis. 2014a. 2015 Exploration Campaign Oil Spill Response Plan. Document number: FK-SL-PMO-EV-PLN-004. Prepared for Premier Oil.

Genesis. 2014b. J20490B-Y-RT-24002 B03 - Sea Lion ESIA Scoping Report rev 7.8.2014. unpublished.

Genesis. 2014c. Assessment of possible effects of releases of oil and chemicals from disturbance of cuttings piles - summary of supporting information. Report for Department of Energy and Climate Change, submitted to OSPAR.

Genesis. 2015a. Sea Lion drill cuttings modelling. Document Number: J73700A-Y-TN-24001/B1. Prepared for Premier Oil.

Genesis. 2015b. Sea Lion Produced Water and Cooling Water modelling. Document Number J73700A-Y-TN-24003/B1. Prepared for Premier Oil.

Genesis. 2015c. Sea Lion oil spill modelling. Document Number: J73700A-Y-TN-24004/A2. Prepared for Premier Oil, October 2015.

Genesis. 2015d. Oil spill modelling for the Rhea-1 Exploration Well. Document number: J73727A-Y-TN-24001/B1. Prepared for Argos Ltd/Noble Energy.

Genesis. 2015e. Sea Lion atmospheric emissions modelling. Prepared for Premier Oil.

Genesis. 2016. Sea Lion Development - Underwater Noise Modelling. Document Number: J73700A-Y-TN-24005/B4. Prepared for Premier.

Genesis. 2017. Review of Seabird Data at Sea Lion. Document Number: J74462B-A-RT-00001/A1. Prepared for Premier.

Geomotive & MRAG. 2011. Marine Mammal and Sea Birds Observation and Passive Acoustic Monitoring During the 3D Survey in the North Falkland Basin 11-Jan-11 to 02-May-11. Report for Rockhopper Exploration.

Gerrard, S., Grant, A., March, R. & London, C., 1999. Drill Cuttings Piles in the North Sea. Management options during Platform Decommissioning. Centre for Environmental Risk Report No 31. University of East Anglia.

GESAMP. 2007. Estimates of oil entering the marine environment from sea-based activities. GESAMP (IMO/FAO/UNESCO-IOC/UNIDO/WMO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection)– Rep. Stud. GESAMP No. 75.

Gesteira J.L.G. & Dauvina, J.C. 2000. Amphipods are good bioindicators of the impact on soft-bottom Macrobenthic Communities. Marine Pollution Bulletin, 40, 1017-1027.

Gillon, K.W., White, R.W. & Black, A.D. 2001 Grey-backed storm-petrels Garrodia nereis and other seabirds associating with free-floating kelp. Atlantic Seabirds. 3, 75-84.

Glass, J.P. & Ryan, P.G. 2013. Reduced seabird night strikes and mortality in the Tristan rock lobster fishery. African Journal of Marine Science. 35, 589-592.

Glasson, J., Therivel, R. & Chadwick, A. 2013. Introduction to Environmental Impact Assessment, 4th Ed. Natural and Built Environment Series. Routledge.

Glegg, G.A. & Rowland, S.J. 1996. The *Braer* oil spill - hydrocarbon concentrations in intertidal organisms. Marine Pollution Bulletin, 32, 486-492.

Glemarec, M. & Hussenot, E. 1982. A three-year ecological survey in Benoit and Wrac'h Abers following the Amoco Cadiz oil spill. Netherlands Journal of Sea Research, 16, 483– 490.

Goldsworthy, S.D., Giese, M., Gales, R.P., Brothers, N., & Hamill, J. 2000. Effects of the Iron Baron oil spill on little penguins (Eudyptula minor). II. Post-release survival of rehabilitated oiled birds. Wildlife Research. 27, 573-582.

Gollasch, S., Lenz, J., Dammer, M. & Andres, H-G. 2000. Survival of tropical ballast water organisms during a cruise from the Indian Ocean to the North Sea. Journal of Plankton Research, 22, 923-937.

Gomes, F., Oliveira, M., Ramalhosa, M.J., Delerue-Matos, C. & Morais, S. 2013. Polycyclic aromatic hydrocarbons in commercial squids from different geographical origins: Levels and risks for human consumption. Food and Chemical Toxicology, 59, 46-54.

Gómez-Liach, A., Wilson, R.P., Sala, J.E., Luzenti, A. & Quintana, F. 2015. Moving northward: comparison of the foraging effort of Magellanic penguins from three colonies of northern Patagonia. Marine Biology. 162,1451-1461.

González-Solís, J., Croxall, J.P. & Wood, A.G. 2000. Foraging partitioning between giant petrels Macronectes spp. And its relationship with breeding population changes at Bird Island, South Georgia. Marine Ecology Progress Series. 204, 279-288.

Goodwin, C., Jones, J., Neely, K. & Brickle, P. 2011. Sponge biodiversity of the Jason Islands and Stanley, Falkland Islands with descriptions of twelve new species. Journal of the Marine Biological Association of the United Kingdom. 91, 275-301.

Goodwin, C., Jones, J., Neely, K., & Brickle, P. 2016. Sponge biodiversity of Beauchêne and the Sea Lion Islands and south-east East Falkland, Falkland Islands, with a description of nine new species. Journal of the Marine Biological Association of the United Kingdom. 96, 263-290.

Gordon, J., Gillespie, D., Potter, J., Frantzis, A., Simmonds, M.P., Swift, R. & Thompson, D. 2004. A review of the effects of seismic surveys on marine mammals. Marine Technology Society Journal. 37, 16-34.

Graham, I. M., Pirotta, E., Merchant, N. D., Farcas, A., Barton, T. R., Cheney, B., Hastie, G. & Thompson, P. M. 2017. Responses of bottlenose dolphins and harbour porpoises to impact and vibration piling noise during harbour construction. Ecosphere, 8, 1-16. DOI: 10.1002/ecs2.1793

Granadeiro, J.P., Phillips R.A., Brickle, P. & Catry, P. 2011. Albatrosses following fishing vessels. How badly hooked are they on an easy meal? PLoS ONE. 6, e17467.

Gregory, M.R. 2009. Environmental implications of plastic debris in marine settings - entanglement, ingestion, smothering, hangers-on, hitch-hiking and alien invasions. Philosophical Transactions of the Royal Society B. 364, 2013-2025.

Grob, C. & Pollet, B.G. 2016. Regrowth in ship's ballast water tanks: Think again! Marine Pollution Bulletin, 109, 46–48.

GSGSSI. 2009. Government of South Georgia Low Flight Avoidance Map.

Gubbay, S. & Earll, R. 2000. Proposed guidelines for dealing with cetaceans in the event of an oil spill in the Moray Firth. Report to Talisman Energy (UK) Limited & Scottish Natural Heritage.

Guerrero, R.A., Baldoni, A. & Benavides, H. 1999. Oceanographic Conditions at the Southern End of the Argentine Continental Slope. INIDEP Documento Cientifico. 5, 7-22.

Gunlach, E.R. & Hayes, M.O. 1978. Vulnerability of Coastal Environments to Oil Spill Impacts. Marine Technology Society Journal. 12, 18-27.

Hamilton, J.E. 1939. The leopard seal, Hydrurga leptonyx (de Blainville). Discovery Reports. 18, 239-264.

Hanchet, M.S., Tracey, D., Dunn, A., Horn, P. & Smith, N. 2012. Mercury concentrations of two toothfish and three of its prey species from the Pacific sector of the Antarctic. Antarctic Science 24, 34–42

Harrison-Matthews, L. 1932. Lobster krill: Anomuran crustacea that are the food of whales. Discovery Reports. 5, 467-484.

Hart, T.J. 1946. Report on trawling surveys on the Patagonian continental shelf. Discovery Reports. 23, 223-408.

Hartung, R. 1967. Energy Metabolism in Oil-Covered Ducks. The Journal of Wildlife Management. 31:4. 798-804

Hastings, M.C. & Popper, A.N. 2005. Effects of sound on fish. Report to Jones and Stokes for California Department of Transportation, 2005.

Hatanaka, H. 1986. Growth and life span of short-finned squid Illex argentinus in the waters off Argentina. Bulletin of the Japanese Society for the Science of Fish. 52, 11-17.

Hatch, L., Clark, C., Merrick, R., Van Parijs, S., Ponirakis, D., Schwehr, K., Thompson, M., & Wiley, D. 2008. Characterizing the relative contributions of large vessels to total ocean noise fields: A case study using the Gerry E. Studds Stellwagen Bank National Marine Sanctuary. Environmental Management. 42, 735-752.

Hawkins, A.D., Pembroke, A.E. & Popper, A.N. 2015. Information gaps in understanding the effects of noise on fishes and invertebrates. Reviews in Fish Biology and Fisheries. 25, 39-64.

Hawkins, A.D. & Popper, A.N. 2014. Assessing the impact of underwater sounds on fishes and other forms of marine life. Acoustics Today. 10, 30-41.

Hedd, A., Montevecchi, W.A., Phillips, R.A. &, Fifield, D.A. 2014. Seasonal sexual segregation by monomorphic sooty shearwaters Puffinus griseus reflects different reproductive roles during the pre-laying period. PLoS ONE. 9(1): e85572.

Hendley, N. 1937. The plankton diatoms of the Southern Seas. Discovery Reports. Vol XVI, 151-364, Plates VI-XIII.

Hilliard, R. 2004. Best practice for the management of introduced marine pests: A review. GISP: the Global Invasive Species Program, GISP Secretariat.

Hipsey, S.J., Delarue, J., Martin, B., Burns, R.D.J. & Lumsden, E. 2013. Static Acoustic Monitoring Programme for the Sea Lion Development Area. JASCO Document 00591, Version 1.0. Technical report by JASCO Applied Sciences for Premier Oil Plc, Falkland Islands Business Unit.

Hiscock K., Sharrock S., Highfield J. & Snelling D. 2010. Colonization of an artificial reef in south-west England – ex-HMS ‘Scylla’. Journal of the Marine Biological Association of the United Kingdom. 90, 69–94. BSL.

Holdway, D.A. 2002. The acute and chronic effects of wastes associated with offshore oil and gas production on temperate and tropical marine ecological processes. Marine Pollution Bulletin. 44, 185-203.

Hölker, F., Wolter, C., Perkin, E.K. & Tockner, K. 2010. Light pollution as a biodiversity threat. Trends in Ecology & Evolution. 25, 681-682.

Holmes, N. Atkin, D., Mahdi, S. & Ayress, M.A. 2015. Integrated biostratigraphy and chemical stratigraphy in the development of a reservoir-scale stratigraphic framework for the Sea Lion Field area, North Falkland Basin. Petroleum Geoscience, 21. 171-182.

Holst., S. & Jarms, G. 2007. Substrate choice and settlement preferences of planula larvae of five Scyphozoa (Cnidaria) from German Bight, North Sea. Marine Biology. 151, 863-871.

Hoornweg, D. & Bhada-Tata, P. 2012. What a waste. A Global Review of Solid Waste Management. World Bank Urban Development Series. Knowledge Papers. No. 15

Hope-Jones, P. 1980. The effect on birds of a North Sea gas flare. British Birds. 73, 547-555.

Horvath, C. 2013. Confidence, Uncertainty, and Risk in Environmental Assessment. IAIA13 Conference Proceedings. Impact Assessment the Next Generation 33rd Annual Meeting of the International Association for Impact Assessment 13–16 May 2013.

HSE. 2008. Safety zones around oil and gas installations in waters around the UK. www.hse.gov.uk/pubns/indg189.pdf

HSE. 2011. Offshore COSHH Essentials: Hydrogen Sulphide. HSE: OCE6.

HSE. 2011. EH40/2005 Workplace exposure limits. http://www.hse.gov.uk/pUbns/priced/eh40.pdf (Accessed September 2016)

Hu, M. Y., Yan, H. Y., Chung, W-S., Shiao, J-C., Hwang, P-P. 2009. Acoustically evoked potentials in two cephalopods inferred using the auditory brainstem response (ABR) approach. Comparative Biochemistry and Physiology, Part A. 153, 278-283.

Hughes, K.A., Waluda, C.M., Stone, R.E., Ridout, M.S. & Shears, J.R. 2008. Short-term responses of king penguins Aptenodytes patagonicus to helicopter disturbance at South Georgia. Polar Biology. 31, 1,521-1,530.

Huhta, H-K., Rytkönen, J. & Sassi, J. 2007. Estimated nutrient load from waste waters originating from ships in the Baltic Sea area. Espoo 2007. VTT Tiedotteita . Research Notes, 2370.

Huin, N. 2002. Foraging distribution of the black-browed albatross Thalassarche melanophrys, breeding in the Falkland Islands. Aquatic Conservation. 12, 89-99.

Huin, N., & Croxall, J.P. 1996. Fishing gear, oil and marine debris associated with seabirds at Bird Island, South Georgia, during 1993/1994. Marine Ornithology. 24, 19– 22.

Hunt, G.L. 1987. Offshore oil development and seabirds: the present status of knowledge and long-term research needs. In: Long-term environmental effects of offshore oil and gas development. (Boesch, D.F. & Rabalais, N.N., eds), pp. 539–586. London: Elsevier Applied Science.

IAIA. 2013 Conference Proceedings. Impact Assessment the Next Generation 33rd Annual Meeting of the International Association for Impact Assessment 13–16 May 2013.

IAQM. 2011. Institute of Air Quality Management: Guidance on the Assessment of the Impacts of Construction on Air Quality and the Determination of their Significance. http://iaqm.co.uk/text/guidance/construction_guidance_2011.pdf

IEEM. 2010. Institute of Ecology and Environmental Management: Guidelines for Ecological Impact Assessment in Britain and Ireland.

IEMA. 2008. Institute of Environmental Management and Assessment: Practitioner: Environmental Management Plans. Best Practice Series. Volume 12.

IFAW. 2013. Whales: avoiding collisions prevents damage to ships and injuries to passengers, crew and whales. International Fund for Animal Welfare. http://iwc.int/private/downloads/80ff3jv9j7oko8gcggcw0ocg8/IFAW%20ship%20strike%20English%202013_web.pdf [Accessed September 2014].

IFC. 2007a. Environmental, Health and Safety (EHS) Guidelines: Noise Management. The International Finance Corporation

IFC. 2007b.: Environmental Health and Safety Guidelines. Wastewater and Ambient Water. International Finance Corporation

Imber, M.J. 1975. Behaviour of petrels in relation to the moon and artificial lights. Notornis. 22, 302-306.

IMO. 2001. International conference on the control of harmful anti-fouling systems on ships, adoption of the final act of the conference and any instruments, recommendations and resolutions resulting from the work of the conference, 18 October 2001. International Maritime Organisation Headquarters, London, UK.

IMO. 2004. International Convention for the Control and Management of Ships' Ballast Water and Sediments (ISBN 92-801-0033-5).

IMO. 2005. Marine Environment Protection Committee Resolution 127 (53).

IMO. 2014. Guidelines for the reduction of underwater noise from commercial shipping to address adverse impacts on marine life. MEPC. 1/Circ.8, 33, 7 April 2014.

IMO. 2015. Ballast Water Management. http://www.imo.org/en/OurWork/Environment/BallastWaterManagement/Pages/Default.aspx [Accessed December 2015].

IMO. 2016a. Summary of Status of Conventions. http://www.imo.org/en/About/Conventions/StatusOfConventions/Pages/Default.aspx [Accessed September 2016].

IMO. 2016b. Train the Trainer (TTT) Course on Energy Efficient Ship Operation. Module 2 – Ship Energy Efficiency Regulations and Related Guidelines.

Incardona, J.P., Gardner, L.D., Linbo, T.L., Brown, T.L., Esbaugh, A.J., Mager, E.M., Stieglitz, J.D., French, B.L., Labenia, J.S., Laetz, C.A., Tagal, M., Sloan, C.A., Elizur, A., Benetti, D.D., Grosell, M., Block, B.A. & Scholz, N.L. 2014. Deepwater Horizon crude oil impacts the developing hearts of large predatory pelagic fish. Proceedings of the National Academy of Science of the United States of America. 111.

Inciner8. 2017. General Catalogue 2017 Edition.

Iñíguez, M., Masello, J.F., Gribaudo, C., Arcucci, B., Krohling, F. & Belgrano, J. 2010. On the occurrence of sei whales, Balaenoptera borealis, in the south-western Atlantic. Marine Biodiversity Record. 3, 1-6.

INSITE. 2016. http://www.insitenorthsea.org

Institute of Lighting Professionals. 2012. Guidance Notes. https://www.theilp.org.uk/documents/obtrusive-light/ [Accessed August 2016].

Institute of Petroleum, 2000. Guidelines for the calculation of estimates of energy use and gaseous emissions in the decommissioning of offshore structures.

Invenio. 2013. Safety Review and Statistical Analysis Stanley – Darwin (MPC) Road. Data derived from FIG.

IPCC. 1995. Intergovernmental Panel on Climate Change Second Assessment Report (SAR): Climate Change 1995.

IPCC. 2007. Intergovernmental Panel on Climate Change Fourth Assessment Report (AR4): Climate Change 2007.

IPCC. 2013. Cubasch, U., Wuebbles D., Chen D., Facchini M.C., Frame D., Mahowald N. & Winther J.G. 2013. Introduction. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., Qin D., Plattner G.K., Tignor M., Allen S.K., Boschung J., Nauels A., Xia Y., Bex V. and Midgley P.M. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC. 2014. Synthesis Report, Summary for Policy Makers Report http://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf

International Chamber Of Shipping, Oil Companies International Marine Forum, International Association Of Ports And Harbours. 1996. International Safety Guide for Oil Tankers & Terminals, Fourth Edition.

