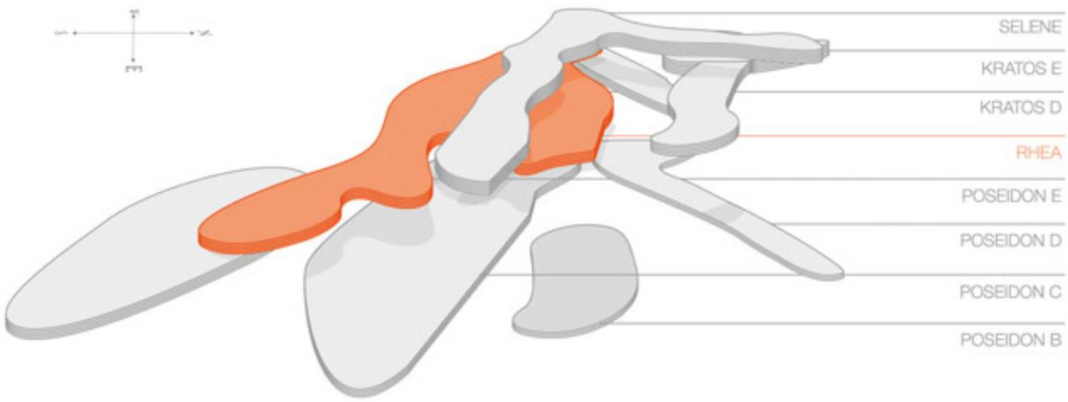
Noble Energy Falklands Limited

Rhea-1 Exploration Well
Environmental Impact Statement



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Abbreviations

Abbreviation	Definition	Abbreviation	Definition
ACAP	Agreement for the Conservation of Albatrosses and Petrels	LTOBM	Low Toxicity Oil Based Mud
ACC	Antarctic Circumpolar Current	m	metre
AIS	Automatic Identification System	MBA	Marine Biological Association
AIW	Antarctic Intermediate Water	MMO	Marine Mammal Observer
Al	Aluminium	MoD	Ministry of Defence
ALARP	As Low as is Reasonably Practicable	MPA	Marine Protected Area
AR4	IPPC Fourth assessment Report 2007	MPC	Mount Pleasant Complex
AVS	Area Vulnerability Score	MRP	Media Response Plan
BAS	British Antarctic Survey	NEF	North Eastern Front
bbls	Barrel of Oil	NEFL	Noble Energy Falkland's Limited
BSP	Biosecurity Plan	NFB	North Falkland Basin
BSMP	Bird Strike Management Plan	Ni	Nickel
BOD	Basis of Design	NNR	National Nature Reserve
BOP	Blow-Out Preventer	NOSCP	Falklands National Oil Spill Contingency Plan
cm	Centimetre	NPD	Naphthalene, Phenanthrene and Dibenzothiophene
CMS	Conservation of Migratory Species	NPOA-S	National Plan of Action - Seabirds
CTD	Conductivity, Temperature, Depth	NPOA-Tr	National Plan of Action - Trawling
Cu	Copper	NS	Northern Slope
DMP	Discharge Management Plan	NT	Near Threatened
DMR	Department of Mineral Resources	NWOS	North-western Outer Shelf
DNR	Department of Natural Resources	OBM	Oil Based Mud
DP	Dynamic Positioning	ODPO	Offshore Discharge Management Programme
DS	Deepwater Slope	ODS	Ozone Depleting Substances
DST	Drill Stem Test	OSPAR	Oslo Paris Convention
ECA	Emissions Control Areas	OSRP	Oil Spill Response Plan
EEZ	Exclusive Economic Zone	OSV	Offshore Supply Vessel
EIA	Environmental Impact Assessment	OVI	Oil Vulnerability Index
EIS	Environmental Impact Statement	PAH	Polycyclic Aromatic Hydrocarbons
EMP	Environmental Management Plan	Pb	Lead
EMPA	Emergency Management Plan	pH	Measure of Acidity
EPD	Environmental Planning Department	PHCB	Patagonia High Chlorophyll Band
ERA	Environmental Risk Assessment	PL	Production Licence number
ERRV	Emergency Response and Rescue Vessel	PLONOR	Pose Little Or NO Risk
ESIA	Environmental and Social Impact Assessment	PON	Petroleum Offshore Notification
F-Gas	Fluorinated Gases	ppg	Pounds per gallon
FCO	Foreign Commonwealth Office	PM	Particulate Matter
FIBU	Falkland Islands Business Unit	PMO	Premier Oil
FICZ	Falklands Interim Conservation Zone	ppge	Pounds per gallon equivalent

Abbreviation	Definition	Abbreviation	Definition
FIG	Falkland Islands Government	ppt	Parts per thousand
FIGAS	Falkland Islands Government Air Service	PS	Performance Standards
FIGFD	Falkland Islands Government Fisheries Department	PSV	Platform Support Vessel
FIMBAr	Falkland Islands Marine Biodiversity Archive	ROV	Remotely Operated Vehicle
FIPASS	Falklands Interim Port and Storage System	SAERI	South Atlantic Environmental Research Institute
FMCF	Falkland/Malvinas Current Front	SAR	IPPC Second Assessment Report 1995
FOCZ	Falklands Outer Conservation Zone	SAST	Seabirds at Sea Team
FOGL	Falklands Oil and Gas Limited	SASW	Sub-Antarctic surface waters
FOSA	Falklands Offshore Sharing Agreement	SD	Standard Deviation
FPB	Falkland Plateau Basin	SDS	Safety Data Sheet
FPV	Fisheries Patrol Vessel	SEOS	South-eastern Outer Shelf
FWL	Free Water Level	SEP	Stakeholder Engagement Plan
GDP	Gross Domestic Product	SF	Southern Front
GIIP	Good International Industry Practise	SFB	South Falkland Basin
GIS	Geographic Imaging System	SLMC	Sea Lion Main Complex
GOC	Gas-Oil Contact	SMSG	Shallow Marine Surveys Group
GOR	Gas:Oil Ratio	SS	Southern Slope
GWP	Global Warming Potential	TD	Total Depth
H_2S	Hydrogen Sulphide	TDF	Temporary Dock Facility
HMP	Harbour Management Plan	TDS	Tourism Development Strategy
HOCNS	Harmonised Offshore Chemical Notification Scheme	THC	Total Hydrocarbon Concentration
HSES	Health, Safety, Environment and Security	TOC	Total Organic Carbon
HVAC	Heating, Ventilation and Air Conditioning	TOM	Total Organic Matter
IBA	Important Bird Area	TVDSS	True Vertical Depth Sub-Sea
IFC	International Finance Corporation	TZ	Transition Zone
IMO	International Maritime Organisation	UKOOA	UK Offshore Operators Association
IPA	Important Bird Area	VMS	Vessel Monitoring System
IPA	Important Plant Area	VSP	Vertical Seismic Profile
IPCC	Intergovernmental Panel on Climate Change	VU	Vulnerable
IS	Inner Shelf	WBG	World Bank Group
IUCN	International Union for Conservation of Nature	WBM	Water Based Mud
JNCC	Joint Nature Conservation Committee	WIF	Western Inshore Front
KCl	Potassium Chloride	WMPA	Waste Management Plan
KEMH	King Edward Memorial Hospital	WOF	Western Offshore Front
km	Kilometre	WRP	Wildlife Response Plan
KPI	Key Performance Indicator	Zn	Zinc
LC	Least Concern	µm	Micrometre

Glossary

Abbreviation	Definition
bbls	One barrel of oil, equal to 159 litres of oil.
Benthic fauna	Organisms that live on, associated with, or in the seabed sediments.
Bentho-pelagic	Species that feed both within the water column and near the seabed
Biogenic	Produced by a living organism.
Block	Division of the FICZ/FOCZ into units. Block is a sub-division of a Quadrant. There are 30 Blocks within one Quadrant. Block 14/05 is the 5th Block in Quadrant 14.
Brood-guard	The period during a bird's nesting season when the chick is attended, brooded, by one of the adult birds.
Depo-centre	An area or site of thickest deposition in a sedimentary basin.
Ecotone	Transitional area between two habitats and communities.
Endemic	Native to or confirmed to a particular region
Environmental Impact Assessment	Process to identify and assess the impacts associated with a particular activity or plan.
Equator Principles	The Equator Principles is a risk management framework, adopted by financial institutions, for determining, assessing and managing environmental and social risk in projects and is primarily intended to provide a minimum standard for due diligence to support responsible risk decision-making.
Falkland Plateau Basin (FPB)	Area containing Licence Blocks to the east of the Falklands referred to as East Plateau Basin (EPB) in some references.
Good International Industry Practise	Defined in IFC's Performance Standard 3 on Pollution Prevention and Abatement as the exercise of professional skill, diligence, prudence, and foresight that would reasonably be expected from skilled and experienced professionals engaged in the same type of undertaking under the same or similar circumstances globally or regionally
Graben	Depressed block of land bordered by parallel faults
International Finance Corporation	IFC is a member of the World Bank Group. It finances and provides advice for private sector ventures and projects.
MMbbls	One million barrels of oil
P50 Reserves	Probable reserves for recovery
Petrogenic	Unburned petroleum products
Photic Zone	The upper water column, which received enough light for photosynthesis to occur.
Physico-chemical	Parameters such as temperature, nutrients or chemicals.
Post-guard	During brooding period whilst adults feeding older chicks. Adult does not remain on nest during the daytime.
Pyrogenic	Produced under conditions involving intense heat
STOIIP	Stock-tank oil initially in place, the volume of oil in a reservoir prior to production.
Syncline	Downward fold of stratified rock in which the strata slope towards a vertical axis
Trophic	Relates to feeding.
World Bank Group	The World Bank Group is a family of five international organisations that make leveraged loans to developing countries.

1.0 Non-technical Summary

1.1 Introduction

This Environmental Impact Statement (EIS) presents the findings of the Environmental Impact Assessment (EIA) conducted by Noble Energy Falklands Limited (NEFL), a subsidiary of Noble Energy Incorporated, for the Rhea-1 exploration well operation in the North Falkland Basin (NFB).

1.2 Project description

NEFL is planning to drill one exploration well in the North Falkland Basin within Licence Block PL001 (Figure 1). The purpose of the drilling campaign is to evaluate an exploration target in the NFB that was identified during seismic processing. The well location is named Rhea-1 and will be drilled during the joint NEFL and Premier Oil 2015 exploration drilling campaign.

The exploration well will be drilled from the *Eirik Raude* drilling rig, which will be in Falkland Islands waters to conduct the joint 240 day drilling campaign shared by NEFL and Premier Oil. An outline of the intended schedule is given below (Table 1) although this might be subject to change, dependent on final planning stages between NEFL and Premier Oil, and operations. NEFL will liaise with the Fisheries Department throughout the drilling programme and will notify the Department of rig moves and the new rig location in advance of the move.

Table 1: Summary of proposed exploration drilling activities

Activity	Operator	Start Date	Duration
Rig transits from West Africa and arrives in Falkland Island Waters	Premier Oil	01 February 2015	Approximately 38 days
Drill and abandon Zebedee well		06 March 2015	Approximately 30 days
Rig move to next well location			
Drill and abandon Isobel Deep well		08 April 2015	Approximately 30 days
Rig move to next well location			
Spud Chatham well		24 April 2015	4 days
Spud Jayne East well		27 April 2015	7 days
Return to Isobel Deep well		03 May 2015	2.5 weeks
Rig move to NEFL location	NEFL	May-June 2015	Approximately 60 days
Drill and abandon Humpback-1 well			
Rig move to Jayne East well location	Premier Oil	July 2015	Approximately 30 days
Drill and abandon Jayne East well			
Rig move to Chatham well location		August 2015	Approximately 30 days
Drill and abandon Chatham well			
Rig move to NEFL location	NEFL	August / September 2015	Approximately 38 days
Drill and abandon Rhea-1 well			
Rig transits from Falkland Island Waters to West Africa		November 2015	

The *Eirik Raude* is a semi-submersible rig, which will be supported by two rig supply vessels operating from a shore base in Stanley. The recently constructed Temporary Dock Facility (TDF) will be used for all cargo transfers but refuelling will be undertaken at Falklands Interim Port and

Storage System (FIPASS). A 500 m exclusion zone will be established around the rig whilst on location at each well site, which will be continually monitored by an Emergency Response and Rescue Vessel (ERRV).

The exploration well will be drilled in four sections, bore diameter decreases with increasing depth: 42″ diameter top section, 26″ diameter section for surface casing, 17 ½″ diameter intermediate section and a 12 ¼″ diameter objective section. The well will be drilled to a specified total depth using water based muds. Drill cuttings and muds from the top two well sections will be discharged to the seabed and those from the third and fourth sections discharged at the sea surface. A Vertical Seismic Profile (VSP) of the well will validate the geology at the site. On completion, the well will be plugged and abandoned.

1.3 Environmental Management

NEFL will conduct the Rhea-1 exploration well operation in a manner that is consistent with the Noble Energy Inc. Environment, Health and Safety Policy. The policy acknowledges Noble's EHS responsibilities in relation to its business activities and states Noble's intention to conduct its business in a manner which safeguards people, the environment and surrounding communities.

NEFL implements the EHS policy through the Noble Energy Global Environment, Health and Safety, Management System (hereafter referred to as the GMS). The GMS interfaces with relevant contractor management systems via development of contractor bridging documents.

The monitoring and mitigation measures identified during this EIA process will be incorporated into license conditions issued by FIG post-approval. To ensure compliance with all commitments made in the EIS, a project specific Environmental Management Plan (EMP; NEFL, 2015a) will be developed by NEFL in conjunction with the drilling rig contractor and other key contractors. Where necessary, additional management plans will be developed to ensure best environmental practice throughout the Rhea-1 well operation.

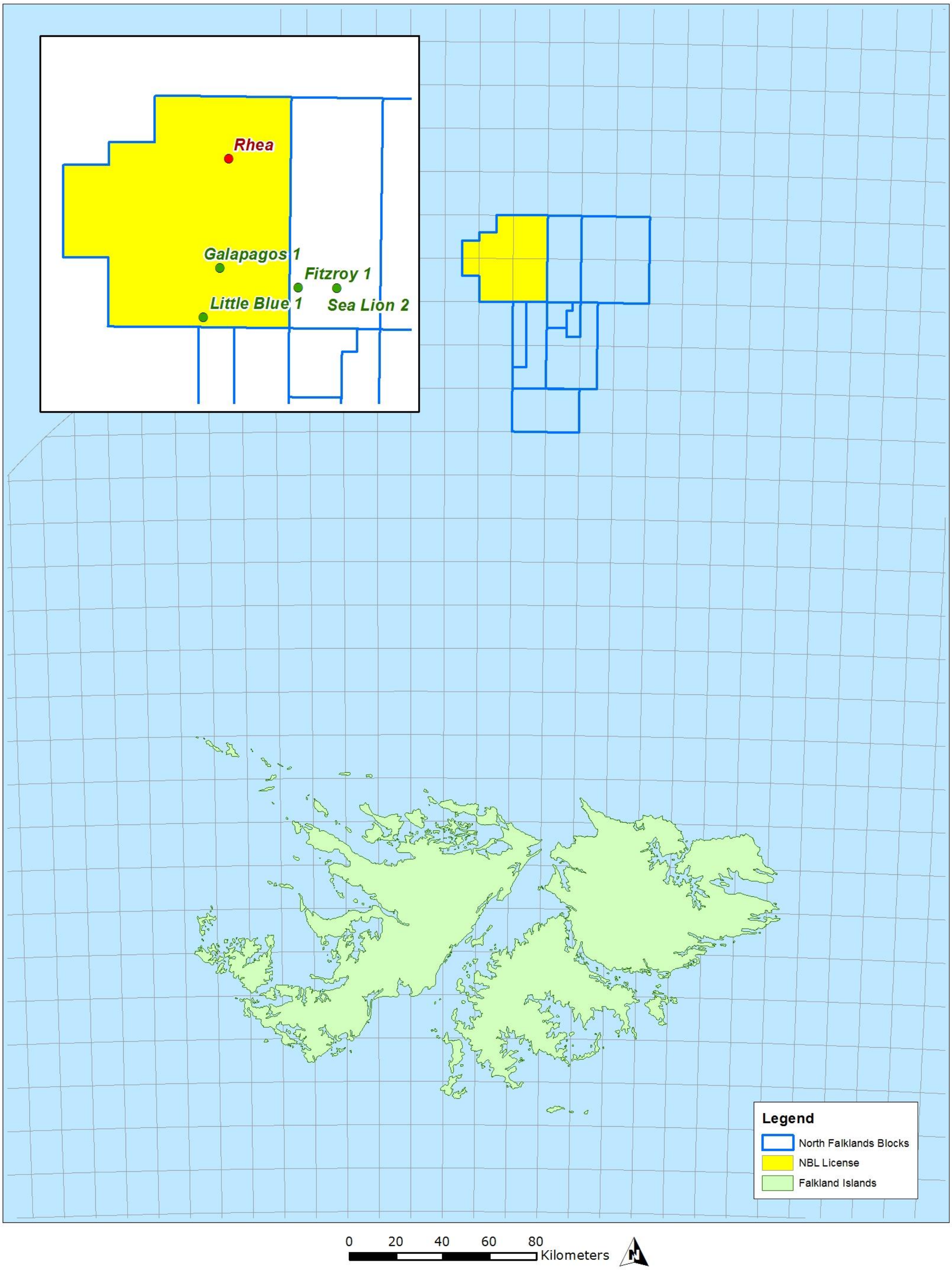

Figure 1: Licence Block Location and the Rhea-1 Exploration Well Location

1.4 Environmental Baseline Description

1.4.1 Physical Environment

The Rhea-1 exploration well site is located in the NFB, approximately 250 km north of the Falkland Islands, 925 km northeast of Cape Horn and 500 km from the nearest point on the South American mainland (Figure 2). The well site is located in waters approximately 470 m in depth.

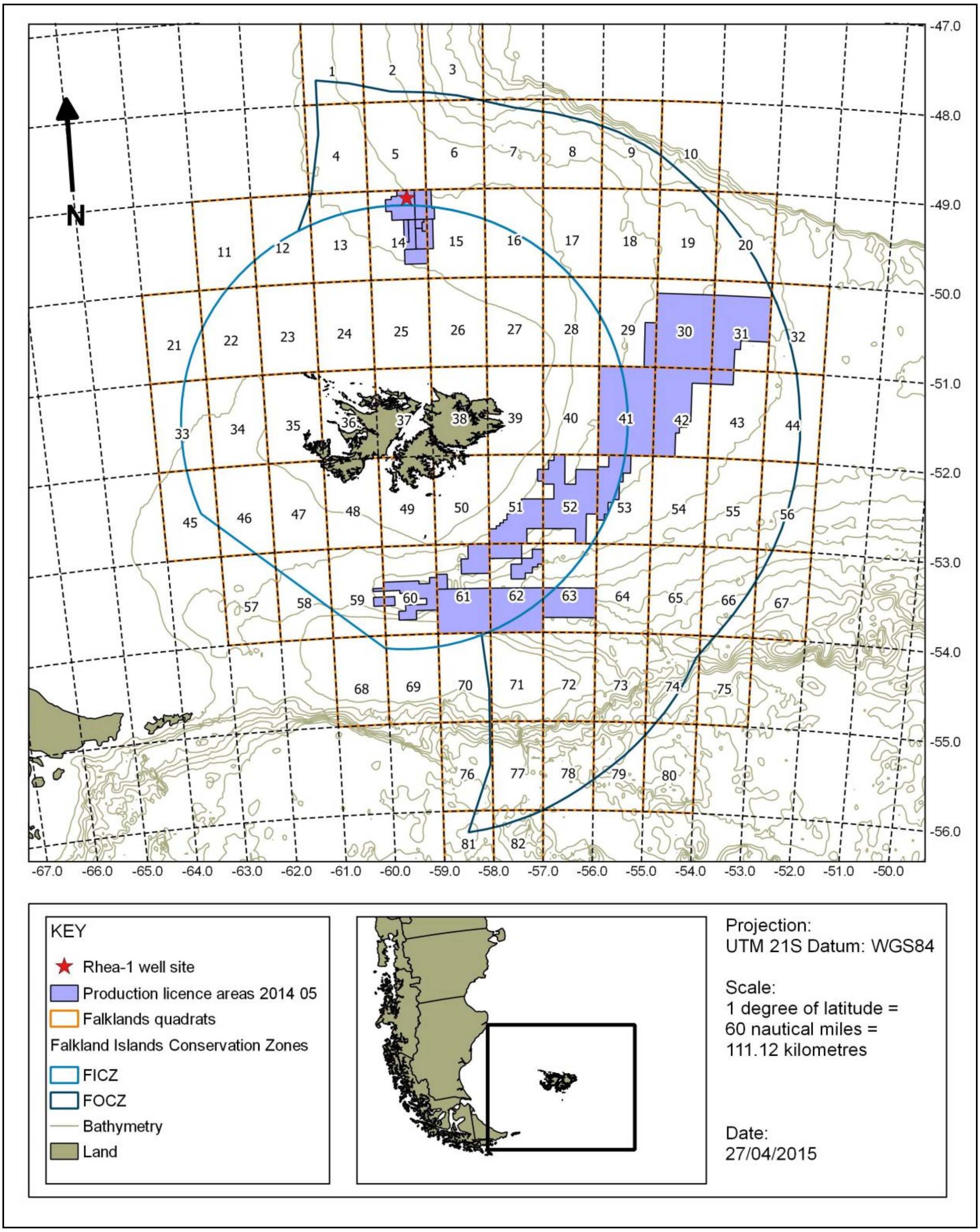

Figure 2: The location of the Rhea-1 well site in relation to the Falkland Islands, fisheries conservation zones and the South American mainland

Oceanography

The oceanography of the region is dominated by the influence of the Falkland Current, a northward flowing offshoot of the Antarctic Circumpolar Current. The Falkland Current splits into two branches, one passes to the east and the other to the west of the Islands. A number of oceanographic fronts exist on the Falkland Islands continental shelf, primarily in areas to the south and east of the Falkland Islands. Few have been identified on the northern shelf in the vicinity of the Rhea-1 well site.

Previous survey data

In 2012, Premier Oil and their partner, Rockhopper Exploration, conducted an area wide environmental baseline survey of the Sea Lion Field component of the northern Licence Blocks (PL032) in the NFB to determine the physical, chemical and biological character of the environment in support of future development of the area. The survey consisted of 54 stations spaced at approximately two km intervals. 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 (Figure 2) in the NFB.

Several other environmental surveys have been conducted in the vicinity of the Drilling Campaign Area and further afield on the Falklands continental shelf and deeper oceanic waters to the southeast of the Islands, which provide background and contextual data for comparison with the Sea Lion area.

1.4.2 Biological Environment

Plankton

The Falkland Current brings nutrient rich waters to the southern Patagonian Shelf and creates an area of very high zooplankton productivity immediately to the north of the Islands on the shelf break (approximately 70-90 km south of the Rhea-1 well site). The waters to the north of the Falkland Islands thus support complex communities of zooplankton, which in turn support complex pelagic and demersal ecosystems.

The waters to the north of the Falkland Islands are characterized by seasonally high diatom abundance and zooplankton that is dominated by the amphipod *Themisto gaudichaudii* and gelatinous salps and comb jellies.

Benthic ecology

Drilling activity has a direct effect on the benthic ecology through physical disturbance and chemical discharges, both associated with cuttings discharge. A number of pre- and post-drilling surveys have been undertaken in association with previous campaigns. The Rhea-1 well site has not previously been surveyed but a visual ROV survey will be completed before well drilling commences and repeated once the well is abandoned. Sediment and fauna samples will be collected for later analysis during the ROV survey. Overall, the general taxonomic assemblage found across all these surveys is very similar, with polychaetes and crustaceans being the two most abundant groups present, followed by molluscs.

The community throughout the NFB areas surveyed, both pre- and post-drilling, is that of a typical silt/mud benthic environment, and also appears to be undisturbed and unpolluted. To date, drilling activities appear to have had no effect on the benthic community within the historic drilling areas.

Benthic surveys conducted approximately 65 km south of the Rhea-1 well identified areas slightly different in character, to sites surveyed in the vicinity (20 km) of the Rhea-1 well, due to the influence of ancient iceberg groundings, from the Pleistocene or older. Some hard corals were present in the soft sediment and isolated octocorals were found in association with glacial erratic rocks on the seabed.

Fish and squid

The productive waters surrounding the Falklands are important feeding grounds for a number of species of fish and squid, some of which are commercially exploited. The area of Rhea-1 exploration drilling lies between the productive finfish trawl fishery on the edge of the Falklands Continental Shelf (200 m water depth) and the Patagonian toothfish (*Dissostichus eleginoides*) longline fishing grounds in deeper water of the Continental Slope (>600 m). The largest fishery in Falkland Islands waters targets Argentine shortfin squid (*Illex argentinus*), which are seasonally present within Falklands waters, between February and June. This species seasonally passes near and through the NFB, depending on environmental conditions, but is not present during the proposed Rhea-1 drilling period.

Marine mammals

Marine mammals comprise cetaceans (whales and dolphins) and pinnipeds (seals and sea lions). Confirmed sightings and stranding records indicate that 25 species of cetacean occur within Falkland Islands waters. Many of these species are rare and inconspicuous, some are only known from stranded animals. Of the 25 species listed, two species are listed as 'Endangered' on the International Union for the Conservation of Nature (IUCN) Red List. These are the fin (*Balaenoptera physalus*) and sei whales (*B. borealis*). One species, the sperm whale (*Physeter macrocephalus*), is listed by the IUCN as 'Vulnerable'.

Three species of pinniped breed on the Islands and a number of other species have been recorded as visitors or vagrants.

A number of visual and acoustic surveys have been conducted in Falkland waters in recent years, which provide a brief glimpse into the lives of these animals. However, like elsewhere in the world, the distribution of marine mammals within Falklands' waters is poorly understood.

Seabirds

Internationally important populations of seabirds breed on the Falkland Islands and feed in the productive waters that surround the Islands. Over 70% of the global population of black-browed albatross (*Thalassarche melanophris*), 39% of the global population of gentoo penguins (*Pygoscelis papua*) and 36% of the global population of rockhopper penguins (*Eudyptes chrysocome*) all breed on the Islands. Of the species of seabird recorded in the NFB the Atlantic petrel (*Pterodroma incerta*), grey-headed albatross (*Thalassarche chrysostoma*) and northern royal albatross (*Diomedea sanfordi*) are listed as 'Endangered' on the IUCN Red List, and the white-chinned petrel (*Procellaria aequinoctialis*), southern royal albatross (*Diomedea epomophora*) and the wandering albatross (*D. exulans*) are listed as 'Vulnerable'.

Numerous studies have been conducted over the past 20 years, which give an indication of the seasonal distribution patterns of seabirds around the Falklands. However, much is still to be learned and studies into seabird ecology are ongoing.

Protected areas

The Falklands Conservation Zones are managed sustainably and afford a level of protection to seabirds, marine mammals and other marine species. This is achieved through measures such as; closed areas, catch limits and seabird bycatch mitigation measures. However, there are no designated marine protected areas in Falkland Islands waters. Several candidate marine Important Bird Areas (IBA) have been proposed but have not been accepted due to insufficient tracking data. On land however, a number of IBAs have been designated on account of the breeding seabird populations that they support. Additionally, a network of National Nature Reserves (NNR) and Important Plant Areas (IPA) protect many of the most important seabird breeding sites and areas supporting native flora.

Socio-economic environment

The Falkland Islands is one of 14 British Overseas Territories. Supreme authority is vested in HM The Queen and exercised by the Governor of the Falkland Islands on her behalf, with advice and assistance from the Executive Council and Legislative Assembly.

The Falkland Islands were first inhabited in 1764, and the current permanent population of the Islands stands at 2,931. The majority of the Falkland Islands population (74.7%) live in the capital Stanley, which is the only town on the Islands and is situated on East Falkland. Outside Stanley, in what is referred to as Camp; there are a number of smaller settlements. According to the 2012 Falkland Census, the total population of Camp represents about 12% of the total resident population of the Falkland Islands. The remainder are civilians working at the military base at Mount Pleasant Complex (MPC).

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 Falklands Interim Conservation Zone in 1986 for fishery purposes, and 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 fleets operating within Falklands' waters. The income from these licence fees fluctuates, but currently makes between 50-60% of the Government's revenue.

Falkland Islands fisheries

The two most important fisheries within the Falklands EEZ are the jig fishery for Argentine shortfin squid and the trawl fishery for Patagonian long-finned squid (*Doryteuthis gahi*), which accounted for 54% and 15% of the 2013 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 the deeper waters.

Marine archaeology

The UK Hydrographic Office Wrecksite database indicates that there are 177 wrecks recorded within Falkland Islands waters, with records dating from the 1800's to present day. There are nine recorded wrecks within 100 nautical miles of the proposed drilling site; the two closest of these wrecks are located approximately 40 nautical miles from the Rhea-1 well site.

1.5 Scoping Consultation Summary

NEFL conducted an EIA scoping exercise in September 2013 to raise awareness of its 2015 exploration drilling campaign and to invite comment on the proposed programme and associated activities. A similar exercise was carried out by Premier Oil Exploration and Production Limited (Premier) in July 2014. Initial consultation meetings were held with the Department of Mineral Resources (DMR), statutory consultees and other interested parties.

This phase of consultation provided stakeholders with an opportunity to enter into a discussion about the proposed project so that any issues and concerns could be identified at an early stage and be considered within the scope of the EIA.

Areas of concern raised during the consultation meetings can be broadly summarised in the following categories:

- Generation of artificial light to attract seabirds resulting in potential collision risk or mortality if in relation to flaring;
- Assessment required for drilling mud and drill cuttings discharges;
- Supply vessels associated with the campaign could cause overcrowding in Stanley Harbour;
- Noise generated from helicopter transits between Stanley and the rig could disturb sensitive seabird colonies underneath the flight path;
- Potential for vessels from outside the Falkland Islands to carry marine invasive species;

- The drilling campaign will increase demand for local accommodation and could lead to shortages in availability for visitors;
- Waste management is required as there is limited capacity for waste disposal in the Falkland Islands;
- Potential opportunities for the charter flight to benefit Falkland Islanders through additional passenger and cargo spaces.

1.6 Impact Assessment Methodology

The EIA process provides a framework for assessing the environmental consequences of a project during the planning stages. The EIA ensures that favourable alternatives may be considered, and mitigation measures may be proposed to adjust any impacts to acceptable levels prior to the decision on project sanction, or otherwise.

NEFL conducted this EIA in accordance with Falkland Islands Government's DMR *Field Developments Environmental Impact Statements Guidance Notes (2012)* and Noble Energy's EHS Policy.

The EIA follows a structured methodology (Figure 3) to systematically identify and assess the nature and significance of environmental impacts arising from project activities and risks arising from unplanned or accidental events. Where impacts and risks were assessed to be of a moderate or high significance, mitigation measures have been developed to reduce the severity or likelihood of the impact or risk. Where confidence in the assessment is compromised by data gaps and/or uncertainties, monitoring measures have been identified, where feasible, to provide an early indication of whether impacts have exceeded acceptable levels.