International Commission on Illumination (CIE). 2003. Report 150: Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations.

Intertek. 2011. Laboratory Test Report No. 11-006706-ABDN dated 12th October 2011.

IPIECA. 2011. Sensitivity mapping for oil spill response. OGP Report No 000 IPIECA/IMO/OGP 2011.

Irwin, R.J., Mouwerik, M.V., Stevens, S., Seese, M.D. & Basham W. 1997. Environmental contaminants encyclopedia—PAHs entry. National Parks Service Report, Water Resources Division.

ITOPF, 2012. Country profiles Falkland Islands: A summary of oil spill response arrangements & resources worldwide. www.itopf.com/country_profiles

ITOPF. 2016. The International Tanker Owners Pollution Federation, Oil Tanker Spill Statistics 2015. http://www.itopf.com/fileadmin/data/Documents/Company_Lit/Oil_Spill_Stats_2016.pdf.

IUCN. 2016. The IUCN Red List of Threatened Species. Version 2016-1. www.iucnredlist.org [Accessed May 2016].

IWC. 2014. The International Whaling Commission global database on ship strikes. http://data.iwcoffice.org/whalestrike [Accessed August 2014].

IWC. 2015. International Whaling Commission: Status of whales. https://iwc.int/status#species [Accessed November 2015].

IWC/Agreement of the Conservation of Cetaceans in the Black Sea Mediterranean Sea (ACCOBAMS). 2011. Report of the Joint IWC-ACCOBAMS Workshop on Reducing Risk of Collisions between Vessels and Cetaceans http://iwc.int/private/downloads/2dm38ob6d9a8wwss04gskk80w/Ship%20strikes%20workshop%20report%20final.pdf [Accessed August 2014].

Jackson, G.D. 1993. Growth zones within the statolith microstructure of the deep-water squid Moroteuthis ingens (Cephalopoda: Onychoteuthidae): evidence for a habitat shift? Canadian Journal of Fisheries and Aquatic Sciences. 50, 2365-2374.

Jackson, G.D., George, M.J.A. & Buxton, N. 1998. Distribution and abundance of the squid Moroteuthis ingens (Cephalopoda: Onychoteuthidae) in the Falkland Islands region of the South Atlantic. Polar Biology. 20, 161-169.

Jee. 2013. Sea Lion Fishing Trawling Risk Study. FK-SL-SE-SU-001. Report for Premier Oil.

Jenssen, B. M. 1996. An overview of exposure to, and effects of, petroleum oil and organochlorine pollution in Grey seals (Halichoerus grypus). Science of the Total Environment. 186, 109-118.

Jenssen, B.M., Ekker, M., 1989. Rehabilitation of oiled birds – a physiological evaluation of 4 cleaning agents. Marine Pollution Bulletin. 20, 509–512.

JNCC. 2010a. The protection of marine European Protected Species from injury and disturbance. Guidance for the marine area in England and Wales and the UK offshore marine area. Joint Nature Conservation Committee, Draft June 2010.

JNCC. 2010b. Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise. Joint Nature Conservation Committee.

JNCC. 2012. Environmental mainstreaming in the Falkland Islands; Workshop report, summary document. Joint Nature Conservation Committee, May, 2012.

JNCC. 2016. UK BAP priority species and habitats. http://jncc.defra.gov.uk/page-5705

Jødestøl, K., & Furuholt, E. 2010. Will drill cuttings and drill mud harm cold water corals. In Paper SPE 126486 presented at the SPE International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, Rio de Janeiro, Brazil (pp. 12-14).

Johansen, O., Rye, H., Melbye, A.G., Jensen, H.V., Serigstad, B. & Knutsen, T. 2001. Deep Spill JIP Experimental Discharges of Gas and Oil at Helland Hansen. SINTEF Technical Report No: STF66 F01082.

Kampa, M. & Castanas, E. 2008. Human health effects of air pollution. Environmental Pollution.151, 362-367.

Keith, D.A., Rodríguez, J.P., Rodríguez-Clark, K.M., Nicholson, E., & Aapala, K. 2013. Scientific Foundations for an IUCN Red List of Ecosystems. PLoS ONE. 8(5): e62111.

Khalaf, F., Literathy, V. & Anderlini, V. 1982. Vanadium as a tracer of oil pollution in the sediments of Kuwait. Hydrobiologica. 91-92:147-154.

King, J.G., Sanger, G.A., 1979. Oil vulnerability index for marine oriented birds. In: Conservation of Marine Birds of Northern North America, (Eds: Bartonek, J.C., Nettleship, D.N.) pp. 227–239.

Kingston, P. F. 2002. Long-term environmental impact of oil spills. Spill Science & Technology Bulletin. 7, 53-61.

Kjeilen-Eilertsen, G., Trannum, H., Jak, R., Smit, M., Neff, J. & Durell, G. 2004. Literature report on burial: derivation of PNEC as component in the MEMW model tool. Akvamiljø Report no. AM-2004/024. https://www.sintef.no/project/ERMS/Reports/ERMS%20Report%20no%209B_Burial_RF-AM.pdf [Accessed September 2014]).

Klinger, D.H., Dale, J.J., Machado, B.E., Incardona, J.P., Farwell, C.J., Block, B.A. 2015. Exposure to Deepwater Horizon weathered crude oil increases routine metabolic demand in chub mackerel, Scomber japonicas. Marine Pollution Bulletin. 98, 259-266.

Kooyman, G.L., Cherel, Y., Le Maho, Y., Croxall, J.P., Thorson, P.H., Ridoux, V. & Kooyman, C.A. 1992. Diving behaviour and energetics during foraging cycles in king penguins. Ecological Monographs. 62, 143-163.

Kuepfer, A., Crofts, S., Tierney, M., Blake, D., Goyot, L. 2018. Falkland Islands National Plan of Action for Reducing Incidental Catch of Seabirds in Trawl Fisheries, 2019 (FI NPOA-S-T-2019). Stanley, Fisheries Department, Directorate of Natural Resources, Falkland Islands Government.

Kuperman, W.A. and Roux, P. 2007. Underwater acoustics. In: Rossing, T.D. Handbook of acoustics, Springer. ISBN: 978-0-387-30446-5.

Kyhn, L.A., Tougaard, J., Jensen, F., Wahlberg, M., Stone, G., Yoshinaga, A., Beedholm, K. & Madsen, P.T. 2009. Feeding at a high pitch: Source parameters of narrow band, high-frequency clicks from echolocating off-shore hourglass dolphins and coastal Hector's dolphins. Journal of the Acoustical Society of America. 125, 1783-1791.

Kyne ,P.M., Lamilla, J., Licandeo, R.R., Jimena San Martín, M., Stehmann, M.F.W. & McCormack, C. 2007. Zearaja chilensis. The IUCN Red List of Threatened Species 2007: e.T63147A12623314. http://dx.doi.org/10.2305/IUCN.UK.2007.RLTS.T63147A12623314.en. Downloaded on 02 December 2018.

Laflamme, R.E. & Hites, R. A. 1978. The global distribution of polycyclic aromatic hydrocarbons in recent sediments. Geochimica et Cosmochimica Acta. 42, 289-303.

Laist, D. 1987 Overview of the biological effects of lost and discarded plastic debris in the marine environment. Marine Pollution Bulletin. 18, 319-326. http://www.researchgate.net/publication/222160961_Overview_of_the_biological_effects_of_lost_and_discarded_plastic_debris_in_the_marine_environment._Mar._Pollut._Bull._18_319-326 [Accessed December 2015].

Laist, D.W., Knowlton, A.R., Mead, J.G., Collet, A.S. & Podesta, M. 2001. Collisions between ships and great whales. Marine Mammal Science. 17, 35-75.

Lambert, G., Peakall, D.B., Philogene, B.J.R., Engelhardt, F.R., 1982. Effect of oil and oil dispersant mixtures on the basal metabolic-rate of ducks. Bulletin of Environmental Contamination and Toxicology. 29, 520–524.

Langford, T.E. 1990. Ecological Effects of Thermal Discharges. Elsevier Applied Science.

Laptikhovsky, V.V. 2004. A comparative study of diet in three sympatric populations of Patagonotothen species (Pisces: Nototheniidae). Polar Biology. 63, 428-441.

Laptikhovsky V.V. 2007. New data on spawning and bathymetric distribution of the Patagonian squid, Loligo gahi. JMBA2 – Biodiversity Records. Published on-line (http://www.mba.ac.uk/jmba/pdf/5560.pdf).

Laptikhovsky, V.V. & Arkhipkin, A.I. 2003. An impact of seasonal squid migrations and fishing on the feeding spectra of sub-Antarctic notothenioids Patagonotothen ramsayi and Cottoperca gobio around the Falkland Islands. Journal of Applied Ichthyology. 19, 35-39.

Laptikhovsky, V.V., Arkhipkin, A.I. & Brickle, P. 2006. Distribution and reproduction of the Patagonian toothfish Dissostichus eleginoides (Smitt) around the Falkland Islands. Journal of Fish Biology. 68, 849-861.

Laptikhovsky, V.V., Arkhipkin, A.I. & Brickle, P. 2013. From small by-catch to main commercial species: Explosion of stocks of rock cod Patagonotothen ramsayi (Regan) in the Southwest Atlantic. Fisheries Research. 147, 399-403.

Lardicci, C., Rossi, F. & Maltagliati, F. 1989. Detection of Thermal Pollution: Variability of Benthic Communities at Two Different Spatial Scales in an Area Influenced by a Coastal Power Station. Marine Pollution Bulletin. 38, 296-303.

Law, R.J. & Moffat, C.F. 2011. The *Braer* Oil Spill, 1993. In: Oil Spill Science and Technology, Chapter 36, pp 1119–1126.

Lazar, L., Gomoiu, M-T., Boicenco, L. & Vasiliu, D. 2012. Total Organic Carbon (TOC) of the surface layer sediments covering the seafloor of the Romanian Black Sea coast. Geo-Eco-Marina. 18, 121-132.

Le Corre, M., Ollivier, A., Ribes, S. & Jouventin, P. 2002. Light-induced mortality of petrels: a 4-year study from Réunion Island (Indian Ocean). Biological Conservation. 105, 93-102.

Lee, J.E. & Chown, S.L. 2009. Mytilus on the move: transport of an invasive bivalve to the Antarctic. Marine Ecology Progress Series. 339, 307-310.

Lee, K. and Neff, J. 2011 Produced Water: Environmental Risks and Advances in Mitigation Technologies.

Lee, R.F., Köster, M., Paffenhöfer, G.A. 2012. Ingestion and defecation of dispersed oil droplets by pelagic tunicates. J. Plankton Res. 34. 1058-1063.

Leighton, F.A. 1991. The toxicity of petroleum oils to seabirds: an overview. In: The effects of oil on wildlife. (Ed: White, J.), p 43-57. Sheridan Press, Hanover, PA.

Levy, E.M., 1980. Oil pollution and seabirds - Atlantic Canada 1976-77 and some implications for northern environments. Marine Pollution Bulletin, 11, 51-56.

Lewis, J.A. & Coutts, A.D.M. 2010. Biofouling invasions. In: Biofouling.(Eds: Durr, S. & Thomason, J. C.,), pp 348-358. Oxford: Blackwell Publishing.

Long, E.R., MacDonald, D.D., Smith, S.L., & Calder, F.D. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management, 19, 81–97.

Lowe, S., Browne, M., Boudjelas, S. & De Poorter, M. 2004. 100 of the World's Worst Invasive Alien Species A selection from the Global Invasive Species Database. Published by The Invasive Species Specialist Group (ISSG) a specialist group of the Species Survival Commission (SSC) of the World Conservation Union (IUCN), 12pp. First published as special lift-out in Aliens 12, December 2000. Updated and reprinted version: November 2004.

MAIB, 1993. Report of the Chief Inspector of Marine Accidents into the engine failure and subsequent grounding of the motor tanker *Braer* at Garths Ness, Shetland on 5 January 1993.

https://assets.publishing.service.gov.uk/media/54c11606e5274a15b3000015/MAIBReport_*Braer*-1993.pdf

MAIB. 1996. Marine Accident Investigation Branch: Report of the Investigation into the grounding of the tanker Borga at Milford Haven on 29 October 1995. https://assets.publishing.service.gov.uk/media/54c1137340f0b6158d00001d/MAIBReport_Borga-1995.pdf (Accessed September 2016)

MAIB, 1997. Report of the Chief Inspector of Marine Accidents into the grounding and subsequent salvage of the tanker Sea Empress at Milford Haven between 15 and 21 February 1996. https://www.gov.uk/maib-reports/grounding-of-oil-tanker-sea-empress-in-the-approaches-to-milford-haven-wales-and-the-subsequent-salvage-operation#summary (Accessed September 2016)

Malme, C. I., Miles, P. R., Miller, G. W., Richardson, W. J., Reseneau, D. G., Thomson, D. H. & Greene, C. R. 1989. Analysis and ranking of the acoustic disturbance potential of petroleum industry activities and other sources of noise in the environment of marine mammals in Alaska. BBN Report No. 6945 OCS Study MMS 89-0005. Reb. From BBN Labs Inc., Cambridge, MA, for U.S. Minerals Managements Service, Anchorage, AK. NTIS PB90-188673.

Marengo, I. 2014a. GIS-based analysis of the coastal habitats and the shallow water marine habitats identified in three areas of East Falklands. Technical report #2. Report by SAERI to Premier Oil.

Marengo, I. 2014b. GIS-based assessment of coastal vulnerability to oil spill of the north-east coastline of the Falkland Islands. Technical report #1. Report by SAERI to Premier Oil.

MCA. 2012. Marine and Coastguard Agency Ship-to-Ship Transfer Regulations (MSN 1829)

McKenna, M.F, Ross, D., Wiggins, S.M. & Hildebrand, J.A. 2012. Underwater radiated noise from modern commercial ships. Acoustical Society of America. 131, 92-103.

Marquenie, J.M. 2007. Green light to birds: Investigation into the effect of bird-friendly lighting. NAM LOCATIE L15-FA-1

Marquenie, J.M., & van de Laar, F. 2004. Protecting migrating birds from offshore production. Shell E&P Newsletter: January issue.

Marsh, H.W. & Schulkin, M. 1962. Shallow-water transmission. Journal of the Acoustical Society of America. 34, 863-864.

Martin, A. R., Poncet, S., Barbraud, C., Foster, E., Fretwell, P. & Rothery, R. 2009. The White-chinned Petrel (Procellaria aequinoctialis) on South Georgia: population size, distribution and global significance. Polar Biology. 32, 655-661.

Martos, P. & Piccolo, M.C. 1988. Hydrography of the Argentine continental shelf between 38° and 42°S. Continental Shelf Research. 8, 1043–1056.

Maruyama, A., Maeda, M. & Simidu, U., 1989. Microbial production of auxin indole-3-acetic acid in marine sediments. Marine Ecology Progress Series, 58, 69-75.

Masello, J.F., Mundry, R., Poisbleau, M., Demongin, L., Voigt, C.C., Wikelski, M. & Quillfeldt P. 2010. Diving seabirds share foraging space and time within and among species. Ecosphere. 1, 1-28.

Matkin, C.O., Saulitis, E.L., Ellis, G.M., P. Olesiuk, P. & Rice, S.D. 2008. Ongoing population-level impacts on killer whales Orcinus orca following the 'Exxon Valdez' oil spill in Prince William Sound, Alaska. Marine Ecology Progress Series. 356, 269-281.

McEwan, E.H., Koelink, A.F.C., 1973. Heat production of oiled mallards and scaup. Canadian Journal Of Zoology-Revue Canadienne De Zoologie 51, 27–31.

McHugh, R.D., Mclaren, D. & Hayes, S. 2005. Hydroacoustic monitoring of piling operations in the North Sea. Heraklion, Crete, Greece: Underwater Acoustic Measurements Technologies & Results, 28th June-1st July 2005, Heraklion, Crete, Greece.

McIntyre, T., deBruyn, P.J.N., Ansorge, I.J., Bester, M.N., Bornemann, H., Plötz, J. & Tosh, C.A. 2010. A lifetime at depth: vertical distribution of southern elephant seals in the water column. Polar Biology. 33, 1037-1048.

McMahon, C.R., Burton, H.R. & Bester, M.N. 2000. Weaning mass and the future survival of juvenile southern elephant seals, Mirounga leonina, at Macquarie Island. Antarctic Science. 12, 149-153.

Meador, J.P. 2003. Bioaccumulation of PAHs in marine invertebrates. In: Douben, P. E.T. (Ed.), PAHs: An Ecological Perspective. John Wiley and Sons, IncHoboken, NJ. 147-172

MEPC. 2008a. Marine Environment Protection Agency: Guidelines for approval of ballast water management systems (G8). 174(58).

MEPC. 2008b. Procedure for approval of ballast water management systems that make use of active substances (G9). The Marine Environment Protection Agency. 169(57).

MEPC. 2009. Guidelines for the development of a VOC management plan (resolution 185(59).

MEPC. 2011. Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species. MEPC 62/24/Add.1 Annex 26

Merkel, F.R. 2010. Light-induced bird strikes on vessels in Southwest Greenland. Technical Report No. 84, Pinngortitaleriffik, Greenland Institute of Natural Resources.

Merkel, F.R. & Johansen, K.L. 2011. Light-induced bird strikes on vessels in southwest Greenland. Marine Pollution Bulletin, 62, 2330-2336.

MG3 Ltd. 2014. Premier Oil; Sea Lion Development Environmental and Geochemical Programme. Isobel/Elaine Habitat Assessment Report.

Michalik, A., van Noordwijk, H., Brickle, P., Eggers, T. & Quillfeldt, P. 2010. The diet of the Imperial Shag Palacrocorax articeps at a colony on New Island, Falkland Islands using three different sampling techniques. Polar Biology. 33, 1537-1546.

Minchin, D. & Gollasch, S. 2003. Fouling and Ships' Hulls: How Changing Circumstances and Spawning Events may Result in the Spread of Exotic Species. Biofouling. 19, 111-122.

Mitson, R.B. (ed). 1995. Underwater Noise of Research Vessels: Review and Recommendations. Cooperative Research Report, No. 209. International Council for the Exploration of the Sea, Copenhagen, Denmark.

Ministry of Defence (MoD). 2014. Falkland Islands Range and Avoidance Areas. Series: GSGS 5563, Edition 5.

MMS. 2010. Literature review, synthesis. and design of monitoring of ambient artificial light intensity on the OCS regarding potential effects on resident marine fauna. U.S. Department of the Interior, Minerals Management Service, Anchorage, Alaska. OCS Study MMS 2007-055. http://www.boem.gov/Alaska-Reports-2007/

Montevecchi, W.A. 2006. Influences of artificial light on marine birds. In: Ecological consequences of artificial night lighting. (Rich, C. & Longcore, T., eds.), pp. 94-113. Island Press, Washington, USA.

Montgomery, J.C., Jeffs, A., Simpson, S.D., Meekan, M.G. & Tindle, C. 2006. Sound as an orientation clue for the pelagic larvae of reef fish and crustaceans. Advances in Marine Biology. 51, 143-196.

Mooney, A.T., Hanlon, R.T., Christensen-Dalsgaard, J., Madsen, P.T., Ketten, D.R. & Nachtigall, P.E. 2010. Sound detection by the longfin squid (Loligo pealeii) studied with auditory evoked potentials: sensitivity to low-frequency particle motion and not pressure. The Journal of Experimental Biology. 213, 3748-3759.

Moore, M.J., Berrow, S.D., Jensen, B.A., Carr, P., Sears, R., Rowntree, V.J., Payne, R. & Hamilton, P.K. 1999. Relative abundance of large whales around South Georgia (1979-1998). Marine Mammal Science. 15, 1287-1302.

Moore, S.F. & Dwyer, R.L. 1974. Effects of oil on marine organisms: a critical assessment of published data. Water Research. 8, 819-827.

Moorhead, 1969. Darwin and the Beagle. Harper and Row.

Morris, P. & Therivel, R. (eds.). 2009. Methods of Environmental Impact Assessment. 3rd Edition. Natural and Built Environment Series. Routledge.

Morais, S., Gomes, F., Ramalhosa, M.J. & Oliveira, M. 2013. Occurrence of polycyclic aromatic hydrocarbons in cephalopods. In: Occurrence of Polycyclic Aromatic Hydrocarbons in Cephalopods (Eds: Bandeira, G.C., Meneses, H.E.). Nova Science Publishers.

Moise, T.D. 2014. The obscure future of the Kyoto protocol. L'espace geographique (English edition). 41, 346-351.

Mouat, B., Collins, M.A., & Pompert, J. 2001. Patterns in the diet of Illex argentinus (Cephalopoda: Ommastrephidae) from the Falkland Islands jigging fishery. Fisheries Research. 52, 41-49.

Munro, G. 2011. Seabird and marine mammal observations during well test flaring of Sea Lion 14/10-5 in the North Falkland Basin. Unpublished report to Rockhopper Exploraion PLC.

Mueller-Blenkle, C., McGregor, P.K., Gill, A.B., Andersson, M.H., Metcalfe, J., Bendall, V., Sigray, P., Wood, D., Thomsen, F. 2010. Effects Of Pile-Driving Noise On The behaviour Of Marine Fish. COWRIE Ref: Fish 06-08 / Cefas Ref: C3371Technical Report 31th March 2010

Murphy, R.C. 1936. Oceanic birds of South America. Macmillan, New York, USA.

Muschenheim, D. K., & Lee, K. 2002. Removal of oil from the sea surface through particulate interactions: review and prospectus. Spill Science & Technology Bulletin. 8, 9-18.

Mystikou, A. 2015. Seaweed biodiversity around the Antarctic Convergence in the South Atlantic. PhD Thesis, University of Aberdeen.

NAEI National Atmospheric Emissions Inventory. International Aviation – Aircraft between UK and other OTs (excl Gib.) http://naei.defra.gov.uk/data/ef-all-results?q=12309 [Accessed August 2014].

Nakamura, I., Inada, T., Takeda, M. & Hatanaka, H. 1986. Important Fishes Trawled off Patagonia. Tokyo: Japan Marine Fishery Resource Research Centre.

NAM, 2007 Green light to birds: Investigation into the effect of bird-friendly lighting. NAM LOCATIE L15-FA-1, December 2007, ING. F.J.T. Van de Laar

Natural England. 2014a. An approach to Seascape Character Assessment. Natural England.

Natural England. 2014b. An Approach to Landscape Character Assessment. Natural England

NCSU. 2013. https://climate.ncsu.edu/edu/k12/.AtmComposition.

Nedwell, J.R. & Edwards, B. 2004. A Review of Measurements of Underwater Man-made Noise Carried out by Subacoustech Ltd, 1993 – 2003, Subacoustech Report to the DTI, Ref: 534R0109, 29th September 2004.

Neely, K. 2010. Summary report of the Falkland Islands Shallow Marine Programme 2008-2010. Shallow marine Survey Group.

Neely, K., Brickle, P., & Laptikhovsky, V. 2010a. Biotopes of the Falkland Islands Shallow Marine Environment. Report to FIG. Shallow Marine Surveys Group.

Neely, K., Brickle, P., & Laptikhovsky, V. 2010b. Marine Resources of the Falklands' Shallow marine Environment, A Review of species, distributions and sustainability. Report to FIG. Shallow Marine Surveys Group.

Neely, K. & Brickle, P. 2013. Marine life of the Falkland Islands. Shallow Marine Survey Group: Stanley.

Neff, J.M. 2002. Bioaccumulation in marine organisms, effect of contaminants from oil well produced water. Elsevier press, Oxford, UK.

Neff, J.M. 2005. Composition, environmental fates, and biological effects of water based drilling muds and cuttings discharged to the marine environment: a synthesis and annotated biography. Prepared for the Petroleum Environmental Research Forum (PERF) and the American Petroleum Institute. American Petroleum Institute. Washington, DC. http://www.perf.org/images/Archive_Drilling_Mud.pdf [Accessed September 2014].

Neff, J.M., 2010. Fate and Effects of Water Based Drilling Muds and Cuttings in Cold Water Environments. A Scientific Review prepared for Shell Exploration and Production Company. http://s08.static-shell.com/content/dam/shell-new/local/country/usa/downloads/alaska/neff-final-draftgs072010.pdf [Accessed September 2014].

Neff, J.M., & Haensly, W.E. 1982. Ecological study of the Amoco Cadiz oil spill. Report of the NOAA-CNEXO Joint Scientific Commission, USDC. 269-327 pp. Boulder, CO: National Oceanic and Atmospheric Administration.

Neff, J.M., Breteler, R.J. & Carr, R.S. 1988b. Bioaccumulation, Food Chain Transfer, and Biological Effects of Barium and Chromium from Drilling Muds by Flounder, Pseudopleuronectes americanus, and Lobster, Homarus Americanus. In: Drilling Wastes (Eds: Engelhardt, F.R., Ray J.P. and Gillam, A.H.) pp. 439-459. Elsevier Applied Science.

Neff, J.N., Hillman, R.E. & Waugh J.J. 1988a. Bioaccumulation of trace metals from drilling mud barite by benthic marine animals pp. 461- 479. In: Drilling Wastes, Engelhardt, FR, Ray JP and Gillam, AH (eds) Elsevier Applied Science.

Neff J., Lee K. & DeBlois E.M., 2011. Produced water: Overview of composition, fates, and effects. In: Produced Water. (Eds: Lee, K. & Neff, J.), Chapter 1, Springer, NY.

NEFL. 2013. ESHIA for Temporary Dock Facility Stanley Harbour, Falkland Islands. Noble Energy Falklands Limited ESIA, prepared by RPS Energy.

NEFL. 2015. Biosecurity Management Plan. Noble Energy Falklands Limited: Document 021-15-EHSR-BSP-PA-T4

NETC. 2000. Mapping of nitrogen dioxide and PM10 in the UK for Article 5 Assessment. A National Environmental Technology Centre report produced for The Department of the Environment, Transport and the Regions, The National Assembly for Wales, The Scottish Executive and the Department of the Environment in Northern Ireland.

NMFS. 2005. National Marine Fisheries Service: Recovery Plan for the North Atlantic Right Whale (Eubalaena glacialis). National Marine Fisheries Service, Silver Spring, MD. http://www.nmfs.noaa.gov/pr/pdfs/recovery/whale_right_northatlantic.pdf

NMFS. 2016. Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-55, 178 p.

NOAA. 2004. Final Report of the National Oceanic and Atmospheric Administration (NOAA) International Symposium: Shipping Noise and Marine Mammals. A Forum for Science, Management, and Technology 18-19 May 2004, Arlington, Virginia, U.S.A.

NOAA. 2009. A Prudent Mariner's Guide to Right Whale Protection CD-ROM Version 1.1 - Updated April 2009. http://www.greateratlantic.fisheries.noaa.gov/shipstrike/doc/mtr.html

NOAA. 2013. Draft guidance for assessing the effects of anthropogenic sound on marine mammals: Acoustic threshold levels for onset of permanent and temporary threshold shifts. National Oceanic and Atmospheric Administration, USA. http://www.nmfs.noaa.gov/pr/acoustics/draft_acoustic_guidance_2013.pdf.

NOAA. 2015. Draft Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammals. July 2015.

Noise Management in European Ports (NoMEPorts). 2008. Good Practice Guide on Port Area Noise Mapping and Management. Amsterdam.

NoiseNet. 2008. Noise Terms – Energy Averaging. http://www.noisenet.org/Noise_Terms_Leq.htm [Accessed September 2016].

Norman, J.R. 1937. Coast fishes. Part II. The Patagonian region. Discovery Reports. 16, 1-150.

Norske Olje & Gass. 2014. Norwegian Oil and Gas Guideline 114: Recommended Guidelines for Handling Noise.

NRC. 1983. National Research Council: Risk assessment in the federal government. Managing the process. National Academy Press, Washington, DC.

NRC. 1985. National Research Council: Oil in the sea: inputs, fates and effects. The National Academies Press, Washington, DC.

NRC. 2003. Oil in the Sea III: Inputs, Fates, and Effects. The National Academies Press, Washington, DC.

NRC. 2005. Marine mammal populations and ocean noise: Determining when noise causes biologically significant effect. The National Academies Press, Washington DC.

NSTF. 1993. North Sea Quality Status Report 1993. North Sea Task Force. Oslo and Paris Commissions, London.

OECD. 2013. Sulphur oxides (SOx) and nitrogen oxides (NOx) emissions. Environment at a Glance. 2013. Organisation for Economic Co-operation Development Indicators. OECD Publishing, Paris.

Oilfield Chemical Technology Ltd. 2011. Sea Lion underwater blow-out simulation dated 17th November 2011. Report RRH.003.

OGUK. Produced Water. http://oilandgasuk.co.uk/knowledgecentre/producedwater.cfm

OGUK. 2008. EEMS Atmospheric Emissions Calculations. Issue 1.810a. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/136461/atmos-calcs.pdf [Accessed August 2014].

O'Brien. 2002. Impacts of marine acoustic technology on the Antarctic environment, Version 1.2, July 2002. SCAR Ad Hoc Group on marine acoustic technology and the environment. http://www.geoscience.scar.org/geophysics/acoustics_1_2.pdf

O'Brien, P.Y. & Dixon, P.S. 1976. The effects of oils and oil components on algae: a review. British Phycological Journal. 11, 115-142.

O'Hara, P.D. & Morandin, L.A. 2010. Effects of Sheens Associated with Offshore Oil and Gas Development on the Feather Microstructure of Pelagic Seabirds. Environmental Studies Research Funds: Report 196.

OCIMF & ICS. 2005. Ship to Ship Transfer Guide (Petroleum). 4th Ed. Witherby Publishing Group, Livingston, UK.

Ognedal, T.A. 2012. The noise project of Norwegian oil industry. Presentation to BNAM 2012, Joint Baltic-Nordic Acoustics Meeting, June 18th – 20th June 2012, Odense, Denmark. www.olf.no/Stoy

OGP. 1994. Methods for estimating atmospheric emissions from E&P operations. International Association of Oil and Gas Producers publication 197.

OGP, 2005. Fate and naturally occurring substances in produced water on the marine environment. Report No. 364. Available for download at: http://www.ogp.org.uk/pubs/364.pdf

OGP. 2010. International Association of Oil and Gas Producers: Risk Assessment Data Directory. Report No. 434 – 17 March 2010.

OGP/IPIECA. 2010. Alien invasive species and the oil and gas industry: Guidance for prevention and management.

Oil and Gas UK. 2015. Annual Environmental Report 2015. http://oilandgasuk.co.uk/environment-report.cfm

Okeanos. 2008. Shipping noise and marine mammals. A background paper. International Workshop on Shipping Noise and Marine Mammals. Okeanos: Foundation for the Sea, Hamburg, Germany.

Olsgard, F & Gray, J.S. 1995. A comprehensive analysis of the effects of offshore oil and gas exploration and production on the benthic communities of the Norwegian continental shelf. Marine Ecology Progress Series, 122, 277-306.

Orensanz, J.M., Schwindt, E., Pastorino, G., Bortolus, A., Casas, G., Darrigran, G., Elias, R., Lopez Gappa, J.J., Obenat, S., Pascual, M.M., Penchaszadeh, P., Piriz, M.L., Scarabino, F., Spivak, E.D. & Vallarino, E.A. 2002. No longer the pristine confines of the world ocean: A survey of exotic marine species in the southwestern Atlantic. Biological Invasions. 4, 115-143.

Orkney Islands Council. 2014. The development of an Orkney Ballast Water Management Policy.

Orr, J.C., Fabry, V.J., Aumont, O., Bopp, L., Doney, S.C., Feely, R. A., Gnanadesikan, A., Gruber, N., Ishida, A., Joos, F., Key, R.M., Lindsay, K., Maier-Reimer, E., Matear, R., Monfray, P., Mouchet, A., Najjar, R.G., Plattner, G.-K., Rodgers, K.B., Sabine, C.L., Sarmiento, J.L., Schlitzer, R., Slater, R.D., Totterdell, I.J., Weirig, M.-F., Yamanaka, Y. & Yool, A. 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. Nature. 437, 681-686.

Ortego, B. 1978. Blue-faced boobies at an oil production platform. Auk, 95, 762-763.

OSPAR. 1998. OSPAR Decision 98/3 on the Disposal Of Disused Offshore Installations. http://www.ospar.org/documents/dbase/decrecs/decisions/od98-03e.doc

OSPAR. 2000. Quality Status Report, Chapter 4 -Chemistry.

OSPAR Decision 2000/2 on the Harmonised Mandatory Control System for the Use and Discharge of Offshore Chemicals.

OSPAR. 2000/3. on the Use of Organic-Phase Drilling Fluids (OPF) and the Discharge of OPF-Contaminated Cuttings.

OSPAR, 2004-12. OSPAR List of Chemicals for Priority Action (Update 2000, 2005, 2006, 2007 and 2010).

OSPAR, 2008. Descriptions of habitats on the OSPAR list of threatened and/or declining species and habitats.

OSPAR. 2009a. Assessment of the impacts of offshore oil and gas activities in the north-east Atlantic. Offshore Industry Series. Publication No. 453/2009. ISBN 978-1-906840-93-8.

OSPAR. 2009b. Overview of Impact of anthropogenic underwater sound in the marine environment. Biodiversity Series , OSPAR Commission, 2009.

OSPAR, 2012. Report of the OSPAR Workshop on research into possible effects of regular platform lighting on specific bird populations. OSPAR Commission 2012.

OSPAR. 2013. OSPAR List of Chemicals for Priority Action (Revised 2013) (Reference number 2004-12) http://www.ospar.org/documents?d=32745

OSPAR, 2014. OSPAR report on discharges, spills and emissions from offshore oil and gas installations in 2012.

http://www.ospar.org/documents/dbase/publications/p00603/p00603_offshore%20discharges_report%202011.pdf [Accessed September 2014].

OSPAR. 2015. Assessment of the discharges, spills and emissions from offshore oil and gas operations on the United Kingdom Continental Shelf 2009 – 2013.

OSPAR, 2015-08. Guidelines to reduce the impact of offshore installations lighting on birds in the OSPAR maritime area.

Otley, H. 2012. The composition of the cetacean community in the Falkland (Malvinas) Islands, southwest South Atlantic Ocean. Revista de Biologia Marina y Oceanografia. 47, 537-551.

Otley, H.M., Clausen, A.P., Christie, D.J. & Pütz, K. 2005. Aspects of the breeding biology of the Gentoo Penguin Pygoscelis papua at Volunteer Beach, Falkland Islands, 2001/02. Marine Ornithology. 33, 167-171.

Otley, H., Reid, T., Phillips, R., Wood, A., Phalan, B. & Forster, I. 2007. Origin, age, sex and breeding status of wandering albatrosses (Diomedea exulans), northern (Macronectes halli) and southern giant petrels (Macronectes giganteus) attending demersal longliners in Falkland Islands and Scotia Ridge waters, 2001-2005. Polar Biology. 30, 359-368.