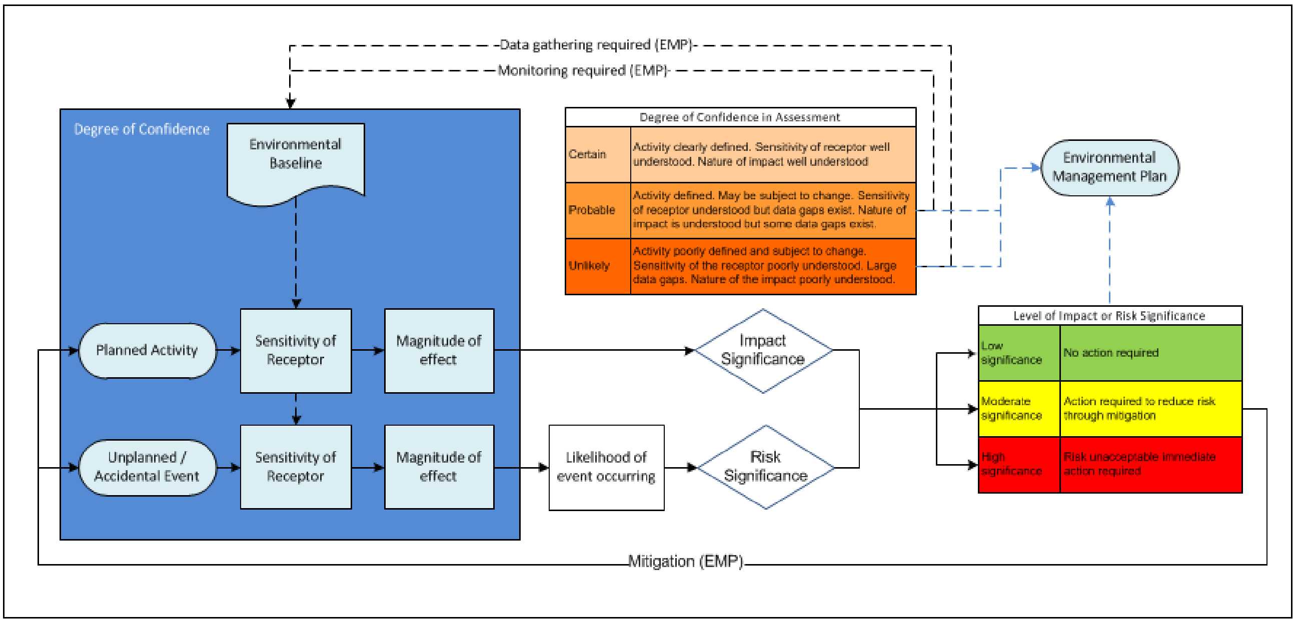

Figure 3: Overview of the Environmental Impact Assessment Process

The project activities that the environmental impact and risk assessment process identified as requiring further consideration in the EIA are:

- Generation of underwater noise;
- Generation of atmospheric emissions;
- Generation of light offshore, attracting seabirds and marine life;
- Onshore and inshore impacts;
- Generation of waste and waste management;
- Discharge of drilling mud and cuttings; and

- Potential for accidental events;
  - Significant loss of containment during an uncontrolled release or from rig failure to maintain location via dynamic positioning;
  - Loss of rig or vessel resulting from collision.

1.7 Underwater Noise Assessment

The properties of sound in water are used by many marine animals to communicate, find food and navigate. Anthropogenic sounds have the potential to interfere directly and/or indirectly with these processes and, in extreme cases, have the potential to cause temporary or permanent hearing loss and physical injury.

Activity during the Rhea-1 drilling operations involving vessels and rig movements will generate underwater sound. The intensity of the sound produced varies between vessels according to engine/thruster size and activity. The loudest continuous sounds will be produced by the Dynamic Positioning (DP) thrusters used to maintain the position of the rig and supply vessels.

Other sources of sound include drilling operations and Vertical Seismic Profiling (VSP). A VSP uses an airgun to create a sound impulse that is used to verify the geology of the well and is the most intense sound source associated with the drilling campaign. A VSP will be conducted on each well and will last for 12-15 hours.

Some species of fish, squid and planktonic organisms are sensitive to intense sound, however, the impact on these species is regarded as insignificant and the assessment focused on the impact on marine mammals, which are generally considered to be of greatest conservation concern in relation to underwater noise.

There is still much to learn regarding the seasonal distribution of marine mammals within Falklands waters and ‘new’ species to the area are still being discovered (for example false killer whale was recorded for the first time in 2013). Visual and acoustic surveys indicate that a number of species of marine mammal; including baleen whales such as the IUCN Endangered sei and fin whales, are present in the NFB throughout the year. However, the number of animals present is generally highest during the summer months. The hearing range of baleen whales is believed to be most sensitive to low frequencies (<1 kHz, reflecting their vocal range), which overlaps with the sound generated by vessels and airguns. Therefore, due to their conservation status and hearing range, baleen whales were assessed to be the most sensitive environmental receptor to anthropogenic sound. Other species of cetacean are most sensitive to higher frequencies (20-40 kHz). Although there will be some anthropogenic sounds produced in this frequency range the intensity of the sound is lower and therefore the potential impact is also lower. Potential impacts upon baleen whales represent the worst-case scenario and are therefore the focus of this assessment.

Sound levels for the various anthropogenic sound sources were obtained from the literature and the sound attenuation was calculated to indicate sound levels at increasing distances from the source. These values were compared with the hearing sensitivity of marine mammals to assess whether potential direct or indirect impacts such as disturbance, avoidance behaviours or potential trauma could be experienced by an animal exposed to sound at this level.

Due to a lack of data for baleen whales, the hearing sensitivity used was generic and represented a worst-case scenario (based on the minimum hearing sensitivities of a range of marine species). The only sound source with the potential to cause trauma (temporary or permanent hearing loss) was the VSP airgun. It is assessed that animals within 100 m of the airgun could suffer trauma. All other vessel sources of sound were assessed to elicit a range of responses, from strong avoidance at close range to disturbance at moderate range (within 1,000 m for large vessels).

The conservation status of the most vulnerable receptors (fin and sei whales) which represent the worst-case make the overall sensitivity of the receptor ‘**High**’ and the severity of noise from VSP airguns ‘**Moderate**’. Therefore the VSP was assessed as being of ‘**Moderate**’ significance. Marine mammals are known to react to approaching vessels, which causes avoidance behaviour and disturbance, the severity of disturbance from vessels was assessed as ‘**Minor**’. Overall, the significance of vessel traffic for the most sensitive receptors was assessed as '**Moderate**'. 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**' and the data gaps are not considered to have the potential to significantly change the outcome of the assessment.

The major difference between these sources of sound is the duration of the output. Engine noise is constant and will increase, or decrease, gradually, which enables marine mammals to move away from excessively loud sounds. However, VSP airguns are pulsed sounds and therefore a marine mammal could be exposed to a sudden intense sound that has the potential to result in hearing loss.

In an attempt to reduce the potential impact on marine mammals, a dedicated marine mammal observer (MMO) will be deployed during VSP operations. Observations will be conducted for 60 minutes prior to the start of airgun discharges to ensure the area within a 500 m radius of the rig is clear of marine mammals. Soft-start procedures (a slow increase in sound intensity) will commence once the area is confirmed clear of marine mammals.

1.8 Atmospheric Emissions

Activities associated with the Rhea-1 well operation will generate atmospheric emissions as a result of power generation, transportation of crew and cargo.

The main sources and potential sources of emissions generated by the operations and activities during the exploration drilling operation will be:

- Drilling rig transit to well location and maintaining position during drilling operations;
- Power generation during drilling operations (e.g. use of gas turbines, diesel engines, generators);
- OSV/PSV transporting materials and equipment to and from the rig;
- ERRV providing support to the drilling rig in the field throughout the operation;
- Coaster vessels delivering cargo to and from the UK;
- Transportation associated with crew change, including charter flights to and from the UK, minibus transfer from MPC to Stanley and helicopter flights between Stanley and the rig;
- Power generation for non-operational activities e.g. in accommodation block;
- Refrigeration, heating, ventilation, air conditioning on the rig and vessels i.e. use of ozone depleting substances (ODS) and fluorinated gases (F-Gas); and
- Operation of the onshore supply base.

Combustion of fuels and the use of ODS and F-Gases during the above activities all have the potential to impact upon the global and regional atmosphere and/or the marine environment.

The products of combustion of each fuel type are known and therefore it is possible to calculate the total project emissions. The quantities of fuel used in each phase of the well operation were estimated from projected activity and known fuel consumption rates. Standard emissions factors were used to calculate the quantities of each gas produced.

Atmospheric emissions contribute to global warming, ozone depletion and ocean acidification. The impact on regional air quality is also considered.

Global warming

Greenhouse gas emissions are governed by the legally binding international treaty known as the Kyoto Protocol, which came into force in 2005. Gases that cause global warming are referred to as greenhouse gases because they absorb and effectively trap heat within the Earth's atmosphere. The six main Kyoto greenhouse gases relevant to the oil and gas industry are: Carbon Dioxide (CO_2), Methane (CH_4) and Nitrous Oxide (N_2O) and the three F-Gases, Sulphur Hexafluoride (SF_6), Hydrofluorocarbons (HFCs) and Perfluorocarbons (PFCs). To account for the varying efficiency of different greenhouse gases in warming the Earth, the Global Warming Potential (GWP) is applied to the atmospheric emissions to calculate the CO_2 equivalent.

In order to put the emissions from the drilling operation into context, the emissions were compared with those of the UK. Although overall emission figures are available for the Falklands, the lack of major industries in the Islands makes the comparison inappropriate. In this context, the total emissions generated from the Rhea-1 well operation would represent 0.01% of total UK emissions, or 23% of declared Falkland Islands emissions. The quantity of greenhouse gases resulting from the operation is relatively low in comparison to similar exploration and oil and gas activity in the rest of the world; the operation is of a short duration (38 days) and the emissions in isolation would have a barely detectable effect.

Ozone depletion

Another global issue related to atmospheric emissions is ozone depletion. Ozone in the upper atmosphere (stratosphere – 15-25 miles above the Earth's surface) intercepts much of the harmful ultraviolet (UV) light produced by the sun. Ozone depleting substances (ODS) contribute to the breakdown of ozone into oxygen in the upper atmosphere, and consequently allow these harmful rays to pass through the Earth's atmosphere. It is suspected that a variety of biological consequences such as increases in skin cancer, cataracts, damage to plants, and reduction of plankton populations in the oceans' photic zone may result from the increased UV exposure due to ozone depletion.

ODS (e.g. the man-made chlorofluorocarbons (CFC's), hydrochlorofluorocarbons (HCFC's) and Halon) were commonly used in oil and gas exploration and production activities in refrigerants, solvents, foam blowing agents, high voltage switch gear, heating, ventilation, air conditioning (HVAC) and firefighting fluids. Under the Montreal Protocol (and the aligned MARPOL 73/78 Annex VI), the use of ODS's is being phased out. The phase-out of most ODS's is now complete. Notwithstanding critical use exemptions where applicable, the use of virgin and reclaimed/recycled Halon and CFC's in new equipment and during maintenance is now prohibited. The use of new HCFC's is prohibited and the use of reclaimed/recycled HCFC's must be phased out by 1st January 2020.

The only ozone depleting substance used on the *Eirik Raude* is HCFC in hermetically sealed domestic appliances (e.g. refrigerators) with an inventory <3kg. In accordance with the Montreal protocol and MARPOL Annex VI, no HCFC will be released to the environment during drilling operations as the relevant systems are contained and fully operational.

NEFL has audited the *Eirik Raude* and was provided with sufficient evidence that all international standards and controls with regard to the use of ODS are sufficient.

Ocean acidification

Along with the impact of CO_2 as a greenhouse gas, it is also responsible for ocean acidification. As CO_2 is absorbed from the atmosphere by direct air-sea exchange it dissolves in the oceans to form carbonic acid (H_2CO_3), which leads to ocean acidification. One well-known effect of ocean acidification is the lowering of calcium carbonate saturation states, which impacts shell-forming marine organisms from plankton to benthic molluscs, echinoderms, and corals (Doney *et al*, 2009).

The principal combustion product of the proposed well operation is CO_2, which is directly related to the rate of ocean acidification. The amount of CO_2 generated as a result of the proposed drilling operation is finite and very low in relation to overall UK emissions and would therefore have a negligible effect on the oceans' pH.

Regional air quality

At the local, regional and transboundary levels, gaseous emissions may impact air quality. Key issues include the formation of acid rain from oxides of sulphur (SO_X) and nitrogen (NO_X), direct impacts on human health from particulate matter (formed by chemical reactions involving pre-cursor gases NO_X, SO_X, and volatile organic compounds (VOCs)) (EEA, 2012).

The primary contributors to atmospheric emissions come from rig and vessel movement and operation, and return charter flights to the UK. These activities will either take place in the offshore environment over 200 km from the nearest land or along the flight path from the UK to the Falkland

Islands. Any impacts to the local air quality from offshore operations are considered to be minimal, and would only have a very low level and short-term effect on local air and marine life with no expected effects on the population of the Falkland Islands.

Environmental Impacts

The quantity of emissions generated during the Rhea-1 well operation is expected to have a '**Slight**' effect to the environmental receptors, which in the context of global emissions have a **'Low'** sensitivity. Consequently the overall significance has been assessed as '**Very Low**'. These activities will contribute a very small incremental effect to global atmospheric emissions. The activity has been well defined, the sensitivity of the receptor and nature of the impacts are well understood and hence the impact predictions are considered to be of '**Certain**' degree of confidence.

1.9 Generation of Artificial Light Offshore

Artificial light can affect the natural behaviour of animals leading to attraction and disorientation. This behaviour can be exploited to catch squid, as seen in the large fleet of jiggers that operate in Falklands waters. Seabirds have evolved in what is essentially a dark night-time environment. However, they do use naturally occurring sources of light, such as the moon, stars and bioluminescence to navigate and find food. It has long been known that seabirds are attracted to artificial lights at-sea, which can lead to birds colliding with vessels. When large numbers of birds are involved, this is known as a bird strike. Birds can suffer injury or die directly from a collision. Where they survive, their feathers frequently come into contact with oil or grease on the deck, which results in a loss of waterproofing and a subsequent risk of hypothermia.

Offshore operations associated with the Rhea-1 drilling operations will introduce several sources of artificial light into the offshore waters of the NFB, including OSV/PSVs, the ERRV and the drilling rig. Drilling, and other rig activities, will operate for 24 hours a day and to do this safely, all working areas will have to be well illuminated. Sources of light on the vessels will include navigational lights, illuminated living spaces within the ships and rig and floodlighting to provide a safe working environment on the decks of ships and rig.

Recorded bird strike events indicate that the most vulnerable species are small nocturnally active petrels and shearwaters. The abundance of these birds within the NFB varies seasonally, with highest numbers encountered during the summer months. Plankton, fish and squid may also be attracted to artificial light but there is no apparent negative impact on these animals.

Bird strikes occur sporadically and are associated with: light use, seabird abundance and current weather conditions. Although birds can become disorientated at any time, large bird strikes tend to be associated with the use of bright lights in areas containing high densities of birds on nights when visibility is poor (due to fog or snow).

It is not possible to quantify the number of birds at risk from bird strikes caused by artificial lighting during the Rhea-1 drilling operations. However, from experience gained on vessels that operate in Falkland Islands waters and on oil and gas platforms elsewhere, it is considered likely that some bird collisions with vessels at-sea or the rig will occur. Although the species concerned have large population sizes ('**Low**' sensitivity), a collision with a vessel or the rig is likely to result in injury and/or death of the individual. However, it is considered that the impact would be barely detectable on the size of any species' population, as the impact is localised and short-term ('**Minor**' severity). The proportion of the local populations that are at risk is considered to be small, as most of the vulnerable species migrate away from Falklands waters in the winter. Overall, the significance of the impact of artificial light on seabirds has been assessed as '**Low**'. The duration of the campaign and light sources have been confirmed, and flaring activities will not take place. The nature of the impact on the environmental receptor is understood, however, the scale of the potential impact is difficult to predict due to its episodic nature. As such, the level of confidence in the impact predictions is considered to be '**Probable**'.

Despite the apparently Low impact, some simple measures can be taken to reduce the horizontal spread of light, which will further reduce the risk to seabirds. Floodlights can be directed downwards and inboard whenever possible and practical, and accommodation should be blacked-out.

1.10 Inshore and Onshore Impacts

1.10.1 Introduction

Stanley will be the hub through which all cargo and personnel will pass before onward transport to the drilling rig. Inshore and onshore impacts cover a range of activities associated with the operation of vessels, onshore supply base and TDF. These include:

- Interference to other sea users due to increased vessel traffic in Stanley Harbour;
- Collisions between support or supply vessels and marine mammals;
- Introduction of marine invasive species by support or supply vessels;
- Disturbance to wildlife and the human population onshore from helicopter noise;
- Introduction of terrestrial invasive species with cargo;
- Disturbance to Stanley residents and wildlife from inshore and onshore light and noise sources; and
- Demands for accommodation in Stanley.

Impacts associated with each of these aspects and activities are described below.

1.10.2 Interference to other sea users due to increased vessel traffic in Stanley Harbour

Stanley is a working harbour used by fishing vessels, cruise ships and cargo vessels. Space for vessel manoeuvres in Stanley Harbour and through the passage into Port William (The Narrows) can be tight and there is a history of vessel collisions and groundings within these areas. The joint NEFL and Premier Oil 2015 drilling campaign will increase the amount of shipping traffic in the Harbour, which has the potential to interfere with other sea users.

A number of different vessels associated with the Rhea-1 drilling operations will be using Stanley Harbour. These include:

- Coaster cargo vessels travelled between Aberdeen (Scotland) and Stanley to deliver all the equipment required for the drilling campaign in the early months of 2015. On arrival, coasters moored alongside the TDF to facilitate the transfer of cargo.
- The two OSV/PSVs will travel between the drilling rig and Stanley on a five to seven day rotation throughout the Rhea-1 exploration drilling campaign. On arrival in Stanley Harbour, these vessels will moor alongside the TDF to facilitate the transfer of cargo.
- The rig ERRV vessel will spend the majority of the time offshore, close to the position of the rig, however, it will return to Stanley occasionally (on a four-six week basis) to refuel and change crew.
- At the end of the joint 2015 campaign, coasters will return to demobilise equipment and ship waste back to Aberdeen.

Disruption to third-party vessels has the potential to impact fishing and cargo operations, which could result in a loss of business revenue, due to the additional time and fuel needed to complete their activities. The key factor restricting shipping activity in Stanley Harbour is the lack of berth space at the Falklands Interim Port and Storage System (FIPASS). At times, demand outstrips available space and vessels may have to leave FIPASS and anchor to create space for other vessels, or to wait for a berth to become available. Due to the necessity to transfer cargo to and from lay-down yards onshore, the oil and gas industry have been heavy users of FIPASS in previous drilling campaigns.

The number of visits to FIPASS by regular users (fishing and cargo vessels etc.) was reasonably consistent between 2008 and 2013, however, supply vessel visits varied considerably, reflecting oil and gas exploration activity. Exploration drilling campaigns were on-going throughout most of 2010, 2011 and into 2012. The necessity to move cargo through FIPASS resulted in a considerable increase in demand for this facility. For instance; during 2011, OSV/PSVs accounted for over 39% of all vessel visits to FIPASS.

The TDF was constructed in 2014 to take some of the pressure from the oil and gas industry away from FIPASS during the 2015, and future, drilling campaigns. The TDF is situated in an area to the east of FIPASS, which is not usually used as an anchorage so the disruption to other users of Stanley Harbour, who wish to anchor, will be minimal. On the basis of the localised and short-term nature of the impact, the severity of disruption to other users of Stanley Harbour is assessed as '**Minor**'. With the TDF in place, there is moderate capacity to absorb the added pressure on FIPASS from the oil and gas industry without significant alterations to present working practices. Nonetheless, the TDF has no capacity to refuel vessels and therefore there will be some disruption to other users of Stanley Harbour, which may have economic implications. Therefore the sensitivity of the receptors involved has been assessed as '**Moderate**'. The overall significance is assessed as '**Moderate**' and measures proposed to reduce the impact on other users of Stanley Harbour include;

- The appointment of a Marine Superintendent who will liaise with the Harbour Master, FIPASS management, Stanley Services and other users, and who will help to keep everyone well informed and promote good working relationships;
- The issue of Notes to Mariners to inform all masters of vessels of the presence of a new shoreline facility;
- The completion of a navigational risk assessment to inform the preparation of a Stanley Harbour Management Plan (HMP). This Plan will be prepared in close collaboration with the Harbour Master and cover the following as a minimum: pre-notification protocols associated with the entry of vessels in Stanley Harbour; pre-defined passage routes within Stanley Harbour; procedures associated with vessel collision and emergency response;
- The use of marine night-time lighting with procedures in place for periods of poor weather.

1.10.3 Collisions between support or supply vessels and marine mammals

Elsewhere in the world, collisions between cetaceans and vessels are having a negative impact on the populations of Endangered species.

As discussed in Section 1.10.2, the 2015 drilling campaign will increase the amount of shipping traffic over inshore waters close to Stanley. At certain times of the year, large numbers of sei whales can be encountered within these waters of the Falkland Islands. As a hub for vessel traffic and sei whale activity there is a risk of collisions between vessels and these animals in inshore waters close to Stanley. However, the Rhea-1 well will be drilled at a time when large cetacean abundance within Falklands waters is at its lowest.

The sei whale is by far the most numerous species of large whale in the coastal waters near Stanley but they are also found throughout the inshore waters of the entire archipelago. Anecdotally, there is evidence that the number of sei whales within Falklands waters, has been increasing over the past 15 years. However, sufficient survey data to determine a population estimate is currently unavailable.

Sei whales appear to respond to approaching vessels and are relatively fast swimmers, although they also tend to swim just below the surface leaving a clear trail of 'fluke prints' in their wake. There are many records from around the world of collisions between sei whales and vessels, collated by the International Whaling Commission.

The probability of a collision between a cetacean and a vessel is related to the density of shipping traffic and cetacean density in the same area. The outcome of the collision is related to the size and speed of the vessel. The OSV/PSVs used during drilling operations are 97 m in length and travel at about 12 knots. The available data suggests that a cetacean would have in the region of a 50% chance of surviving a collision with such a vessel.

As shipping traffic increases and whale populations begin to recover from the impact of commercial whaling, the likelihood of collisions between cetaceans and shipping increases. Currently, this is a very much understudied area and research efforts have been focused on protecting 'Critically Endangered' species, such as northern right whale.

The conservation status and life history of large cetaceans mean that any collision that could result in mortality would have a moderate short-term impact on the species. For these reasons the sensitivity of large cetaceans is assessed as '**High**' and severity of collisions between ships and cetaceans has been assessed as '**Moderate**'.

Although the Rhea-1 drilling operations will increase shipping by about 6%, the total number of vessel visits to Berkeley Sound and Port William is relatively low (about 1,500 per year) when compared with ports elsewhere in the world. While collisions between cetaceans and shipping are often unreported or unobserved, the lack of recorded incidents and relatively low density of shipping suggest that this is not currently a major issue in the waters around the Falklands. The likelihood of a collision has been assessed as '**Remote**'.

The overall significance of collisions between vessels and cetaceans has been assessed as '**Moderate**' and measures will be put in place to reduce the risk. Data gaps exist regarding the inter-annual variation in density of marine mammals in the Falklands, and 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 assessment is '**Probable**'.

A number of common sense precautions should be taken to reduce the likeliness of collisions with cetaceans;

- Mariners should be made aware of the issue and how it relates to the Falkland Islands (see IFAW (2013) leaflet); and
- Along with the usual duties of a watch keeper, additional vigilance is required to detect cetaceans in inshore waters.

1.10.4 Introduction of marine invasive species by support or supply vessels

The IUCN has identified the introduction of non-native species as one of the major threats to native biological diversity. Island ecosystems are particularly vulnerable to the introduction of non-native species, as animals and plants may have evolved in the absence of competitors, predators or disease. If non-native species are introduced, and go on to survive, reproduce and thrive, they often have a major impact on native biodiversity and can also have a socio-economic impact. At this stage, the introduced species becomes invasive.

The nature of the impact of an invasive species depends on the species concerned and how it interacts with the local environment and species.

The nature of the marine environment makes it difficult to detect the introduction of non-native species before they have become established. Once established, marine invasive species are virtually impossible to remove. There are many examples from around the world where invasive species are having a dramatic impact. Recent dive surveys in Stanley Harbour have identified several invasive species but their impact appears to be minor at present.

The past history of a vessel and the similarity between the home and destination ports, in terms of water temperature and salinity, both influence the likelihood of a non-native species being introduced. For instance, vessels that are tied up in port will accumulate more biofouling organisms than a vessel that is active offshore. The identities of the vessels involved in the Rhea-1 drilling operations are known. Prior to arriving in the Falklands, their last ports of call were and Aberdeen or Cape Town.

In the marine environment, there are two main routes for non-native species introduction;

- Ballast water – ballast, in the form of seawater, is used to trim a vessel to improve stability. Ballast water will contain planktonic organisms; including larval stages and eggs. When ballast water is discharged, these organisms can be introduced to a 'new' environment.
- Biofouling – is the growth of marine organisms on the subsea surface of a vessel. In particular, semi-enclosed areas (such as sea chests) can harbour a diverse assemblage of encrusting organisms.

In recognition of this threat, there are International conventions and International Maritime Organisation (IMO) guidelines to prevent the spread of marine invasive species.

If invasive species were introduced during the drilling operations the impact on the benthic ecology of the Islands may not be evident for a number of years. The potential to have an impact on a regional scale and therefore the sensitivity of receptors has been assessed as '**High**'. The long-term implications for the Islands' ecology could be severe and irreversible. The severity of the impact will be species specific but following the precautionary principle (worst-case scenario) the severity has been assessed as '**Major**'.

There are International conventions regarding ballast water and biofouling management. Although the Falklands are currently not signatories, the vessels used during the drilling operations will follow the IMO's best practice guidelines. The IMO's guidelines on exchanging ballast water and managing biofouling organisms will greatly reduce the likelihood of introducing non-native species. Introduction of invasive species has happened in the Falklands, and by the industry elsewhere, and therefore the likelihood of invasive species becoming established as a result of the Rhea-1 drilling operations has been assessed as '**Remote**'.

The overall significance of the introduction of invasive species has been assessed as **'Moderate'** and measures will be put in place to reduce the significance, including;

- The use of the IMO guidelines during ballast water exchange by the rig, *Eirik Raude*, which will be carrying some ballast water while on passage to the Falklands;
- Completion of a second cleaning and survey of the *Eirik Raude* by divers prior to departing for the Falklands;
- The use of the IMO guidelines during ballast water exchange by all vessels entering Falklands waters
- Checks which will be made to ensure that the Biofouling Management Plans of all vessels involved in the campaign are up to date.

1.10.5 Disturbance to wildlife, livestock and the human population onshore from helicopter noise

Helicopters will be used throughout the drilling campaign to transport personnel between Stanley (and Mount Pleasant Complex, MPC) and the drilling rig. There is concern that overflying helicopters could cause disturbance to wildlife, the local community and livestock.

Three Sikorsky S92 helicopters will be used throughout the campaign. Flights will occur on a daily basis but multiple flights (five) will occur every two weeks to facilitate crew changes. If the same flight path is used, this has the potential to cause disturbance to wildlife, livestock and the human population of the Falklands.

Penguins appear to be particularly vulnerable to this type of disturbance, particularly when breeding or moulting. Disturbance of breeding birds could result in the loss of eggs or chicks to predators or crushing by panicked adults. When moulting, penguins are unable to enter the water to feed for about a month, this is energetically extremely demanding and any disturbance would place an additional burden on the animal's reserves. The most vulnerable species are king penguins, which breed year-round at Volunteer Point.

The helicopters will be based at Stanley Airport, which is approximately 3.5 km from the nearest residents of Stanley. There are, however, numerous Camp settlements that are potentially on the flight path between Stanley and the rig.

The positions of all vulnerable seabird colonies, NNRs, IBAs and Camp settlements are known and flight plans can be routed to avoid overflying these areas. When it is not possible to avoid an area completely minimum flight heights will be specified.

Due to the potential for chronic effects in small areas over the course of the campaign (scheduled August/September), the severity of helicopter over-flights on wildlife has been assessed as '**Moderate**'.

There are areas that are designated as NNRs close to the direct flight paths between the rig and Stanley or MPC: Kidney and Cochon Islands, Volunteer Point and Cow Bay, Cape Dolphin and Moss Side. Additionally, the north coast of East Falkland, known as Seal Bay, and Bertha's Beach, near MPC, are designated IBAs for their colonies of penguins. The national importance of these areas means that the sensitivity of the receptors is assessed as '**High**'. The overall significance of the potential disturbance caused by helicopters to local wildlife is '**Moderate**'. To mitigate this, specific flight paths will be planned to avoid sensitive areas. Where this is not possible a minimum flight height of 3,000 ft (900 m) will be required.

Following the austral winter, local farmers are concerned about the condition of their livestock and the likelihood of a poor lambing season (mid Sep - end Oct). The danger is one of mass panic by a corralled flock, which has been startled by aircraft noise (FILFH, 2014). Generally, 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, if animals were gathered in a confined space the impact would be more severe. Following the precautionary approach, the severity of helicopter disturbance on livestock is assessed as '**Moderate**', due to the small area that will be affected and short-term nature of the impact. Where animals are gathered, there is the potential to impact a high proportion of any one farms livestock, therefore, the sensitivity of receptors has been assessed as '**Moderate**'. Overall significance of the impact has been assessed as '**Moderate**'.

The impact of helicopter noise will be localised and short-term resulting in a barely detectable impact on the local population. The severity of the impact on Falklands' residents is therefore considered to be '**Minor**'.

The use of aircraft to transport passengers is an everyday occurrence in the Falklands so there is a degree of tolerance. Direct flight lines between the heliports and the drilling rig locations do not pass directly over settlements. The sensitivity of the local population to helicopter disturbance is assessed as '**Low**'. The overall significance of helicopter noise on the human population is '**Low**'. However, flight paths will be planned and reviewed to ensure minimal disturbance to the human population, along with wildlife and livestock.

The project activities are clearly defined and avoiding sensitive areas should be easily achievable. As such, confidence in the assessment is '**Certain**'.

1.10.6 Introduction of terrestrial invasive species with cargo imports

In the past, there have been numerous introductions of non-native terrestrial species into the Falkland Islands. There are numerous examples in the Islands where an invasive species has impacted upon socio-economic and biodiversity aspects on the Islands. For example, the invasion by the European earwig (*Forficula auricularia*) of Stanley is a timely reminder of the risks posed by non-native species. In recent years, there has been a concerted effort by the Falkland Islands Government (FIG) to reduce the risk of visitors to the Islands unintentionally introducing more non-native species and biosecurity procedures have been improved.

Any cargo arriving from outside the Islands during the Rhea-1 drilling operaitons poses a risk of unintentionally introducing non-native species. In this regard, the highest risks are invertebrates and seeds and soil (containing micro-organisms) that can adhere to the outside of containers or be hidden within cargo. During the previous round of exploratory drilling in 2011, fresh fruit and vegetables were imported into the Falkland Islands on the campaign charter flight. Whilst this was welcomed by local residents, it also represents one of the greatest risks of introducing non-native species either within the produce or in adhering soil or packaging.

While many species have been introduced in the past, quantifying the risk is not straight forward. It is likely that many cargos arriving in the Falklands are harbouring some non-native species, whether these are able to survive and breed to become invasive depends on the species concerned and whether they find a niche to exploit in the Falklands. Therefore, the impact of any introduction should be assessed on a case-by-case basis.

The long-term implications for the Islands could be severe and difficult to reverse; the severity is assessed as '**Major**'. In the terrestrial environment the possibility of detecting potential invasive species and eradication, thereby reversing the effect, is easier than in the marine environment, on this basis the sensitivity has been assessed as '**Moderate**'.

The transportation of invasive species to the Falklands has happened in recent years. Additionally, the introduction of invasive species has happened in the industry elsewhere in the world and therefore the likelihood of invasive species becoming established as a result of the drilling campaign has been assessed as '**Possible**'. The overall significance of the impact is assessed as '**Moderate**' and measures will be taken to reduce the potential impact. Confidence in the assessment is assessed as '**Probable**'.

The best means of reducing the likelihood of introducing non-native species is to ensure that all materials are clean when packed or loaded in the port of origin, particularly items of fresh fruit and vegetables.

- All NEFL personnel should be briefed on the significance of non-native species and instructed to capture/kill any invertebrates that are found while unloading/unpacking cargo.
- Cargo should be clean when packed and sealed in invertebrate proof packaging, where appropriate.
- Falkland Islands Biosecurity Guidelines will be adhered to for any freight imported via the charter flight.

On arrival in the Falkland Islands, cargo will be inspected for biosecurity breaches. Any breaches should be reported to the FIG Biosecurity Officer.

1.10.7 Disturbance to Stanley Residents and Wildlife from Inshore and Onshore Light and Noise Sources

The primary sources of onshore and inshore light and noise are the TDF and laydown yards which will occasionally be floodlit to enable safe working and management of cargo. Prior to construction of the TDF, an EIA, and associated modelling, was completed to cover the construction, operation and decommissioning stages (NEFL/RPS, 2013). The findings of that assessment with regard to the impact of light and noise sources are discussed and updated in line with activities specific to the Rhea-1 drilling operations.