Otley, H., Smith, J. & Dalebout, M.L. 2011. Beaked whale strandings on the Falkland Islands and South Georgia, South Atlantic Ocean, between 1866 and 2008. Journal of the Marine Biological Association of the United Kingdom. 92, 1851-1864.

Padovani, L.N., Viñas, M.D, Sánchez, F. & Mianzan, H. 2012. Amphipod-supported food web: Themisto gaudichaudii, a key food resource for fishes in the southern Patagonian Shelf. Journal of Sea Research. 67, 85-90.

Page, B., McKenzie, J., McIntosh, R., Baylis, A., Morrissey, A., Calvert, N., Haase, T., Berris, M., Dowie, D., Shaughnessy, P.D. & Goldsworthy, S.D. 2004. Entanglement of Australian sea lions and New Zealand fur seals in lost fishing gear and other marine debris before and after Government and industry attempts to reduce the problem. Marine Pollution Bulletin. 49, 33-42.

Pakhomov, E., and Perissinotto, R. (1996). Trophodynamics of the hyperiid amphipod Themisto gaudichaudi in the South Georgia region during late austral summer. Marine Ecology Progress Series, 134, 91-100.

Pale Maiden Consultancy. 2013. Summary Report: Fishing Activity over the Sea Lion Development Area. Report for Premier Oil.

Pang, K. & Martindale, M.Q. 2008. Ctenophores. Current Biology. 18, 1119-1120.

Passchier-Vermeer, W. & Passchier, W.F. 2000. Noise Exposure and Public Health. Environmental Health Perspectives, Supplement 1: Reviews in Environmental Health. 108, 123-131.

Patin, S. 2004. Environmental Impact of Crude Oil Spills. Encyclopaedia of Energy, Volume 1.

Payá, I. & Ehrhardt, N.M. 2005. Comparative sustainability mechanisms of two hake (Merluccius gayi gayi and Merluccius australis) populations subjected to exploitation in Chile. Bulletin of Marine Science. 76, 261-286.

Payá, I. 2009. Grenadier (Macrourus carinatus) Stock Assessment and Total Allowable Catch 2009. Falkland Islands Governement Fisheries Department Scientific Report. pp 34.

Peckol, P., Levings, S.C. & Garritty, S.D. 1990. Kelp response following the World Prodigy oil spill. Marine Pollution Bulletin, 21, pp 473-476.

Perez, C., Munilla, I., Lopez-Alonso, M., & Velando, A. 2009. Sublethal effects on seabirds after the Prestige oil-spill are mirrored in sexual signals. Biology Letters. 6, 33-35.

Peterson, R.G. & Whitworth, T.III. 1989. The Sub-Antarctic and Polar fronts in relation to deep water masses through the Southwestern Atlantic. Journal of Geophysical Research. 94, 10817-10838.

Phillips, D.J.H. & Rainbow, P.S. 1993. Biomonitoring of Trace Aquatic Contaminants. Elsevier, London.

Phillips, R.A., Silk, J.R.D., Croxall, J.P. & Afanasyev, V. 2006. Year-round distribution of white-chinned petrels from South Georgia: Relationships with oceanography and fisheries. Biological Conservation. 129, 336-347.

PhysE. 2016. Metocean Criteria for Berkeley Sound Volume 2 – Operational Presentations. R716-15 2F, Feb 2016.

Pierce, G.J., Valavanis, V.D., Guerra, A., Jereb, P., Orsi-Relini, L., Jose M. Bellido, J.M., Katara, I., Piatkowski, U., Pereira, J., Balguerias, E., Sobrino, I., Lefkaditou, E., Wang, J., Santurtun, M., Boyle, P.R. Hastie, L.C. MacLeod, C.D., Smith, J.M., Viana, M., Gonza´lez, A.F. & Zuur, A.F. 2008. A review of cephalopod–environment interactions in European Seas. Hydrobiologia, 612, 49–70.

Pichegru L, Nyengera R, McInnes AM, Pistorius P. 2017. Avoidance of seismic survey activities by penguins. Scientific Reports 7:16305 doi:10.1038/s41598-017-16569-x.

Pike, S., Medcalf, K. & Cameron, I. 2014. Seabed and land cover maps to support comparative assessment of sites for inshore transfer of oil. A report produced for Premier Oil on behalf of the South Atlantic Environmental Research Institute by Environment Systems Ltd.

Pistorius, P.A., Baylis, A., Crofts, S. & Pütz, K. 2012. Population development and historical occurrence of king penguins at the Falkland Islands. Antarctic Science. 24, 435-440.

Platt, N.H. & Phillip, P.R. 1995. Structure of the southern Falkland Islands continental shelf: initial results from new seismic data. Marine and Petroleum Geology. 12, 759-771.

Plexus Energy. 2012. Socio-economic Impact Study of the Sea Lion Oil Development Project (Falkland Islands). Report for Rockhopper Exploration Plc.

Polarcus. 2011. Marine Mammal and Seabird observations during 3D seismic survey in the North Falkland Basin (Nov-10 to May-11). Report for Desire Petroleum Plc and Rockhopper Exploration.

Pompert , J.W. 2011. On the biology of two skate species Bathyraja macloviana (Norman, 1937) and Bathyraja cousseauae (Díaz de Astarloa & Mabragaña, 2004) around the Falkland Islands. MSc Thesis, University of Aberdeen.

Poncet, S., Robertson, G., Phillips, R.A., Lawton, K., Phalan, B., Trathan, P.N. & Croxall, J.P. 2006. Status and distribution of Wandering, Black-browed and Grey-headed Albatrosses breeding at South Georgia. Polar Biology. 29, 772-781.

Poncet, S. 2014. Report on a baseline survey of coastal birds, mammals and wildlife habitats of Stanley Harbour, Navy Point and Cape Pembroke. Beaver Island LandCare.

Poncet, S., Wolfaardt, A.C., Black, A., Browning, S., Lawton, K., Lee, J., Passfield, K., Strange, G., Phillips, R.A. 2017. Recent trends in numbers of wandering (Diomedea exulans), black-browed (Thalassarche melanophris) and grey-headed (T. chrysostoma) albatrosses breeding at South Georgia. Polar Biology 40: 1347-1358.

Poot, H., Ens, B.J., de Vries, H., Donners, M.A.H., Wernand, M.R. & Marquenie, J.M. 2008. Green light for nocturnally migrating birds. Ecology and Society. 13, 47.

Pope, C.A., Bates, D.V. & Raizenne, M.E. 1995. Health effects of particulate air pollution: time for reassessment? Environmental Health Perspectives. 103, 472-480.

Popper, A.N. & Hastings, M.C. 2009. Effects of anthropogenic sources of sound on fishes. Journal of Fish Biology. 75, 455-498.

Popper, A. N. Hawkins, A. D., Fay, R. F., Mann, D. A., Bartol, S., Carlson, T. J., Coombs, S., Ellison, W. T., Gentry, R. L., Halvorsen, M. B., Løkkeborg, S., Rogers, P. H., Southall, B. L., Zeddies, D. G. & Tavolga, W. N. 2014. Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. ASA S3/SC1.4 TR-2014.

Portsmouth News. 2011. HMS Protector.

http://www.portsmouth.co.uk/news/local/hms-protector-will-be-endurance-replacement-1-2358055 [Accessed December 2015].

Premier. 2014a. Premier Oil; '2015 Exploration Campaign Environmental Impact Statement' (CP-BA-PMO-HS-SE-ST-0001).

Premier. 2014b. North Falklands Coastline Environmental Sensitivity for Oil Spill Response. September 2014. pp 154. Premier Oil FIBU HSES Element Standard. (FK-BU-HS-ST-0005).

Premier. 2014c. Premier Oil; 'Environmental Assessment of Potential Inshore Transfer Sites' (FK-SL-PMO-EV-REP-0007-B03).

Premier. 2014e. Sea Lion Field Environmental Baseline Description. Premier Oil Exploration & Production Limited, Falkland Islands Business Unit.

Premier. 2014f. Temporary Dock Facility: Oil spill response plan. Premier Oil Exploration & Production Limited, Falkland Islands Business Unit. November 2014.

Premier. 2014g. Drilling EIS Addendum Isobel Deep. Premier Oil Exploration & Production Limited, FK-BU-PMO-EV-REP-0004 REV 1.0.

Premier. 2015a. Basis of Design Document Rev 4. Premier Oil Exploration & Production Limited, Document number:

Premier. 2015b. Bird-strike Monitoring Plan. Document number TBC

Premier. 2015c. Environmental assessment of potential inshore transfer sites. Premier Oil Exploration & Production Limited, Falkland Islands Business Unit.

Premier. 2015d. Premier Oil Bird strike report. Premier Oil Exploration & Production Limited, Document number

Premier. 2015e. 2015 Exploration Campaign. Title: Zebedee End of Well Environmental Report. Premier Oil Exploration & Production Limited, FK-BU-PMO-EV-REP-0005 Rev. B01 (26/05/2015)

Premier. 2015f. Sea Lion Development; Iceberg Management Strategy (Doc: FK-SL-PMO-NA-STY-0001)

Premier. 2016a. 2015 Exploration Campaign. Title: Chatham End of Well Environmental Report. Premier Oil Exploration & Production Limited, FK-BU-PMO-EV-REP-0012 Rev. A (28/06/2016)

Premier. 2016b. 2015 Exploration Campaign. Title: Isobel Deep End of Well Environmental Report. Premier Oil Exploration & Production Limited, FK-BU-PMO-EV-REP-0010 Rev. A (28/06/2016)

Premier. 2016c. 2015/16 Exploration Campaign. Title: Isobel Elaine End of Well Environmental Report. Premier Oil Exploration & Production Limited, FK-BU-PMO-EV-REP-0013 Rev. A (28/06/2016)

Premier. 2016d. 2015 Exploration Campaign. Title: Jayne East End of Well Environmental Report. Premier Oil Exploration & Production Limited, FK-BU-PMO-EV-REP-0011 Rev. A (28/06/2016)

Premier. 2016e. FPSO Field Design Specification. Document Number TBC

Premier. 2016f. Inshore Environmental Modelling Report Premier Oil Exploration & Production Limited, FK-SL-PMO-EV-REP-0010.

Premier. 2016g. Oil Spill Strategy for Inshore Crude Oil Transfer Operations. Premier Oil Exploration & Production Limited, FK-SL-PMO-EV-STY-0003.

Premier. 2016h. Sea Lion Inshore, At Shore, Onshore ENVID Report, Premier Oil Exploration & Production Limited, Document Reference FK-SL-PMO-EV-REP-0009. Rev B03, 19/07/2016.

Premier, 2016i. Oil export inshore transfer bow tie assessment report. Premier Oil Exploration & Production Limited, Document No. FK-SL-PMO-HS-REP-0001, March 2016.

Premier. 2016j. Fate and Behaviour Tests for 'Dead' Sea Lion Crude Oil Inshore Transfer Operations Berkeley Sound. Research conducted by SpillConsult for Premier Oil Exploration & Production Limited, Document No. FK-SL-PMO-EV-TTR-0001, April 2016.

Premier. 2017a. Sea Lion Development Onshore Storage Facilities – Major Accident Hazard Assessment. Assessment conducted by Risktec for Premier Oil Exploration and Production Limited, Document No. FK-SL-PMO-HS-REP-0004, June 2017.

Premier. 2017b. Sea Lion Phase 1 Design Notification. Premier Oil Document No. FK-SL-PMO-HS-REP-0003, May 2017.

Premier. 2017c. Sea Lion Phase 1 Field Development Plan. Premier Oil Document No. FK-SL-PMO-PLN-0004.

Premier. 2017d. Sea Lion Phase 1 Environmental Modelling Report. Premier Oil Document No. FK-SL-PMO-EV-REP-0100.

Premier. 2017e. Sea Lion Inshore Oil Spill Strategy. Premier Oil Document No. FK-SL-PMO-EV-STY-0003.

Premier. 2017f. Sea Lion Development Oil Spill on Paper Workshop – Report. Document No. FK-SL-PMO-EV-REP-0012.

Premier. 2018. Sea Lion Field Development Phase 1 Environmental Impact Statement. Document No. FK-SL-PMO-EV-REP-0008, Revision B03.

Premier. 2019. Invasive species monitoring: Stanley Harbour and Pt William Report- Final Report. Prepared by Shallow Marine Surveys Group. 15 July 2019.

Procter, D.and Fleming, L.V. (Edited). 1999. Biodiversity: the UK Overseas Territories, ISBN 1 86107 502 2.

Pütz, K. 2002. Spatial and temporal variability in the foraging areas of breeding king penguins. Condor. 104, 528-538.

Pütz, K. & Cherel, Y. 2005. The diving behaviour of brooding king penguins (Aptenodytes patagonicus) from the Falkland Islands: variation in dive profiles and synchronous underwater swimming provide new insights into their foraging strategies. Marine Biology. 147, 281-290.

Pütz, K., Ingham, R.J. & Smith, J.G. 2000b. Satellite tracking of the winter migration of Magellanic Penguins Spheniscus magellanicus breeding in the Falkland Islands. Ibis. 142, 614-622.

Pütz, K., Ingham, R.J. & Smith, J.G. 2002a. Foraging movements of Magellanic Penguins Spheniscus magellanicus during the breeding season in the Falkland Islands. Aquatic Conservation. 12, 75-87.

Pütz, K., Smith, J.G., Ingham, R.J. & Lüthi B.H. 2002b. Winter dispersal of Rockhopper Penguins Eudyptes chrysocome from the Falkland Islands and its implications for conservation. Marine Ecology Progress Series. 240, 273-284.

Putz, K., Smith, J.G., Ingham, R.J. and Luthi, B.H. 2003. Satellite tracking of male rockhopper penguins Eudyptes chrysocome during the incubation period at the Falkland Islands. Journal of Avian Biology, 34. 139-144.

Pütz, K., Rey, A. R., Huin, N., Schiavini, A., Pütz, A. & Lüthi, B. H. 2006. Diving characteristics of southern rockhopper penguins (Eudyptes c. chrysocome) in the southwest Atlantic. Marine Biology. 149,125-137.

Quillfeldt, P., Masello, J.F., Brickle, P. & Martin-Creuzburg, D. 2011. Fatty acid signatures reflect inter- and intra-annual changes in diet of a small pelagic seabird, the Thin-billed prion Pachyptila belcheri. Marine Biology. 158, 1805-1813.

RAF. 2015. British Forces South Atlantic Islands. https://www.raf.mod.uk/currentoperations/opsfalklands.cfm

Ratcliffe, N., Crofts, S., Brown, R., Baylis, A.M.M., Adlard, S., Horswill, C., Venables, H., Taylor, P., Trathan, P.N. & Staniland, I.J. 2014. Love thy neighbour or opposites attract? Patterns of spatial segregation and association among crested penguin populations during winter. Journal of Biogeography. 41, 1183-1192.

Raimondi, P.T., Schmitt, R.J., 1992. Effects of produced water on settlement of larvae: field test using red abalone. In: Produced Water: Technological/Environ- mental Issues and Solutions. (Eds: Ray, J.P., & Engelhardt, F.R.), Plenum Press, New York, pp. 415– 430.

Raymond, B., Lea, M.A., Patterson, T., Andrews-Goff, V., Sharples, R., Charrassin, J.B., Cottin, M., Emmerson, L., Gales, N., Gales, R., Goldsworthy, S.D., Harcourt, R., Kato, A., Kirkwood, R., Lawton, K., Ropert-Coudert, Y., Southwell, C., van den Hoff, J., Wienecke, B., Woehler, E.J., Wotherspoon, S. & Hindell, M.A. 2015. Important marine habitat off east Antarctica revealed by two decades of multi-species predator tracking. Ecography, vol. 38, no. 2, pp. 121-129. https://doi.org/10.1111/ecog.01021.

Reed, D.C., Lewis, R.J., Anghera, M., 1994. Effects of an open-coast oil-production outfall on patterns of giant kelp (Macrocystis pyrifera) recruitment. Marine Biology, 120, 25–31.

Reed, M., Aamo, M. & Downing, K. 1996. Calibration and testing of IKU's oil spill contingency and response (OSCAR) model system. In: Proceedings of the 1996 Arctic and Marine Oil Spill Program (AMOP) Technical Seminar, pp. 689-726.

Reed, M., French, D., Rines, H., & Rye, H. 1995. A three dimensional oil and chemical spill model for environmental impact assessment. In: Proceedings of the 1995 International Oil Spill Conference, pp. 61-66.

Regan, C.T. 1913. The Antarctic fishes of the Scottish National Antarctic Expedition. Transcriptions of the Royal Society of Edinburgh. 49, 229-292.

Regel, J. & Pütz, K. 1997. Effect of human disturbance on body temperature and energy expenditure in penguins. Polar Biology. 18, 246-253.

Regeneris. 2013. Socio-economic Study of Oil and Gas Development in the Falklands. Report by Regeneris Consulting Ltd for the Falkland Islands Government.

Regeneris. 2015. Social Economic Monitoring Programme. Report by Regeneris Consulting Ltd for the Falkland Islands Government.

Reid, T.A. & Huin, N. 2005. Census of the Southern Giant-Petrel Population of the Falkland Islands 2004/2005. Falklands Conservation Report to OTEP and FIG. http://www.falklandsconservation.com/images/wildlife/birds/GiantPetrelReport.pdf

Reid, T.A., Lecoq, M. & Catry, P. 2007. The white-chinned petrel Procellaria aequinoctialis population of the Falkland Islands. Marine Ornithology. 35, 57-60.