Activity on the TDF could occur 24 hours a day, seven days a week such that there could be a visual impact during night-time hours. The most significant noise generating sources and activities during operations are considered to be:

- Vessel arrival / departure during drilling programme, typically vessels 5,000 to 10,000 brake horsepower; and
- Vessel loading / unloading using a 250-tonne crane, a 30-tonne crane; and a 15-tonne forklift.

The potential receptors to light and noise disturbance are;

- The residents of Stanley;
- FIG Air Service (FIGAS) pilots; and
- Local wildlife.

Light and Stanley Residents

Light spillage towards Stanley will be minimised, given the orientation of the lights and attenuation with distance. In addition, the lighting is unlikely to add significantly to the light emitted by FIPASS and will be of a similar nature to that already employed there. The impact will be localised and short-term and therefore the severity is assessed as '**Minor**'. The sensitivity of Stanley residents is assessed as '**Low**' as they are already subjected to artificial light from FIPASS and from within the town. Overall the significance of the laydown yard lighting on the residents of Stanley is assessed as '**Low**' and no mitigation measures are proposed.

Light and FIGAS Pilots

The main deck lights of vessels alongside the TDF will face east, towards Stanley airport. Although lights are downwards facing this has the potential to temporarily interfere with the night vision of pilots and the severity is assessed as '**Moderate**'. The potential for disruption to night flights from Stanley Airport is clearly of concern to stakeholders. Therefore, without mitigation, the sensitivity of FIGAS pilots is assessed as '**Moderate**'. The overall significance of laydown yard lighting on FIGAS pilots is assessed as '**Moderate**'. Mitigation measures proposed, or already implemented, to reduce the impact includes;

- All lamp units, with the exception of those required for safety and navigation aids, will be pointed in-board towards the causeway and barge, to reduce potential light pollution to local residents in Stanley;
- The TDF and laydown yard permanent lighting was designed and implemented in accordance with the Health and Safety in Ports (SIP009) Guidance on Lighting. This is a document jointly prepared by Port Skills and Safety with assistance from the UK Health & Safety Executive (HSE). This ensures that the artificial lighting used does not generate light spill or reflection that could be a possible nuisance to local residents or attract wildlife; and
- Ongoing consultation with FIGAS to ensure that the lighting design minimises any potential issues related to the operations of flights in and out of Stanley Airport.

Light and Local Wildlife

The impact resulting from the drilling operations will be localised and short-term and in the context of current ambient light levels will have a barely detectable impact on the species concerned e.g. sooty shearwaters, therefore the severity of the impact has been assessed as '**Minor**'.

The nearest breeding colonies of such species are not in direct line of sight of the TDF and laydown yard and most of the drilling activity will be outside the breeding season. The sensitivity of receptors has been assessed as '**Low'**. The significance of the impact of laydown yard lighting on local wildlife is assessed as '**Low**' and no mitigation measures are proposed.

Noise and Environmental Receptors

The magnitude of noise impact during loading and unloading at the TDF and laydown yard during a calm and dry night for which there is a light easterly wind (worst-case scenario) is considered to be barely detectable and unlikely to cause any potential impact to local residents (NEFL/RPS, 2013). The predominant wind direction is westerly so these conditions occur for a minority of the time. Consultations with local residents indicated that this assessment was overly optimistic. The severity of the impact is therefore assessed as '**Minor**' and the sensitivity of receptors is '**Low**'.

The significance of noise has been assessed as '**Low**'; however, the following measures will further reduce the impact on Stanley residents and local wildlife.

- Vessel movements will be reduced where possible through optimised planning, making efficient use of vessel loads;
- All vessel engines shall be switched off whilst not in use and not left to idle, where possible; and
- Loading or unloading operations at night shall not normally occur and if necessary will be minimised where practicable.

This assessment relies largely on the EIA, and associated modelling, that was presented prior to the construction of the TDF (NEFL/RPS, 2013). The TDF and laydown yard add to existing sources of light and noise in the industrialised area to the east of Stanley and therefore the nature of the impact is well understood. However, a degree of monitoring is required to ensure that artificial lights do not interfere with FIGAS flights or local wildlife. Therefore the confidence in the above assessments of light and noise is '**Probable**'.

1.10.8 Demands for Accommodation in Stanley.

Throughout the Rhea-1 drilling operations, it is anticipated that approximately 85 additional personnel (representing, NEFL, third parties and stand-by crew) will be based in Stanley. The majority of personnel will be based offshore but will pass through Stanley during crew changes. During previous exploration campaigns, personnel have been accommodated in local hotels, guesthouses or rental property. However, there is a limit to the number of available beds and properties in Stanley and therefore a purpose built temporary accommodation unit has been constructed to accommodate the majority of these personnel during the 2015 campaign. The temporary accommodation unit has the capacity to house up to 160 workers, which would be the case in the event that all workers were evacuated from the rig, i.e. it was 'down-manned'.

A small number of additional shore based personnel (five individuals) will be working in Stanley during the Rhea-1 operations. These personnel will be based in local rented accommodation, and will consequently add some pressure to the local housing market.

At the time of writing, construction of the temporary accommodation unit has been completed and it is in use.

1.11 Waste Management

All industrial waste falls under the category of 'controlled waste' and thus has to be accounted for and recovered or disposed of in a safe and environmentally responsible way. The discharge of waste to sea is prohibited with the exception of certain discharges which are permitted under international law and the majority of waste must be transferred to shore. Once ashore, modern disposal and recycling techniques can be employed to minimize the impact of waste on the environment, however, waste disposal options in the Falkland Islands are limited.

A range of hazardous and non-hazardous controlled waste will be produced during the Rhea-1 well operation. These can be broadly categorized as:

- Galley and domestic waste (e.g. blackwater (sewage), grey water (water from domestic use) and galley food waste)
- Non-hazardous waste (e.g. paper, packaging, scrap metal)
- Hazardous waste (e.g. empty chemical drums, oily rags, waste oil, oily water (drainage and bilge water) etc.)

Given the limited waste management facilities in the Falklands, NEFL has developed a waste management plan (WMPA) specific to exploratory drilling operations in the Falkland Islands to ensure that all waste is processed, stored, transported and disposed of responsibly. International legislation (notably MARPOL) and the 'Duty of Care' principle outlined in the UK's Environmental Protection Act 1990 guide much of the NEFL WMPA.

During the Rhea-1 well operation, black water, grey water and galley food waste will be treated and discharged to sea in accordance with MARPOL and rig/vessel procedures. Solid waste (sewage and food) will be macerated before being discharged, to achieve no floating solids and no discolouration of surrounding water as per MARPOL requirements. The discharge point is 12.5 m below the surface of the water. The discharge of black water, grey water and food may lead to localised nutrient enrichment; however, the dynamic nature of the offshore environment will rapidly disperse the additional nutrients with little impact on water quality. Additionally, the activity of bacteria and other marine organisms will rapidly break down organic waste. The assessment indicates that there is no significant impact on the marine environment from the planned discharges at-sea.

Deck drainage water and vessel bilge water will be discharged via an oil separator designed to remove any contaminants that may have been picked-up from the deck or bilge. Drainage and bilge water discharges will only occur when the oil in water content is below 15 parts per million; in compliance with MARPOL and rig/vessel procedures. While seabirds may potentially be affected by surface oil sheens, at a concentration of 15 ppm, oil does not create a sheen on the water surface and hence birds do not become oiled (Wiese, 2002). Whether oil at this concentration still has the potential to damage other marine organisms is not known. Nonetheless, wave action will help to dilute and disperse any oil entering the sea.

All other waste will be categorized and segregated, stored securely and transported to the supply base in Stanley for storage prior to onward processing. The majority of waste will be shipped back to the UK for recovery or disposal. In agreement with FIG, combustible non-hazardous wastes will be disposed of via the incinerator on the Falklands with waste ash deposited to landfill (e.g. Eliza Cove). NEFL has committed not to add any waste directly to the landfilled waste at Eliza Cove or Mary Hill Quarry. Waste oil will either be shipped to the UK or provided to the local community for use on oil burners in agreement with FIG.

The quantities of other waste products produced during the Rhea-1 drilling operations have been estimated from the amount of waste generated in previous exploratory drilling campaigns. All waste will be handled, transported and processed of in accordance with the WMPA and waste production will be minimised by implementation of the Waste Hierarchy thus minimising the impact of waste. Each stream will be stored separately in appropriate containers thus minimising the likelihood, and thus the risk, of loss of waste while in transit or storage. The provision of hard-standing and bunding within waste storage areas will contain hazardous materials in the event of an accidental release thus enabling rapid on-site clean-up and minimizing impact on the environment or human health.

With the appropriate waste handling and storage protocols in place, the impact of waste and the risk of the accidental release of hazardous waste into the environment is not anticipated to be an issue.

1.12 Discharge of Drilling Mud and Cuttings

A combination of seawater and water base muds (WBM) (an aqueous suspension of clay or other viscosifiers such as bentonite) will be used during the drilling operations to lubricate the drill bit and to return the rock cuttings from the wellbore bore back to the surface. The mud and cuttings will eventually be discharged to sea at the Rhea-1 well site. The majority of chemicals planned for use within the WBM system are considered to Pose Little or No Risk, known as PLONOR chemicals.

During drilling of the top two sections of the well, drill cuttings will be discharged directly onto the seabed. When drilling the third and fourth sections of the well, the mud and cuttings will be returned to the rig through a riser pipe and will be discharged near the sea surface.

Discharges of WBM and drill cuttings results in the suspension of particulates in the water column, which may affect the local water quality and the plankton and fish species living within it. Affects may result from increased turbidity which reduces light levels to particulates which may cause physical damage to gill structures. Deposition of the discharged material on the seabed, affects the sediment quality through change in particle size, which also leads to habitat modification for animals living on the seabed. Where deposition thickness exceeds 6.5mm this may lead to smothering of sessile organisms and particle overloading of suspension feeders.

The predicted impact of the discharge of mud and cuttings was estimated using the DREAM/ParTrack model, developed by SINTEF (Stiftelsen for industriell og teknisk forskning – The Foundation for Scientific and Industrial Research) in Norway. This model calculates the dispersion and deposition of drilling muds and cuttings on the seabed, and the dispersion of chemicals and particles in the water column (Genesis, 2015a). The ParTrack model predicted environmental risk to the sediment due to cuttings deposition persisting for approximately four years post drilling, with effect remaining relatively localised within 45 m of each well. Effects relating to changes in sediment grain size were predicted to account for the majority of environmental risk to the sediment, with effects persisting for at least four years and affecting an area of 0.185km^2. Risk to the water column was primarily due to dissolved components and was predicted to extend further than risks to the seabed, affecting a maximum volume of approximately 0.0648 km^3 when discharged from the 26″ tophole section. However, the effects will be very short-term with risk falling to acceptable levels within several hours of each discharge as particles are dispersed by the currents. The impacts to each environmental receptor are discussed below:

- Seabed Sediment - The severity of the impact to sediment quality is assessed as '**Moderate**' having an effect over a relatively small area, but that will persist for at least ten years. The sensitivity is assessed as '**Very Low**' as the habitat is undesignated and widespread. The overall significance is '**Low**'.
- Water Quality - The increase in turbidity will reduce water quality in a small volume of water in surface waters and near the seabed. The operations will be of short duration with recovery occurring within hours hence the severity of impact to the water column was assessed as '**Minor**' and the sensitivity as **'Very Low'** given that the area of affected water column is not very productive in the austral winter. The overall significance is **'Low'**.
- Phytoplankton and Zooplankton - The increase in turbidity will affect a very small volume in the upper water column and is predicted to recover within hours, consequently the severity to plankton is assessed as '**Minor**', and the receptor of '**Low**' sensitivity as species are widely distributed throughout the water column. The overall significance is '**Low**'.
- Benthic Fauna - Some organisms close to the well will be buried with re-colonisation commencing within 1-2 years of the end of cuttings discharge. Modification of sediment grain size will account for the greatest percentage of environmental risk and could affect the community structure for at least ten years. Consequently the severity of the impact to the benthic fauna is assessed to be '**Moderate**' and the sensitivity to be '**Moderate**' taking a precautionary approach as no site specific surveys have yet been conducted. The overall significance is '**Moderate**'.
- Fish and fisheries – Based on the absence of spawning commercial fish species on the Northern Slope, which are the most sensitive life stage; the relatively localised area of effect; short-term impact and reversibility of the effect the severity is assessed as '**Minor**'. The sensitivity of fish and fisheries is assessed as '**Low**', due to the mobile nature and very small proportion of any species population that would be affected. The overall significance is '**Low**'.

The pre-mitigation significance of cuttings discharge is assessed as '**Moderate**' for Benthic Fauna. This is a prcautionary assessment due to the lack of benthic survey data. Pre-drilling surveys will help to determine the habitat type and species present at the drill site. With this information, the sensitivity and severity of the impact, and therefore significance, are likely to be down-graded.

1.13 Accidental Events

The following accidental events were identified during the Environmental Impact and Risk Identification (ENVID) process:

- Emergency situation leading to a significant loss of containment or an uncontrolled release;
- Accidental loss of containment during operations leading to small diesel or chemical spills;
- Major rig incident resulting in loss of rig;
- Major vessel incident resulting in a collision with rig or another vessel;
- Loss of containment of drilling mud from riser due to rig failing to maintain station.

1.13.1 Emergency Situation Leading to a Significant Loss of Containment, an Uncontrolled Release or Blow-out

There are two main control measures that prevent the uncontrolled release of hydrocarbons during drilling, primary (maintaining hydrostatic pressure in the wellbore) and secondary (a blow-out-preventer (BOP) installed on the wellhead). In the unlikely event that both primary and secondary well controls fail, an uncontrolled release can occur.

A large scale uncontrolled release/blow-out would have far reaching impacts on the marine, and potentially terrestrial, environment. To investigate the potential impact, an oil spill scenario in which 1,163 barrels (163.2 tonnes) per day for 15 days from Rhea-1 well site was modelled by Genesis (2015b). Modelling was conducted using the Oil Spill Contingency and Response (OSCAR) model developed by SINTEF. Two different types of oil with different properties were adopted for the blow-out modelling to account for the unknown nature of the crude at the Rhea-1 well at this stage of the exploration programme. The first type was based on the characteristics of Sea Lion crude, which is extremely waxy crude; the second was based on the characteristics of Ekofisk crude, which is a typical light volatile crude. The scenario chosen in this assessment represents the worst-case conditions and the maximum spill possible for the Rhea-1 well. The likelihood of a blow-out occurring has been assessed as '**Remote**', it has happened in the industry but on extremely rare occasions.

The environmental impact would affect a wide range of environmental receptors. The severity of impact to each environmental receptor will be different and dependent on the environmental conditions, and subsequent dispersion of oil, experienced in the weeks following any spill. The severity of the impact on each receptor is discussed below;

- Plankton - The results of the model predict that the Sea Lion crude will spread as waxy droplets under the influence of wind and currents, primarily in the surface layers of water. The Ekofisk crude will create a visible sheen spreading to the north, the area of predicted surface coverage is less than that of the Sea Lion crude due to the latter forming persistent waxlets. This zone is occupied by planktonic organisms and therefore the severity of the impact on plankton was assessed as '**Moderate**'.
- Benthic Fauna – A small quantity of wax and oil will settle to the seabed about 50 days after the start of the uncontrolled release, with much lower proportion of the lighter crude ending up in the sediments. At this stage the wax will continue to slowly degrade but with unknown long-term consequences for benthic fauna. Therefore the severity of the impact has been assessed as '**Major**'.
- Seabirds – Due to the spatial extent of the slick (potentially covering important seabird foraging areas) and the potential for chronic impacts on reproductive biology in long lived late reproducing species, the severity of the impact on seabirds is assessed as '**Major**'.
- Marine Mammals - The severity of the impact on marine mammals was assessed as '**Moderate**' because the waxy nature of the Sea Lion crude will mean a lower exposure to volatile and toxic components than the Ekofisk crude.
- Fish and Fisheries - The model predicts that a slick would overlap with major fishing grounds, affecting different fisheries depending on the time of the year. An uncontrolled release might result in the closure of the fishing grounds due potential tainting and contamination. For fish and fisheries the severity of the impact is assessed as '**Major**'.
- Northern Coastline - The model predicts that there would be a <5% chance of wax reaching the north coast of the Falklands whereas the lighter Ekofisk crude is not predicted to reach any coastline. By the time the wax reaches the coast, it will be much dispersed and in the form of small waxy droplets. As there is still some uncertainly over the longer term chronic impacts on this environment, the severity of the impact on the coastal environment is assessed as '**Moderate**'.
- Tourism - It is likely that a major loss of containment/blow-out and the media attention that such an event would generate would have long lasting negative impacts on tourism due to the perceived environmental degradation. The severity of this impact is assessed as '**Major**'.

Taking all of the potential receptors into account, the overall impact severity of a major loss of containment on the NFB ecosystem would be '**Major**'. However, there are many unknowns in the model and the impact on environmental receptors. Although the impact may have serious multi-year consequences for the ecosystem of the NFB, this impact would be reversible. Seabirds were assessed as the most sensitive receptor, due to the internationally important populations of birds that feed to the north of the Falklands. Sensitivity is assessed as '**Very High**' for seabirds. The likelihood of the impact occurring is '**Remote**', and hence the overall significance of the impact is '**Moderate**'.

There is a discernible risk to the environment; however, a number of measures to manage the risk are built into standard operational controls (such as the use of a BOP). Nonetheless, NEFL have produced a Rhea-1 specific Oil Spill Response Plan (OSRP). If a spill occurred, tiered responses would be initiated, proportional to the spill. Key aspects of the response would be;

- Well intervention operations – these are means of stopping the flow of oil and could include the drilling of a relief well or the use of a subsea capping device;
- Surveillance - it is vital to track the progress of any spill with the aid of aerial surveys and tracking buoys;
- Dispersants - it is unlikely that dispersants would be effective on oil with a high wax content, like Sea Lion crude, and they are unlikely to be used, although they will be available in field in case hydrocarbons encountered are not as anticipated;
- Containment and recovery – under suitable weather conditions, booms and skimming devices can be used to recover oil at sea. The supply vessels will be appropriately equipped to undertake this;
- Shoreline clean-up – an assessment of the sensitivity has been undertaken to prioritise sites in the event oil approaches the coastline (Premier Oil, 2014);
- Wildlife rescue and rehabilitation – specific response equipment to support wildlife rescue and rehabilitation will be available for the campaign.

With the measures outlined above in place, it is not possible to reduce the likelihood of an uncontrolled release any further; however, in the unlikely event that a spill does occur, implementation of the OSRP will reduce the severity of the impact on the marine environment.

1.13.2 Accidental Loss of Containment During Operations Leading to Diesel or Chemical Spills

Diesel fuel will be used to power the rig and all vessels involved in the drilling campaign. Large quantities have to be transferred and stored and accidental events could result in diesel spills. To investigate the likely behaviour of spilt diesel, two scenarios covering worst-case conditions were modelled;

- Scenario 1: Loss of containment during fuel/chemical transfer resulting in 30 tonnes of spilt diesel; and
- Scenario 2: Major loss of containment leading to the loss of the entire rig inventory of diesel (over 4,000 tonnes).

The OSCAR model that was used to describe the behaviour of crude oil following an uncontrolled release/blow-out was also used to characterise the behaviour of offshore diesel spills, using the same environmental parameters.

Modelling results indicated that diesel fuel is rapidly dispersed but its volatile nature makes it more toxic than heavier crude oils. The areas of significant impact would occur over a relatively small area close to the spill site and within the surface layers of the sea. Potential receptors are plankton, fish and squid, seabirds and marine mammals.

The size of the spill does not necessarily relate directly to the magnitude of the impact, the impact is determined by how many receptors are exposed to the pollutant. Seasonal variations in the distribution of receptors may influence the scale of the impact as much as the size of the spill, although smaller spills will disperse more rapidly. However, it is likely that the presence of the rig will act as a focal point for marine animals and therefore the greatest impact is likely to be close to the rig.

- Plankton – In both scenarios the diesel remains on or close to the surface of the water throughout the course of the model. Planktonic organisms will be contaminated over a small area for a short period of time and the severity is therefore considered to be '**Minor**'.
- Fish, Squid and fisheries – As both scenarios are short lived and localised also only small concentrations will enter the water column, the severity is assessed as '**Minor**'.
- Seabirds, Scenario 1 – As diesel will only be on the surface for a matter of hours the impact is short-lived and localised. However, the presence of the rig is likely to attract birds and it is these animals that are at greatest risk of suffering from the chronic impact of small scale leaks and spills and loss of containment events. The severity of scenario 1 to seabirds is assessed as '**Moderate**'.
  Scenario 2 – A far larger diesel spill, indicates that diesel will be on the surface for longer and will spread over a larger area. The potential impact increases in proportion to the size of the spill. Nonetheless, the area covered by the spill is still relatively small (on the scale of the NFB), the slick will be short-lived and any species of seabird impacted would recover relatively rapidly, hence the severity of the impact is assessed as '**Moderate**'.
  Seabirds were assessed as the most sensitive receptor, due to the internationally important populations of birds that feed to the north of the Falklands. Sensitivity is assessed as '**Very High**' for seabirds.
- Marine Mammals – Scenario 1 –. 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. As cetaceans are more vulnerable to inhaling toxic vapour than to contact with skin, the short duration of the spill in surface water means the severity is assessed as '**Minor**'.
  Scenario 2 – The potential impact from a larger spill increases. However, large diesel spills are short-lived and localised and the likelihood of marine mammals being exposed and suffering serious adverse effects is low, therefore the severity is '**Minor**'.
- Coastal Impact – In both scenarios the diesel evaporates quickly biodegrades or is dispersed in the water column, none of the diesel is transported to the coast, therefore the severity is assessed as '**Slight**'.

In order to assess the significance of these events, the likelihood of each scenario occurring has to be considered. Minor spills do occur in the oil and gas industry, however, the quantities involved are usually far smaller (< one tonne) than that modelled in Scenario 1. The likelihood of small spills is assessed as '**Rare**'. Scenario 2 would be far less likely and the likelihood is assessed as '**Remote**'. Although on the scale used in this EIA the significance of Scenario 1 is '**Moderate**' for all receptors, except the coast, and '**Moderate**' in Scenario 2 for seabirds and '**Low**' for all other receptors. Therefore, the greater likelihood of a smaller spill indicates that these are more significant events.

Preventative measures will be in place to minimise the likelihood, and therefore the risk, of all accidental events. Those specific to reducing the risk or severity of small diesel spills are:

- Operating equipment within specified safe limits;
- Conducting maintenance and inspection routines on time and diligently;
- Investigating all leaks to determine root causes and take action to prevent reoccurrence;
- Ensuring that all pipe-work is isolated, drained and purged as required by the permit to work before breaking containment; and
- All hoses used to transfer diesel oil will be fitted with dry-break couplings, which will seal the end of the hose in the event of the hose becoming accidentally disconnected and limit the amount discharged.

In Scenario 2, the most likely cause of a complete loss of diesel inventory is a collision with another vessel. The following preventative measures will be in place to minimise the likelihood, and therefore the risk, of vessel collisions:

- A 500 m radius exclusion zone will be established around the rig;

- A ERRV will be on permanent standby to ensure the exclusion zone is maintained, and assist in the event of accidental events;
- Automatic Identification System (AIS) and radar will monitor vessel traffic in the area; and
- Security radio broadcasts will warn all sea users of the rig's position.

There is little more that can be done to prevent, or reduce the likelihood of, these events occurring and therefore an OSRP is required to mitigate against the severity of the impact on the marine environment in the event that a spill occurs. By way of mitigative control, all, support vessels will be equipped with oil spill response equipment to respond appropriately to all credible scenarios.

The volatile nature of diesel fuel means that any spill will rapidly evaporate, disperse and biodegrade, the impact will be localised and short-lived. The impact will depend on the density of environmental receptors in the immediate vicinity of the rig, which is not possible to predict. The rig itself will influence the distribution of seabirds and may also influence the distribution of marine mammals and their prey. The confidence in the impact assessment of diesel spills on the marine environment is therefore **'Probable'**.

1.13.3 Loss of Containment of Drilling Mud from Riser due to Rig Failing to Maintain Station.

Damage to the riser (the tube connecting the rig to the wellhead) during drilling operations could result in a loss of the drilling mud and cuttings within the riser, this can happen in the event that the drilling rig loses station in an emergency situation. Reasons for loss of station include: failure of position references, operator error, thruster failure and DP computer failure. The environment could also be a factor especially in extreme weather conditions.

The loss of drilling mud would impact the water column and the seabed. Potential environmental receptors are:

- Seabed Sediment – discharge direct to the seabed and settlement of particles through the water column will impact sediment chemistry and particle size over the affected area;
- Water Quality – suspension of mud and cuttings in the water column as well as discharge to surface waters will impact water chemistry and turbidity;
- Phytoplankton and Zooplankton – organisms with limited mobility will be impacted by changes in local water quality;
- Benthic Organisms – discharge of drill cuttings and mud affects benthic organisms through direct burial, habitat change and sediment suspension at the seabed; and
- Fish – mobile species such as fish may be affected if drilling coincides with certain life history stages such as spawning periods and juvenile stages when they inhabit particular spawning or nursery grounds, or if it coincides with productive feeding season and feeding grounds.

The mud used during the drilling campaign will be Water Based Mud (WBM). The impact of the loss of WBM contained within the riser was modelled using the same DREAM/ParTrack model, used to assess the impact of discharging drill cuttings and mud during drilling operations (Genesis, 2015a). The scenario for the release of WBM following a ruptured riser is based on release quantity of 100 m^3 over one minute and the simulated duration was over one day.

WBM contains a number of chemical additives, most of which Pose Little Or No Risk (PLONOR) to the environment. In addition to chemicals, the muds contain Barite which due to the angular nature of the particles can damage the gills of marine organisms.

Any impact from the WBM released would be extremely localised and short-term. There is no significant effect on grain size, deposition thickness averages 0.005 mm and particles settle to the seabed within five minutes. The severity of the impact on plankton, fish, water quality, sediments and benthic organisms is assessed as '**Minor**'. Any impact would influence a small proportion of the available habitat or proportion of populations, sensitivity was assessed as '**Low**'. The likelihood of a loss of mud containment due to a loss of station is assessed as '**Remote**' and the overall significance of the event would be is '**Low**'.

However, the loss of station is clearly undesirable and a number of preventative controls will be in place to reduce the likelihood, and thus the risk, of loss of station and loss of containment within the riser:

- Redundancy is designed to ensure that DP related equipment are always available;
- DP trials on the rig will be undertaken when the rig reaches location and before operations commence;
- An exclusion zone of 500 m, guard vessel, radar, AIS and radio broadcasts to reduce the probability of vessel collision;
- Iceberg collision. Work to date shows that the risk of significant icebergs in the exploration drilling area is low. However, NEFL will have an ice management plan in place for the duration of the drilling campaign; and
- Continual monitoring of long-range and short-range weather forecasts, so that if storm conditions are predicted to exceed the safe weather conditions for the rig, a controlled containment and release from the wellhead could be performed if required.

1.14 Environmental Management

Through a systematic evaluation of the proposed Rhea-1 exploration drilling operations project related activities and their interactions with the environment, a variety of potential sources of impact were identified. The majority of activities were of limited extent and duration and deemed minor.

Those activities that were identified as being of potentially greater concern were assessed further in the main risk assessment chapters. A number of environmental management actions and operational controls were identified for consideration during final project planning and execution. NEFL will manage these actions within the framework of its project specific Environmental Management Plan (EMP) and its GMS. Specific management actions identified in the EIS (primarily in the context of impact/risk management and effects mitigation and monitoring), will thus be taken forward into detailed planning and through the project execution phase.

1.15 Conclusion

The overall conclusion of the EIA is that with the implementation of the proposed prevention and mitigation controls, the proposed exploration campaign will not result in any significant adverse effects on the physical, social or biological environment.

Table 2: Summary of Impact and Risk Assessment Process and Outcomes

Aspect	Source	Activity Description	Potential Effects and Significance	Legislation/NEFL policy/Mitigation	Residual Impact / Concern
All Aspects	Generation of atmospheric emissions from vessel movements, drilling	Combustion of fuel contributing to greenhouse gases (direct CO_2, CH_4, N_2O, indirect NOx, SO_2, CO, VOCs); local air quality (via photochemical pollution formation (NO_X, SO_2, VOCs)); and ocean acidification (CO_2)	Total greenhouse gases generated from the campaign would be ~0.01% of total UK emissions. The offshore conditions in the North Falkland Basin would rapidly dissipate any effects on air quality, which would be temporary and localised. CO_2 generated during the campaign would have a negligible effect on the oceans pH. Severity: Slight; Sensitivity: Very Low; Significance: LOW; Certainty: Certain	All vessels used during the campign will comply with MARPOL and the Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2008, which controls the levels of pollutants entering the atmosphere. Vessel will be audited. Well schedules will be optimised to minimise time drilling.	Low
Rig and Vessel operations	Underwater noise from rig and vessel movements, drilling and VSP	Vessel activities produce predominantly low frequency (<1,000 Hz) continuous sounds that are less than 190 dB re.1μPa at source. VSP airguns produce high intensity (230-240 dB re.1μPa), low frequency (10-150 Hz) pulsed sounds.	Marine mammals are considered to be of the greatest conservation concern in relation to underwater noise pollution, they are protected species that are known to use sound to communicate over large distances, navigate and detect potential prey or predators. Marine animals within 100 m of the airgun could experience hearing loss, which in terms of the North Falkland Basin is a very localised area. Severity: Moderate; Sensitivity: High; Significance: MODERATE; Certainty: Probable	JNCC guidance will be followed, marine mammal observers will be deployed to search for marine mammals within a mitigation zone (500 m radius) for a period of 60 minutes prior to firing of airguns, soft-start procedures will be followed and VSP activity will commence during daylight hours. Sources of man-made noise will be quantified with acoustic equipment to inform future EIAs	Moderate

Aspect	Source	Activity Description	Potential Effects and Significance	Severity	Sensitivity	Significance	Certainty	Legislation/NEFL policy/Mitigation	Residual Impact / Concern
Rig and Vessel operations	Placement of rig clump weight on the seabed	A clump weight is a relatively small (465 kg) weight that sits on the seabed and is connected to the rig by a tension wire. This system is used to automatically maintain the rig's position.	The deployment of a clump weight will cause a degree of disturbance to the seabed. This represents such a small area it was regarded as insignificant.	Slight	Very Low	LOW	Certain	A Longbase Line (LBL) system will be used, which relies on the accurate positioning of transponders. This also minimises disturbance on the sea bed.	Low
Rig and Vessel operations	Physical presence of rig	The presence of the rig and its 500 m radius exclusion zone could potentially interfere with commercial fishing or shipping.	All vessels will be excluded from a 500 m radius of the rig. This will cause virtually no impact as the well locations are not on busy shipping lanes or fishing grounds.	Slight	Very Low	LOW	Certain	All vessels in the area will be informed of the rig's position and intentions by radio broadcast and AIS, which will allow vessels to reroute with minimal disruption. An ERRV will be present in the field during drilling operations and will enforce the 500m exclusion zone.	Low
Rig and Vessel operations. Drilling operations	Generation of artifical light on rig and support vessels	Attraction of marine life, e.g. plankton, fish, squid and seabirds to artifical light offshore. Subsequent collision risk for seabirds with the rig or vessels.	Impact on zooplankton, fish and squid very small and localised - minor severity. Impact on seabirds localised and short-term, less than 1% of the local population at risk	Minor	Low	LOW	Probable	The use of blackout blinds/curtains will eliminate light from living spaces. The majority of lights on the rig will be directed inwards to allow safe working conditions, however, outward facing lights are necessary for navigation and safety. Implementation of NEFL's Bird Strike Management Plan (BSMP). All lights that do not need to be on will be turned off at night.	Low

Aspect	Source	Activity Description	Potential Effects and Significance				Legislation/NEFL policy/Mitigation	Residual Impact / Concern
Rig and Vessel operations	Discharges of vessel drainage, firewater, sewage and galley waste from rig and vessels	Release of contaminants leading to deterioration in seawater quality and localised increase in Biological Oxygen Demand (BOD) around the discharge point	Impact on water quality, plankton, fish and squid will be very small, localised and temporary.				Sewage will be treated prior to disposal at sea. Vessels will be audited to ensure compliance. Food waste will be macerated as required by MARPOL and The Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008. Rig/vessel MARPOL compliance audits will be carried out. Implementation of NEFL's Offshore Discharge Program (ODPO).	Low
			Severity	Sensitivity	Significance	Certainty		
			Slight	Very Low	LOW	Certain		
Rig and Vessel operations	Discharge of closed drains following separation, and firewater foam to sea during system test	Release of contaminants leading to deterioration in seawater quality and localised increase in BOD around the discharge point	Impact on water quality, plankton, fish and squid will be very small, localised and temporary.				Main deck, helideck, machinery spaces drainage routes to the closed drains. Drainage water is treated to remove oil content down to 15 ppm of oil concentration prior to discharge in accordance with MARPOL 73/78 Annex I requirements. Rig/vessel MARPOL compliance audits will be carried out. Implementation of NEFL's ODPO.	Low
			Severity	Sensitivity	Significance	Certainty		
			Slight	Very Low	LOW	Certain		

Aspect	Source	Activity Description	Potential Effects and Significance				Legislation/NEFL policy/Mitigation	Residual Impact / Concern
Drilling operations	Discharge of drill cuttings, WBM, cement and chemicals, to marine environment	Increased turbidity in the water column, sedimentation leading to smothering of benthic organisms, modification of sediment particle size and habitat.	Discharges would impact small areas of seabed and small volume of water relative to the available habitat on the Northern Slope. Impacts would be short term, with potential for rapid recovery. Modification of sedments would persist for over 10 years in a very small area. The significance of the impact on all environmental receptors was assessed to be Low except for 'Benthic Fauna'. The significance of the impact on 'Benthic Fauna; was assessed as Moderate (see below).				Drilling fluids will be recirculated and cuttings separated from the mud for re-use of the mud to minimise discharges. The majority of WBM chemicals will Pose Little Or NO Risk (PLONOR) to the environment, where safety or operational criteria dictates non-PLONOR chemcials use will be monitored and minised. ROV surveys of the proposed drilling location for the Rhea-1 well will be conducted prior to commencing drilling activities. Should any sensitive habitats or species be identified, DMR will be notified and agreement to move the well location will be sought. Sediment traps will be deployed around the drilling location during operations to assess and validate the model sedimentation predictions. Implementation of NEFL's ODPO.	Low
			Severity	Sensitivity	Significance	Certainty		
			Moderate	Moderate	MODERATE	Probable		

<table>
<tr><th>Aspect</th><th>Source</th><th>Activity Description</th><th colspan="4">Potential Effects and Significance</th><th>Legislation/NEFL policy/Mitigation</th><th>Residual Impact / Concern</th></tr>
<tr><td rowspan="3">Drilling operations</td><td rowspan="3">Generation of non-hazardous and hazardous waste for disposal in UK/FI</td><td rowspan="3">Use of landfill resource in the UK.</td><td colspan="4">The majority of waste generated during the campaign will be transported back to the UK in the returning coaster vessels for landfill in the UK.</td><td rowspan="3">Small quantities of waste may be disposed of in the Falkland Islands, in line with NEFL's WMPA, and will not include direct disposal of waste to Eliza Cove or Mary Hill Quarry.</td><td rowspan="3">Low</td></tr>
<tr><td>Severity</td><td>Sensitivity</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Slight</td><td>Very Low</td><td>LOW</td><td>Certain</td></tr>
<tr><td rowspan="3">Drilling operations</td><td rowspan="3">Intake of seawater</td><td rowspan="3">Potential organism uptake in seawater intakes</td><td colspan="4">Plankton and possibly fish eggs or larvae could be removed from the ecosystem. This is on such a small scale that it is insignificant, in comparison with the overall egg/larval production, more an issue in terms of the potential for machinery to over heat due to blocked filters.</td><td rowspan="3">Guards and filters are used to reduce the number of marine organisms that enter with seawater.</td><td rowspan="3">Low</td></tr>
<tr><td>Severity</td><td>Sensitivity</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Slight</td><td>Very Low</td><td>LOW</td><td>Certain</td></tr>
<tr><td rowspan="3">Drilling operations</td><td rowspan="3">Discharge of heated seawater from heating /cooling medium or Reverse Osmosis unit</td><td rowspan="3">Warm water or increase saline water discharges have the potential to impact seawater quality and marine organisms.</td><td colspan="4">Discharges to surface waters will dilute and disperse rapidly in the offshore environment. Plankton may experience small, short-term, localised effects. Fish are highly mobile species and are expected to avoid temperatures outside their tolerance range.</td><td rowspan="3">Discharges will be in line with NEFL's discharge programme, all applicable regulations, and all previous drilling rigs in the Falklands and rig's water maker will reduce use of in-country water resources.</td><td rowspan="3">Low</td></tr>
<tr><td>Severity</td><td>Sensitivity</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Slight</td><td>Very Low</td><td>LOW</td><td>Certain</td></tr>
<tr><td rowspan="3">Shore based operations</td><td rowspan="3">Physical presence of laydown yard</td><td rowspan="3">The use of land resources and the impact on native flora and fauna.</td><td colspan="4">Disturbance of native flora. A short length of track will has been laid to join the existing road with the TDF.</td><td rowspan="3">The majority of the infrastructure was in place prior to the start of the campaign.</td><td rowspan="3">Low</td></tr>
<tr><td>Severity</td><td>Sensitivity</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Slight</td><td>Very Low</td><td>LOW</td><td>Certain</td></tr>
</table>

Aspect	Source	Activity Description	Potential Effects and Significance	Severity	Sensitivity	Significance	Certainty	Legislation/NEFL policy/Mitigation	Residual Impact / Concern
Shore based operations	Waste	Generation of domestic waste from operations at the laydown yard	The majority of waste generated during the campaign will be transported back to the UK in the returning coaster vessels for landfill in the UK.	Slight	Very Low	LOW	Certain	The majority of waste from the laydown yard will be shipped to the UK with the waste generated offshore. Small quantities of waste may be disposed of in the Falkland Islands, in line with NEFL's WMPA, and will not include direct disposal of waste to Eliza Cove or Mary Hill Quarry.	Low
Shore based operations. Drilling operations	Use of electrical and freshwater resources	Domestic electrical and freshwater use in support of laydown yard activity. Use of local water supply for preparation of drilling mud.	Emissions from electricity generation, added burden on the freshwater supply. The scale of the electricity and water use is considered insignificant	Slight	Very Low	LOW	Certain	The TDF has freshwater storage tanks which will be constantly trickle-fed with water from the Moody Brook reservoir. This will disconnect any peak in campaign demands from the supply to Stanley.	Low
Shore based operations	Generation of light during 24hr operations in relation to local population and wildlife	Artifical light can attract and disorientate seabirds. Stakeholder raised concerns that the potential for east-facing lighting from the TDF and bright lighting on vessels facing into the prevailing westerly winds may affect night-time flying at Stanley Airport.	The laydown yard will be located on the outskirts of Stanley, artifical light from the base is not expected to significanlty add to light emitted by FIPASS. Potential for disruption by night flights causes concern for local residents.	Moderate	Moderate	MODERATE	Probable	Permanent lighting will be designed and implemented in accordance with the Health and Safety in Ports (SIP009) Guidance on Lighting, prepared by Port Skills and Safety and UK HSE. Consultation with FIGAS to minimise impacts through lighting design.	Low

Aspect	Source	Activity Description	Potential Effects and Significance	Legislation/NEFL policy/Mitigation	Residual Impact / Concern
Shore based operations	Generation of noise during 24hr operations in relation to local population and wildlife	Noise arising from vessel engines moored alongside the TDF, vessel loading/unloading activities and operation of forklift trucks at the laydown yard, may be a nuisance to local residents.	Noise modelling undertaken for the TDF indicated operations at the laydown yard and TDF on a calm dry night would have barely detectable impacts to Stanley residents, approximately one kilometre away. Severity: Minor; Sensitivity: Low; Significance: LOW; Certainty: Probable	Vessel movements will be reduced where possible through optimised planning, making efficient use of vessel loads. All vessel engines shall be switched off whilst not in use and not left to idle, where possible. Loading or unloading operations at night shall not normally occur and if necessary will be minimised where practicable	Low
Shore based operations	Demands for temporary accommodation in Stanley	During the campaign approximately 85 additional personnel will be based in Stanley, which will place pressure on the limited number of available beds in Stanley for visitors.	A temporary accommodation block for the exclusive use of the 2015 drilling campaign has been constructed on a brown field site to the south of Stanley (near Stanley Services).	This facility will satisfy the bulk of the Rhea-1 well campaign's accommodation needs, and will also be able to cope with the eventuality of delayed flights, for instance due to bad weather, when 'emergency' accommodation may be required.	N/A
Inshore operations	Physical presence of vessels interfering with other users of Stanley Harbour	Vessels associated with the campaign will increase traffic in Stanley Harbour. Space for manoeuvering in the harbour is limited and the additional traffic could disrupt exisiting fishing and cargo use of the harbour.	During the campaign an estimated six vessel refueling visits will be required at FIPASS, lasting approximately 6-20 hrs each. Consequently the disruption to other users is considered to be moderate given the limited space at FIPASS. Severity: Minor; Sensitivity: Moderate; Significance: MODERATE; Certainty: Certain	The TDF has a Marine Superintendent to liaise with the Harbour Master, FIPASS management, Stanley Services and other users to keep everyone well informed. A harbour management plan has been produced.Management Plan.	Low

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<tr><td rowspan="3">Unplanned Event</td><td rowspan="3">Introduction of marine invasive species</td><td rowspan="3">Non-native species may be transported and introduced through ballast water and biofouling on the hull of vessels.</td><td colspan="4">Marine invasive species typically impact inshore benthic communities of native species. Invasive species may not be evident for a number of years, but their long-term impacts could be severe and irreversible. Vessel will be required to follow IMO guidelines for ballast water and biofouling</td><td rowspan="3">The Eirik Raude and support vessels will comply with IMO Guidelines. However, there remains a residual risk largely due to uncertainties in the assessment. Monitoring will be required to keep a check on the potential presence of marine invasive species, settlement plates will be attached to the TDF to provide an early warning. NEFL have an Exploratory Drilling Biosecurity Plan (BMP) in place to manage the risks. NEFL will also work within the Temporary Dock Facility Biosecurity Plan (BSP)</td><td rowspan="3">Moderate</td></tr>
<tr><td>Overall Impact</td><td>Likelihood</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Moderate</td><td>Remote</td><td>MODERATE</td><td>Probable</td></tr>
<tr><td rowspan="3">Crew Transport</td><td rowspan="3">Generation of noise, flight path over sensitive seabird colonies and local communities</td><td rowspan="3">Low flying helicopters over sensitive breeding colonies of penguins can invoke strong responses leading to trampling of adults, chicks and eggs. Helicopters may also be a nuisance to local settlements and disturb livestock on farms.</td><td colspan="4">The impact of a single helicopter is likely to be short-term and rapidly reversible. However the combined impact of numerous daily flights could have serious implications for the survival of moutling birds and young livestock. The severity to local residents is considered to be low and as direct flight lines do not pass over settlements, sensitivity is low. The risk assessment below pertains to seabirds and livestock.</td><td rowspan="3">NEFL will use the flight avoidance map as the basis for flight planning, follow the FI Low Flying Handbook Guidance, and brief helicopter pilots in flight avoidance protocols.</td><td rowspan="3">Low</td></tr>
<tr><td>Severity</td><td>Sensitivity</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Moderate</td><td>High</td><td>MODERATE</td><td>Certain</td></tr>
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<tr><td rowspan="3">General presence of industry</td><td rowspan="3">Presence of oil industry could have adverse effect on tourism</td><td rowspan="3">The presence of oil and gas activites in the Falkalnd Islands could have an adverse effect on the image as a wilflide destination.</td><td colspan="4">The drilling operation is currently planned to occur over the Falkland Islands winter, within the main drilling activity occuring offshore to the north of the Islands out of view of visiting tourists.</td><td rowspan="3">The campaign is currently scheduled for the winter – spring months which is outwith the prime tourist season.</td><td rowspan="3">Low</td></tr>
<tr><td>Severity</td><td>Sensitivity</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Slight</td><td>Moderate</td><td>LOW</td><td>Certain</td></tr>
<tr><td rowspan="3">Unplanned Event</td><td rowspan="3">Dropped object</td><td rowspan="3">Large items that are accidentally dropped overboard during drilling operations could pose a hazard to trawl fishing in the area.</td><td colspan="4">Oil and gas industry historical data indicate that the risk of an incident is relatively low at about 1 incident in 60 drilling campaigns. Annual fishing statistics show that there is very little fishing in the area.</td><td rowspan="3">Best practise for preventing serious events will be followed during the campaign and include; secure all tools, material and equipment; take measures to prevent dropped objects when working over grating; remove tools on completion of the job; erect barriers around drop zones; inspect structures and equipment at risk of falling.</td><td rowspan="3">Low</td></tr>
<tr><td>Overall Impact</td><td>Likelihood</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Very Low</td><td>Possible</td><td>LOW</td><td>Certain</td></tr>
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<tr></tr>
<tr><td rowspan="3">Unplanned Event</td><td rowspan="3">Accidental minor spill of diesel, oil, chemical during loading operations</td><td rowspan="3">Release of contaminants leading to deterioration in seawater quality and toxic impacts on marine life.</td><td colspan="4">Diesel spill would only remain in surface waters for a short time, but releases toxic substances that will have small a localised impact on water quality, plankton, fish and squid. The presence of the rig may attract birds that are more vulnerable to toxic surface pollution and several species in the area are classifed as Endangered.</td><td rowspan="3">All diesel transfer hoses will be fitted with dry-break seals, where possible, which will limit the amount discharged in the event a hose is accidentally disconnected. Additionally NEFL will provide working procedures which outline control and preventative measures.</td><td rowspan="3">Moderate</td></tr>
<tr><td>Overall Impact</td><td>Likelihood</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>High</td><td>Rare</td><td>MODERATE</td><td>Probable</td></tr>
<tr><td rowspan="3">Unplanned Event</td><td rowspan="3">Storm water overwhelming rig deck drains resulting in discharge of contaminated water

Unplanned discharge from rig open or closed drain system</td><td rowspan="3">Release of contaminants leading to deterioration in seawater quality and toxic impacts on marine life.</td><td colspan="4">Drainage management will be in place on the rig via processes and procedures to minimise overloading of the oily water separator during storms and heavy rain.</td><td rowspan="3">NEFL will provide working procedures which outline controls and preventative measures.</td><td rowspan="3">Low</td></tr>
<tr><td>Overall Impact</td><td>Likelihood</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Low</td><td>Remote</td><td>LOW</td><td>Certain</td></tr>
</table>

Aspect	Source	Activity Description	Potential Effects and Significance				Legislation/NEFL policy/Mitigation	Residual Impact / Concern
Unplanned Event	Collision between support or supply vessel with marine mammals	An increase in general shipping traffic throughout the campaign could lead to an increase in the risk of vessel collisions with marine mammals.	Large numbers of marine mammals are present in inshore waters coinciding with the period of the campaign. Of these whales, sei whales are Endangered. The campaign will increase shipping near Stanley by 6%, however lack of historically reported incidents suggests that few collisions occur around the Falkland Islands.				Mariners should be made aware of the issue and how it relates to the Falkland Islands (see IFAW (2013) leaflet). Along with the usual duties of a watch keeper, additional vigilance is required to detect cetaceans in inshore waters.	Low
			Overall Impact	Likelihood	Significance	Certainty		
			Moderate	Remote	MODERATE	Probable		
Unplanned Event	Introduction of terrestrial alien species at laydown yard via equipment import from UK	Risk of introducing invertebrates, seeds and soil (containing micro-organisms) that can adhere to the outside of containers or be hidden in cargo. Species that may be transported in cargo from the UK are very likely to survive.	If invasive species were introduced the impact through parasites, disease, competitors or predators may not be immediately evident. Long-term implications could be severe and difficult to reverse. Vessels will be arriving throughout the campaign and a large amount of cargo will be brought onshore. The introduction of invasive species has happened in industry elsewhere.				All materials are clean when packed or loaded in the port of origin, particularly items of fresh fruit and vegetables. Personnel will be briefed on the significance of non-native species. Falkland Islands Biosecurity Guidelines will be adhered to. Cargo will be inspected on arrival for biosecurity breaches. NEFL will also work within the Temporary Dock Facility Biosecurity Plan (BSP)	Moderate
			Overall Impact	Likelihood	Significance	Certainty		
			Moderate	Possible	MODERATE	Probable		

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<tr><td rowspan="3">Accidental Event</td><td rowspan="3">Vessel collision in Stanley Harbour, potential for small leaks or tanks to overflow during re-fueling leading to loss of diesel</td><td rowspan="3">Whilst Stanley Harbour is not recognised as a habitat of great conservation value, it is home to steamer ducks and other coastal species, as well as Commerson's dolphin, and is used recreationally by Stanley residents.</td><td colspan="4">Collision with a fully re-fueled vessel could lead to a total inventory loss of 800 tonnes diesel. This would be spread between various segregated tanks and would be very unlikely that all or any would be lost. However as a worst-case this could represent a sizeable spill in sheltered coastal waters.</td><td rowspan="3">The same precautionary measures that apply to all vessels bunkering at FIPASS will apply to the rig supply vessels.
A Harbour mangement plan and oil spill response plan are in place.
The support vessels will be fully equipped to deal with spills offshore and the same equipment would be used to deal with small spills inshore. Oil spill respone equipment available at the TDF.</td><td rowspan="3">Low</td></tr>
<tr><td>Overall Impact</td><td>Likelihood</td><td>Significance</td><td>Certainty</td></tr>
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<tr><td rowspan="3">Accidental Event</td><td rowspan="3">Major loss of containment/ blow-out of hydrocarbons</td><td rowspan="3">Prolonged release of crude oil to the water column which could impact water quality, plankton, benthic organisms, seabirds, marine mammals, fish and fisheries, coastal fauna and tourism.</td><td colspan="4">The predicted oil is very waxy and has a high viscosity and is expected to form waxy droplets on the surface following release. However, a lighter oil could be encountered. Impacts to plankton are considered to be short-term and recoverable. Impacts to benthic filter feeders are unknown. Seabirds and marine mammals are not considered significantly at risk due to the semi-solid nature of the wax droplets, although this may differ if a different hydrocarbon is encountered. The direction of the prevailing conditions is likely to spread the spill over fishing areas and could result in short-term closed areas. The coastline of East Falkland is at greatest risk of beaching. The impact to tourism is considered to be major.</td><td rowspan="3">The well design will be peer reviewed by NEFL's well examiner and the Health and Safety Executive to ensure that the risk of an uncontrolled release is minimised.
The well will be fitted with a blow-out preventer that will seal the well in the event of a major incident.
NEFL is preparing an Oil Spill Response Plan that would initiate a tiered response in the event of a spill.</td><td rowspan="3">Moderate</td></tr>
<tr><td>Overall Impact</td><td>Likelihood</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Very High</td><td>Remote</td><td>MODERATE</td><td>Probable</td></tr>
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<tr><td rowspan="3">Accidental Event</td><td rowspan="3">Loss of containment of WBM from the riser</td><td rowspan="3">Increased turbidity in the water column, sedimentation leading to smothering of benthic organisms, modification of sediment particle size and habitat.</td><td colspan="4">Discharges would impact small areas of seabed and a small volume of water relative to the available habitat on the Northern Slope. Impacts would be short term, with potential for rapid recovery. Modification of sediments would persist for over 10 years in a very small area.</td><td rowspan="3">Redundancy is designed in to ensure DP related equipment are always available. DP trials will be undertaken when the rig reaches location. An exclusion zone of 500m will be maintained. Mariners will be advised of the rig location to avoid collision, Meteorological analysis of extreme weather events will be assessed. Continual monitoring of long-range and short-range weather forecasts.</td><td rowspan="3">Low</td></tr>
<tr><td>Overall Impact</td><td>Likelihood</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Low</td><td>Remote</td><td>LOW</td><td>Probable</td></tr>
<tr><td rowspan="3">Accidental Event</td><td rowspan="3">Loss of containment/ blow-out</td><td rowspan="3">Waste management during clean-up</td><td colspan="4">If a major spill occurred, the clean-up operation would generate a large volume of hazardous waste (oil, contaminated materials, PPE etc.), which would have to be disposed of responsibly. This would potentially have a serious environmental impact in its own right but under the circumstances of a major incident, the impact would be relatively insignificant.</td><td rowspan="3">Contaminated waste from a spill clean-up would be managed in line with NEFL's Waste Management Plan. It is expected that waste of this kind will be exported to the UK</td><td rowspan="3">Low</td></tr>
<tr><td>Overall Impact</td><td>Likelihood</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Slight</td><td>Remote</td><td>LOW</td><td>Probable</td></tr>
</table>

Aspect	Source	Activity Description	Potential Effects and Significance				Legislation/NEFL policy/Mitigation	Residual Impact / Concern
Accidental Event	Loss of containment/ blow-out	Air Quality would be affected by light oils, such as diesel, which evaporate quickly and release noxious compounds into the atmosphere. Heavier crude oil takes longer to breakdown and therefore releases gases slowly over a period of weeks or months.	Following an oil spill, Volatile Organic Compounds, Polycyclic Aromatic Hydrocarbons, Hydrogen Sulphide and other noxious compounds are released, which all impact on air quality. In the offshore environment, atmospheric pollution is rapidly dispersed.				The impacts of a blow-out would be far reaching but air quality was not deemed to be of great significance.	Low
			Overall Impact	Likelihood	Significance	Certainty		
			Minor	Low	LOW	Certain		
Accidental Event	Major incident such as collision with another vessel resulting in loss of rig inventory	Loss of the total diesel fuel inventory, 4,631m^3. Resulting in release of contaminants and subsequent deterioration in seawater quality and toxic impacts on marine life.	Spilt diesel only remains in surface waters for a short time, but releases toxic substances that would have a small localised impact on water quality, plankton, fish and marine mammals. The presence of the rig may attract birds that are more vulnerable to toxic surface pollution and several species in the area are classifed as Endangered. The risk to the coastline is slight as diesel quickly evaporates and disperses from surface waters therefore is unlikely to reach the coastline.				An exclusion zone of 500m will be maintained. Mariners will be advised of the rig location to avoid collision. All vessels in the area will be informed of the rig's position and intentions by radio broadcast and AIS. The ERRV will patrol the 500m exclusion zone and ensure other vessels do not approach.	Moderate
			Overall Impact	Likelihood	Significance	Certainty		
			High	Remote	MODERATE	Probable		

Aspect	Source	Activity Description	Potential Effects and Significance					Legislation/NEFL policy/Mitigation	Residual Impact / Concern
				Overall Impact	Likelihood	Significance	Certainty		
Accidental Event	Major incident resulting in loss of rig	Disruption to shipping in the area	There is very little vessel traffic in the area.	Slight	Very Low	LOW	Certain	Mariners and FIGFD will be advised of the rig location to avoid collision. Meteorological analysis of extreme weather events will be assessed.	Low

2.0 Introduction

This Environmental Impact Statement (EIS) presents the findings of the Environmental Impact Assessment (EIA) conducted by Noble Energy Falklands Limited (NEFL) for the Rhea-1 exploration drilling operations in the North Falkland Basin (NFB).

The project involves the drilling and abandonment of one exploration well to determine the extent of hydrocarbons in the Rhea-1 prospect, measure the formation characteristics and gain geological information.

The project is located within Licence Block PL001, Quadrant 14 of the NFB, which straddles the boundary between the Falklands Interim Conservation Zone (FICZ) and the Falklands Outer Conservation Zone (FOCZ). The Rhea-1 well is located in the FOCZ, in a water depth of 470 m.

2.1 Purpose of the EIA Process and the Environmental Impact Statement

The aim of the EIA process is to assess the potential environmental impacts that could arise from the project and identify measures that will be put in place to prevent or minimise these impacts.

The EIA process is integral to the exploration project, assessing potential impacts and challenging design and operational procedures to ensure that the residual impacts of the project are minimal. The process also provides for the concerns of stakeholders to be identified and addressed as far as possible at an early stage, and ensures that the planned activities comply with environmental legislative requirements and with NEFL's Environmental, Health and Safety (EHS) policy.

The EIS is a report summarising the EIA process and outcomes. It also includes details of how the project decision-making was undertaken and how environmental criteria were incorporated into that process. The EIS is submitted to the Falkland Islands Government (FIG) to inform the decision on whether or not the project may proceed, based on the acceptability or otherwise of the residual levels of impact, and is subject to formal public consultation.

2.2 Scope of the Environmental Statement

In March 2015, NEFL submitted an EIS for drilling two exploration wells in the Falkland Plateau Basin (FPB). One of the two wells in this campaign will be drilled during May-June 2015, the Humpback-1 well, and NEFL have since decided not to drill the second well in the FPB and instead drill a prospect within the NFB, the Rhea-1 well. NEFL are partnering with Premier Oil, who are also drilling exploration wells in the NFB, to provide the drilling rig and support infrastructure required to conduct the 2015 exploration campaign. The impacts associated with transporting the rig from South Africa to Falkland Islands waters have already been address by both NEFL and Premier Oil in their EIS submissions for their respective campaigns in the FPB and NFB, and consequently will not be repeated within this EIS.

This EIS covers the impacts associated with the drilling of the Rhea-1 in the NFB location, and the transit of the rig to the new well location in the NFB. The activities associated with the Rhea-1 well can be summarised into the following categories:

- Drilling operations – physical presence and operation of the drilling rig, *Eirik Raude*; well design; mud system, drill cuttings, cementing and chemical discharge; waste production and management; 24 hour operations.
- Shore base operations – operation of the laydown yard; inshore vessel refuelling and loading activities; onshore workforce; waste production and management; 24 hour operations; onshore transportation.
- Support operations – supply vessel operations; transportation of equipment, supplies and the workforce to the Falkland Islands; helicopter operations.

The potential for unplanned or accidental events associated with all of the operational activities has been considered to ensure that sufficient mitigation and control measures can be put in place to prevent such events from occurring.

2.3 Regulatory Overview

This section provides a brief overview of the current legislation that governs oil and gas activities in the Falkland Islands. Genesis (2013) conducted a thorough review of the legislation pertaining to the oil and gas industry in the Falkland Islands and this summary draws on the findings of that review.

The FIG Department of Mineral Resources (DMR) is the regulatory body for offshore activities and is responsible for approving all applications. As a UK Overseas Territory, FIG shall also seek advice and consult with the UK Department of Energy and Climate Change (DECC) on proposed developments prior to approval being granted. In the absence of specific FIG guidance, the preparation of required consents shall be based on UK guidance issued by DECC, therefore the relevant legislation and guidelines applicable to oil and gas developments in the UK were also considered as part of the thorough review.

Both the Falkland Islands and the relevant UK regulations that govern NEFL's exploration operations are listed below, the relevant Falkland Islands national legislation are described more fully in the proceeding sections:

Falkland Islands National Legislation

- Offshore Minerals Ordinance 1994 (1997 & 2011 Amendments);
- Offshore Petroleum (Licensing) Regulations 1995 and Offshore Petroleum (Licensing) Regulations 2000 including amendments made in 2004 and 2009;
- Petroleum Survey Licences (Model Clauses) Regulations 1992;
- Marine Environment (Protection) Ordinance 1995;
- Deposits in the Sea (Exemptions) Order 1995;
- Environmental Protection (Overseas Territories) (Amendment) Order 1997;
- Marine Mammals Ordinance 1998;
- Conservation of Wildlife and Nature Ordinance 1999;
- Fisheries (Conservation and Management) Ordinance 2005; and
- Endangered Species Ordinance 2003.

UK and International Legislation

- The Energy Act, 1976 (Amendment) Regulations 2008;
- The Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1999 (amendment) Regulations 2007;
- The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (amendment) Regulations 2007;
- Offshore Combustion Installations (Prevention and Control of Pollution) Regulations 2001 (Amendment) Regulations 2007;
- Offshore Chemical Regulations 2002 including amendments made by the Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005; The Energy Act 2008 (Consequential Modifications) (Offshore Environmental Protection) Order 2010; and The Offshore Chemicals (Amendment) Regulations 2011;

- The Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended Regulations 2011);
- Offshore Installations (Emergency Pollution Control) Regulations 2002;
- Offshore Marine Conservation of Habitat Regulations (2007, 2010);
- The REACH Enforcement Regulations 2008;
- The Fluorinated Greenhouse Gas Regulations (2009, 2015);
- The Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation Convention) Regulations 1998;
- Greenhouse Gas Emissions Trading Scheme Regulations 2005;
- 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;
- Dangerous Substances in Harbour Regulations 1987; and
- EU Ozone Depleting Substances (ODS) Regulation (EC) No. 1005/ 2009.

2.3.1 Falkland Islands National Legislation

Offshore Minerals Ordinance 1994 (1997 & 2011 Amendments)

The Offshore Minerals Ordinance 1994 (The Regulations) provides the regulatory framework for requiring and undertaking an EIA and reporting it within an EIS in the Falkland Islands.

These Regulations were amended by the Offshore Minerals Ordinance Amendment(s) 1997 and 2011 and clarified through the development of “Guidelines Notes for Industry - Guidelines Notes On The Production Of Offshore Environmental Impact Statements For Field Developments – 2012” issued by the Department of Mineral Resources (DMR). Schedule 4 of The Regulations provides further details on the expected content of an EIS.

‘The Regulations’ relate to the granting and renewal of production consents for field developments, the drilling of wells and the construction and installation of production facilities and pipelines in the Falkland Islands Exclusive Economic Zone (EEZ).

‘The Regulations’ require that any Operator who wishes to carry out those activities must first make an EIA of the activity and then present the conclusions in an EIS. The Operator must then submit the EIS to the DMR.

On submission, the EIS is subject to formal public consultation. Operators are required to notify the public of the EIS submission by advertising submission in the local press.

Once comments are included to the satisfaction of DMR, the EIS shall be considered at Executive Council where a decision on consent will be reached. Consent may be given or refused, or the consent may be subject to conditions that require modification to the activity to reduce impacts to the environment, remedy them or to offset them. 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 is satisfied with the information provided and that there will be no significant impact on the environment.

Offshore Petroleum (Licensing) Regulations 1995 and Offshore Petroleum (Licensing) Regulations 2000 (as Amended 2004 and 2009)

These Regulations stipulate the licensing requirements for oil and gas 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 provided open invitation for exploration or production licences for specific blocks.

Petroleum Survey Licences (Model Clauses) Regulations 1992

These Regulations describe the regulatory framework governing offshore exploration activities including: field observations, geological and geophysical investigations, the use of remote sensing techniques and sea floor sampling.

These Regulations were made under the Continental Shelf Ordinance 1991 and were enforced by the Offshore Minerals Ordinance 1994. The 1992 Regulations were amended by Offshore Petroleum (Licensing) Regulations 1995.

Marine Environment (Protection) Ordinance 1995
Deposits in the Sea (Exemptions) Order 1995
Environmental Protection (Overseas Territories) (Amendment) Order 1997

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.

The UK Environment Protection (Overseas Territories) Order 1988 was 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, if there is any contradiction between the two, the more stringent legislation will be applied.

The Deposits in the Sea (Exemptions) Order 1995 is also largely 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, cooling water originating on the vessel are exempt from licensing requirements. Deposits of any substance during firefighting, normal navigation or maintenance, and salvage operations do not require a licence. Deposit of any chemicals, drill cuttings, or drilling mud in the course of drilling and production are also exempt under this Order but would be subject to regulation through other legislation.

Marine Mammals Ordinance 1998

Harming, taking or killing of any marine mammal (including whales, porpoises, dolphins, otters, seals, sea lions and elephant seals) or using 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 is prohibited under this Ordinance. Within this legislation, Falkland Islands waters correspond to the boundaries of the FOCZ.

The import and export of any marine mammal or any part of a marine mammal, living or dead, without a licence is also unlawful according to this Ordinance.

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. This legislation protects wild birds, wild animals and wild plants, by prohibiting certain activities and making provision for National Nature Reserves (NNR).

According to this Ordinance it is prohibited to kill, injure, capture, replace, or disturb any protected wild animal, bird or plant without a licence. It also makes provision for the designation of NNRs on the seabed or land or private estate by agreement, with associated regulations for their preservation. Its Schedules also list protected bird, animal and plant species, which may not be killed at any time as well as detail on relevant species that may be killed out with the timing of their closed seasons.