Reid, T.A., Sullivan, B.J., Pompert, J., Endicott, J.W. & Black, A.D. 2004. Seabird mortality associated with Patagonian toothfish (Dissostichus eleginoides) longliners in Falkland Islands waters. Emu. 104, 317-325.

Riedman, M. 1990. The pinnipeds: Seals, sea lions and walruses. University of California press.

Reilly, S.B., Bannister, J.L., Best, P.B., Brown, M., Brownell Jr., R.L., Butterworth, D.S., Clapham, P.J., Cooke, J., Donovan, G.P., Urbán, J. & Zerbini, A.N. 2008. Balaenoptera borealis.

The IUCN Red List of Threatened Species. Version 2014.2. https://www.iucnredlist.org [Accessed July 2014].

Reilly, S.B., Bannister, J.L., Best, P.B., Brown, M., Brownell Jr., R.L., Butterworth, D.S., Clapham, P.J., Cooke, J., Donovan, G.P., Urbán, J. & Zerbini, A.N. 2013. Eubalaena australis. The IUCN Red List of Threatened Species. Version 2014.2. www.iucnredlist.org [Accessed September 2014].

Renzi, M.A. 1986. Aspectos biologico-pesqueros del abadejo (Genypterus blacodes). Revista de Investigaciones y Desarrollo Pesquero. 6, 5-19.

Richards, P.C. & Fannin, N.G.T. 1997. Geology of the North Falkland Basin. Journal of Petroleum Geology. 20, 165-183.

Richards, P.C. & Hillier, B.V. 2000. Post Drilling Analysis of the North Falkland Basin – Part 1: Tectono-Stratigraphic Framework. Journal of Petroleum Geology. 23, 273-292.

Richardson, W.J., Greene, C.R., Malme, C.I. & Thompson, D.H. 1995. Marine mammals and noise. Academic Press Inc., San Diego.

Ridoux, V., Lafontaine, L., Bustamante, P., Caurant, F., Dabin, W., Delcroix, C. & Hassani, S. 2004. The impact of the ‘Erika’ oil spill on pelagic and coastal marine mammals: Combining demographic, ecological, trace metals and biomarker evidences. Aquatic Living Resources. 17, 379-387.

Ríos, C., Arntz, W.E., Gerdes, D., Mutschke, E. & Montiel, A. 2007. Spatial and temporal variability of the benthic assemblages associated to the holdfasts of the kelp Macrocystis pyrifera in the Straits of Magellan, Chile. Polar Biology. 31, 89-100.

Risch, D., Gales, N.J., Gedamke, J., Kindermann, L., Nowacek, D.P., Read, A.J., Siebert, U., Opzeeland, I.C., Van Parijs, S.M. & Van Friedlaender, A.S. 2014. Mysterious bio-duck sound attributed to the Antarctic minke whale (Balaenoptera bonaerensis). Biological Letters. 10:20140175.

Robertis, A. & Handegard, N.O. 2013. Fish avoidance of research vessels and the efficacy of noise-reduced vessels: a review. ICES Journal of Marine Science. 70, 34-45.

Roberts, J.M. 2002 The Occurrence of the Coral Lophelia pertusa and Other Conspicuous Epifauna around an Oil Platform in the North Sea. Journal of the Society for Underwater Technology, Vol 25, No. 2. pp. 83-91.

Roberts, D.A., Johnston, E.L. & Knott, A. 2010. Impacts of desalination plant discharges on the marine environment: A critical review of published studies. Water Research. 44, 5117-5128.

Rocke, T.E. 1999. Field Manual of Wildlife Diseases, General Field Procedures and Diseases of Birds, Biological Resources Division, Information and Technology Report 1999–001. U.S. Geological Survey. Chapter 42.

Rodhouse, P.G., Elvidge, C.D. & Trathan, P.N. 2001. Remote sensing of the global light-fishing fleet: an analysis of interactions with oceanography, other fisheries and predators. Advances in Marine Biology. 39, 261-303.

Rodhouse, P.G., Symon, C. & Hatfield, E.M.C. 1992. Early life cycle of cephalopods in relation to the major oceanographic features of the southwest Atlantic Ocean. Marine Ecology Progress Series. 89, 183-195.

Rodríguez, D., Bastida, R., Moron, S., Rodríguez, S. & Luoreiro, J. 2003. Occurrence of leopard seals in Northern Argentina. Latin American Journal of Aquatic Mammals. 2, 51-54.

Rodríguez, A. & Rodríguez, B. 2009. Attraction of petrels to artificial lights in the Canary Islands: effect of the moon phase and age class. Ibis. 151, 299-310.

Rodríguez, A., García, D., Rodríguez, B. Cardona, E., Parpal, L. & Pons, P. 2015a. Artificial lights and seabirds: is light pollution a threat for the threatened Balearic petrels? Journal of Ornithology, 156, 893-902.

Rodríguez, A. & Rodríguez, B. & Negro, J.J. 2015b GPS tracking for mapping seabird mortality induced by light pollution. Nature Scientific Reports 5, Article number 10670, doi:10.1038/srep10670. http://www.nature.com/articles/srep10670

Rolland R.M., Parks, S.E., Hunt, K.E., Castellote, M., Corkeron, P.J., Nowacek, D.P., Wasser, S.K. & Kraus, S.D. 2012. Evidence that ship noise increases stress in right whales. Proceedings of the Royal Society B. 279, 2363-2368.

Romero, S.I., Piola, A.R., Charo, M. & Eiras Garcia, C.A. 2006. Chlorophyll-a variability off Patagonia based on SeaWiFS data. Journal of Geophysical Research. 111, C05021.

Ronconi, R.A., Allard, K.A. & Taylor, P.D. 2015. Bird interactions with offshore oil and gas platforms: Review of impacts and monitoring techniques. Journal of Environmental Management. 147, 34-45.

Ross, D.G. 1993. On ocean underwater ambient noise. Acoustics Bulletin. Jan/Feb, 5-8.

Røstad, A., Kaartvedt, S., Klevjer, T.A. & Melle, W. 2006. Fish are attracted to vessels. ICES Journal of Marine Science. 63, 1431-1437.

Rounsevell, D. & Binns, D. 1991. Mass deaths of king penguins (Aptenodytes patagonica) at Lusitania Bay, Macquarie Island. Aurora. 10, 8-10.

Royal Navy. 2015a. Royal Fleet Auxiliary Vessel. http://www.royalnavy.mod.uk/our-organisation/the-fighting-arms/royal-fleet-auxiliary [Accessed December 2015].

Royal Navy. 2015b. South Atlantic Patrol Vessel. http://www.royalnavy.mod.uk/news-and-latest-activity/operations/south-atlantic/falkland-islands-patrol-vessel [Accessed December 2015].

RPS Energy. 2009. Environmental Impact Statement for Offshore Drilling Licences PL032 & PL033 in the Falkland Islands. Report for Rockhopper Exploration.

Runciman, D. 2001. Investigation of the toxicokinetics of water based mud cuttings. ERT Ltd. Phase II, Task 2a. UKOOA Drill Cuttings Initiative 2001.

Russell, J.C., Meyer, J-Y., Holmes, N. D., Pagad, S. 2017. Invasive alien species on islands: impacts, distribution, interactions and management. Environmental Conservation. Thematic Section: Humans and Island Environments, 1-12.

Ryan, P.G. 1991. The impact of the commercial lobster fishery on seabirds at the Tristan da Cunha islands, South Atlantic. Biological Conservation. 57, 339-350.

Ryan, P.G., de Bruyn, P.J.N., Bester, M.N. 2016. Regional differences in plastic ingestion among Southern Ocean fur seals and albatrosses. Marine Pollution Bulletin. 104, 207-210

Rye, H. 2010. Calculation of stresses (depositions and water column concentrations) at the sea floor caused by drilling discharges. Presentation at the 2010 OLF cold-water coral workshop, held at IRIS, Stavanger, 31 May – 1 June 2010.

SAERI. 2015. South Atlantic Environmental Research Institute. http://south-atlantic-research.org/

SAERI (with assistance from Austral Biodiversity). 2017. Berkeley Sound Coastal Bird Survey Report. Prepared for Premier Oil Exploration and Production Ltd, July 2017.

SAERI & SMSG. 2016. Berkeley Sound Environmental Baseline Survey: Qualitative subtidal habitat assessment. Prepared for Premier Oil Exploration and Production Limited, July 2016.

Saha S., Moorthi S., Pan H-L., Wu X., Wang J., Nadiga S., Tripp P., Kistler R., Woollen J., Behringer D., Liu H., Stokes D., Grumbine R., Gayno G., Wang J., Hou Y-T., Chuang H-Y., Juang H-M H., Sela J., Iredell M., Treadon R., Kleist D., Van Delst P., Keyser D., Derber J., Ek M., Meng J., Wei H., Yang R., Lord S., Van Den Dool H., Kumar A., Wang W., Long C., Chelliah M., Xue Y., Huang B., Schemm J-K., Ebisuzaki W., Lin R., Xie P., Chen M., Zhou S., Higgins W., Zou C-Z., Liu Q., Chen Y., Han Y., Cucurull L., Reynolds R.W., Rutledge G. & Goldberg M. 2010. The NCEP Climate Forecast System Reanalysis. Bulletin of American Meteorological Society. 91: 1015–1057.

Salazar, S. 2003. Impacts of the Jessica oil spill on sea lion (Zalophus wollebaeki) populations. Marine Pollution Bulletin. 47, 313-318.

Sanvito, S. and Galimberti, F. 2018. Killer whales of Sea Lion Island (Falkland Islands) Photo-identification catalogue 2017-2018 http://eleseal.org/pdf_vari/KW_SLI_catalogue.pdf

Schanning, M., Ruus, A., Bakke, T., Hylland, K., Olsgard, F., 2002. Bioavailability of metals in weight materials for drilling muds. NIVA Report No. 4597-02, 36 pp.

Schiel, D.R., Steinbeck, J.R. & Foster, M.S. 2004. Ten years of induced ocean warming causes comprehensive changes in marine benthic communities. Ecology. 85, 1833-1839.

Schwacke, L.H., Smith, C.R., Townsend, F.I., Wells, R.S., Hart, L.B., Balmer, B.C., Collier, T.K., De Guise, S., Fry, M.M, Guillette, Jr., L.J., Lamb, S.V., Lane, S.M., McFee, W.E., Place, N.J., Tumlin, M.C., Ylitalo, G.M., Zolman, E.S. & Rowles, T.K. 2014. Health of Common Bottlenose Dolphins (Tursiops truncatus) in Barataria Bay, Louisiana, Following the Deepwater Horizon Oil Spill. Environmental Science and Technology. 48, 93-103.

SAIC. 2011. Final Summary Report: Environmental Science Panel for Marbled Murrelet Underwater Noise Injury Threshold. Prepared for U.S. Navy NAVFAC Northwest by Science Applications International Corporation September 7, 2011.

SEPA. 2010. Scottish Environmental Protection Agency, Odour Guidance. http://www.sepa.org.uk/media/154129/odour_guidance.pdf [Accessed August 2016].

SEPA. 2016a. Waste sites and capacity information. List of waste sites and capacities in Scotland. https://www.sepa.org.uk/environment/waste/waste-data/waste-data-reporting/waste-site-information/waste-sites-and-capacity-excel/

SEPA. 2016b. Waste data reporting. Waste from all sources - data and quality report. https://www.sepa.org.uk/environment/waste/waste-data/waste-data-reporting/

Scottish Executive. 2007. Guidance Note: Controlling Light Pollution and Reducing Light Energy Consumption. Edinburgh: Scottish Executive.

Sea Watch Foundation. 2012. Species information sheet: Sei whale in UK waters. http://seawatchfoundation.org.uk/wp-content/uploads/2012/07/Sei_Whale1.pdf [Accessed September 2014].

Skamarock, W.C., Klemp, J.B., Dudhia, J., Gill, D.O., Barker, D.M., Duda, M.G., Huang, X-Y., Wang, W. & Powers, J.G. 2008. A Description of the Advanced Research WRF Version 3, Tech. rep., UCAR.

Sharp, T. 2012. Earth's Atmosphere: Composition, Climate & Weather. http://www.space.com/17683-earth-atmosphere.html

Shirihai, H. 2006. Whales, dolphins and seals: A field guide to marine mammals of the world. A & C Black Publishers Ltd.

Silber, G.K., Bettridge, S. & D. Cottingham. 2009. Report of a workshop to identify and assess technologies to reduce ship strikes of large whales, 8-10 July, 2008, Providence, Rhode Island. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-42. 55 p.

Singh, A. & Agrawal, M. 2008. Acid rain and its ecological consequences. Journal of Environmental Biology. 29, 15-24.

SINTEF. 2008. Background noise levels in Europe. Truls Gjestland, SINTEF A6631. https://www.easa.europa.eu/system/files/dfu/Background_noise_report.pdf

SINTEF. 2014. DREAM/Partrack model. First commercial release of the DREAM/Partrack model. March 2014. (Foundation for Scientific and Industrial Research) Available at https://www.sintef.no/globalassets/upload/materialer_kjemi/brosjyrer-faktaark/faktaark/miljo/dream.pdf

Širović, A., Hildebrand, J.A., Wiggins, S.M. & Thiele, D. 2009. Blue and fin whale acoustic presence around Antarctica during 2003 and 2004. Marine Mammal Science. 25, 125-136.

Skottsberg, C. 1921. Botanische Ergebnise der schwedischen Expedition nach Patagonien und dem Feurlande 1907-1909. Marine algae I. Phaeophyceae. K.Sv.Vet. Akad.Handl 61, 1-56.

Slabbekoorn, H., Bouton, N., van Opzeeland, I., Coers, A., ten Cate, C. & Popper, A.N. 2010. A noisy spring: the impact of globally rising underwater sound levels on fish. Trends in Ecology and Evolution. 25, 419-427.

Smethurst (David) Consultancy. 2013. Towards an Infrastructure Delivery Plan. Report commissioned by the Director of Central Services, Falkland Islands Government.

Smit, M. G. D., Frost, T. K. & Johnsen, S. 2011. Achievements of Risk-based produced water management on the Norwegian Continental Shelf (2002-2008), Integrated Environmental Assessment and Management. 7: 668-677.

Smit, M.G.D., Tamis, J.E., Jak, R.G., Karman, G., Kjeilen-Eilertsen, G., Trannum, H., Neff, J. 2006. Threshold levels and risk functions for non-toxic sediment stressors: burial, grain size changes and hypoxia. Summary. TNO Report no. 2006-DH-0046/A.

SMSG. 2008. Benthic survey of the Jason Islands, Falkland Islands. Shallow Marine Survey Group.

SMSG. 2009a. Benthic survey of Berkeley Sound, Shallow Marine Survey Group.

SMSG. 2009b. Benthic survey of Beauchêne and Sea Lion Islands, Falkland Islands. Shallow Marine Survey Group.

SMSG 2009c. Benthic survey of Adventure Sound, Falkland Islands. Shallow Marine Survey Group: Stanley.

SMSG. 2011. Shallow Marine Surveys Group: Survey report: Invasive species, March 2011. Unpublished Shallow Marine Surveys Group report.

SMSG. 2012. Shallow Marine Surveys Group: Kidney Island National Nature Reserve. Survey of the Marine Environment. Shallow Marine Survey Group.

SMSG. 2013. Shallow Marine Surveys Group: Stanley Harbour Environmental Baseline Survey (EBS). Qualitative Subtidal and Intertidal Habitat Assessment. Contract Number FI-2013-C-029. Prepared for Premier Oil and Production Limited.

SMSG, 2016. Shallow Marine Surveys Group. http://smsg-falklands.org/

Snelgrove, P.V.R. & Butman, C.A. 1994. Animal–sediment relationships revisited: cause versus effect. Oceanography and Marine Biology: An Annual Review. 32, 111-177.

Sol Environmental. 2016. Air Quality Assessment: Energy from waste plant, Mearclough Rd, Sowerby Bridge. Prepared for Calder Valley Skip Hire Ltd. November 2016.

Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J., Gentry, R.L., Greene, C.R. Jr., Kastak, D., Ketten, D.R., Miller, J.H., Nachtigall, P.E., Richardson, W.J., Thomas, J.A. & Tyack, P. 2007. Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. Aquatic Mammals. 33, 411-521.

Southwell, C. 2005. Response behaviour of seals and penguins to helicopter surveys over the pack ice off East Antarctica. Antarctic Science. 17, 328-334.

Stafford, K.M., Mellinger, D.K., Moore, S.E. & Fox, C.G. 2007. Seasonal variability and detection range modelling of baleen whale calls in the Gulf of Alaska, 1999–2002. Journal of Acoustical Society of America. 122, 3378-3390.

Stagg, R.M. and McIntosh, A. 1996. The effects of drill cuttings on the Dab (Limanda limanda).E&P Forum Report. The Physical and Biological Effects of Processed Oily Drill Cuttings.

Stankovic, A., Spalik, K., Kamler, E., Borsuk, P. & Weglenski, P. 2002. Recent origin of sub-Antarctic notothenioids. Polar Biology. 25, 203–205.

Staniland, J., Robinson, S.L., Silk, J.R.D., Warren, N. & Trathan, P.N. 2012. Winter distribution and haul-out behaviour of female Antarctic fur seals from South Georgia. Marine Biology. 159, 291-301.

Stanworth, A. 2014 Falkland Islands Seabird Monitoring Programme Annual Report 2013/2014 (SMP21). Unpublished Falklands Conservation (FC) report.

Stark, J.S., Snape, I. & Riddle, M.J. 2003. The effects of petroleum hydrocarbon and heavy metal contamination of marine sediments on recruitment of Antarctic soft-sediment assemblages: a field experimental investigation. Journal of Experimental Marine Biology and Ecology, 283, 21– 50.