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 beyond territorial waters to cover the entire FICZ and 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 to 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.

Endangered Species Ordinance 2003

The Endangered Species Ordinance 2003 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.

2.3.2 Hydrocarbons Development Policy Statement 2013

In order to plan for the future development of the hydrocarbons industry in the Falklands, a policy statement to provide clarity on the purpose of hydrocarbon development and how the implications of developments will be managed was prepared. In 2013, the hydrocarbons development policy statement was released with the following eight recommendations:

1. 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.
2. The Falkland Islands Government will maintain constant supervision and control over all hydrocarbon activities within the Falkland Islands Designated Area.
3. 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.
4. Development of the hydrocarbons industry must ensure the protection and conservation of the Falkland Island's environment and biodiversity.
5. Development of the hydrocarbons industry must take into consideration existing commercial activity and promote the development of local business capacity.
6. The exploitation of finite natural resources will be used to develop lasting benefits to society across the whole of the Falkland Islands.
7. Transparency and accountability must be present throughout the hydrocarbon development process from all parties involved.
8. 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.

2.4 Areas of Uncertainty

A number of assumptions have been made to inform the EIA process as this EIS has been prepared during the design process for the Rhea-1 exploration well operation and consequently some areas have not yet been fully defined:

- Site-specific environmental baseline surveys have not yet been conducted for the Rhea-1 well location. NEFL intend to conduct Remotely Operated Vehicle (ROV) surveys of the area prior to commencing drilling operations. The pre-drilling survey will comprise; 100 m radius ROV video inspection for habitat and species, such as potential biogenic reef communities; up-stream and down-stream (at 50 m, 100 m and 200 m) sediment samples collected using a specialist environmental ROV corer with samples analysed for macrofauna communities and physic-chemical properties. The video inspection survey will be analysed in real-time by RPS who have taxonomists experienced in the identification of Falkland Islands fauna. Prior to deployment to the rig, the RPS taxonomist will meet with experts, including from FIGFD, to receive local input. Should any sensitive habitats or species be identified, DMR will be notified and agreement to move the well location will be sought where necessary. Should a new well location be necessary, an ROV survey would also be conducted at that location prior to drilling. Nevertheless, the absence of site-specific habitats, species and physic-chemical data from the vicinity of the Rhea-1 well during preparation of this EIA leaves a data gap in this assessment and consequently a precautionary approach has been taken for activities, such as the discharge of drill cuttings, which will impact benthic communities.
- Final selection of offshore chemicals and the mud programme has yet to be confirmed;
- The detailed drilling schedule has yet to be confirmed;
- The type of hydrocarbon encountered whilst drilling the exploration well is unknown. To account for this uncertainty two different types of crude oil have been assessed in the EIS. The first is based on the properties of the hydrocarbon characterised in nearby Sea Lion field, which is a heavy waxy crude, and the second is a lighter more volatile crude based on the characteristics of Ekofisk crude from the North Sea which is a typical light crude;
- It is recognised that there remain gasp in knowledge regarding the biological environment of the NFB, and Falkland Islands waters in general, these include; littoral/sublittoral environments, offshore benthic ecosystems, oceanography in relation to oil spill modelling, seabird, pinniped and cetacean distributions.

Where assumptions have been made the environmentally 'worst-case' option was assessed and where definition is missing worst-case estimates of emissions, discharge and other sources of interaction are used in the consideration of possible effects.

2.5 Consultation

2.5.1 Scoping Consultations Introduction

NEFL conducted an EIA scoping exercise in September 2013 to raise awareness of its 2015 exploration drilling campaign and to invite comment on the proposed programme and associated activities. A similar exercise was carried out by Premier Oil Exploration and Production Limited (Premier) in July 2014. Initial consultation meetings were held with DMR, statutory consultees and other interested parties, including:

- Biosecurity, Department of Agriculture;
- Environmental Planning Department;
- Falkland Islands Residents;
- Falklands Conservation;
- FIFCA (Falkland Islands Fishing Companies Association);
- Fisheries Department;

- Joint Nature Conservation Committee (JNCC) (Local Representative);
- Public Works Department;
- Shallow Marine Surveys Group; and
- SAERI (South Atlantic Environmental Research Institute).

These consultations provided stakeholders with an opportunity to enter into a discussion about the proposed NEFL and Premier campaigns so that any issues and concerns could be identified at an early stage and be considered within the scope of the respective EIA's. Given the similarities between the Rhea-1 well operation and the Premier campaign wells with regard to location in the NFB, the rig, time of year, and in agreement with Premier and FIG, NEFL has utilised the Premier consultation outcomes, in addition to its own, to produce this EIS. Table 3 provides a summary of the comments, issues and concerns raised during the initial NEFL and Premier consultation meetings (summarised on a non-attributable basis), and the location in the EIS where those concerns have been addressed.

Table 3: Summary of concerns raised during the preliminary stakeholder consultations

Consultation	Main Activity	Area of Concern	ES Chapter
NEFL Sept 2013	Waste Management	Concerns over the generation, storage and treatment/disposal of waste as there are limited reception facilities on the Islands.	11
NEFL Sept 2013	Logistical support, ERRV & supply vessels	Navigational risk associated with increased vessel traffic to/from the drilling unit.	10
NEFL Sept 2013	Logistical support	Limited emergency resources on the Islands in the event of an emergency/MedEvac situation.	N/A
NEFL Sept 2013	Drilling operations	Potential for oil spills and accuracy of any oil spill modelling that is carried out.	13
NEFL Sept 2013	Drilling operations	Potential discharge of oil based mud (OBM) and discharge of drilling chemicals.	12
NEFL Sept 2013	Drilling operations	Potential disruption of fishing activities.	12
NEFL Sept 2013	Rig Transit, ERRV & supply vessels	Bio-security – risk of introduction of invasive species.	10
PMO July 2014	Pre-drilling Preparations	Light and noise generation could affect seabirds as well as marine mammals. We had considerable advice previously on potential for seabird species to crash into man-made objects at sea when confused by a combination of artificial light and low cloud/fog. Many such events are documented including in the Falklands and South Georgia. Suggest including references to protocols to reduce light impact.	9.0
PMO July 2014	Drilling operations	If flaring could occur, considerable detail on this should be included in the EIS. Will there be night flaring? There is a high chance of killing seabirds if there is night flaring. What mitigation is in place? Reference previous Rockhopper EIS addendum on flaring.	9.0
PMO July 2014	Drilling operations	The drilling mud and cuttings dispersion modelling report is of great interest to compare the effect footprint with the main fisheries in the area. Suggested that using the fishing traffic reports could be a good proxy for fish abundance in key areas.	12.0
PMO July 2014	Drilling operations	Suggested that Premier and NEFL should coordinate efforts in monitoring the effects and distribution of cuttings material with Noble.	14.2
PMO July 2014	Drilling operations	Advised that water column effects of drilling discharges should not be underestimated. It was suggested that mitigation measures such as fitting a diffuser device to the end of the cuttings discharge caisson, that could aid faster dispersion of the cuttings in the water column, should be considered.	12.0
PMO July 2014	Monitoring	The exploration drilling campaign provides opportunity to gather environmental data ahead of further development activities.	14.2

Table 2 continued: Summary of concerns raised during the preliminary stakeholder consultations

Consultation	Main Activity	Area of Concern	ES Chapter
PMO July 2014	Logistical support, ERRV & supply vessels	Additional supply vessel traffic could lead to crowding in Stanley Harbour, particularly during refuelling operations at the Falklands Interim Port and Storage System (FIPASS). There are many other users of the Harbour, from cruise ships to fishing vessels. Periods of peak vessel movement will need to be considered in the development of a Harbour Management Plan. Depth restrictions in the Harbour could lead to limitations on multiple vessel manoeuvres, particularly through the Narrows. Premier Oil should liaise with the Harbour Master and FIPASS management regarding their vessel requirements to ensure smooth management.	10.2
PMO July 2014	Logistical support, ERRV & supply vessels	Physical presence of support vessels could impact seabirds and marine mammals by the generation of artificial light.	9.0 and 10.7
PMO July 2014	Waste Management	NEFL should confirm that there is sufficient capacity within the Falkland Islands to handle expected quantities of non-hazardous waste that is intended to be disposed of locally.	11.0
PMO July 2014	Helicopter operations	Recommend including a reference to avoiding low-flying over sensitive seabird colonies when flying over the Falkland Islands. The MoD range and avoidance map has recommended flying heights over sensitive seabird colonies. Likely areas affected in the Stanley/East Falkland area are Kidney Island and Cochon Island, Volunteer Point area, the Seal Bay area and Eddystone Rock. All have a restriction on flying below 1500ft.	10.5
PMO July 2014	Shore Base	It would be advisable to implement an invasive species monitoring plan for the temporary dock facility. There are existing invasive species within Stanley Harbour such as the parchment worm, which has a wide distribution around the Falkland Islands and the vase tunicate which appears to be limited to the confines of Stanley Harbour and East Cove and may represent closed populations. See Shallow Marine Surveys Group (SMSG) Survey Report Invasive Species 2011.	10.4
PMO July 2014	Additional Data	Suggested that Falkland Island Marine Biological Archive (FIMBAr) would be a useful source of information for species assemblages in Falkland Islands waters.	5.4
PMO July 2014	Shore Base	Who will be operating the temporary dock facility throughout the campaign?	3
PMO July 2014	Waste	Could the abattoir incinerator be used for inert non-hazardous waste to minimise waste being transported to the UK?	11
PMO July 2014	Accommodation	At times during the last campaign, it was difficult for visitors to find vacant hotel accommodation in Stanley, due to the number of oil workers based in the town.	10.8
PMO July 2014	Rig	NEFL are advised to inform the Fisheries Department of the rig locations in advance.	3 and 14.2

Table 2 continued: Summary of concerns raised during the preliminary stakeholder consultations

	General Public Comments		
NEFL Sept 2013	Community	Potential for conflict between incoming workers and local residents.	10
NEFL Sept 2013	Resource Use	Water requirements and potential impact on public water supply.	10
PMO July 2014	Accommodation	The drilling campaign will generate a demand for accommodation, from crew changes to emergency accommodation. Premier Oil should have an accommodation plan in place before the rig arrives and should be able to demonstrate its procedures. Local businesses met the demand for accommodation during the previous drilling campaign, and new houses were built. The new campaign could bring additional pressure on housing; although some pressure would have been there anyway. Is there an expectation that the campaign will bring families in or housesharing? Families will be healthy for the community even though this causes more pressure on resources at the beginning. Pressure on housing could also come from local businesses who may wish to bring in more employees.	10.8
PMO July 2014	Accommodation	During the previous drilling campaign the operators brought workers in to Shorty's and then sent them straight out to the rig. They also used 'flotels' as temporary accommodation vessels during the last campaign.	10.8
PMO July 2014	Accommodation	If there has to be additional accommodation it would not be different to what happened during the last drilling campaign. People will just have to get their heads together.	10.8
PMO July 2014	Shore Base	During the previous drilling campaign there were water shortages at the supply yard.	3.0
PMO July 2014	Local Business	The use of charter flights to supplement flights for local Falkland Islanders on the previous campaign was seen as a benefit to the locals, but affected local business such as loss of booking fees.	3.0
PMO July 2014	Community	During the last exploration campaign lots of friendships developed.	N/A
PMO July 2014	Community	During the last drilling campaign the fresh produce brought down to Stanley by the charter flight was very popular with the local community.	3.0

3.0 Project Description

3.1 Introduction

Noble Energy Falklands Limited ('NEFL') is planning to drill one exploration well in the North Falkland Basin (NFB) within Licence block PL001. The purpose of the drilling campaign is to evaluate exploration targets in the NFB that were identified during seismic interpretation. The well location is named Rhea-1 and will be drilled during a 2015 exploration drilling campaign (Table 4 and Figure 4).

The exploration well will be drilled from the *Eirik Raude* drilling rig, which will be in Falkland Islands waters to conduct a joint 240 day drilling campaign shared by NEFL and Premier Oil.

Table 4: NEFL exploration well location coordinates and sub-surface drilling target location (NFB).

Well Name	Approx. Water Depth (m)	Well target location Coordinates*	Licence Block Location
Rhea-1	468	49° 05' 24.9633" S 59° 20' 8.3503" W	PL001

*Geodetic Information Transverse Mercator with a central meridian of -60 degrees
Projection type Transverse Mercator Origin latitude 00° 00' 00.00" North Origin longitude 060° 00' 00.00" West Origin false easting 500,000.0 Origin false northing 10,000,000.0 Scale factor 0.9996 Grid unit Metres

3.2 Overview of Historical Drilling in the Licence Area

Six exploration wells were drilled within the NFB during the 1998 drilling campaign (Sebald, Fitzroy, Braela, Little Blue, Galapagos, and Minke) including two wells in PL001 (Little Blue and Galapagos) and two wells in PL032 (Fitzroy and Sebald). While no commercial finds were discovered, five of the six wells had oil shows and live oil was recovered at surface.

During the 2010-2012 Rockhopper drilling campaign, the Sea Lion well (14/10-2) was drilled, and declared an oil discovery. Samples of crude oil were recovered from the well. Since its discovery, Sea Lion has been appraised with a further six wells and extensive coring.

At the time of preparing this report, the first of six wells during the 2015 drilling campaign (Zebedee, Premier Oil, PL004b) reported 81 feet of net-oil bearing reservoir and 55 feet of gas-bearing reservoir.

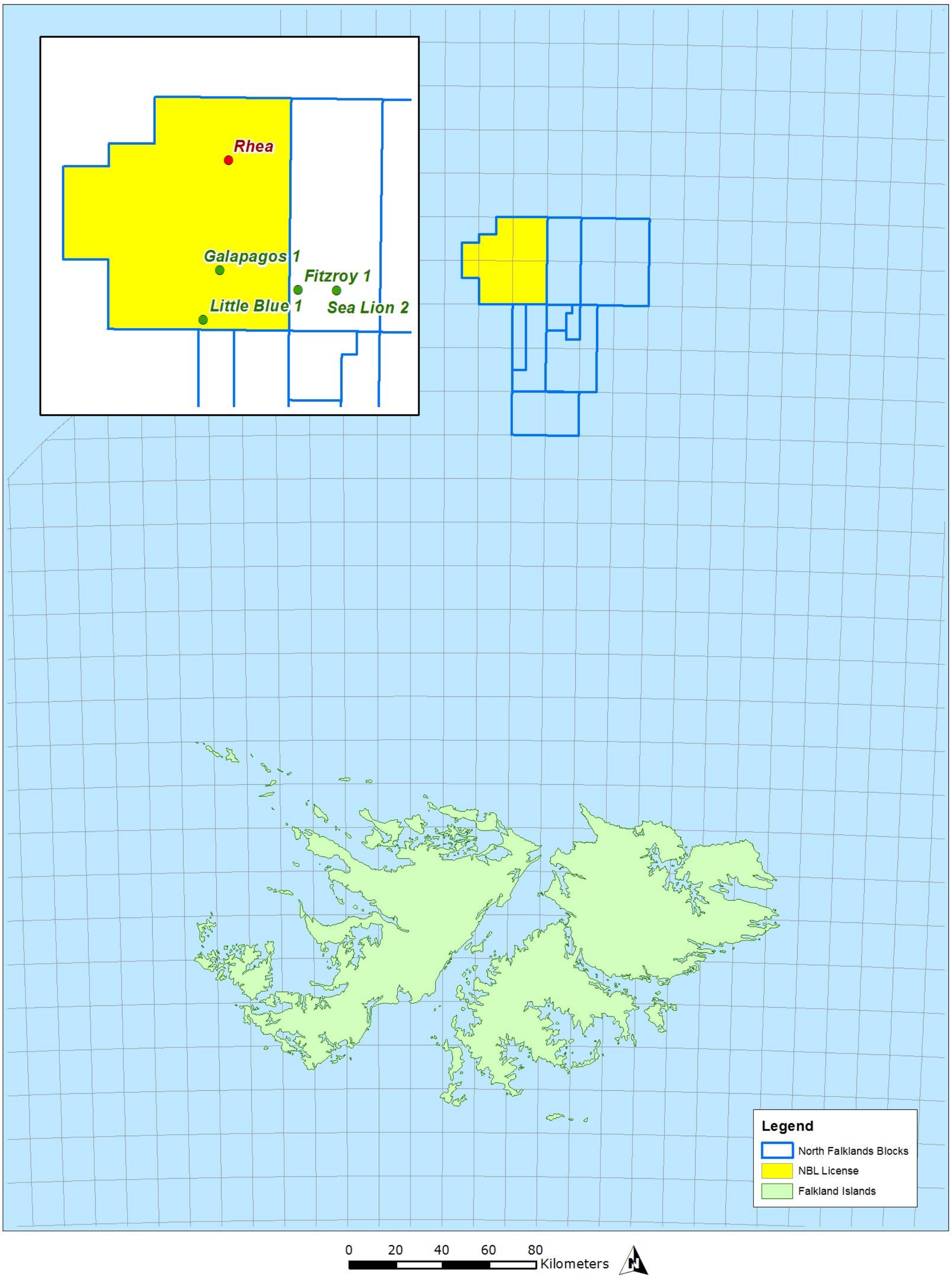


Figure 4: Licence Block Location and the Rhea-1 Exploration Well Location

Although it is likely that a hydrocarbon similar to that of Sea Lion crude will be encountered in the Rhea well, it should be noted that as this is an exploration well it is impossible to know the exact type of hydrocarbon until the well has been drilled. Additionally, as Rhea-1 is further away from the known discoveries, the degree of uncertainty increases. For the Rhea-1 well, it is anticipated that the well will encounter oil with some gas.

3.3 Schedule

NEFL has planned the timing of the exploration drilling programme taking the following aspects into consideration:

- Schedule constraints between NEFL and Premier Oil, the operators who have entered into a consortium agreement for the hire of the drilling rig; and

The drilling rig has been contracted from March 2015 for a 240 day campaign, which will be split 50%/50% between NEFL- Operated Joint Ventures and Premier Oil- Operated Joint Ventures. An outline of the intended schedule is given below (Table 5) although this might be subject to change, dependent on final planning stages between NEFL and Premier Oil, and operations. NEFL will liaise with the Fisheries Department throughout the drilling programme and will notify the Department of rig moves and the new rig location in advance of the move.

Table 5: Summary of proposed exploration drilling activities

<table>
<tr><th>Activity</th><th>Operator</th><th>Start Date</th><th>Duration</th></tr>
<tr><td>Rig transits from West Africa and arrives in Falkland Island Waters</td><td rowspan="8">Premier Oil</td><td>01 February 2015</td><td>Approximately 38 days</td></tr>
<tr><td>Drill and abandon Zebedee well</td><td rowspan="2">06 March 2015</td><td rowspan="2">Approximately 30 days</td></tr>
<tr><td>Rig move to next well location</td></tr>
<tr><td>Drill and abandon Isobel Deep well</td><td rowspan="2">08 April 2015</td><td rowspan="2">Approximately 30 days</td></tr>
<tr><td>Rig move to next well location</td></tr>
<tr><td>Spud Chatham well</td><td>24 April 2015</td><td>4 days</td></tr>
<tr><td>Spud Jayne East well</td><td>27 April 2015</td><td>7 days</td></tr>
<tr><td>Return to Isobel Deep well</td><td>03 May 2015</td><td>2.5 weeks</td></tr>
<tr><td>Rig move to NEFL location</td><td rowspan="2">NEFL</td><td rowspan="2">May-June 2015</td><td rowspan="2">Approximately 60 days</td></tr>
<tr><td>Drill and abandon Humpback-1 well</td></tr>
<tr><td>Rig move to Jayne East well location</td><td rowspan="4">Premier Oil</td><td rowspan="2">July 2015</td><td rowspan="2">Approximately 30 days</td></tr>
<tr><td>Drill and abandon Jayne East well</td></tr>
<tr><td>Rig move to Chatham well location</td><td rowspan="2">August 2015</td><td rowspan="2">Approximately 30 days</td></tr>
<tr><td>Drill and abandon Chatham well</td></tr>
<tr><td>Rig move to NEFL location</td><td rowspan="2">NEFL</td><td rowspan="2">August / September 2015</td><td rowspan="2">Approximately 38 days</td></tr>
<tr><td>Drill and abandon Rhea-1 well</td></tr>
<tr><td colspan="2">Rig transits from Falkland Island Waters to West Africa</td><td colspan="2">November 2015</td></tr>
</table>

3.4 Drilling Programme

3.4.1 Drilling Rig

The exploration drilling campaign will be conducted from the *Eirik Raude* semi-submersible drilling rig (Figure 5, Figure 6). The rig will float on location, maintaining its position with a Dynamic Positioning (DP) system. There will be no requirement to anchor the rig to the seabed during drilling operations.

The *Eirik Raude* is designed to successfully operate in harsh environmental conditions and provide a stable platform from which to drill the wells. The hull of the semi-submersible rig comprises six vertical columns, which are designed to reduce the vessel 'heave' (vertical motion of the vessel in response to wave action) by reducing the area of hull in contact with the water. Three columns are fitted along either side of the rig and terminate in two underwater hulls / pontoons (Figure 5) which contain large tanks for ballast, fuel and fresh water. The columns and pontoons provide buoyancy to keep the rig afloat, and some of the tanks can be flooded to lower the vessel to a sufficient depth in the water to maximize stability and minimize effects of wave movement whilst drilling. Measuring 119 m in length by 86 m width the rig is capable of operating in water depth up to 2,500 m, which is well in excess of the water depth at the proposed drilling locations.

The rig is self-propelled and will sail from its current location in West Africa to the Falkland Islands in early 2015 for the start of the campaign. NEFL and Premier Oil take the rig on hire once it sails from West Africa, with the hire period finishing when the rig has been returned to West Africa hence its activities from the point of hire until the rig leaves the Falkland Islands designated area falls within the scope of this impact assessment.

Once in Falkland Islands waters the rig will move self-propelled between drilling locations. While at each well location the rig will maintain its position by deploying three transponders and potential for an additional tension line with a 465 kg clump weight to the seabed. The DP system of the rig uses the fixed point of the clump weight to maintain position by ensuring appropriate tension on the line. On completion of drilling operations at each well location the clump weight and transponders will be retrieved back to the rig.

During drilling operations, a 500 m exclusion zone will be established around the rig to ensure safe operations and maintain safety for other users of the area. Unauthorised vessels including fishing vessels will not be permitted access to the area. The drilling rig will be equipped with navigation lights, radar and radio communications. A stand-by vessel will patrol the 500 m zone while the rig is on location. Table 6 gives an overview of the rig systems and utilities.

3.4.2 Wells Design and Drilling

The wells will be drilled using a conventional rotary drilling system (Figure 7). This comprises:

- The derrick mounted on the drill floor
- A hoisting drum or draw works, mounted on the drill floor at the base of the derrick
- A drilling line passing from the draw works to the top of the derrick through a system of pulleys known as the 'crown block', which is attached via another series of pulleys (the travelling block) to the hook.

The system operates like a crane and can be raised and lowered within the derrick.

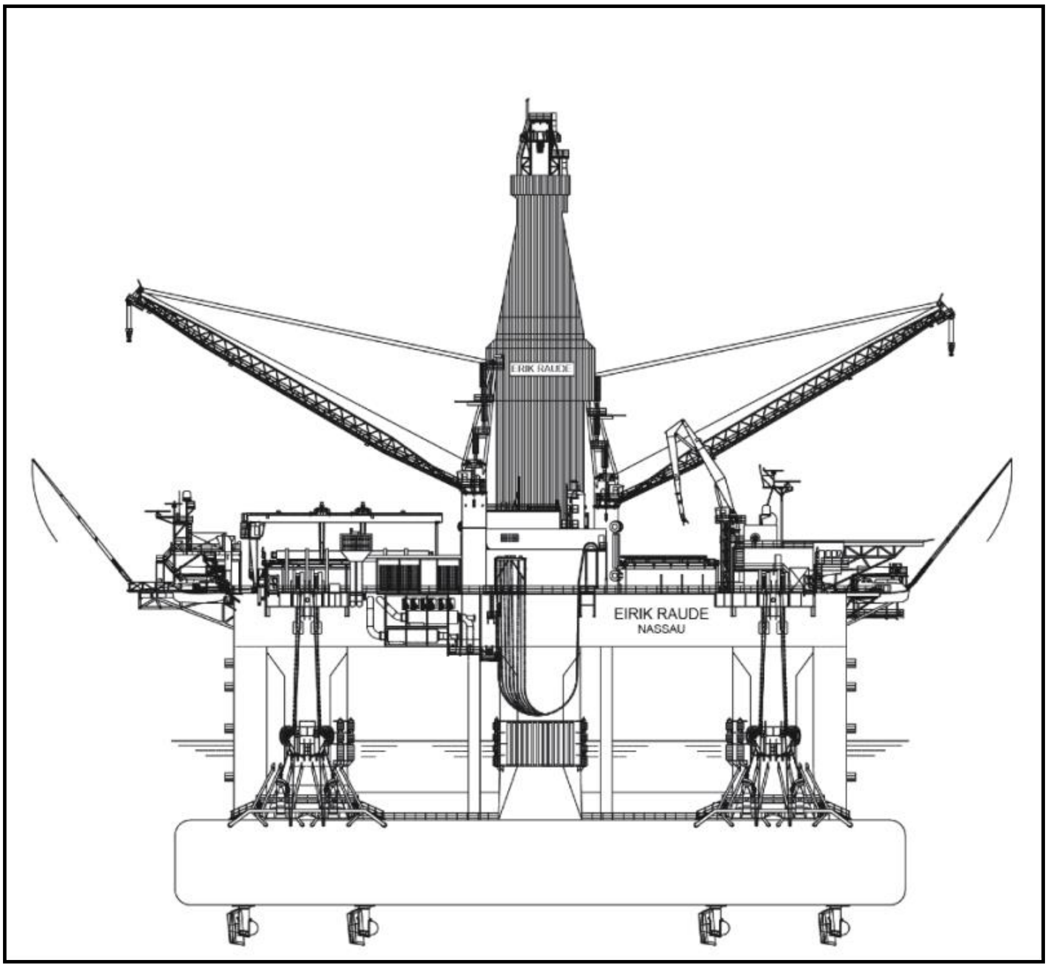


Figure 5: *Eirik Raude* semi-submersible drilling rig side view.

Figure 6: Photo of the *Eirik Raude* semi-submersible drilling

Table 6: Drilling and utility systems on the semi-submersible drilling rig

System	Overview
Operating Parameters	Operating water depth – 2,500m Self propelled transit speed – 6 knots Dynamically positioned – DP Class 3 Helicopter deck Lifesaving – 4 Norsafe lifeboats, 8 life rafts
Drilling mud storage system	Liquid mud tanks – 1,657 m^3 total capacity Bulk mud – 4 tanks, 350 m^3 total capacity Bulk cement – 4 tanks, 350 m^3 total capacity Base oil – 406 m^3 total capacity NOV automatic mud mixing system Free placement cement unit
Drill cuttings treatment	Shale shakers – 5 x VSM 300 units
Well control system	Blow-Out Preventer (BOP) – Cameron 4 ram 18 3/4″. 15,000psi. Cameron multiplex BOP control system, with deadman system. BOP equipped with acoustic back-up system and ROV intervention.
Power generation	6 main diesel powered engines
Maximum diesel inventory	4, 631 m^3
Diesel consumption	During transit – 120 tonnes/day Whilst drilling – 50 tonnes/day On-standby – 50 tonnes/day Refuelling approximately once per month dependent on location and activity
Helicopter fuel	Helicopter fuel will be stored in bunded tanks on the main deck. Maximum inventory would be approximately 8.1 m^3
Accommodation	Maximum capacity – 160 persons On-board potable water storage facilities
Operational waste disposal	There will be segregation of hazardous and non-hazardous wastes. Scrap metal and other solid operational wastes will be segregated and stored in designed skips for onshore recycling and disposal in the UK.
Domestic and general waste disposal	General waste from the rig will be sent to shore for treatment and/or disposal. Food waste will be macerated to acceptable levels prior to discharge in accordance with MARPOL 73/78 Annex V requirements.
Sewage treatment	Treatment with an approved marine sanitation until that achieves no floating solids, no discolouration of surrounding water as per MARPOL 73/78 Annex IV requirements.
Drainage and oily water treatment systems	The main deck and helideck have a contained drainage system, which routes to the drains. Drainage water is treated to remove oil content down to 15 mg/l of oil concentration and 20 mg/l of oil in water threshold (monthly weighted average) in accordance to MARPOL 73/78 Annex I requirements. Separated oil will be collected and stored in drums / transit tanks for shipping back to the UK/FI for disposal.
Bilge water	Treated to remove oil content down to 15 mg/l of oil concentration and 20 mg/l of oil in water threshold (monthly weighted average) in accordance to MARPOL 73/78 Annex I requirements.

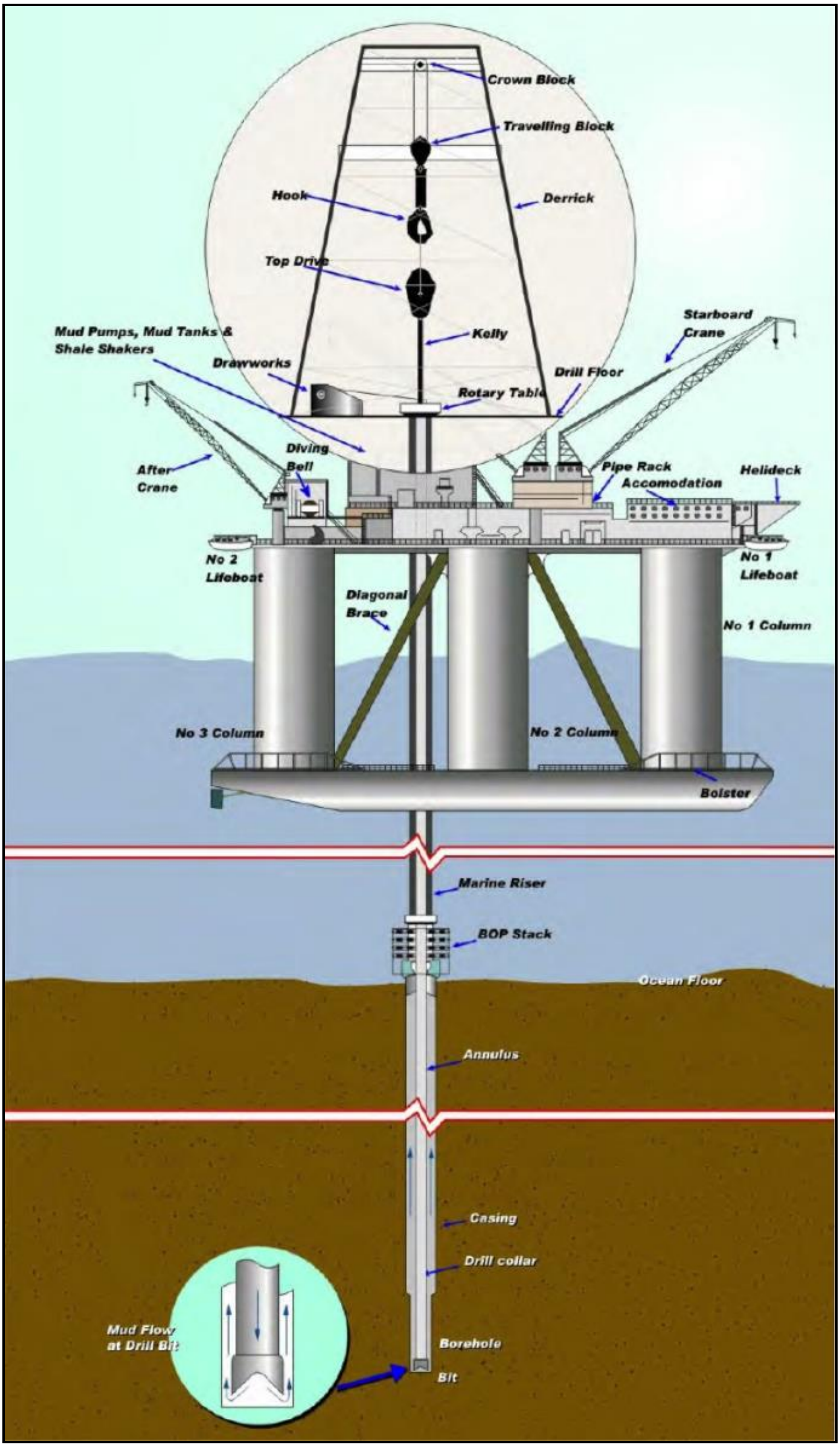


Figure 7: Conventional rotary drilling system diagram

Well Design

The exploration wells will be drilled in three sections with decreasing diameter bore with increasing depth, 42″ diameter top section, 26″ diameter section for surface casing, 17 ½″ diameter intermediate section and a 12 ¼″ diameter objective section (Table 7, Figure 8).