Stephenson, M.T., R.C. Ayers, L.J. Bickford, D.D. Caudle, J.T. Cline, G. Cranmer, A. Duff, E. Garland, T.A. Herenius, R.P.W.M. Jacobs, C. Inglesfield, G. Norris, J.D. Petersen, and A.D. Read. 1994. North sea produced water: fate and effects in the marine environment. Report No. 2.62/204. E&P Forum, London, England. 48 pp.

Stone, P. 2008. Charles Darwin in the Falkland Islands, 1833 to 1834. NERC Open Research Archive. http://nora.nerc.ac.uk/5311/1/Darwin4FIJ.pdf [Accessed October 2015].

Strange, I.J. 1992. A field guide to the wildlife of the Falkland Islands and South Georgia. Harper and Collins, London.

Sullivan, B.J., Reid, T.A. & Bugoni, L. 2003. Seabird mortality on factory trawlers in the Falkland Islands and beyond. Biological Conservation. 131, 495-504.

Tabak, M.A., Anderson, O.R., Robb, G., Poncet, S., Passfield, K., Martinez, M. & Martinez del Rio, C. 2016. Comparative isotopic natural history of two native passerines (Troglodytes cobbi and Cinclodes antarcticus) and the invasive rats (Rattus norvegicus) that extirpate them. Austral Ecology. 41, 622-632.

Tabak, M.A., Poncet, S., Passfield, K., Goheen, J.R. & Martinez del Rio, C. 2015. Rat eradication and the resistance and resilience of passerine bird assemblages in the Falkland Islands. Journal of Animal Ecology. 84, 755-764.

Tarling, G. A., Ward, P., Shaeder, M., Williams, J. A. & Symon, C. 1995. Distribution patterns of macrozooplankton assemblages in the southwest Atlantic. Marine Ecology Progress Series. 120, 29-40.

Tasker, M.L. & Pienkowski, M.W. 1987. Vulnerable Concentrations of Birds in the North Sea. Nature Conservation Council.

Tasker, M.L., Hope-Jones, P., Blake, B.F., Dixon, T. & Wallis, A.W. 1986. Seabirds associated with oil production platforms in the North Sea. Ringing and Migration. 7, 7-14.

Thompson, D., Moss, S. & Lovell, P. 2003. Foraging behaviour of South American fur seals (Arctocephalus australis): extracting fine scale foraging behaviour from satellite tracks. Marine Ecology Progress Series. 260, 285-296.

Thompson, D, Strange, I, Riddy, M, & Duck, C. 2005. The size and status of the population of southern sea lions Otaria flavescens in the Falkland Islands. Biological Conservation. 121, 357-367.

Thompson, K.R. 1992 Quantitative analysis of the use of discards from squid trawlers by black-browed albatrosses Diomedea melanophris in the vicinity of the Falkland Islands. Ibis. 134, 11-21.

Thompson, K.R. 1993. Falkland Islands Seabird Monitoring Programme Summary of Results. Falklands Conservation Report SMP/3, Falkland Islands.

Thompson, K.R. & Riddy, M. 1995. Utilization of offal discards from 'finfish' trawlers around the Falkland Islands by the black-browed albatross Diomedea melanophris in the vicinity of the Falkland Islands. Ibis. 137, 198-206.

Thomsen, I. & Munro, G. 2014. Results from the pilot line transect survey for inshore cetaceans in the Falkland Islands and designing a full Falkland Islands line transect survey for inshore cetaceans. Unpublished report to the Darwin Initiative.

Thomson, R.B. 1977. Effects of human disturbance on an Adelie Penguin rookery and measures of control. In: Adaptations within Antarctic ecosystems. (Ed: Llano, G.A.), pp 1177–1180. Smithsonian Institute, Washington, DC.

Tingley, G., Saunders, G., Harries, D. & King, J. 1996. The first shallow marine survey around the Falkland Islands. IC Consultants Ltd and Brown and Root Environmental, UK.

Trannum H.C. 2004. Calculation of the PNEC for changed grain size based on data from MOD. Akvaplan Niva report APN-411.3088.1 ERMS report 9A.

Trannum, H.C., Nilsson, H.C., Schaanning, M.T.& Øxnevad, S. 2010. Effects of sedimentation from water-based drill cuttings and natural sediment on benthic macrofaunal community structure and ecosystem processes. Journal of Experimental Marine Biology and Ecology. 383, 111-121.

Trathan P.N., Warwick-Evans V., Hinke J.T., Young, E.F., Murphy, E.J., Carneiro, A.P.B., Dias, M.P., Kovacs, K.M., Lowther, A.D., Godø, O.R., Kokubun, N., Kim, J.H., Takahashi, A., & Santos, M. 2018. Managing fishery development in sensitive ecosystems: identifying penguin habitat use to direct management in Antarctica. Ecosphere 9: . doi: 10.1002/ecs2.2392.

Troy, J.R., Holmes, N.D. & Green, M.C. 2011. Modeling artificial light viewed by fledgling seabirds. Ecosphere. 2, 1-13.

Tussenbroek, B.I. 1989. Seasonal growth and composition of fronds of Macrocystis pyrifera in the Falkland Islands. Marine Biology. 100, 419-430.

Tyack, P.L. 2008. Implications for marine mammals of large-scale changes in the marine acoustic environment. Journal of Mammalogy. 89, 549-558.

Tyler Grange. 2016. Transfer Mooring Buoy, Berkeley Sound, Falkland Islands: Landscape and Visual Impact Assessment (Report No: 10102_R01a_JJ_AR)

UK Environmental and Emissions Monitoring System (EEMS) Report. 2013.

UK Hydrographic Office. 2014. Falkland Islands Wreck Chart, via Wrecksite. http://www.wrecksite.eu/chartDetails.aspx?511 [Accessed January 2014].

UKOOA. 1999. Activity 2.1. Faunal Colonisation Of Drill Cuttings Pile Based On Literature Review. United Kingdom Offshore Operators Association (UKOOA) Drill Cuttings Initiative, Research and Development Programme. Report by Dames and Moore; and NIOZ.

UKOOA. 2001. United Kingdom Offshore Operators Association: An analysis of UK offshore oil & gas environmental surveys 1975-95. Heriot-Watt University.

UKSAC. 2015. http://www.ukmarinesac.org.uk/activities/water-quality/wq9_8.htm#a1

UNCLOS. 2012. United Nations Convention on the Law of the Sea (UNCLOS) Contiguous zone. "SECTION 4. CONTIGUOUS ZONE, Article 33". UNCLOS PART II – TERRITORIAL SEA AND CONTIGUOUS ZONE. United Nations. Retrieved 2012-01-19 in Wikipedia (2015c)

UNDP. 2006. Human Development Report 2006: Beyond scarcity: Power, poverty and the global water crisis. United Nations Development Program http://hdr.undp.org/sites/default/files/reports/267/hdr06-complete.pdf

UNEP CBD. 2010. Decision adopted by the conference of the parties to the Convention on Biological Diversity at its tenth meeting: The Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets. UNEP/CBD/COP/DEC/X/2

USEPA. 1975 Tamano Oil Spill in Casco Bay: Environmental Effects and Cleanup Operations. United States Environmental Protection Agency

USEPA. (1991). EPA/505/2-90-001 PB91-127415 EPA Technical Support Document For Water Quality-based Toxics Control March 1991.

USEPA. 2000. Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data. United States Environmental Protection Agency EPA-420-R-00-002.

USEPA. 2016. Carbon Monoxide (CO) Pollution in Outdoor Air. https://www.epa.gov/co-pollution [Accessed October 2016].

University of California. 1971. Santa Barbara oil spill: Short-term analysis of macroplankton and fish. A report for the Office of Water Quality Research, Environmental Protection Agency.

Upson, R. 2012. Important Plant Areas of the Falkland Islands. Unpublished Report, Falklands Conservation. 80pp.

Upson, R. & Lewis, R. 2014. Updated atlas and checklist of Falkland Islands plants. Report to Falklands Conservation.

Upson, R., McAdam, J. & Clubbe, C. 2016. Climate Change Risk Assessment for Plants and Soils of the Falkland Islands and the Services they provide.

Vaes, T. & Druon, J-N. 2013. Mapping of potential risk of ship strike with fin whales in the Western Mediterranean Sea: A scientific and technical review using the potential habitat of fin whales and effective vessel density. Report by the Joint Research Centre of the European Commission. ISBN: 978-92-79-28851-7.

Vanderlaan, A.S.M. & Taggart, C.T. 2007. Vessel collisions with whales: The probability of lethal injury based on vessel speed. Marine Mammal Science. 23, 144-156.

Veil, J.A., Puder, M.G., Elcock, D. & Redweik, R.J. Jr., 2004. A white paper describing produced water from production of crude oil, natural gas, and coal bed methane. Pittsburgh: US Department of Energy, National Energy Technology Laboratory. 79 pp

Venn-Watson, S., Garrison, L., Litz, J., Fougeres, E., Mase, B., Rappucci, G.,Stratton, E., Carmichael, R., Odell, D., Shannon, D., Shippee, S., Smith, S., Staggs, L., Tumlin, M., Whitehead, H. & Rowles, T. 2015. Demographic Clusters Identified within the Northern Gulf of Mexico Common Bottlenose Dolphin (Tursiops truncatus) Unusual Mortality Event: January 2010 - June 2013. PLoSONE 10. e0117248. doi:10.1371/journal.pone.0117248

Wagstaff, R.A. 1973. RANDI: Research Ambient Noise Directionality Model. Naval Undersea Centre, San Diego. Report number NUC-TP-349.

Wakefield, E.D., Phillips, R.A., Trathan, P.N., Arata, J., Gales, R., Huin, N., Robertson, G., Waugh, S.M., Weimerskirch, H. & Matthiopoulos J. 2011. Habitat preference, accessibility, and competition limit the global distribution of breeding Black-browed Albatrosses. Ecol Monogr 81:141–167. doi: 10.1890/09-0763.1

Wale, M.A, Briers, R.A, Bryson, D., Hartl, M.G.J. & Diele, K. 2016. The Effects of Anthropogenic Noise Playbacks on the Blue Mussel Mytilus edulis. MASTS: Annual Science Meeting, 16-21 October 2016

Wales, S. C. & Heitmeyer, R. M. 2002. An ensemble source spectra model for merchant ship-radiated noise. Journal of the Acoustical Society of America. 111, 1211-1231.

Walker, T.R., Boyd, I.L., McCafferty, D.J., Huin, N., Taylor, R.I. & Reid, K. 1998. Seasonal occurrence and diet of leopard seals (Hydrurga leptonyx) at Bird Island, South Georgia. Antarctic Science. 10, 75-81.

Walsh, G.E. 1978. Toxic effects of pollutants on Plankton. Principles of Ecotoxicology. John Wiley & Sons, Inc., New York, 257-274.

Waluda, C.M., & Staniland, I.J. 2013. Entanglement of Antarctic fur seals at Bird Island, South Georgia. Marine Pollution Bulletin. 74, 244-252.

Waluda, C.M., Griffiths, H.J. & Rodhouse, P.G. 2008. Remotely sensed spatial dynamics of the Illex argentinus fishery, Southwest Atlantic. Fisheries Research. 91, 196-202.

Wang, X.C. & Zhao, H.M. 2007. Uptake and Biodegradation of Polycyclic Aromatic Hydrocarbons by Marine Seaweed. Journal of Coastal Research, 50, 1056 – 1061 (Proceedings of the 9th International Coastal Symposium).

Wanless, R.M., Scott, S., Sauer, W.H.H., Andrew, T.G., Glass, J.P., Godfrey, B., Griffiths, C. & Yeld, E. 2010. Semi-submersible rigs: A vector transporting entire marine communities around the world. Biological Invasions. 12, 2573-2583.

Wartzok, D., Popper, A.N., Gordon, J. & Merrill, J. 2004. Factors affecting the responses of marine mammals to acoustic disturbance. Marine Technology Society Journal. 37, 6-15.

Warwick-Evans, V., Ratcliffe, N., Lowther, A.D., Manco, F., Ireland, L., Clewlow, H.L., & Trathan, P.N. 2018. Using habitat models for chinstrap penguins Pygoscelis antarctica to advise krill fisheries management during the penguin breeding season. Divers Distrib 1–16 . doi: 10.1111/ddi.12817.

Watkins, W.A. 1981. Activities and underwater sounds of fin whales. Scientific Reports of the Whales Research Institute. 33, 83-117.

Watkins, W.A. 1986. Whale reactions to human activities in Cape Cod waters. Marine Mammal Science. 2, 251-262.

WBG. 1998a. World Bank Group: Pollution Prevention and Abatement Handbook. Nitrogen Oxides.

WBG. 1998b. World Bank Group: Pollution Prevention and Abatement Handbook. Sulphur Oxides.

WDCS. 2006. Vessel collisions and cetaceans: What happens when they don’t miss the boat? A Whale and Dolphin Conservation Society (WDCS) Report by Dolman, S., Williams-Grey, V., Asmutis-Silvia, R. and Isaac, S.

Weatherspark. 2016. Weather statistics from MPA, Falkland Islands. https://weatherspark.com/averages/28800/Falkland-Islands-East-Falkland 28/08/2015.

Weilgart, L.S. 2007. A brief review of known effects of noise on marine mammals. International Journal of Comparative Psychology. 20, 159-168.

Weir, C.R. 2017. Developing a site-based conservation approach for sei whales Balaenoptera borealis at Berkeley Sound, Falkland Islands. Falklands Conservation report. 114 pp.

Weir, C.R. 2018. A preliminary assessment of endangered sei whales (Balaenoptera borealis) in two candidate Key Biodiversity Areas in West Falkland. Falklands Conservation report. Version 1.2, 3 September 2018. 128 pp.

Weir, C.R. and Black, A. 2018. Records of the dusky dolphin (Lagenorhynchus obscurus) in the Falkland Islands, including associations with Peale’s dolphin (L. australis). Marine Biodiversity Records, 11:18. https://doi.org/10.1186/s41200-018-0153-2.

Wells, E. 2010. Intertidal and subtidal benthic marine algae of the Falkland Islands. Unpublished survey report, Wells Marine.

White, R.W., Gillon, K.W., Black, A.D. & Reid, J.B. 2001. Vulnerable concentrations of seabirds in Falkland Islands waters. JNCC, Peterborough.

White, R.W., Gillon, K.W., Black, A.D. & Reid J.B. 2002. The distribution of seabirds and marine mammals in Falkland Islands waters. Joint Nature Conservation Committee, Peterborough, UK. pp. 107

Whitehead, H. 2003. Sperm whales: Social evolution in the ocean. The University of Chicago Press.

WHO. 1987. World Health Organisation: Air Quality Guidelines for Europe. WHO Regional Publications, European Series 23. Copenhagen: WHO Regional Office for Europe.

WHO. 1999. World Health Organisation: Guidelines for Community Noise. Geneva: WHO.

WHO. 2000. (updated 2005). World Health Organisation: Air Quality Guidelines for Europe. Geneva: WHO.

WHO. 2006. Air Quality Guidelines. Global update 2005. Particulate matter, ozone, nitrogen dioxide and sulphur dioxide. WHO Regional Office for Europe, Copenhagen.

WHO. 2009. World Health Organisation: Night Noise Guidelines for Europe. Geneva: WHO.

WHO. 2014. EU Air Quality Policy and WHO Guideline Values for Health. Study for the Committee on Environment, Public Health and Food Safety (ENVI).

Wiese, F.K., Montevecchi, W.A., Davoren, G.K., Huettmann, F., Diamond, A.W. & Linke, J. 2001. Seabirds at risk around offshore oil platforms in the north-west Atlantic. Marine Pollution Bulletin. 42, 1285-1290.

Williams, J.M., Tasker, M.L., Carter, I.C. & Webb, A. 1994. A method of assessing seabird vulnerability to surface pollutants. Ibis. 137, S147-S152.

Williams, R. & O'Hara, P. 2010. Modelling ship strike risk to fin, humpback and killer whales in British Columbia, Canada. Journal of Cetacean Research and Management. 11, 1-8.

Williams, T.D., Kato, A., Croxall, J.P., Naito, Y., Briggs, D.R., Rodwell, S. & Barton, T.R. 1992. Diving pattern and performance in nonbreeding Gentoo penguins (Pygoscelis papua) during winter. The Auk. 109, 223-234.

Wills, J. 1999. A Survey of Offshore Oilfield Drilling Wastes and Disposal Techniques to Reduce the Ecological Impact of Sea Dumping: Environmental Effects of Drilling Waste Discharges. In: Environmental Impact of the Offshore Oil and Gas Industry (Ed: Patin, S.).

Wills, J.D. 2000. Muddied waters: a survey of offshore oilfield drilling wastes and disposal techniques to reduce the ecological impacts of sea dumping. The effects of discharges of produced water [Web resource]. East Northport, NY: Offshore- environment.com. www.offshore-environment.com/producedwaters.html [Accessed Aug 2006]

Wilson, K.J., Taylor, R.H. & Barton, K.J. 1990. The impact of man on Adelie penguins at Cape Hallett, Antarctica. In: Antarctic ecosystems: ecological change and conservation. (Eds: Kerry, K.R. & Hempel, G.)Springer, Berlin, pp 183–190

Woehler, E.J. 2002. Hearing abilities in Antarctic penguins. Polarforschung. 72, 95 - 98.

Wolfaardt, A.C, Rendell, N. & Brickle, P. 2010. Falkland Islands implementation plan for the Agreement on the Conservation of Albatrosses and Petrels (ACAP): review of current work and a prioritised work programme for the future. Falkland Islands Government. Stanley, Falkland Islands.