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 is completed, the drill string is lifted and protective steel pipe or casing lowered into the well and cemented into place.

The casing helps to maintain the structural strength of the hole and also eliminates mud losses from the well bore into surrounding rock formations.

The first two sections of each well will be drilled with the drill string and drill bit left open to the seawater, consequently drilling mud and cuttings will be discharged straight to the seabed as there will be no means of containing them. On completion of the top-hole section (42″) the conductor casing will be cemented in place, this prevents drilling fluids circulating outside the casing and causing surface erosion. Surface casings are cemented into the second well section (26″) to prevent hydrocarbons encroaching into freshwater zones in the formation.

Prior to drilling the third section of each well a pipe known as a 'riser' will be run and between the rig and secured to the top-hole conductor casing on the seabed, the drill string will then operate through the centre of the riser. The riser provides a closed system through which the drilling mud can be circulated from the rig into the well (through the centre of the drill string) and subsequently returned to the rig in the space (or annulus) between the drill string and the riser casing / open hole.

NEFL has included a contingency well section (8 ½″) that would only be drilled if problems were encountered while drilling the 12 ¼″ section that meant it could not be completed successfully. In this scenario, the contingency section would be drilled to the same total depth as the 12 ¼″ section and a further surface casing installed. The design for a typical well is shown below (Table 7).

Table 7: Indicative well design and cuttings produced from the four planned exploration wells

Hole Section (inches)	Depth below seabed (m)	Section Length (m)	Casing diameter (inches)	Casing section length (m)
42	75	75	36 x 30 conductor	75m
26	800	715	20 surface casing	~800m
17 ½	800	715	13 $^{3}/_{8}$ surface casing	~800m
12 ¼	2,520	1,736	No casing	No casing

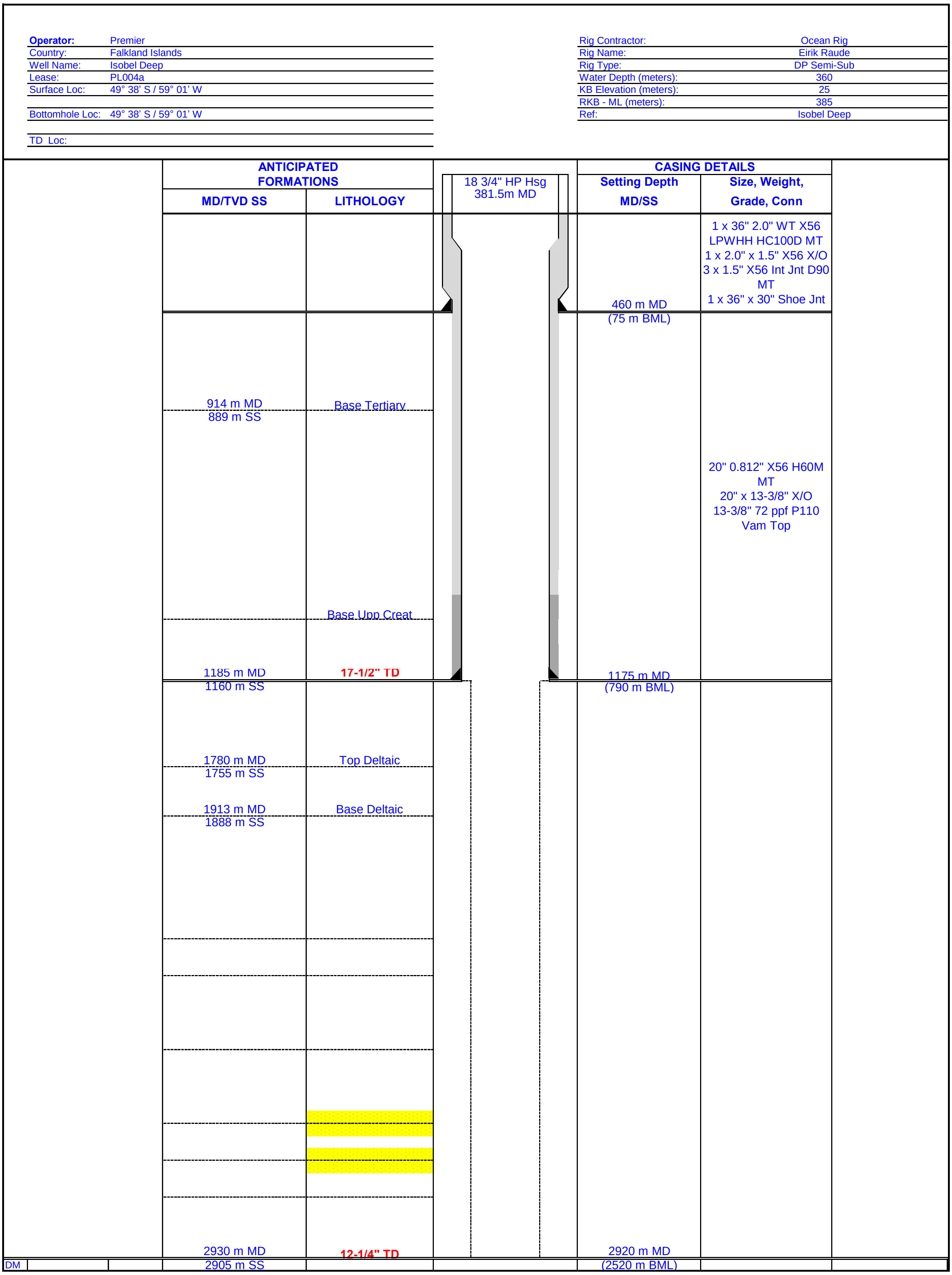


Figure 8: Wellbore Schematic for the Isobel Deep well

3.4.3 Mud System, Cuttings, Cementing and Chemical Discharge

During the drilling operations, drilling mud is pumped through the centre of the drill string down to the drilling bit. Once the riser has been installed the mud can circulate in the closed system and return back to the rig through the annulus between the drill string and riser. The recovered mud is passed through a mud recovery system on the rig, which removes the solid drill cuttings prior to re-use.

Drilling mud is essential to the drilling operation as it performs the following functions:

- The hydrostatic pressure generated by the mud's weight controls the down-hole pressure and prevents formation fluids from entering the 'well bore'.
- It 'sweeps' up the rock cuttings from the bottom of the hole and carries them to the surface.
- It lubricates and cools the drill bit and string.
- It deposits an impermeable cake on the wall of the 'well bore' effectively sealing and stabilising the formations being drilled.

A variety of chemicals may be added to the drilling mud to control a number of conditions:

- Fluid loss control - The layer of mud (wall cake) on the wall of the 'well bore' retards the passage of liquid into the surrounding rock formation. In water-based muds, bentonite is the principal material for fluid loss control although additional additives such as starch and cellulose, all naturally occurring substances, are also used.
- Lubricity - Normally drilling mud alone is sufficient to adequately lubricate and cool the bit. However, under extreme loading, other lubricants are added to prevent the drill string from becoming stuck.
- pH control - Caustic and lime are used to control the alkalinity of the mud to a pH of 9 to 10. This ensures the optimum performance of the polymers in the mud and controls bacterial activity.
- Pressure control - Barite (barium sulphate) is generally used as a weighting agent to control downhole pressure.
- Lost circulation - When drilling through some formations mud can be lost through fissures in the surrounding rock reducing the volume of mud returning to the rig to be cleaned and reused. Naturally occurring fibrous, filamentous, granular or flake materials are used to stop lost circulation when the drill bit enters a porous or fractured formation. Typical materials include ground nut shells and mica.

Two major types of mud are currently typically used in offshore drilling:

- Water Based Mud (WBM) – water forms the continuous phase of the mud (up to 90% by volume);
- Low Toxicity Oil Based Mud (LTOBM) – base oils refined from crude oil form the continuous phase of the mud.

For simple vertical exploration wells, WBM is typically used, and will be used in this campaign. These drilling fluids and associated solids may be discharged to sea under permit, and additional volume can also be built on the rig. The drilling fluid system used in previous wells within the Licence Blocks PL032, PL004, was a water / glycol based polymer mud system, which will be very similar to the muds used on the proposed wells. These fluids provided an acceptable level of chemical inhibition for the formations encountered.

Water base mud properties for the 2015 exploration campaign will be selected on the basis of historical drilling experience in the licence blocks. Consequently a water based mud based on the following generic components will be selected:

- KCl based fluid for chemical inhibition;
- Viscosifier for pressure regulation;
- Mud filtrate reduction, and filtrate control agents;
- Oxygen scavenger for corrosion control;
- pH buffer to regulate pH;
- Polymer addition for clay cuttings encapsulation;
- Glycol for hydrate suppression and fluid lubricity;
- Lime, for H_2S neutralisation, should it be present (not expected).

Specific drilling and completion chemicals have not been finalised at the time of writing this EIS (May 2015), however, all chemical additives will be selected to minimise the potential environmental impacts as much as possible. The vast majority (by volume) of planned chemicals have a Harmonised Offshore Chemical Notification Scheme (HOCNS) category of 'E' (which are of low aqua toxicity, readily biodegradable and non-bioaccumulative) and are naturally occurring products (e.g. barite) that are either biologically inert or readily dispersible or biodegradable. The HOCNS is used by the UK and Netherlands governments to manage the chemical use and discharge by their offshore petroleum industries.

Drilling muds for each hole section for the proposed wells are described below and summarised in Table 8.

42" Hole Section and 26" Hole Section

The two top-hole sections will be drilled with seawater and bentonite viscous sweeps, with drilling mud and cuttings being discharged directly to the seabed. Bentonite viscous sweeps will be circulated to remove debris and residual fluids. Bentonite is the preferred viscous sweep material; this has been selected for its wellbore 'plastering' properties, which reduce the risk of large washouts.

Once the 42″ section has been drilled to the total depth, the hole will be displaced to 10.5 ppg mud, to maintain wellbore stability prior to running the conductor. On completion the 26″ will be displaced to 11 ppg (pounds per gallon) mud, to maintain wellbore stability prior to running the 13 $^3/_8$″ surface casing.

17 ½", 12¼"and 8½" Contingency Hole Sections

The 17 ½″ and 12 ¼″ section will be drilled with water base mud, which will be recycled and maintained in good condition throughout the operation. The mud and suspended cuttings will be processed on the platform through screens called 'shale shakers' to maximise recovery of the mud.

It is not currently planned to drill an 8½″ section but if problems are encountered while drilling the 12 ¼″ section, it may be considered. A contingency 8½″ section is included here for completeness.

Table 8: Estimated Total Quantity of Mud and Cuttings Discharged per Exploration Well

Hole Section (inches)	Mud type	Mud weight	Cuttings generated (tonnes)	Mud discharged (tonnes)	Cuttings discharge point
42	Seawater with bentonite sweeps	Seawater displaced to 10.5 ppg mud	182	229	Direct to seabed
26	Seawater with bentonite sweeps	Seawater displaced to 11 ppg mud	357	342	Direct to seabed
17 ½	Seawater with bentonite sweeps	Seawater displaced to 11 ppg mud	348	482	Direct to seabed
12 ¼	High performance WBM	9.3 – 9.6	175	415	At sea surface from the rig
Total (contingency section not included)			1,062	1,468	

Cementing Chemicals

Cementing chemicals will be used to seal the well casing in place and provide cement design support by:

- Obtaining a strong casing shoe, and isolating all weaker formations drilled in the previous hole section;
- Providing structural support;
- Providing annular isolation of permeable formations (where allowed by trapped pressure considerations).

As for the chosen drilling muds, all cementing chemicals will be selected to minimise the potential environmental impacts as far as possible. The vast majority (by volume) of planned chemicals have a HOCNS category of ‘E’ (which are of low aqua toxicity, readily biodegradable and non-bioaccumulative). Standard cement slurries will be used, and an alternative ‘blended’ solution will be developed for 36˝ and 13 $^{3}/_{8}$˝ section. The 12 ¼˝ open hole will be plugged with standard cement, which is commonly used in the North Sea (Table 9).

Table 9: Indicative well design and cuttings produced from the four planned exploration wells

Casing Size (inches)	Cementing Method	Slurry Density (ppg)	Planned Top of Cement	Verification Method
36 x 30 conductor	Inner String	13.2	Seabed	Returns observed with ROV. Possible use of pH meter.
13 $^{3}/_{8}$ Surface casing	Inner String	15.8	Seabed	

3.4.4 Well Control and Blow-out Prevention

In addition to careful monitoring and control of the fluid system and installation of casing in each section of the well, a blow-out preventer stack (or BOP) consisting of a series of individual preventers will be installed on the wellhead at the seabed after the top hole sections have been drilled.

The function of the BOP is to prevent uncontrolled flow from the well by positively closing in the well-bore, if flow from the well-bore is detected. The BOP is made up of a series of hydraulically operated rams and can be operated in an emergency from the drill rig.

The well is not anticipated to encounter any zones of abnormal pressure and the BOP will be rated for pressures well in excess of those that might be encountered in the wells.

During drilling operations small amounts of BOP water-based hydraulic fluid are typically discharged every week, during testing of the BOP.

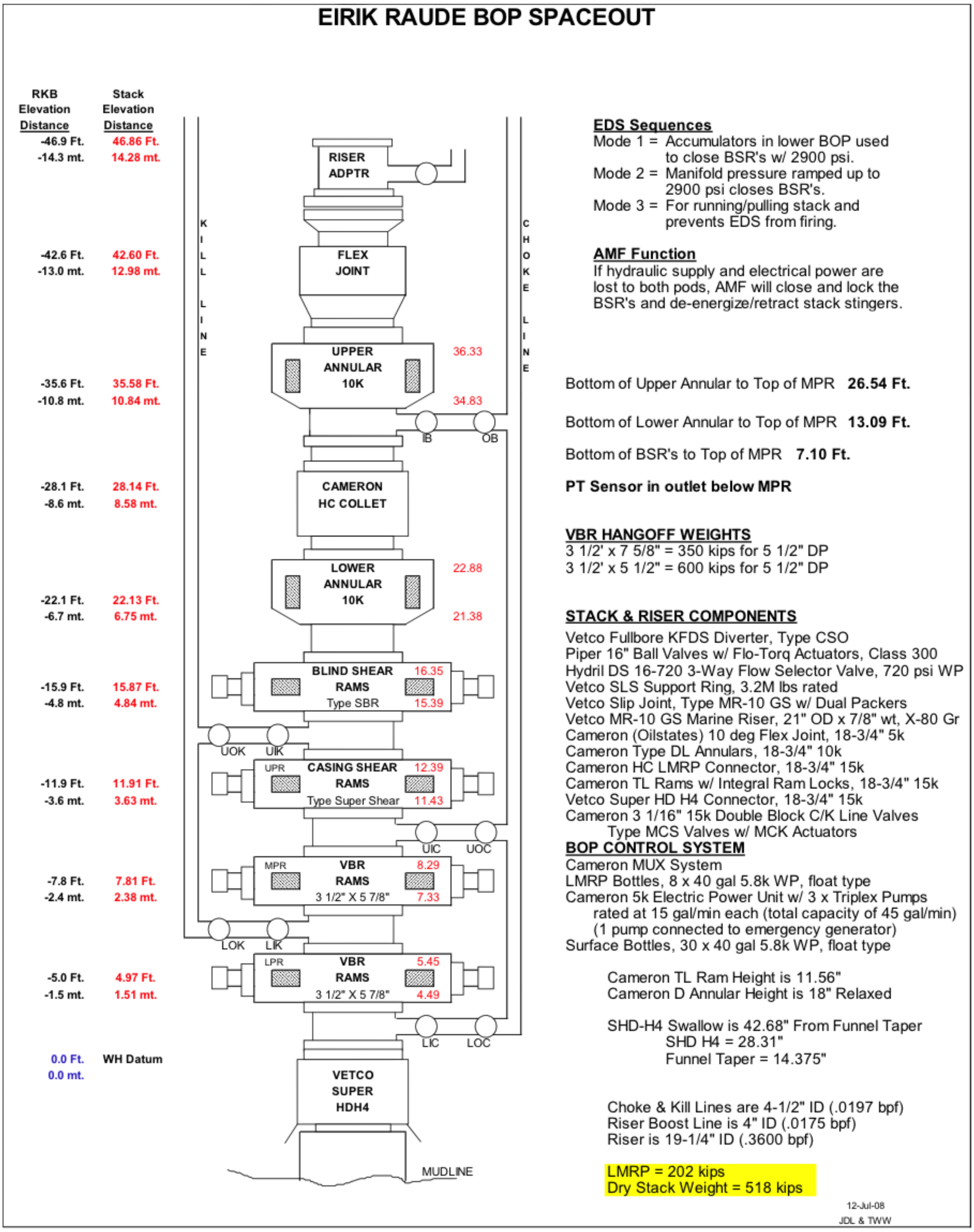


Figure 9: *Eirik Raude* Blow-out Preventer Spaceout Diagram

3.4.5 Well Evaluation

3.4.5.1 Logging and Coring

Formation properties will be measured and logged by LWD (Logging While Drilling) tools integrated into the bottom-hole-assembly (lower portion of the drill string including the drill bit). Wireline logging tools will be used to further evaluate the well. If the results of logging indicate a potential for hydrocarbon bearing formations, it may be considered necessary to collect rotary side wall cores and formation fluid pressures and samples. If it is determined to collect whole core from the objective, it will via an optional by-pass borehole.

3.4.5.2 Well Testing

Well testing is not part of the base case design for this campaign.

3.4.6 Vertical Seismic Profiling

Vertical seismic profiling (VSP) will be conducted as part of the evaluation to correlate the actual data collected by the down-hole well logging process to the surface acquired seismic data. VSP combines the precise lateral control of surface seismic with the fine vertical resolution of down-hole logging techniques, and can be used to ‘ground-truth’ the historical seismic data.

VSP comprises an airgun (10 to 150 Hz) that will be deployed over the side of the rig using the rig crane and a geophone receiving device. The VSP will take approximately 12-18 hours with guns being fired 3-5 times every 10-15 minutes during that window. JNCC guidelines for seismic surveys will be employed during the survey, with designated spotters on the rig for the presence of marine mammals. The operation will commence with a soft start to ensure that any marine mammals within hearing range of the guns, but not visible to the eye, would be given sufficient warning before the guns reach full capacity and are able to move out of the area.

3.4.7 Well Abandonment

After TD logging, the wells will be plugged and abandoned. The plugging and abandonment will be achieved by setting cement plugs across all open hole permeable formations, and then setting an additional cement plug inside the 20″ and 13 $^3/_8$″ casing. The abandonment design will comply with the UKOOA Guidelines for the Abandonment and Suspension of Wells, and ensures that independent cemented barriers are provided against all permeable and over-pressured formations. The number of cement barriers placed in the well bore will depend on whether hydrocarbons are encountered, the presence of hydrocarbons requiring more barriers. A maximum of 5 cement plugs would be set in the well if hydrocarbons were found, each plug being 250m in length and comprising approximately 5 tonnes of cement per plug.

Prior to leaving the location, the wellhead will be cut approximately 3 m below the seabed, and recovered to surface. An ROV seabed clearance survey will then be conducted, to confirm that the seabed is clear of debris.

3.4.8 Drilling Support

Drilling operations will be supported by a supply base or laydown yard of approximately 40,000m^2 near Stanley, current laydown yard plans are shown below. NEFL and Premier Oil will share the yard space during this drilling campaign. The exploration campaign supply base is anticipated to comprise: 5-7 Boxer Bridge, 9-13 Coastal Road and 33 Coastal Road as indicated below in Figure 10. The supply base will be supported by workforce of up to 30 workers, comprising a mix of local workers and some workers from the UK.

Figure 10: Laydown Yard east of Stanley

There will be a pool of coaster vessels, which will keep the supply base stocked from the UK and return any waste or equipment no longer required back to the UK. It is expected that each vessel will make one return journey from the UK to the Falkland Islands to deposit and collect cargo.

The drilling rig will also be supported by two platform supply vessels operating out of the supply base, to the East of Stanley, which will keep the rig stocked with the items needed to carry out its operations. Supply boats are expected to transit between the supply base and the rig once a week during operations plus any additional journeys that may be required. The supply vessels will re-fuel at FIPASS following each visit to the rig once a week.

In addition, an Emergency, Response and Rescue Vessel (ERRV) will be stationed in the vicinity of the rig for the duration of the drilling programme. An ERRV must be able to accommodate the entire complement of the rig and, if required, will come alongside the rig to assist.

Three helicopters will be support the rig operations primarily for routine maintenance, crew change transfers, and/or any emergencies that require air-lifts. It is anticipated that the helicopters will be stationed at Stanley airport and that crew changes will be undertaken every two weeks, changing out approximately 60 personnel from the rig to Stanley airport each time.

Crews will then be transported to Mount Pleasant Complex (MPC) via road vehicle, most likely a coach.

A fixed-wing charter flight will run fortnightly to coincide with the crew change from the rig and will depart from MPC travelling to London. Freight options may be available for non-oil field cargo on the charter flight.

Drilling operations will require large quantities of fresh water as potable water for the accommodation on the rig as well as for preparation of the drilling mud. The majority of drill water will come from domestic supply. The Temporary Docking Facility (TDF) contains freshwater storage tanks which will be constantly trickle-fed with water from the Moody Brook reservoir. This will disconnect any peak in campaign demands from the supply to Stanley. Potable water will be 'made-up' on the rig by taking seawater and processing it to make it drinkable.

The Falkland Islands Government are currently progressing plans to supplement the water supply from Moody Brook with a new supply from the Murrell River. This will involve construction of a small barrage across a tributary of the Murrell River, where an off-take will pump to join the existing main from Moody Brook. This new source will offer both reduced energy needs for pumping relative to Moody Brook (due to much reduced pumping head) and also the potential for virtually direct supply of untreated water to the new port via storage tanks placed on the new main pumping route should this be desired. Latest discussions with FIG indicate that the reservoir is likely to be completed be the third quarter of 2015, in time for the summer months when demand levels are increasingly becoming too high during summer relative to the amount of water available from Moody Brook. The Murrell River reservoir may be online in time for the Rhea-1 exploration well but this is not a prerequisite for drilling, the current (Moody Brook) supply is sufficient to meet the needs of Stanley and trickle feed the TDF, to supply the drilling campaign.

Table 10: Approximate rig and support vessel movements during NEFL 2015 Exploration Campaign

Vessel/transport movements	Frequency	Duration (days / hours)
Drilling rig operations (*Eirik Raude*)	1	38 days
Drilling rig transit	1	1 day
Coaster supply vessels from UK	3	60
Charter flights to/from UK to MPC	3	36 hrs round trip
Helicopter – rig support and crew change	40	3 hrs round trip
Helicopter – emergency response	5 test flights	3 hrs round trip
OSV/PSV – from Stanley to rig	45	1.25
ERRV – alongside rig	1	38 days
Onshore minibus transport – crew change support between MPC and Stanley (15 minibus's x 3 crew changes)	45	2 hrs round trip

3.4.9 Estimated Quantities of Residues and Emissions Resulting from the Project

In line with Paragraph 1, sub-paragraph 4c of Schedule 4 in the Offshore Minerals (2011) Ordinance, characterisation and quantification of the expected residues and emissions resulting from the Rhea-1 well operation are provided in Table 11:

Table 11: Estimated Quantities of Residues and Emissions Resulting from the Project

Type of Emission or Residue	Quantity of Emission or Residue (unit)	EIS Chapter Detailing Full Characterisation and Quantification
Rig, Drilling on DP noise Level at Source	188 (dB re.1μPa)	Chapter 7
Rig, Drilling on DP noise Level at 500m	134 (dB re.1μPa)	Chapter 7
VSP noise Level at Source	240 (dB re.1μPa)	Chapter 7
VSP noise Level at 500m	N/A (directional noise)	Chapter 7
Atmospheric emissions	37,071 (tonnes CO_2e)	Chapter 8
Offshore Light Emission	Estimated 30 kW	Chapter 9
Hazardous Waste	25,280 (kg)	Chapter 11
Non-Hazardous Waste	48,753 (kg)	Chapter 11
Grey Water	1,177 (m^3)	Chapter 11
Black Water	157 (m^3)	Chapter 11
Drill cuttings	1,062 (tonnes)	Chapter 12
Drilling mud	1,468 (tonnes)	Chapter 12

3.4.10 Temporary Dock Facility (TDF)

In support of both the NEFL and Premier Oil 2015 exploratory drilling campaign a Temporary Dock Facility (TDF) was constructed in Stanley harbour. The TDF will be used for loading supplies onto the two rig supply boats.

The TDF has been the subject of a separate environmental and social impact assessment and Environmental Statement prepared by NEFL (Ref: 221-13-EHSR-ESH-PA-T4) and consequently any impacts associated with the TDF will not be included in this ESIA. The location of the TDF is shown below in Figure 11.

3.5 Project Alternatives

3.5.1 Alternatives to Drilling Location

Processed and interpreted seismic data are used to indicate areas where hydrocarbons may be trapped in oil or gas-filled geological structures. Many complex factors dictate the location of oil wells (e.g., geology, topography, communications and engineering technology), meaning only a few viable alternatives can be considered. Rhea-1 was chosen as the PL001 drill target for this campaign as it indicates the highest potential for hydrocarbons in the license area, based on rigorous seismic data interpretation and information currently available. Information gathered in drilling the well will give a better understanding of the seal, stratigraphy, reservoir quality, and depositional environment, and will help calibrate seismic data. These data will help identify drill targets for potential future campaigns.

3.5.2 Alternative Drilling Units

There are alternative designs of mobile offshore drilling unit (MODU) available for hydrocarbon exploration offshore; jack-up rigs, semi-submersible rigs and drill-ships are three of the most common.

Given the variance in water depths across the 2015 exploration campaign, previous operator experience, the environment within which operations will occur and suitable rig availability, an assessment of available rigs indicated that the Ocean Rig *Eirik Raude* DP semi-submersible drilling unit is the optimal and viable option (refer to Section 3.4.1) for this campaign.

3.5.3 No Action Alternative

The implications of not proceeding with an exploration-drilling programme mean that the potential environmental and socio-economic impacts (both positive and negative) from drilling operations will not occur. The offshore environment may not necessarily maintain its current baseline condition, as impacts from routine vessel activity, such as waste water discharge, fall- out of atmospheric pollutants and ballast water discharge are still likely to take place offshore. The potential financial and social-economic benefits of oil and gas production will also not be realised.

As described in this document, the exploration-drilling project is technically feasible. On the basis of the impact assessment presented within this document and the associated mitigation measures, it is not considered that the residual impacts warrant a cancellation of the drilling programme.

The project is also in line with the long-term plans of FIG to work towards a successful and sustainable hydrocarbons industry in the Falkland Islands.

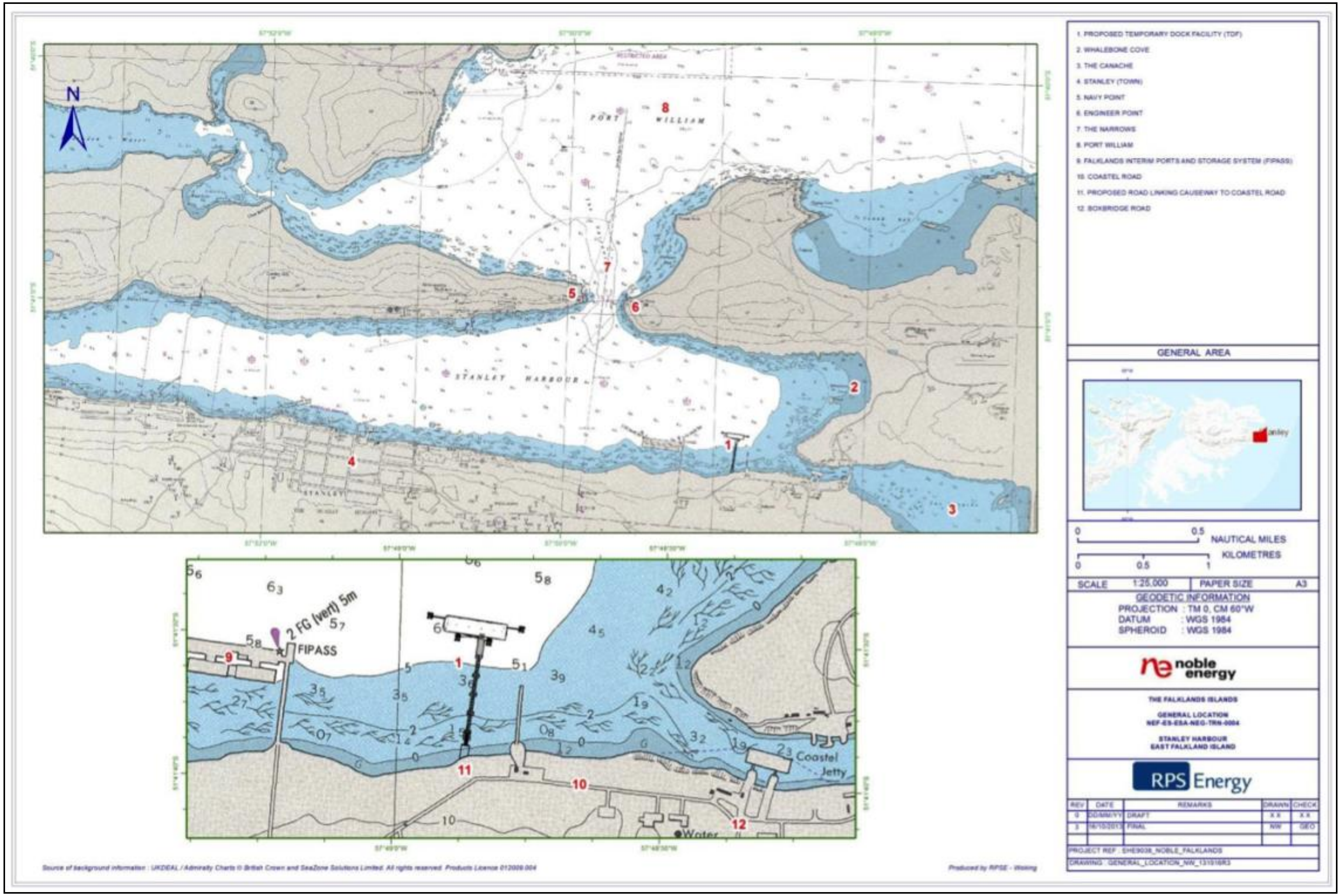


Figure 11: Location of the Temporary Dock Facility

4.0 Environmental Management System

As a subsidiary of Noble Energy Inc., Noble Energy Falklands Ltd. (NEFL) adheres to the Noble Energy Global Environmental, Health and Safety (EHS) Management System (hereafter referred to as the GMS) and aims to conduct its business in a manner that protects the environment and the health and safety of all employees and the public.

4.1 Noble Energy Environmental, Health and Safety Policy

Noble Energy will conduct the exploration drilling operations in a manner consistent with the EHS Policy Statement (Figure 12), which is endorsed by the Noble Energy Environmental, Health, Safety and Regulatory Vice President. The EHS policy states NEFL's intention to conduct its business in a manner that safeguards people, the environment and surrounding communities. The policy statement is supported by the GMS standard that further defines Noble Energy's EHS responsibilities in relation to its business activities.