Wolfaardt, A.C. 2012. An assessment of the population trends and conservation status of Black-browed Albatrosses in the Falkland Islands. Joint Nature Conservation Committee, Stanley Falkland Islands.

Wolfaardt, A.C., Underhill, L.G., Altwegg, R., Visagie. J. 2008. Restoration of oiled African Penguins Spheniscus demersus a decade after the Apollo Sea spill. African Journal of Marine Science. 30, 421-436.

Wolfaardt, A.C., Williams, A.J., Underhill, L.G., Crawford, R.J.M. & Whittington, P.A. 2009. Review of the rescue, rehabilitation and restoration of oiled seabirds in South Africa, especially African Penguins Spheniscus demersus and Cape Gannets Morus capensis, 1983-2005. African Journal of Marine Science. 31, 31-54.

Woods, R.W. 1970. Great shearwater Puffinus gravis breeding in the Falkland Islands. Ibis, 112, 259-260.

Woods, R.W. 1988. Guide to birds of the Falkland Islands. Anthony Nelson, Shropshire.

Woods, R.W. & Woods, A. 1997. Atlas of breeding birds of the Falkland Islands. Anthony Nelson, Oswestry.

Woods, R.W. & Woods A. 2006. Birds and Mammals of the Falkland Islands. WILD Guides, UK.

WSP. 2012. UK Waste Shipment Plan. https://www.gov.uk/government/publications/uk-plan-for-shipments-of-waste

Wursig, B. 1988. Cetaceans and Oil: Ecologic Perspectives. Synthesis of Effects of Oil on Marine Mammals. Report.

Yang, M. & Tulloch, S. 2002. Oil-in-water monitoring - where are we heading? Presentation at the Oil-in-Water Workshop, 23 May.

Yates, O. & P. Brickle. 2007. On the relative abundance and distribution of sperm whales (Physeter macrocephalus) and killer whales (Orcinus orca) in the Falkland Islands longline fishery. Journal of Cetacean Research and Management. 9, 65-71.

Yebra, D.M., Kiil, S. & Dam-Johansen, K. 2004. Antifouling technology—past, present and future steps towards efficient and environmentally friendly antifouling coatings. Progress in Organic Coatings, 50, 75–104.

Youngblood, W.W. & Blumer, M. 1975. Polycyclic aromatic hydrocarbons in the environment: homologues series in soils and recent marine sediments. Geochimica Cosmochimica Acta. 39, 1303-1314.

Zerbini, A.N., Andriolo, A., Heide-Jørgensen, M.P., Pizzorno, J.L., Maia, Y.G., VanBaricom, G.R., DeMasters, D.P., Simões-Lopes, P.C., Moreira, S. & Bethlam, C. 2006 Satellite-monitored movements of humpback whales Megaptera novaeangliae in the Southwest Atlantic Ocean. Marine Ecology Progress Series. 313, 295-304.

Zimmer, W.M.X., Harwood, J., Tyack, P.L., Johnson, M.P. & Madsen, P.T. 2008. Passive acoustic detection of deep-diving beaked whales. Journal of the Acoustical Society of America. 124, 2823-2832.

Zyrjanov, V.N. & Severov, D.N. 1979. Water circulation in the Falkland Patagonian region and its seasonal variability. Okeanologiya. 29, 782-790.

APPENDIX 1 SCHEDULE 4 COMPLIANCE

Cross Reference of the Requirements of Schedule 4 and the Offshore component of the Sea Lion Phase 1 Development

Offshore Minerals (Amendment) Ordinance 2011 Schedule 4			Notes	Location of Information within the EIS	
Para	Sub-Para	Requirement		Chapter / Section	Page
1		**Project Description**		5	
	(1)	Description of the project to which the EIS relates	• An overview of the project is provided in the NTS (Chapter 1) and in the main EIS Introduction (Chapter 2). • A similar summary of the project, followed by full details are provided in the Development Description (Chapter 5). Further presentation of project details are provided in each Impact and Risk assessment Chapter where it is considered necessary for quantification.	1.0 2.0 5.1.1	
	(2)	Detail on location, design and size	• Detail on the location of the Sea Lion Drill Centres (DCs) is provided in Section 5.4.1 and Section 5.8 of the Development Description and detail on the number of wells and drilling design is in Sections 5.4.4 and 5.4.5 respectively. • The location of the FPSO is in section 5.8 and Section 5.8.2 and the design of the unit is described in section 5.8.3. • Detail on the location and scale of inshore operations is provided in section 5.5. • Detail on the crude oil export facilties and process is provided in section 5.10 **Acknowledged uncertainties:** • Whether the well conductors will be pile-driven or drilled is as yet unknown but pile-driving is assumed for the Underwater Noise Chapter (10.4) and drilling is assumed for the Drill Mud and Cuttings Chapter (10.6) to ensure the worst case Impacts are assessed for each eventuality	5.4.1 5.4.4 5.4.5 5.5 5.8.2 5.8.3 5.10	

PremierOil

Offshore Minerals (Amendment) Ordinance 2011 Schedule 4			Notes	Location of Information within the EIS	
Para	Sub-Para	Requirement		Chapter / Section	Page
	(4a)	Land and seabed use requirements during the operational phase	• Detail on the equipment on the seabed is provided in: - MODU anchors – Section 5.4.3.1 - FPSO anchors – Section 5.5.1 - Subsea production systems – Section 5.5.2 - Inshore anchorage – Section 5.5 • The location of the existing Temporary Dock Facility (TDF) is provided in Section 5.11.1.1.1 • The land use requirements with regard to the proposed and anticipated dimensions of the onshore supply base are described in Section 5.11.1.2. • The potential for development of temporary accommodation units is described in Section 5.11.4.1.1. • Land use with regard to the forecasted use of roads is estimated in Section 11.7.4.5 • The area of seabed likely to be used offshore for the DCs, all flowlines, and the MODU/FPSO moorings, as well as the seabed used in Berkley Sound for the LTV anchorage and oil spill boom buoys is quantified in the Disturbance to the Seabed Chapter 10.3.4.3. • The area of seabed that may be 'used' by discharged drill cuttings is quantified in Section 10.6.4.3.4.1 • The fact that land may be used around the coast in the event of an oil spill necessitating the development of lined storage space for oil spill wastes, is described in Section 10.10.2.3 Acknowledged uncertainties: • The area (and location) of the temporary accommodation units is as yet unknown. • The number of MODU anchors is as yet unknown but ten has been assumed for the impact assessment (Section 5.4.3.1 and Section 10.3.4.3.1). • It is not possible to credibly estimate the area of land that may be required for the temporary storage of oil spill waste.	5.4.3.1 5.5.2 5.5.3 5.5.4 5.11.1.1.1 5.11.1.2. 5.11.4.1.1 11.7.7.4.5 10.3.4.3 10.6.4.3.4.1 10.10.2.3	

Offshore Minerals (Amendment) Ordinance 2011 Schedule 4			Notes	Location of Information within the EIS	
Para	Sub-Para	Requirement		Chapter / Section	Page
	(4b)	The nature and quantity of materials used	• Detail on the volumes of: - Drilling mud are provided in Section 5.4.6.1 - Cement are provided in Section 5.4.6.2 • Detail on the chemicals that may be required for the: - Drilling and cementing operations are provided in Section 5.4.6 - Production operations are provided in Section 5.9.1 • Detail on the potential for the use of explosives is described in Section 5.5.8 • Detail on the need for diesel is provided in Section 5.8.3.3 • Detail on the volumes of associated gas that may be used as fuel gas is provided in Section 5.8.4.3 • Detail on the diesel and fuel gas consumption rates is provided in Section 10.9.4.4.2 Use of 'materials' in terms of finite local resources: • Detail on the need for the use of finite 'materials' is provided in the Development Description Chapter as follows: - Accommodation: Section 5.11.4.1.1 - Water: Section 5.11.4.2 - Electricity: Section 5.11.4.3 - Potential for use of commercial flights: Section 5.11.3.1.1 • Quantification of the use of finite materials in provided in the following Impact and Risk Assessment Chapters: - Accommodation: Section 11.3.4.2 (in terms of whether existing accommodation is sufficient to meet Premier requirements) - Water: Section 11.4.4.2.3 - Electricity: Section 11.5.4.2 - Use of airlinks: Section 11.6.4.1 - Use of roads: Section 11.7.4.5 **Acknowledged uncertainties:** • It is acknowledged that the current baseline of water and power availability in the Falklands may change depending upon future developments.	5.4.5.3 5.4.6.2 5.4.6 5.9.1 5.5.8 5.8.3.3 5.8.4.3 10.9.4.4.2 5.11.4.1.1 5.11.4.2 5.11.4.3 5.11.3.1.1 11.3.4.2 11.4.4.2.3 11.5.4.2 11.6.4.1 11.7.4.5	

Offshore Minerals (Amendment) Ordinance 2011 Schedule 4			Notes	Location of Information within the EIS	
Para	Sub-Para	Requirement		Chapter / Section	Page
	(4c)	Estimation of the type and quantity of residues and emissions resulting from the operation of the project:	The type and quantity of residues / emissions and other outputs is quantified within the 'Characterisation and Quantification of the Nature of the Impact / Risk' section in each Impact / Risk Chapter. However, they are also summarised in Section 5.14 of the Development Description. **Acknowledged uncertainties / data gaps:** When forecasting the outputs from the project that may impact upon the environmental and social receptors, it is acknowledged that these are predictions and a precautionary approach is taken throughout the assessment to ensure that the maximum credible residue or emission is assumed. The use of a precautionary approach is described, as necessary, in each chapter, and a final confidence rating is assigned within Section X.X.10 of each Impact / Risk Assessment Chapter.	5.14 X.X.10	117

Offshore Minerals (Amendment) Ordinance 2011 Schedule 4			Notes	Location of Information within the EIS	
Para	Sub-Para	Requirement		Chapter / Section	Page
		• Water quality	The residues that may impact upon water quality are detailed within the characterisation and quantification sections of the: • Drilling muds and cuttings Chapter, Section 10.6.4.3 (dispersion modelling) • Operational Discharges Chapter, Section 10.7 (regarding composition of discharges and modelling) • Thermal discharges Chapter, Section 10.8.4.3.3 • Atmospheric Emissions Chapter, Section 10.9.4.2 (with regard to Impacts of CO_2 on ocean acidification and acid deposition) The residues to water that may result from oil spills are estimated in the Characterisation and Quantification sections of the: • Oil spill offshore Chapter, Section 12.1.4.3 (oil spill modelling regarding spill volumes and trajectories) • Oil spill inshore Chapter, Section 12.2.4.5 (oil spill modelling regarding spill volumes and trajectories) • Oil spill atshore Chapter, Section 12.3.4.1 (regarding the types of fluids that may be spilled)	10.6.4.3 10.7 10.8.4.3.3 10.9.4.2 12.1.4.3 12.2.4.5 12.3.4.1	352 377 413
		• Air quality	The emissions that may Impact upon air quality and the global climate are detailed within the Characterisation and Quantification sections of the: • Atmospheric emissions Chapter, Section 10.9.4.4 (regarding forecast emissions) and Section 10.9.4.5 (air quality modelling) • Air quality Chapter, Section 11.12.4.4 The emissions that may create odour as a nuisance are detailed in the Characterisation and Quantification section of the: • Disturbance to humans from odour Chapter, Section 10.10.4.2	10.9.4.4 11.9.4.5 11.12.4.4 10.10.4.2	386

Offshore Minerals (Amendment) Ordinance 2011 Schedule 4			Notes	Location of Information within the EIS	
Para	Sub-Para	Requirement		Chapter / Section	Page
		• Soil quality	The residues and emissions that may impact upon soil quality and the global climate are detailed within the Characterisation and Quantification sections of the: • Atmospheric emissions Chapter, Section 10.9.4.4 (with regard to acid deposition)	10.9.4.4	332
		• Noise	The noise emissions are detailed within the Characterisation and Quantification sections of the: • Disturbance to wildlife from helicopter noise Chapter, Section 10.2.4.2 (regarding estimated helicopter noise exposure) • Underwater noise offshore Chapter, Section 10.4.4.4 (noise modelling) • Under water noise inshore Chapter, Section 10.5.4.4 (noise modelling) • Disturbance to human population from helicopters and noise Chapter, Section 11.9.4.3 (regarding estimated helicopter noise exposure) and Section 11.9.4.4 (regarding exposure to other noise sources)	10.2.4.2 10.4.4.4 10.5.4.4 11.9.4.3 11.9.4.4	283 300
		• Light	The emissions of artificial light are detailed within the Characterisation and Quantification sections of the: • Artificial light Chapter, Section 10.1.4.1 (regarding light levels) • Disturbance to human population from light Chapter, Section 11.8.4.2 (regarding light levels)	10.1.4.1 11.8.4.2	260
		• Waste	The residues and emissions associated with waste are detailed within the Characterisation and Quantification sections of the: • Waste Chapter, Section 10.10.4.3 (regarding waste estimates)	10.10.4.3	413

Offshore Minerals (Amendment) Ordinance 2011 Schedule 4			Notes	Location of Information within the EIS	
Para	Sub-Para	Requirement		Chapter / Section	Page
2	(2a,b,c)	**Information on mitigation measures to eliminate or reduce, remedy or offset environmental Impacts to/from:**	• Information on the mitigation hierarchy and the types of mitigations that are applied within the EIA are described in Section 8.7 of the EIA methodology Chapter. • The mitigations that are built-in to the basis of the project design (i.e. the base case mitigations) in order to minimise or eliminate residue or emission outputs (thus reducing Impacts) are described throughout the Development Description and summarised in Section 5.13. - Note: where it was deemed appropriate, the base case mitigations are re-iterated in the relevant Chapter as they reduce the forecasted residue / emission / output • The industry-standard mitigations, and the project-specific mitigations (which are applied where necessary), are itemised within each Impact / Risk Assessment Chapter, as itemised below. • With regard to offsetting measures specifically, these are described in Section 8.9 and noted throughout the assessment chapters in Sections X.X.11	8.7 5.13 8.9 X.X.11	
		• Water quality	The industry-standard and project-specific mitigations that apply to Impacts on water quality are described in the following: • Drilling muds and cuttings Chapter, Section 10.6.5 & Section 10.6.7 • Operational Discharges Chapter, Section 10.7.5 & Section 10.7.7 • Thermal discharges Chapter, Section 10.8.5 & Section 10.8.7 • Atmospheric Emissions Chapter, Section 10.9.5 & Section 10.9.7 (with regard to reducing emissions to lessen the Impacts on ocean acidification) • Oil spill offshore Chapter, Section 12.1.5 & Section 12.1.7 • Oil spill inshore Chapter, Section 12.2.5 & Section 12.2.7 • Oil spill atshore Chapter, Section 12.3.5 & Section 12.3.7	10.6.5 & 10.6.7 10.7.5 &10.7.7 10.8.5 & 10.8.7 10.9.5 & 10.9.7 12.1.5 & 12.1.7 12.2.5 & 12.2.7 12.3.5 & 12.3.7	

Offshore Minerals (Amendment) Ordinance 2011 Schedule 4			Notes	Location of Information within the EIS	
Para	Sub-Para	Requirement		Chapter / Section	Page
		• Air quality	The industry-standard and project-specific mitigations that apply to Impacts on air quality and global emissions are described in the following: • Atmospheric Emissions Chapter, Section 10.9.5 & Section 10.9.7 • Air quality Chapter, Section 11.12.5 & Section 11.12.7 The industry-standard and project-specific mitigations that apply to the potential disturbance to humans from odour are described in the following: Disturbance to humans from odour Chapter, Section 11.10.5 & 11.10.7	10.9.5 & 10.9.7 11.12.5 & 11.12.7 11.10.5 & 11.10.7	
		• Soil quality	The industry-standard and project-specific mitigations that apply to Impacts on soil / sediment quality are described in the following: • Drilling Mud and Cuttings Chapter, Section 10.6.5 & Section 10.6.7 • Atmospheric emissions Chapter, Section 10.9.5 & Section 10.9.7 ((with regard to reducing emissions to lessen the Impacts of acid deposition)	10.6.5 & 10.6.7 10.9.5 & 10.9.7	
		• Noise	The industry-standard and project-specific mitigations that apply to noise generation are described in the following: • Disturbance to wildlife from helicopter noise Chapter, Section 10.2.5 & Section 10.2.7 • Underwater noise offshore Chapter, Section 10.4.5 & Section 10.4.7 • Under water noise inshore Chapter, Section 10.5.5 & Section 10.5.7 • Disturbance to human population from helicopters and noise Chapter, Section 11.9.5 & Section 11.9.7	10.2.5 & 10.2.7 10.4.5 & 10.4.7 10.5.5 & 10.5.7 11.9.5 & 11.9.7	283 285 325 325
		• Light	The industry-standard and project-specific mitigations that apply to light generation are described in the following: • Artificial light Chapter, Section 10.1.5 & Section 10.1.7 • Disturbance to human population from light Chapter, Section 11.8.5 & Section 11.8.7	10.1.5 & 10.1.7 11.8.5 & 11.8.7	269 271
		• Waste	The industry-standard and project-specific mitigations that apply to waste generation are described in the following: • Waste Chapter, Section 10.10.5 & Section 10.10.7	10.10.5 & 10.10.7	427 432