Specifically, the GMS make's the following commitments:

Principles

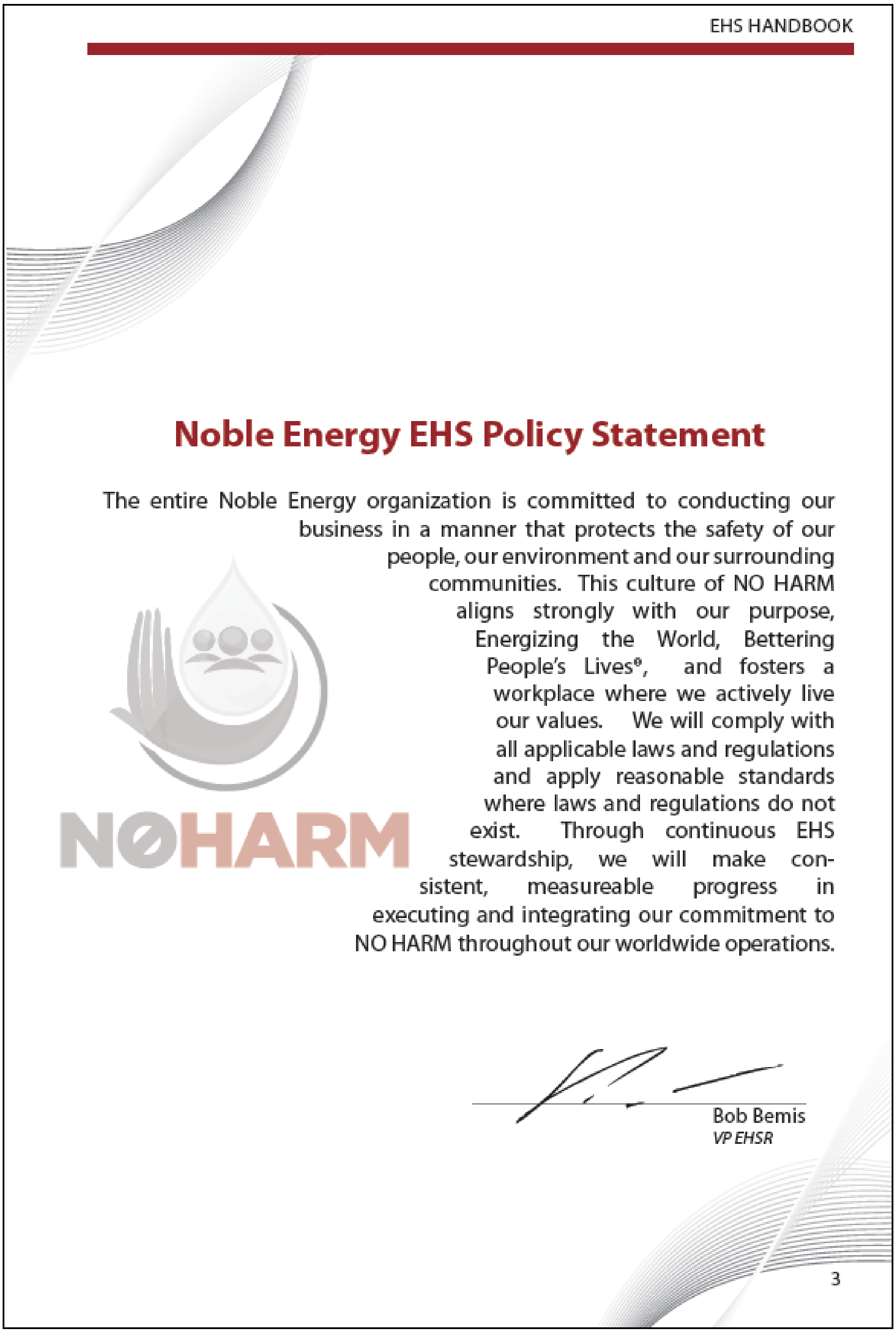
- Leadership: demonstrated through high expectations and personal ownership, responsibility and accountability for EHS performance
- Performance: promoted through positive interaction with people and our environment on a daily basis to achieve excellence
- Excellence: advanced through genuine care and compassion for our fellow man and the environment leading to a strong EHS culture
- Culture: fostered through interpersonal relationships, teamwork and common beliefs; communicated repeatedly, consistently and accurately

Vision

- Demonstrate leadership in safety and environmental management, continuously decreasing the risk of injury, illness, and environmental impact.

Values

- Integrity: we are committed to conducting our business with integrity, respect and ethical standards.
- Teamwork: we are committed to supporting and implementing a team-oriented work environment, ensuring cooperation, communication and professionalism.
- Process: we will continuously challenge existing ideas and best management practices to provide high EHS standards in all of our operations.
- Accountability: we will provide a fair appraisal of our safety and environmental activities and foster a culture that encourages individual responsibility for safety and environmental leadership in each organisational unit.



EHS HANDBOOK

Noble Energy EHS Policy Statement

The entire Noble Energy organization is committed to conducting our business in a manner that protects the safety of our people, our environment and our surrounding communities. This culture of NO HARM aligns strongly with our purpose, Energizing the World, Bettering People's Lives®, and fosters a workplace where we actively live our values. We will comply with all applicable laws and regulations and apply reasonable standards where laws and regulations do not exist. Through continuous EHS stewardship, we will make consistent, measureable progress in executing and integrating our commitment to NO HARM throughout our worldwide operations.

Bob Bemis
VP EHSR

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Figure 12: Noble Energy Environmental, Health and Safety Policy

4.2 NEFL Energy Global EHS Management System

The Noble Energy GMS applies to all business activities associated with NEFL assets, projects and operations. Noble Energy 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 GMS to ensure sound environmental management. In the absence of national legislation or local authority regulatory control within the host-country, Noble Energy will endeavour to utilise best industry practise.

The Noble Energy GMS has been developed in line with:

- The Noble Energy EHS Policy Statement;
- The Global EHS Management System Standard (EHS.MS.001 Rev 02);

The environmental components of the GMS integrate elements from:

- The US Environmental Protection Agency (EPA) Risk Management Planning (RMP) Rule;
- ISO 14001: 2004; and
- International Finance Corporation (IFC) and World Bank Group (WBG) EHS Guidelines.

The GMS comprises 14 key elements which sit within the 'Prepare, Execute, Verify, and Perform' model (Figure 13). The purpose, scope, key requirements and high-level roles and responsibilities associated with each element are provided in the GMS standard. The intention and key commitments associated with these guiding principles are summarised in Table 12.

Figure 13: Global EHS Management System 14 Element Review and Monitoring Cycle

Table 12: Summary of Global EHS Management System Elements

MS cycle	Element	Element Category	Element Description
PREPARE	1	Management Commitment and Employee Participation	Intends to ensure that clear and consistent expectations of personnel are established. Key commitments are: • To provide leadership and resources for protecting the health, safety, environment and social aspects of business; • To maintain high ethical standards; • To ensure implementation of the Global EHS-MS; • To assign and notify each employee of their responsibilities with regard to implementation of the GMS; • To measure performance of the EHS-MS; • To develop goals, objectives and targets, consistent with the Policy Statement through the assessment of inherent environmental, health, safety and social risks and to communicate these the personnel, stakeholders and the public; and • To meet the goals, objectives and targets by developing effective management control plans, programs, and activities.
	2	Legal Aspects and Document Control	Intends to ensure identification and implementation of all responsibilities and requirements for each area of activity. Key commitments are: • To comply with all regulations in each country where Noble Energy conducts business; • To apply best practice in the absence of host country regulations; and • To document all identified risks, the associated responsibilities and requirements and all management control activities performed in support of compliance.
	3	Safe Work and Operating Practices	Intends to ensure the development of Safe Work and Operating Practices for Noble Energy personnel and recognises that third-party contractors will follow their own Safe Work and Operating Practices.
	4	Process Safety and Environmental Information	Intends to ensure that information relevant to each activity that carries EHS impacts and risks is established and documented. Key commitments are: • To identify and evaluate all risks inherent to an operation using industry best practice assessment methods; • To reduce all identified risks to the most feasible level at the design stage; • To manage risks in accordance with risk severity and operational controls in the operational stages; • To maintain information on the significant environmental aspects and related actual or potential impacts at all facilities or appropriate field offices

Table 12 continued: Summary of Global EHS Management System Elements

MS cycle	Element	Element Category	Element Description
PREPARE	5	Emergency Preparedness and Community Awareness	Intends to ensure preparation for potential emergencies that threaten the health and safety of personnel, the environment and/or sustainability and to ensure consideration of the relevant communities. Key commitments are: • To ensure implementation of preventative controls at all times and to deploy mitigation controls in a timely and effective manner in the event of an emergency situations to limit the extent of damage to persons, property or the environment; and • To develop Incident Management Plans (IMP) at the corporate level and for each operation. Operational IMP's include, but are not limited to, the development of an Oil Spill Contingency Plans.
EXECUTE	6	Safety and Environmental Training	Intended to ensure that all Noble Energy personnel are adequately and properly trained with regard to the potential environmental, health, safety and sustainability risks and relevant preventative controls. Contractors are responsible for providing training for their employees prior to commencing on Noble Energy operations and for providing adequate training documentation or verification. Noble Energy requires its contractors to comply with all training requirements set forth by country, federal, state, and local government and all laws and regulations that are applicable. Compliance with this requirement must be assessed in accordance with element 7.
	7	Contractor Safety Management	Intended to ensure the protection of personnel, community health and safety, the environment and sustainability with regard to Noble Energy operations as influenced by contracted personnel. Key commitments are: • To utilise the Noble Energy Contractor Safety Management Plan to ensure that contractors conduct their work in such a manner that they present no risks to Noble Energy employees, contractor personnel, the public, the environment, equipment, or property.
	8	Pre-Start-Up Review	Intended to ensure full communication of schedules, tasks and potential risks to all personnel involved in the start-up of a project/task/operation in order to protect personnel health and safety, the environment and sustainability. Key commitments are: • Each facility must develop a pre-start-up review procedure that verifies the operation/facility is safe to start.
	9	Management of Change	Intended to protect personnel health and safety, the environment and sustainability during and following changes to operations and facilities. Key commitments are: • Implementation of management of change procedures

Table 12 continued: Summary of Global EHS Management System Elements

MS cycle	Element	Element Category	Element Description
EXECUTE	10	Risk Assessment and Management	Intends to protect personnel, assets and the surrounding environment and community by adequately assessing risks and implementing preventative controls to minimise impact/risk. Key commitments are: • To develop a risk assessment program with the goal of reducing the potential for injuries/illnesses and minimising the consequences of uncontrolled releases and other environmental/safety incidents. Risk assessments must be completed at the initial design phase (e.g. new and modified facilities/operations) and as an ongoing aspect of daily operations; • To ensure risk assessment is carried out in line with approved and appropriate methods; • To ensure that all preventative controls designed to minimise impact or the likelihood of impact are integrated into Safety Work and Operating Procedures; and • To ensure that periodic EHS Regulatory Compliance Audits are conducted in order to ensure compliance with applicable regulatory requirements and preventative control measures.
VERIFY	11	Performance Monitoring and Measuring	Intended to support the implementation of health, safety, environmental and sustainability goals, objectives, targets and compliance requirements in an effective and consistent manner that provides for continual improvement. Key commitments are: • To establish performance monitoring and measurement requirements for each operational aspect that has the potential to impact the health, safety, environment or sustainability of its business; • To inform employees of their responsibilities with regard to managing risks and supporting Noble Energy in meeting its goals, objectives, targets and compliance requirements; and • To implement the Performance Monitoring Procedure
	12	Incident Reporting, Analysis and Corrective Action	Intended to ensure that incidents are properly investigated to establish root causes and corrective actions designed to prevent or minimise the risk of recurrence. Key commitments are: • Implementation of incident investigation procedures as appropriate to the event and identification and completion of corrective actions and reporting.
	13	Management System Compliance Audit	Intended to ensure full implementation of the GMS in an effective and consistent manner that promotes continual improvement. Key commitments are: • To conduct periodic audits; and • To adjust and improve the GMS and supporting procedures based on audits findings as necessary.
PERFORM	14	Operational Integrity and Continual Improvement	Intended to ensure operational integrity and support continual improvement of the GMS. Key commitments are: • To design, procure, construct and install all critical equipment in accordance with Noble Energy's standard specifications or other specifications identified by Noble Energy as industry best practice

4.3 Environmental, Social and Health Impact Assessment (ESHIA) Guideline

The ESHIA Guideline (147-13-EHSR-ESH-GL-T2) sits within the GMS and provides detailed guidance on the minimum information that must be included within the EIA and corresponding EIS.

Specifically, implementation of the ESHIA guideline ensures compliance with the following GMS elements (Table 12):

- Element 4: Process Safety and Environmental Information;
- Element 10: Risk Assessment and Management;
- Element 11: Performance, Monitoring and Measuring; and
- Element 12: Incident Reporting, Analysis and Corrective Action.

The guideline provides a framework that conforms to the project financing requirements of an Equator Principles Financial Institution. Even where the NEFL project does not anticipate receiving financial support, the Equator Principles, and the IFC Performance Standards (PS) and EHS Guidelines that underpin them, are considered Good International Industry Practise (GIIP) and are thus utilised.

NEFL recognise that local regulatory authorities may have additional or differing requirements. As such, flexibility exists within the guideline with regard to the applicability of the guideline on a project specific basis, the EIA methodology and the potential requirement for additional information that may be required under host-country legislation.

4.4 Legal Compliance During Operations

All FIG regulations will be adhered to during the Rhea-1 well operation to ensure that all relevant consents and permits are applied for. Where no FIG regulation exists for a given activity, UK and international standards shall be adhered to. Relevant legislation is indicated in each impact/risk assessment chapter where necessary.

In accordance with the FIG DMR guidance notes on operations notices, the FIG Petroleum Operations Notices (PONs) which are relevant to environmental management and permitting during the Rhea-1 well operation are:

- PON2: Reporting procedure - detailing the need for progress meetings, monthly progress reports and daily drilling reports;
- PON4: Application for Consent to Drill Exploration, Appraisal, and Development Wells and the Consent to Locate; and
- PON8: Oil Pollution – detailing the FIG reporting requirements in the event of an accidental hydrocarbon release and the need to liaise with the Department of Natural Resources (DNR) with regard to management of the spill and alignment with the Falklands National Oil Spill Contingency Plan (NOSCP).

Note that the PON10 for the Application to Use and Discharge Non-Aqueous Drilling Fluids and Associated Cuttings does not apply to the Rhea-1 drilling operation as only WBMs are being used.

4.5 Operational Control and Mitigation Measures

The EIA process is designed to enable identification of the planned activities within an operation that may impact upon the environment, and to characterise and quantify what those impacts may be. Equally, the risk assessment process is designed to identify potential unplanned events that may impact upon the environment while assessing both the potential impact and the likelihood of the event and impact occurring. Once the significance of the impact/risk has been assessed, it is necessary to identify what mitigation controls may reduce the impact/risk to As Low as is Reasonably Practicable (ALARP). Identification and development of mitigation controls for significant impacts/risks is informed by the EIA process is carried out in line with elements 3, 4 and 5 of the Noble Energy GMS.

Mitigation controls are designed to either:

- Prevent a predicted impact from occurring;
- Minimise the predicted impact;
- Remediate the impact;
- Prevent or reduce the likelihood of an unplanned event; and/or
- Minimise the severity of consequence in the event of an incident.

Controls identified may comprise one or more of the following:

- Elimination controls e.g. electing not to commence with an operation/activity;
- Substitution controls e.g. electing to carry out the activity in a different way, place or time;
- Engineering controls e.g. 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.

All mitigation controls and measures identified during the EIA must be achievable and measurable and will be recorded within a project specific EMP where it is deemed appropriate.

4.5.1 Standard Operating Procedures

Where appropriate, the GMS standard requires that facility/operation specific procedures/plans be developed to promote efficient and safe operations. Further, operation specific procedures / plans may be required to ensure the appropriate implementation of project specific mitigation measures and/or the monitoring requirements identified in the EIA. Further guidance on project specific plans and procedures which may be required is provided in the Noble Energy ESHIA Guideline.

Where necessary, the rig / drilling contractor will develop specific operational controls to ensure that measures are implemented at the appropriate phase in the project and in an effective manner which is congruent with the Noble Energy GMS requirements and the EIA (Section 4.9).

4.6 Objectives and Targets

In compliance with GMS elements 1 and 11, NEFL will develop project specific environmental objectives, targets and programmes to ensure continual improvement within environmental management. Key actions required to ensure that all objectives and targets are met will be incorporated into the EMP and/or included within the project commitments register in compliance with the ESHIA Guideline.

4.7 Project Specific Management Plans

Management plans are designed to support environmental management, to mitigate against environmental impacts/risks by ensuring the implementation of controls identified in the EIA and to aid communication between Noble Energy and its contractors. Figure 14 illustrates the role of management plans in project realisation as they link the respective management systems and the EIA. Each management plan will detail key actions and associated roles and responsibilities.

Management plans will be required in compliance with:

- The terms of the production license;
- The FIG DMR EIA Guidance Notes (2012);
- The FIG Guidance Note on Approvals required for offshore operations in the Falkland Islands (02/13);
- The Noble Energy ESHIA Guideline; and
- The outcomes of the EIA for the operation.

Detail on the project specific management plans that will be developed and implemented for the Rhea-1 well operation are provided in Section 14 which describes project specific environmental management. Guidance and definition for all management plans that may be required for a given project are provided in the Noble Energy ESHIA guideline.

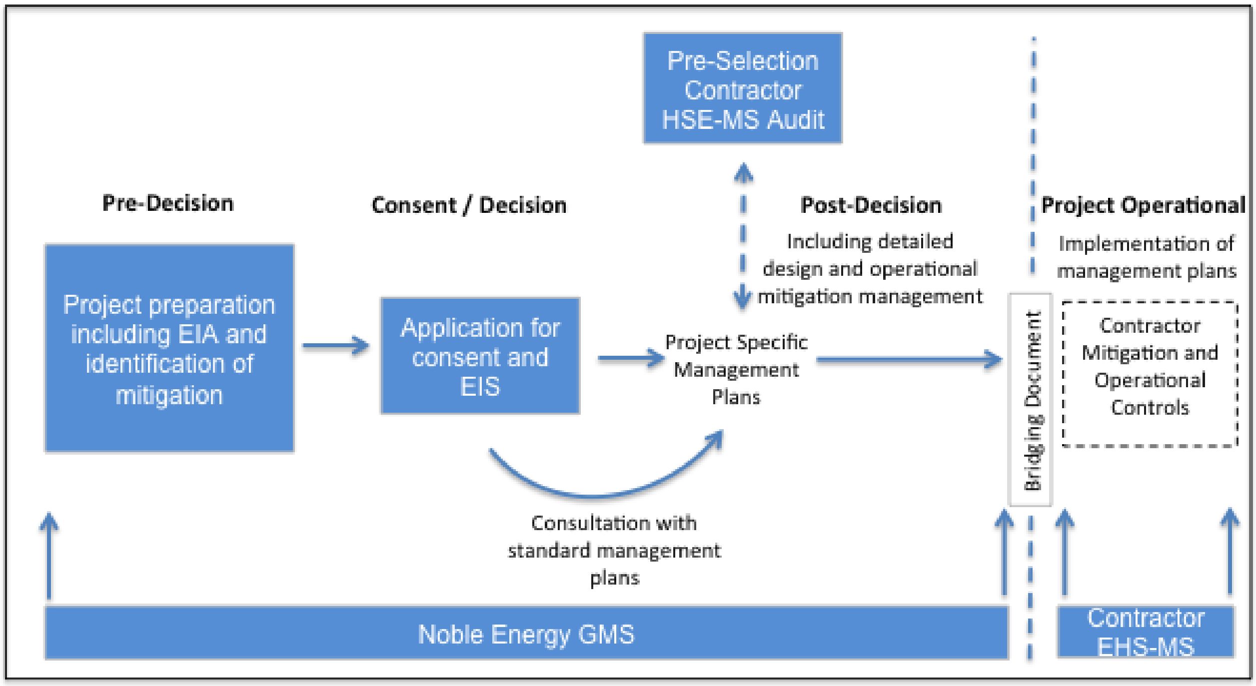


Figure 14: Link between the Environmental Impact Assessment, Management Plans, the NEFL GMS and contractor management systems (adapted from IEMA, 2009)

4.8 Performance Monitoring Measures

Monitoring and measuring is a cornerstone in ensuring compliance and continual improvement within environmental management and is carried out in line with element 11 of the GMS. Further, monitoring enhances understanding of the efficacy of the EIA process with regard to the knowledge and understanding of impacts and is essential to measure the success of mitigation in practice (IEMA, 2008).

It is therefore necessary to identify monitoring requirements throughout the EIA process, which will:

- Determine compliance with regulatory requirements standards and Government policies;
- Provide an early indication should any of the environmental mitigation measures or practices fail to achieve acceptable standards;
- Enable the project to take remedial action if unexpected problems or unacceptable impact arises;
- Monitor the performance of the project and the efficacy of mitigation measures;
- Provide a database against which any short or long-term environmental impacts of the project can be determined;
- Verify the environmental impact predicted in the EIA studies; and
- Provide auditable data.

Priorities for monitoring should include:

- Activities/impacts for which significant impacts were predicted;
- Activities/impacts for which successful mitigation is essential for avoiding significant impacts; and
- Impacts for which there is a high degree of uncertainty in the impact predictions or in the likely success of the proposed mitigations.

Performance monitoring will be carried out by NEFL via the following:

- Participation in daily calls during the entire drilling campaign to discuss the project status, any issues that have arisen and solutions where necessary. This will include EHS issues;
- Receipt of daily, weekly and monthly reports provided by the contractor to track EHS performance and provide detail on how any issues were closed out;
- Receipt of daily report on chemical use will be provided by the contractor;
- Monitoring of all waste received onshore to ensure waste is properly handled; and
- Presence of an EHS representative on board the *Eirik Raude* to ensure effective EHS management.

The Environmental Management Plan (EMP) will clearly state how the assessment of monitoring data is intended to trigger corrective action should monitoring reveal that unacceptable environmental impacts are occurring.

4.9 Contractor Management

The GMS applies to all activities where Noble has any legal and/or moral accountability and where operational activities may present any risk to the business. Throughout this EIS, reference is made to Noble's commitments. However, various contractors will be involved in the detailed planning and execution of the drilling operation.

As stated in the GMS standard, all contractors shall apply their own management systems and training schedules, which must meet the performance standards of the Noble Energy GMS. Prior to procurement and to operations, the Environmental Management Systems (EMS) of each contractor will be audited to ensure congruence with the Noble Energy's GMS. As necessary, bridging documents outlining the required performance standards, will be put in place to ensure compatibility between the systems. Performance standards and the commitments listed within the relevant project management plans will be incorporated into all contractual agreements. Where applicable, key performance indicators (KPI's) will be specified.

Contractor audits shall be managed in compliance with the GMS element 13 (Table 12) and the Noble Energy Contractor Management Procedure (GBL-MS-NEI-OPS-PRO-0002).

4.10 Environmental Audit

In compliance with elements 10, 11 and 13 of the Noble Energy GMS, and in compliance with the DMR EIA Guidance Notes (2012), NEFL will carry out periodic audits to ensure that the Rhea-1 well operation is being carried out in compliance with all regulatory requirements, contractual obligations and management plan commitments.

During audits, corrective actions will be identified to address non-conformances. All corrective actions will be documented within the NEFL Corrective Actions List and tracked through to completion in order to support continual improvement within environmental performance and management.

Audits that will be required prior to, and during, exploration drilling operations include:

- Contractor audits:
  - Rig/vessel compliance audits – conducted prior to accepting the rig/vessels on contract, and pre-mobilisation, to ensure that all of the appropriate certificates are in place and that international standards are being met e.g. ODS/F-gas management, GHG emissions compliance, pre-discharge to sea treatments, waste management facilities, compliance with IMO codes for pollution prevention, ballast water management, fuel bunkering, condition of spill kits, SOPEP etc.
  - Contractor management audits – conducted prior to contract sanction to ensure that Noble Energy and contractor management systems are congruent (or can be bridged), that contractors are in compliance with their own management systems and during operations to ensure adherence to contractual obligations, license conditions and Noble Energy management plans e.g. EMP, WMPA etc.

Compliance audits

- Environmental compliance audits – conducted during and after the operation in order to ensure compliance with applicable regulatory requirements and control measures identified in the EIA and management plans e.g. the EMP, WMPA.

Some of the standard audit requirements listed above may be combined into a single audit and many will have been carried out in preparation for drilling the first NEFL exploration well, Humpback-1, in the FPB. Audit requirements that are specific to the Rhea-1 well operation are detailed in Chapter 14.0 on project specific environmental management.

All audits will be carried out in line with the Noble Energy Audit Procedure (GBL-MS-NEI-EHS-PRO-00002).

4.11 Change Management

It is important for the EMP, and its implementation, to be able to accommodate changes and respond to a need for further assessment as it arises throughout the different project stages. Changes are most likely to occur for the following reasons:

A new environmental sensitivity or impact is identified as a consequence of changing environmental conditions / evolving trends or during monitoring processes; and/or

Changes are introduced to the drilling operations / engineering design.

If and when change is required, this will trigger the management of change process in compliance with element 9 of the GMS. An assessment of the potential environmental effects that could occur as a result of the change, and the subsequent development of any additional EMP actions will be carried out as required.

Management of change will be carried out in line with the Management of Change Procedure (GBL-MS-NEI-OPS-PRO-0001).

5.0 Environmental Baseline Description

5.1 GAP Analyses (Data Gaps)

The Falkland Islands Offshore Hydrocarbons Environmental Forum (FIOHEF) was established in 2011 in order to provide a setting for debate and discussion on 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 need to be filled in order to better inform and monitor the potential impacts to the environment from offshore hydrocarbon activities operating in the Falkland Islands. It was agreed that the priority areas that need examining include; littoral/sublittoral environments, offshore benthic ecosystems, oceanography in relation to oil spill modelling, seabirds, pinnipeds and cetaceans. This section provides a summary of the Environmental Forum GAP analyses programme.

The GAP analysis programme is being led by the Director of the South Atlantic Research Institute (SAERI), supported by two project officers who are co-ordinating different aspects of the project. One project officer co-ordinates the seabird and marine mammal aspects of the work and the other is responsible for review, consolidation and curation of oceanic, benthic, inshore and fisheries related data. It is intended that the project will be Falkland Islands led with the work conducted in the Islands to enable close consultation with stakeholder groups, and that international researchers will be engaged in this process through workshops and collaborative peer review so the work has international standing and transparency.

Data gaps have been identified for each of the priority areas and according to the urgency with which they are required have been classified into one of three categories:

1. High priority data – Immediate action required (<1 year)
2. Medium priority data – short-term action (1-5 years)
3. Low priority data – long-term action (5-10 years).

This data will be ultimately used to inform robust Environmental Risk Assessments (ERA) for proposed operations associated with the oil and gas industry. As much of the data will take a number of years to collect, in the short-term existing data will be collated and used to perform simple qualitative assessments through an expert-led/drive process. These simple assessments could be used to provide initial information for use in upcoming EIAs. Meanwhile the highest priority data gaps (such as targeted tracking) will be simultaneously commenced. A further robust ERA will be conducted on completion of the gap analysis work (or periodically updated as key data becomes available).

The GAP analysis programme will collate a centralised data repository to hold, manage and curate environmental data collected by the Hydrocarbons Industry and other organisations in the Falkland Islands. The Hydrocarbons Industry and other organisations have collected large amounts of information over the last twenty years whilst operating in the Falkland Islands that includes; oceanographic, metocean, seismic, benthic ecology, benthic environmental, multi-beam and ROV footage. Much of these data are held at different locations and the fate/location of some remains unknown. Collation of all of the relevant environmental data will 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. This phase of the project will be completed in May 2016.

5.2 Physical Environment

5.2.1 License Location and its Proximity to International Boundaries

The Rhea-1 well site is located in the NFB, approximately 250 km north of the Falkland Islands, 925 km northeast of Cape Horn and 500 km from the nearest point on the South American mainland (Figure 15).

The Falkland Islands Exclusive Economic Zone (EEZ) extends up to 200 nautical miles from the Islands, and was designated as two successive fisheries conservation and management zones. Initially the FICZ was designated in 1986; and extends 160 nautical miles from the centre of Falkland Sound. The western boundary of the area roughly coincides with the eastern limits of the Argentine EEZ. In 1990 the Falklands Outer Conservation Zone (FOCZ) was designated, this area extends the conservation zone to a distance of 200 nautical miles from the nearest land and defines the eastern perimeter of the Falklands EEZ (Figure 15) (FIG DMR, 2013).

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 Area is subdivided into Quadrants based on one degree of latitude by one degree of longitude (Figure 15), each of which is subdivided into thirty Blocks. The Rhea-1 well site is located in Quadrant/Block 14/04, within the northern boundary of the FICZ in Licence Block PL001 (Figure 15).

5.2.2 Meteorology

Understanding the meteorology of the Falkland Islands and in the region of any proposed exploratory well is highly important as the weather conditions throughout the year may have an impact on drilling activities or other oil-related activities; such as laying subsea equipment, or shipping to/from oil installations. This impact may be from extreme winds or foggy conditions, thus reducing visibility. There is very little meteorological data for the offshore Falkland Islands waters, including the region of the Rhea-1 well site (RPS Energy, 2009), however, RPS Energy collated and reviewed data from several sources.

The Falkland Islands have a temperate oceanic climate, with predominantly westerly winds (RPS Energy, 2009; Anatec, 2015). Data collected during the Fugro Metocean Survey (1999) conducted on behalf of FOSA indicate that approximately 28% of prevailing winds are westerly, followed by approximately 24% being north-westerly (Anatec, 2015). In general, the weather in the NFB is much less extreme than weather conditions south of 50°S, where the frequency of storms and squalls is greater (RPS Energy, 2009). The survey conducted by Fugro (1999) showed that between 65% and 80% of wind speeds measured in the region of the Rhea-1 well site were over 10 knots. Indeed, wind speeds of over 10 knots persisted for six days during one survey event, and the longest duration of wind speeds above 20 knots was for 38 hours (RPS Energy, 2009). Strong winds will influence sea conditions and wave height, which can make shipping and oil related activities difficult.

The Falkland Islands do not experience a broad range of terrestrial annual temperatures (RPS Energy, 2009). Generally, the mean annual minimum temperature experienced is approximately 3°C and the mean annual maximum temperature is approximately 10°C. Monthly temperatures vary throughout the year from -5°C to 20°C, but fluctuation in air temperature over the sea is always much less variable than that over land.

Overall annual rainfall is on average relatively low within the Falkland Islands; however it is also consistent (RPS Energy, 2009). While the mean rainfall in Stanley is approximately 650 mm a year, there is less rainfall further north. Therefore, it is expected that mean annual rainfall within the northern Licence Blocks should be less than 650 mm. Snow falls, on average, 11 days of each year, with a higher frequency occurring in August. Dense fog, causing visibility less than 1 km, within the vicinity of the Rhea-1 well is likely to occur for approximately 5% of the year (Anatec, 2015).

Due to the lack of weather data available for the area of the northern licence blocks, NEFL have utilised two hindcast weather models, both covering 20 years. A wind and wave model was developed by Premier Oil for a wide area around the Falklands, and a current model was developed for the Sea Lion area only, within 22 km of the Rhea-1 well site. The results were calibrated and verified against satellite and measured data, and confirmed previous wind, wave and current assumptions.