<table>
<tr><th colspan="3">Offshore Minerals (Amendment) Ordinance 2011
Schedule 4</th><th rowspan="2">Notes</th><th colspan="2">Location of Information within the EIS</th></tr>
<tr><th>Para</th><th>Sub-Para</th><th>Requirement</th><th>Chapter / Section</th><th>Page</th></tr>
<tr><td>3</td><td></td><td>Requirement for data:
Inclusion of the data required to identify and assess the main effects that the project is likely to have on:</td><td>As explained in Section 2.5.1, (Table 8) each Impact / Risk Assessment Chapter draws on (and references) data from the:
• Development Description (Chapter 5) to enable quantification / estimation of residues, emissions and other outputs associated with the project activities
• Subject-matter literature reviews used to ensure understanding of the nature of the Impact
• Environmental Baseline Chapter (Chapter 7) to enable understanding of the nature of the impact when assessing the ‘sensitivity of the receptor’ and the ‘severity of effect’ in the Falklands Islands specifically
Acknowledged uncertainties / Data Gap:
• Known uncertainties in the project design are listed in Section 2.1.4 and where these exist, the credible worst case is always assumed to ensure that impact assessments are of the highest level of residue / emission / other outputs.
• Uncertainties within the project design are expounded upon further in the Development Description (Chapter 5)
• Uncertainties within the literature are discussed within the Characterising and Quantification Sections of each Impact / Risk Assessment Chapter
• Known data gaps within the Environmental Baseline are identified in Section 7.2.4
• A precautionary approach is taken throughout each Impact / Risk Assessment and the overall Confidence in the data used for each assessment is assigned a score in Section X.X.10 of each Impact / Risk Chapter.</td><td>2.5.1
5
7</td><td></td></tr>
</table>

Offshore Minerals (Amendment) Ordinance 2011 Schedule 4			Notes	Location of Information within the EIS	
Para	Sub-Para	Requirement		Chapter / Section	Page
		• Water quality	The data and background information required to identify and assess the impacts on water quality is provided in: • Drilling muds and cuttings Chapter, Section 10.6.4 • Operational Discharges Chapter, Section 10.7.4 • Thermal discharges Chapter, Section 10.8.4 • Atmospheric Emissions Chapter, Section 10.9.4 (with regard to Impacts on ocean acidification) • Oil spill offshore Chapter, Section 12.1.4 • Oil spill inshore Chapter, Section 12.2.4 • Oil spill atshore Chapter, Section 12.3.4	10.6.4 10.7.4 10.8.4 10.9.4 12.1.4 12.2.4 12.3.4	
		• Air quality	The data and background information required to identify and assess the impacts on air quality and global emissions is provided in: • Atmospheric emissions Chapter, Section 10.9.4 • Air quality Chapter, Section 11.12.4	10.9.4 11.12.4	
		• Soil quality	The data and background information required to identify and assess the impacts on soil / sediment quality is provided in: • Drilling Mud and Cuttings Chapter, Section 10.6.4 • Atmospheric Emissions Chapter, Section 10.9.4 (with regard to quantifying acid deposition)	10.6.4 10.9.4	
		• Noise	The data and background information required to identify and assess the impacts of noise generation is provided in: • Disturbance to wildlife from helicopter noise Chapter, Section 10.2.4 • Underwater noise offshore Chapter, Section 10.4.4 • Under water noise inshore Chapter, Section 10.5.4 • Disturbance to human population from helicopters and noise Chapter, Section 11.9.4	10.2.4 10.4.4 10.5.4 11.8.4	302

Offshore Minerals (Amendment) Ordinance 2011 Schedule 4			Notes	Location of Information within the EIS	
Para	Sub-Para	Requirement		Chapter / Section	Page
		• Light	The data and background information required to identify and assess the impacts of light generation is provided in: • Artificial Light Chapter, Section 10.1.4 • Disturbance to human population from light Chapter, Section 11.8.4	10.1.4 11.7.4	262
		• Waste	The data and background information required to identify and assess the impacts of waste generation is provided in: • Waste Chapter, Section 10.10.4	10.10.4	417
4		**Environmental effects**			
	(2)	Description of the specific aspects of the environment likely to be significantly affected by the project	The specific aspects that may be affected by the project are described in: • The EIA Methodology Chapter: - Sections 8.3 on 'Aspect, Impact and Risk Identification', which lists the high level aspects - Section 8.4 which lists the receptors identified within the Ordinance • Chapter 9 on 'The Identification of Environmental Aspect and Impact Identification' and Screening which provides the outputs of the ENVIID workshop • The Environmental Baseline (Chapter 7) which describes the environmental and social aspects of the environment which may be affected **Acknowledged data gaps**: It is recognised that data gaps still exist with regard to the baseline. These are acknowledged in Section 7.2.4, throughout the Impact / Risk Assessment Chapters in the Characterising and Quantifying sections (X.X.4) and in the Confidence section (X.X.10)	7.0	125
	(2a)	• Human population	The social baseline is described Section 7.7 of the Environmental baseline with the human population described specifically in Section 7.7.2	7.7 7.7.2	207

Offshore Minerals (Amendment) Ordinance 2011 Schedule 4			Notes	Location of Information within the EIS	
Para	Sub-Para	Requirement		Chapter / Section	Page
	(2b)	• Flora	• Phytoplankton are described in Section 7.4.1.2 of the Environmental Baseline Chapter • Marine and intertidal vegetation are described in Section 7.4.2 • Flora are also covered in the description of 'Threatened Terrestrial Habitats' in Section 7.4.4 • Protected terrestrial plant species are described in Section 7.5.1.5 • Important Plants Areas are described in Section 7.5.2.3.2 • Terrestrial Habitats surrounding Berkeley Sound in Section 7.5.2.4	7.4.1.2 7.4.2 7.4.4 7.5.1.5 7.5.2.3.2 7.5.2.4	143 199
	(2c)	• Fauna	Fauna in the NFB and Berkeley Sound are described in: • Section 7.4.3. Benthic Environmental • Section 7.4.4. Fish and Invertebrate Ecology • Section 7.4.5 Seabirds and sea bird vulnerability • Section 7.4.6 Marine mammals The conservation status of fauna is described in • Section 7.5.1.1 benthic species • Section 7.5.1.2 Fish species • Section 7.5.1.3 Seabird species • Section 7.5.1.4 Marine mammal species	7.4.3 7.4.4 7.4.5 7.4.6 7.5.1.1 7.5.1.2 7.5.1.3 7.5.1.4	145 147 148 155 171
	(2d)	• Soil (including seabed and its subsoil)	Seabed sediments are described in Section 7.3.7 of the Environmental Baseline	7.3.7	140
	(2e)	• Water (including the sea)	• Water movements are described in Section 7.3.3 of the Environmental Baseline • Details on background water temperature are provided in the Development Description in Section 5.8.2.1 on Flow Assurance • Details on background salinity is described in Section 10.7.4.1.5	7.3.3 5.8.2.1 10.7.4.1.5	134

Offshore Minerals (Amendment) Ordinance 2011 Schedule 4			Notes	Location of Information within the EIS	
Para	Sub-Para	Requirement		Chapter / Section	Page
	(2f)	• Air	• The global atmosphere is described in Section 7.3.1 of the Environmental Baseline • General detail on the meteorology of the area (wind speed, air temperature etc.) is provided in Section 7.3.2 of the Environmental Baseline • While no data exist with regard to air quality in the Falkland Islands, details with regard to the potential air quality in Berkeley Sound and how the Phase 1 emissions compare to the estimated baseline is provided in Section 10.9.4.5.2 on inshore pollutant concentrations and dispersion	7.3.1 7.3.2 10.9.4.5.2	131
	(2g)	• Climatic factors	• The global atmosphere is described in Section 7.3.1 of the Environmental Baseline	7.3.1	131
	(2h)	• Landscape and seascape	• Scenery, wildlife and tourism are described in Section 7.7.4.6 of the Environmental Baseline	7.7.4.6	
	(2i)	• Tangible property	• Tangible property is described in Section 7.7.4 of the Environmental Baseline	7.7.4	213
	(2j)	• Architectural and archaeological heritage	• Architectural and archaeological heritage is described in Section 7.7.6 of the Environmental Baseline	7.7.6	222
	(2k)	• Interactions between these factors in any combination	While Impact Interactions are touched upon in the relevant Impact / Risk Assessment Chapters, Chapter 13 provides a summary of all the varying interactions that may occur.	13	577
	(3)	Description of the likely significant effects on the environment arising from:	As explained in Section 2.4.1, (Table 8) each Impact / Risk Assessment Chapter has a specific section which draws upon all the data provided in the Chapter thus far to: • Assess the initial Impact and / or the Risk which is in Section X.X.6. • Assess the residual Impact and / or the Risk which is in Section X.X.8. • Assess the cumulative Impacts in Section X.X.9	Chapters 10, 11 &12	

Offshore Minerals (Amendment) Ordinance 2011 Schedule 4			Notes	Location of Information within the EIS	
Para	Sub-Para	Requirement		Chapter / Section	Page
	(3a)	• The existence of the project	• The NTS (Chapter 1) provides a user-friendly overview of the project and the associated impacts and risks • There is not a single Chapter which impact assesses the existence of the project as the entire EIS aims to do this. However, Chapter 14 provides an overall summary of the EIS findings and details the significance of the Impacts / Risks and the confidence in the assessment	1 14	
	(3b)	• The use of natural resources	• The need for resource use is described in the Development Description as follows: - Detail on the need for diesel is provided in Section 5.8.3.3 - Detail on the need for freshwater (and seawater) is provided in Section 5.8.3.5 - Detail on the use of seawater is provided in Section 5.8.4.2 on heating and cooling systems and Section 5.8.5.6.1 on Water injection / reinjection facilities • Detail on the expected consumption of fuels is provided in the Atmospheric Emissions Chapter, Section 10.9.4.4.2 which estimates the planned emissions • Detail on the expected freshwater use is provided in the 'Resource Competition: fresh potable water' Chapter, Section 11.4.4.2.3 which forecasts Phase 1 water usage	5.8.3.3 5.8.3.5 5.8.4.2 5.8.5.6.1 10.9.4.4.2 11.4.4.2.3	386 497
	(3c)	• The emission of pollutants	The emission of pollutants to air are described in: • Atmospheric emissions Chapter, Section 10.9.6, Section 10.9.8 & Section 10.9.9 • Air quality Chapter, Section 11.12.6, Section 11.12.8 & Section 11.12.9	10.9 11.12	386

Offshore Minerals (Amendment) Ordinance 2011 Schedule 4			Notes	Location of Information within the EIS	
Para	Sub-Para	Requirement		Chapter / Section	Page
	(3d)	• The creation of nuisances by the project	The Impacts upon the human population from nuisance factors are described in: • Chapter 11.8 on Disturbance to the human population from light, Section 11.8.6 & Section 11.8.8 & Section 11.8.9 • Chapter 11.9 on Disturbance to the human population from helicopters and noise Section 11.9.6, Section 11.9.8 & Section 11.9.9 • Chapter 11.10 on Disturbance to the human population from odour Section 11.10.6, Section 11.10.8 & Section 11.10.9 • Chapter 11.11 on Disturbance to the human population from visual impact Section 11.11.6, Section 11.11.8 & Section 11.11.9	11.8 11.9 11.10 11.11	476
	(3e)	• The elimination of waste	The Impacts of waste management in accordance with the waste hierarchy is described in: • Chapter 10.10 on Waste Management, Section 10.10.6 & Section 10.10.8 & Section 10.10.9	10.10.6, 10.10.8 & 10.10.9	413

5	(2)	• Details of the forecasting methods used to assess the affects of the project on the environment	In order to carry out any Impact / Risk assessment, it is necessary to understand what the 'outputs' of the project may be e.g. how much C02, how much waste, noise etc. It is therefore necessary to forecast the data. Using data from the Development description, and taking account of the base case mitigations that are intended to reduce outputs, detail on the data quantification is provide in: • Underwater noise offshore Chapter, Section 10.4.4.4 • Underwater noise inshore Chapter, Section 10.5.4.4 • Drill cuttings and mud Chapter, Section 10.6.4.3 • Discharges TO Sea Chapter, Section 10.7.4.5 • Thermal discharges to sea Chapter, Section 10.8.4.3.2 • Atmospheric Emissions Chapter, Section 10.9.4.4 • Waste Management Chapter, Section 10.10.4.3 • Marine mammals collisions Chapter, Section 10.11.4.4 (with regard to forecasted vessel behaviour) • Marine Invasives Chapter, Section 10.12.11.1.1 (with regard to forecasted distribution of ballast water used to identify key monitoring stations) • Terrestrial invasive species Chapter, Section 10.13.4.2. (with regard to forecasted cargo delivery routes) • Disturbance to other users offshore Chapter, Section 11.1.4. (with regard to forecasting vessel behaviour and modelling of collision Risks) • Disturbance to other users inshore Chapter, Section 11.2.4. (with regard to forecasting vessel behaviour, Impacts of exclusion zones and modelling of collision Risks) • Resource competition: Accommodation Chapter, Section 11.3.4.2.1 (with regard to forecasted accommodation requirement and provision) • Resource competition: Fresh potable water Chapter, Section 11.4.4.2.3 (with regard to forecasted local water supply usage) • Resource competition: Use of Electricity Chapter, Section 11.5.4.2.2 (with regard to forecasted energy use) • Resource competition: Air-links Chapter, Section 11.6.4.1.1 (with regard to forecasted Phase 1 transportation requirements) • Resource competition: Use of Roads Chapter, Section 11.7.4.5 (with regard to forecasted Phase 1 road usage) (Cont.d over the page)	10.4.4.4 10.5.4.4 10.6.4.3 10.7.4.5 10.8.4.3.2 10.9.4.4 10.10.4.3 10.11.4.4 10.12.11.1.1 10.13.4.2 11.1.4 11.2.4 11.3.4.2.1 11.4.4.2.3 11.5.4.2.2 11.6.4.1.1 11.7.4.5	311 337 364 380 402 481 512
5	(2)	• Details of the forecasting methods used to assess the	(Cont.d) • Disturbance to the human population from light Chapter, Section 11.8.4.5.2 (with regard to forecasted location, number of light sources etc.)	11.8.4.5.2 11.9.4.3	311 337

Offshore Minerals (Amendment) Ordinance 2011 Schedule 4			Notes	Location of Information within the EIS	
Para	Sub-Para	Requirement		Chapter / Section	Page
		affects of the project on the environment	• Disturbance to the human population from helicopters and noise Chapter, Section 11.9.4.3 and Section 11.9.4.4 (with regard to forecasting noise levels) • Disturbance to the human population from odour Chapter, Section 11.10.4.2. (with regard to forecasting the type and number of odour sources etc.) • Disturbance to the human population from visual Impact Chapter, Section 11.11.4.2 (with regard to forecasting the activities in Berkeley Sound that may Impact upon visual amenity) • Oil Spill offshore Chapter, Section 12.1.4.3 (oil spill modelling) • Oil Spill inshore Chapter, Section 12.2.4.4 (oil spill modelling) • Oil Spill atshore Chapter, Section 12.3.4.1 (with regard to forecasting spill scenarios) **Acknowledged uncertainties:** Where there was uncertainty regarding the project basis of design (e.g. the number of wells and DCs to be used), the worst case forecast was used. Where different options had different impacts (e.g. to pile-drive or drill the well conductors), both options were factored in such that the Underwater Noise Offshore Chapter assumes the conductor will be pile driven while the Drilling Muds and Cuttings Chapter assumes they will be drilled home.	11.9.4.4 11.10.4.2 11.11.4.2 12.1.4.3 12.2.4.4 12.3.4.1	364 380 402 481 512
6		**Remediation:** **Description of the measures envisaged upon termination of the project to eliminate or reduce, remedy or offset environmental Impacts**	The decommissioning of the project will be covered by a separate EIA, as described in Section 5.12. The need for remediation efforts will be determined based on the outcomes of monitoring. The detailed Premier monitoring strategy have been established during the Environmental Monitoring and Management Plan (EMMP) workshop. All monitoring requirements agreed by Premier and FIG will be recorded and managed via the project-specific Phase 1 EMMP, an outline of which is included within the EIS in Chapter 15.	5.12 15	

Offshore Minerals (Amendment) Ordinance 2011 Schedule 4			Notes	Location of Information within the EIS	
Para	Sub-Para	Requirement		Chapter / Section	Page
7		**Alternatives**	Detail on the Consideration of Alternatives is provided in Chapter 4	4	63
	(7a)	An outline of any alternatives that were considered	An outline of alternatives that were considered is provided in Section 4.3	4.3	64
	(7b)	Indication of the main reason for the selected project design (taking into account the environmental effects)	Indication for the main reasons that the proposed project design was selected is provided in: • Section 4.3.1.3 for oil production • Section 4.3.2.3 for oil export.	4.3.1.3 4.3.2.3	66
8		**Non-Technical Summary**	The Non-Technical Summary is located in Chapter 1 and will also be available as a separate document.	1	18
9		**Difficulties encountered**			
	(2)	An indication of any difficulties (including technical difficulties and lack of know-how) encountered when compiling the required information	The only difficulty encountered has related to data gaps in the environmental baseline and uncertainties with regard to the final project design: • Wherever data gaps were encountered, efforts were made to address the gap • Where this was not possible, a very precautionary approach was taken during the Impact / Risk Assessment and the worst case was assumed with regard to the project-design • The presence of data gaps is reflected in the overall Confidence level. • Because a precautionary approach was taken throughout, and worst case assumptions about emissions, residues and other outputs were used, it is possible that where the confidence is 'probable' or 'uncertain', the Impact / Risk may lower than is estimated in this EIS. • As stated above, all monitoring requirements intended to validate the EIS, and fill existing data gaps, will be reported in the EMMP in Chapter 15.	2.1.4 7.2.4 15	66 130