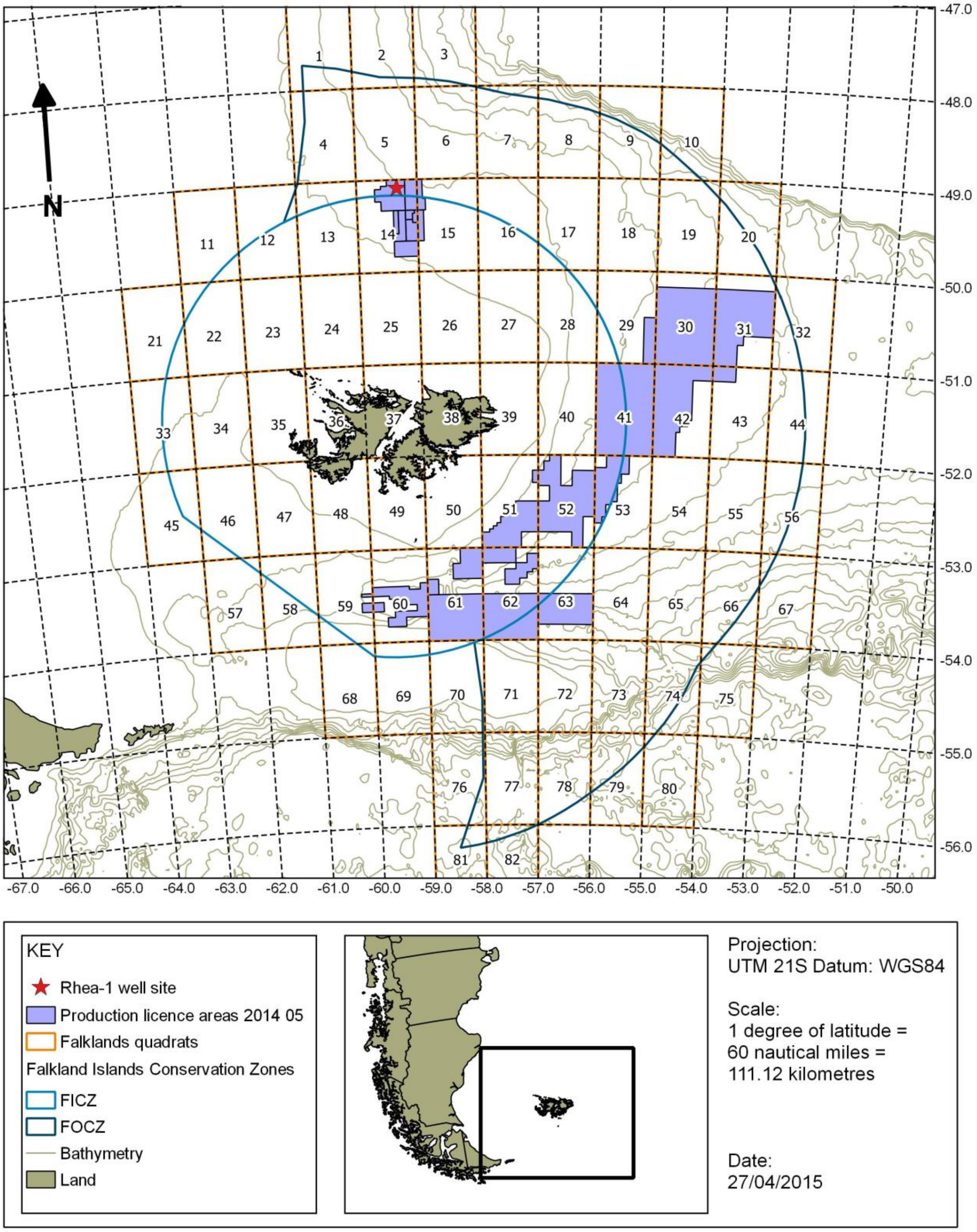


Figure 15: The location of the Rhea-1 well site in relation to the Falkland Islands, fisheries conservation zones and the South American mainland

5.2.3 Oceanography

5.2.3.1 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 (Valdés Front, San Jorge Front and Bahia Grande Front) and seasonal fronts (Patagonian–Magellan Front and Tierra del Fuego Front) originating from cold fresh water 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 Drake Passage and flows northwards (Peterson and Whitworth, 1989). The Current reaches the continental slope to the south of the Falklands and splits into two main northward-flowing branches (Figure 16). The western branch is the weaker with the eastern branch being the strongest (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).

5.2.3.2 Oceanographic Features on the Falkland Islands Shelf

A number of oceanographic fronts exist on the Falkland Islands continental shelf, primarily in areas to the south and east of the Falkland Islands. A number of fronts have also been identified on the northern shelf, to date. Four frontal areas (Western Offshore Front; Western Inshore Front; Southern Front; North Eastern Front) have been identified in the southern part of the Falkland/Malvinas Current Front (FMCF) (between 54°S and 48°S) with well-resolved temperature and salinity gradients (Figure 16, Arkhipkin et al., 2013), interspersed by areas characterised by relatively smooth gradients (non-frontal zones). The FIG conduct oceanographic transects to monitor the Transient Zone across the frontal systems, and to monitor the strength of the Falkland Current (Figure 16).

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 Transient Zone (TZ) at depths of between 120-300 m (Zyryanov & 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 (Arkhipkin et al., 2004a; Arkhipkin et al., 2003) and spawning ground (Arkhipkin et al., 2010). The location of the Transient Zone 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 Loligo squid (*Doryteuthis gahi*), (Arkhipkin et al., 2004b).

The Western Offshore Front (WOF) and Western Inshore Front (WIF) represent the areas of mixing of the western branch of the Falkland Current with Patagonian Shelf waters (WOF) and Falkland Shelf waters and TZ (WIF). The Southern Front (SF) and North East Front (NEF), appear when the eastern branch of the Falkland Current meanders onto the shelf and mixes with Falkland Shelf waters. There is also 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 northern part of the FMCF (37-38°S) shifts seasonally, offshore in summer and inshore in spring and autumn (Carreto et al., 1995). Similar shifts of at least two fronts (WOF and NEF) were observed in the southern part of FMCF (Arkhipkin et al., 2013). It is suggested that the offshore shifts of those fronts are a result of seasonal offshore movements of shelf waters. WIF and SF are also 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 FMCF (Romero et al., 2006).

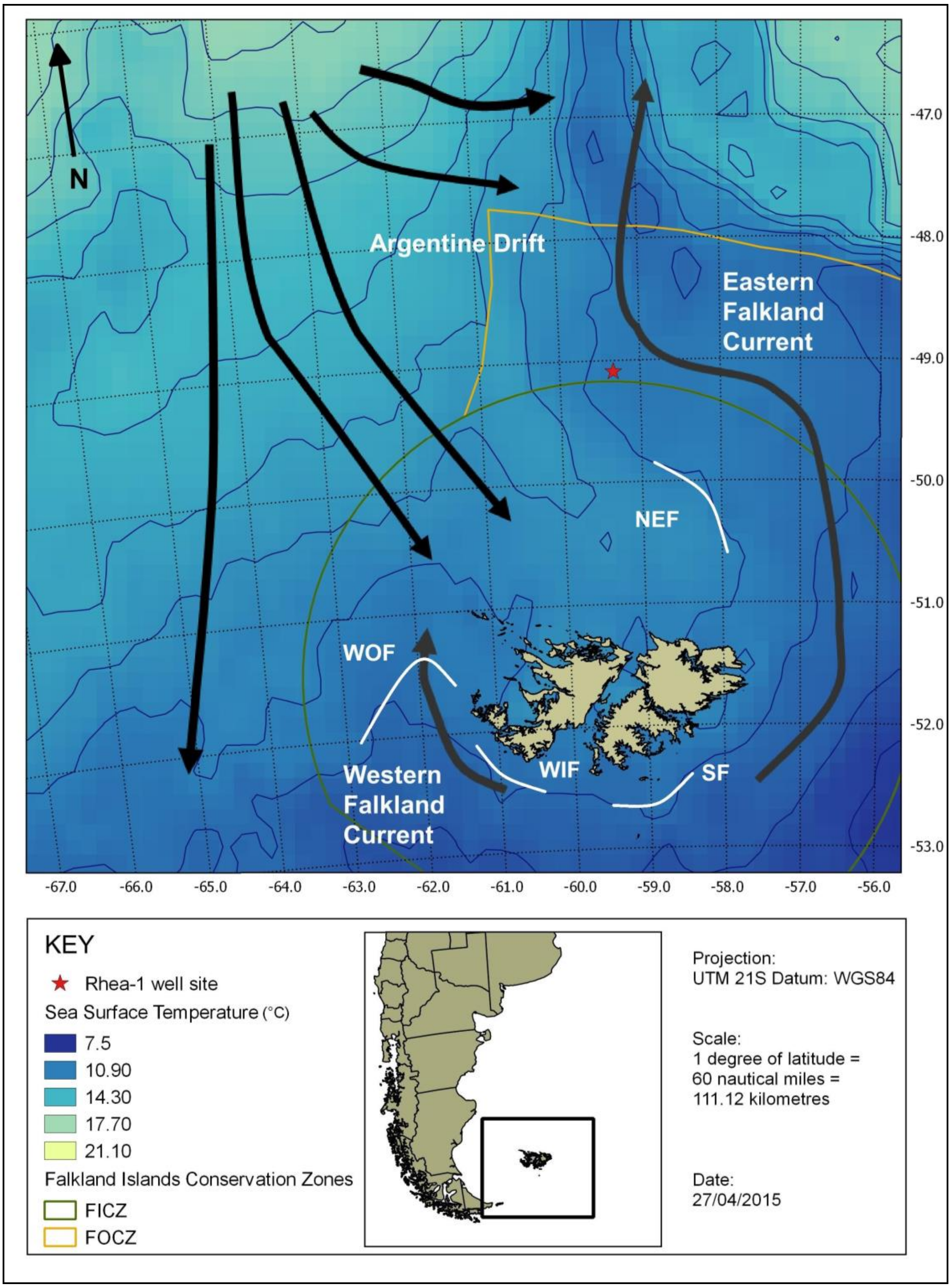


Figure 16**:** Main Patagonian Shelf oceanographic features overlain on Sea Surface Temperature (°C) map, March 2008.

WOF = Western Offshore Front; WIF = Western Inshore Front; SF = Southern Front; NEF = North Eastern Front. Adapted from Arkhipkin, A., Brickle, P. & Laptikhovsky, V., (2013).

5.2.3.3 Oceanographic Features in the Region of the Rhea-1 Well Site

During the environmental baseline survey of the adjacent Licence Block (PL032) in March and April 2012 (over a four week period) water column characteristics were measured using a CTD (conductivity, temperature, and depth) probe, over 47 deployments, to produce water column profiles for the field (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) (Figure 17). It is acknowledged that water column dynamics and the dynamics of water masses in the area can change over time so this is an illustration of the general water mass pattern in the area.

The Rhea-1 well site is located within the near shore area of the Northern Slope (NS); this region is covered by a transition zone between Patagonian Shelf waters and the superficial sub-Antarctic surface water (SASW) mass of the Falkland Current. Temperature-Salinity profiles highlight the SASW water mass of the Falkland Current (Figure 17). There is only slight seasonal variation in temperature (4.8–5.5°C with the maximum observed in April to May) and salinity (34·06–34·11 parts per thousand (ppt)). The offshore deeper part of the NS is covered by the SASW mass with small variations in near-bottom temperatures (4.1–4.3°C) and salinities (34.1–34.2 ppt) (Arkhipkin et al., 2012a).

Generally, a well-mixed surface layer was observed in the CTD data to a depth of c.40 m. Below 40 m depth a distinct thermocline was observed to approximately 80 m, below which temperature decreased gradually to the seabed. Broad trends were observed for temperature, dissolved oxygen and pH, which decreased with depth. Turbidity was slightly higher in the mixed surface layer than the body of water below, immediately below the thermocline (Gardline, 2013a).

During the course of 2014, the oil and gas industry has taken steps to improve on the existing oceanographic data sets on which predicted oil spill modelling has been based. A new coupled inshore tidal and oceanographic circulation model is under development and is due to be fully completed in 2015. This has been undertaken by collaboration between BMT Argos, BMT WBM and the UK Met Office. A Specification Report is available on request (Sea Lion Hydrodynamic Modelling Model Specification, Ref: A14043, Sept 2014). The Fisheries Dept. and other stakeholders have reviewed the model set up and are collaborating with the Industry by providing historic data for model ground truthing.

NEFL is committed to continuing to improve the modelling when new oceanographic data becomes available from third parties. This is part of the ongoing GAP process and will involve data collection strategies to help improve oil spill fate modelling.

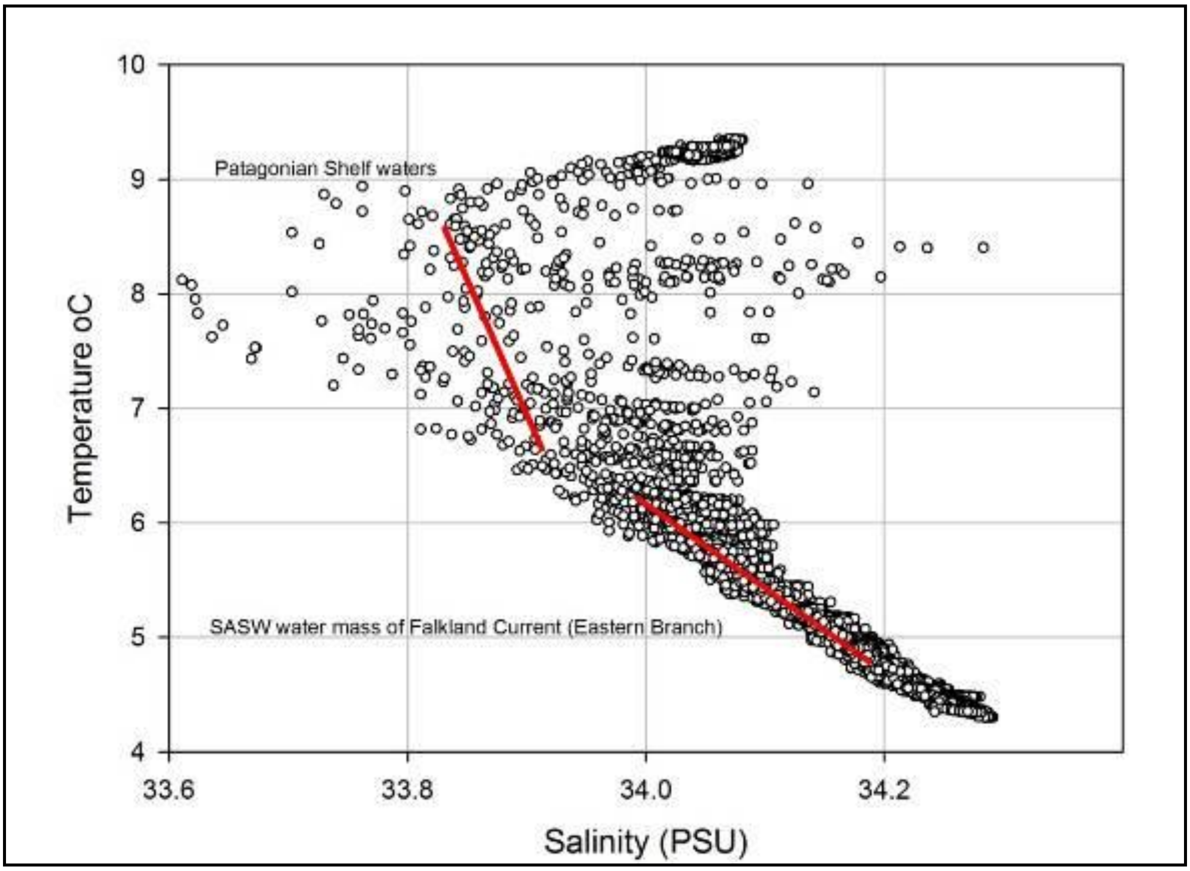


Figure 17**:** Temperature –Salinity plot from CTD Data Collected in Licence Block PL032 in March and April 2012 (data from Gardline, 2013a)

5.2.4 Bathymetry

The Patagonian continental shelf is one of the largest and flattest continental shelves in the world. Its width varies from a few kilometres at 55°S, south of Staten Island on the tip of Tierra del Fuego, to 850 km width along the latitude of 51°S (Martos and Piccolo, 1988). The Falkland Islands are situated on the Patagonian Shelf approximately 700 km off the Argentine coast, between latitudes 52°53'S and 51°S (Figure 15).

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 (approximately 35,000 km^2) 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).

The area to the west of the Falkland Islands is a north western extension of the Falkland Trough that gradually narrows and reduces in depth as it moves northwards onto the shelf break at the northwest tip of the Falkland Islands.

To the north, the continental shelf extends for approximately 200 km beyond the Falkland Islands, representing its widest point, and leads into the steep sloping Falkland Escarpment. The NFB is the area of continental shelf 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 (Otley et al., 2008). The Rhea-1 well site lies within the central area of the NFB at a water depth of approximately 470 m; and lies on flat sea bed, with a gradient of 0.3°.

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, 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).

Across a 3,000 m radius, the seabed around the Rhea-1 well site slopes gently from 437 m in the southwest to 478 m to the north east. The seafloor morphology is gently undulating characterised by the presence of shallow sub-circular depressions with a maximum depth of 3-4 m and a maximum width of approximately 160 m. Poorly defined lineation are visible, interpreted as poorly preserved iceberg scours with little topographic expression. A broad, 700 m, linear depression can be seen 825 m north of the well location (Figures 20 and 21).

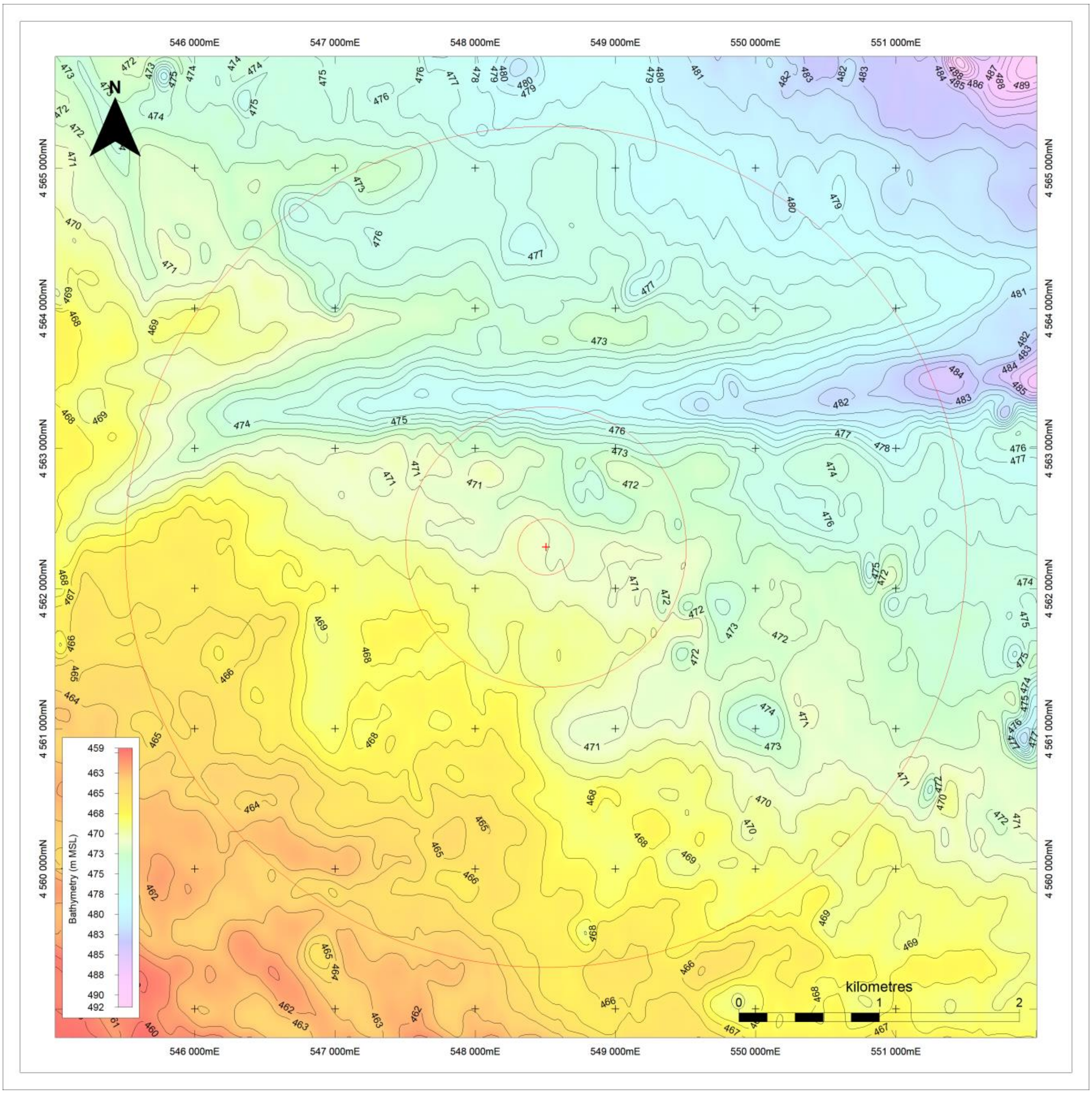


Figure 18: Bathymetry in the area surrounding the Rhea-1 well site, circles mark 200, 1,000 and 3,000 m radius centred on the well site (Source: RPS)

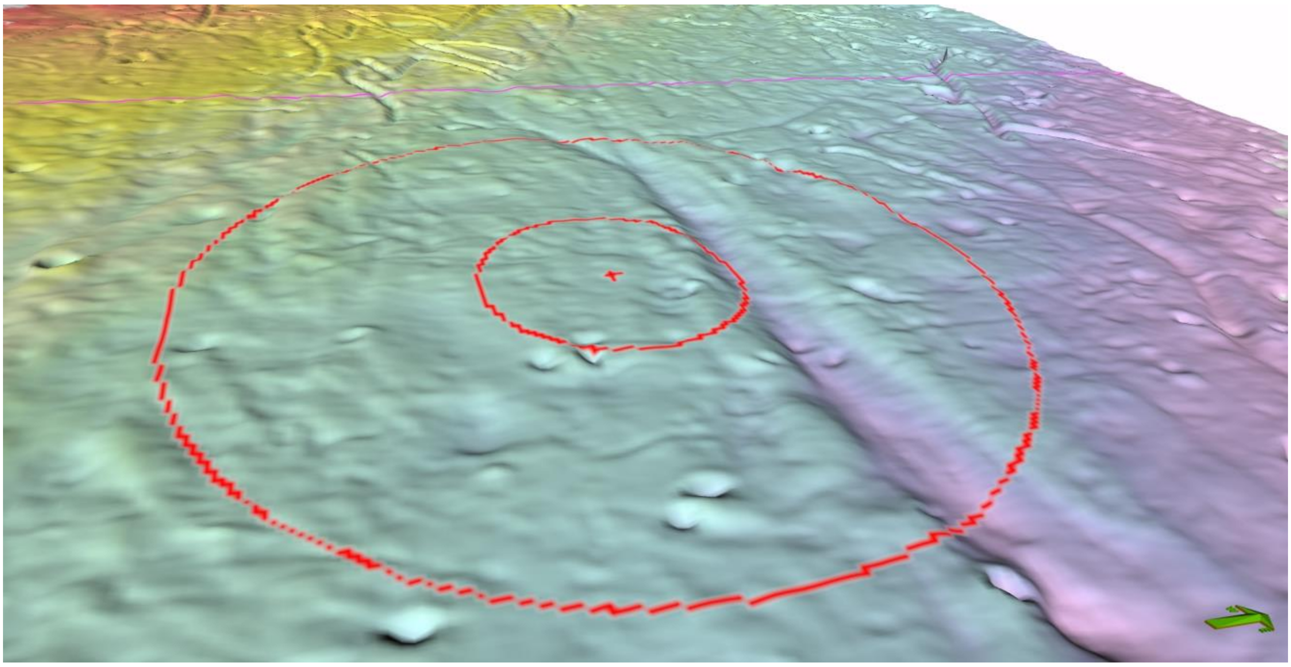


Figure 19: Three dimensional representation of the bathymetry surrounding the Rhea-1 well site, circles at 1,000 and 3,000 m radius from the well site (Source: RPS)

5.2.5 Geology

Subsurface Description

The North Falkland Basin (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 runs north to south, and a Southern Rift Basin (SRB) in which the predominant strike of the main structural elements runs northwest to southeast. The main graben of the NRB is about 150 km long and 50 km wide at its northern end.

The NRB is an Early Cretaceous rift basin in which the east to west extension is related to Pacific margin subduction and Gondwana break-up (Atlantic opening) (Underhill and Lhor, 2013). The basin is filled with Berriasian to Hauterivian syn-rift fluvio-lacustrine sediments, overlain by post-rift (Barremian to Aptian) lacustrine organic claystone and shale interspersed with turbidite sandstones. These elements are overlain by transitional marine, to fully marine, Late Cretaceous and Tertiary sediments. The Early Cretaceous post-rift sequence is the prospective interval targeted by the 2015 exploration drilling campaign.

The Noble Energy Falklands Limited (NEFL) exploration Drilling Campaign Area is located on the northwest to north-central portion of the NRB and east of the Orca Ridge, approximately 220 km north of the Falkland Islands in close proximity to the Sea Lion Field. The Sea Lion Field is located on the northeast margin of the NRB and was discovered in May 2010 by Rockhopper Exploration with well 14/10-2, which encountered oil reservoirs in good quality Lower Cretaceous lacustrine turbidite sandstones that form a series of highly sand prone basin floor fans deposited into a stratified, anoxic lake (Richards and Hillier 2000; Holmes et al 2011). Following discovery of the Sea Lion Field, an appraisal program began to delineate the extent of the Sea Lion accumulation (to date, eight wells and two sidetracks). In addition, the appraisal program has proven 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, which connect into the main graben depo-centre via a series of feeder canyons or channels. These basement highs are primarily to the east for the Sea Lion Field and primarily to the west for the Rhea prospect. Deposition occurred from both turbidity currents and mass flows (for example, fluidized sediment-gravity flows).

A very similar play is being targeted in NEFL's 2015 exploration drilling campaign. Based on 3D seismic data, the exploration prospects have similar geometries and depositional characteristics to the existing discoveries. The prospects are likely being charged from the same or analogous lacustrine source rock as Sea Lion via similar migration pathways; accordingly the predicted hydrocarbon phase for the exploration targets is oil with a similar quality and gas oil ratio (GOR) to the Sea Lion discovery.

5.3 Environmental Surveys in the NFB

5.3.1 Environmental Survey Review

To date, there have been no surveys of the benthic environment in the direct vicinity of the Rhea-1 well site. However, prior to drilling the well ROV surveys of the seabed, within 100 m radius of the well will be undertaken and evaluated by an independent expert to identify any sensitive habitats or species. Additionally, during the pre-drilling ROV survey, sediment samples will be collected by ROV push corer (89mm outer diameter) at 50m, 100m and 200m distance upstream and downstream of the well location and analysed for chemical contaminants and biological samples for species composition.

In 1998, pre-drilling surveys were conducted in the NFB at the 'Little Blue', 'Sebald' and 'Galapagos' well sites, which are the closest to the Rhea-1 well site ranging between 13 and 20 km distance from the Rhea-1 well (Gardline 1998a; 1998b). A further environmental survey post-drilling was conducted at 'Little Blue' (Gardline, 1998h).

Several other environmental surveys have been conducted in the northern Licence Blocks (PL001, PL032 and PL033) and further afield on the Falklands continental shelf, which provide background and contextual data for comparison with the area around the Rhea-1 well site. Table 13 provides a summary of survey and drilling activities conducted within Falkland Islands waters to date.

In recent years, the focus of environmental surveys has been on the area of the Sea Lion Field, which lies approximately 22 km southeast of the Rhea-1 well site. Under contract to Rockhopper Exploration, Gardline International conducted an area wide environmental baseline survey of the Sea Lion Field in the NFB in 2012 to determine the physical, chemical and biological character of the environment (Gardline, 2013) 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 component of the area. These stations ranged in distance from 20km to 38km from the Rhea-1 well location.

5.3.1.1 Rhea-1 Regional Environmental Habitat Assessment

The desk-based Environmental Habitat Assessment was completed using predictive habitat mapping techniques, following standard operating guidelines (e.g. Bulat and Long, 2007). The purpose of the assessment was to provide a characterisation of the seabed (i.e. bathymetry and geomorphology, surface sediments, infaunal communities and epifaunal assemblages) within the NFB, with a specific focus on the Rhea-1 proposed well location.

A number of acoustic datasets (i.e. 3D seabed pick: Two Way Time (TWT) and Amplitude) over the entire Licence Block PL001 and 3D seabed pick (TWT and Amplitude) from other operators over the adjacent blocks and available information such as seeps studies) were used to determine the seabed bathymetry and morphology throughout the Regional Study Area, with environmental sampling data (e.g. grab samples, box cores and seabed photography) used to ground truth this data. Grab samples/box cores provided information on the sediment type and infaunal communities in the region and seabed photography provided data on the epifaunal communities.

Table 13: 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, Gardline 1998 a-i
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, 2008
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
2014	Isobel Deep - environmental baseline survey	NFB	Premier Oil, MG3 2014

Figure 20 and Figure 21 show the location of the 2013 Sea Lion environmental baseline and post-drilling survey locations, and the majority of the other environmental survey on the Falklands continental shelf. It is recognised that the lack of environmental baseline survey data in the vicinity of Rhea-1 constitutes a significant data gap. A review of survey data from adjacent Licence Blocks, of similar water depths, will give an indication of the nature of the environment but is no substitute for dedicated surveys.

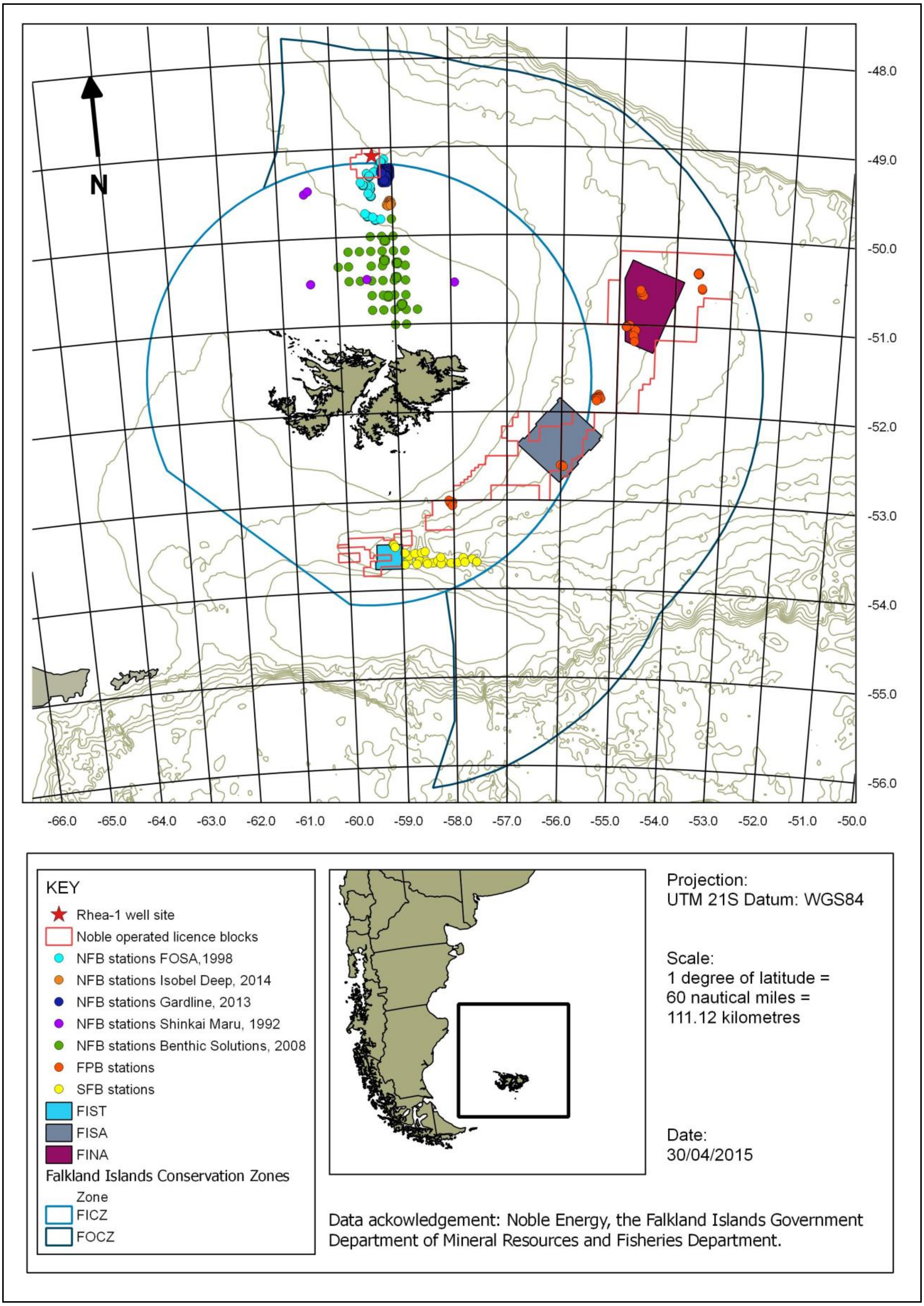


Figure 20: Summary of Environmental Survey Locations on the Falklands Continental Shelf. N.B. Environmental Survey station locations from FIST/FISA/FINA are not included.

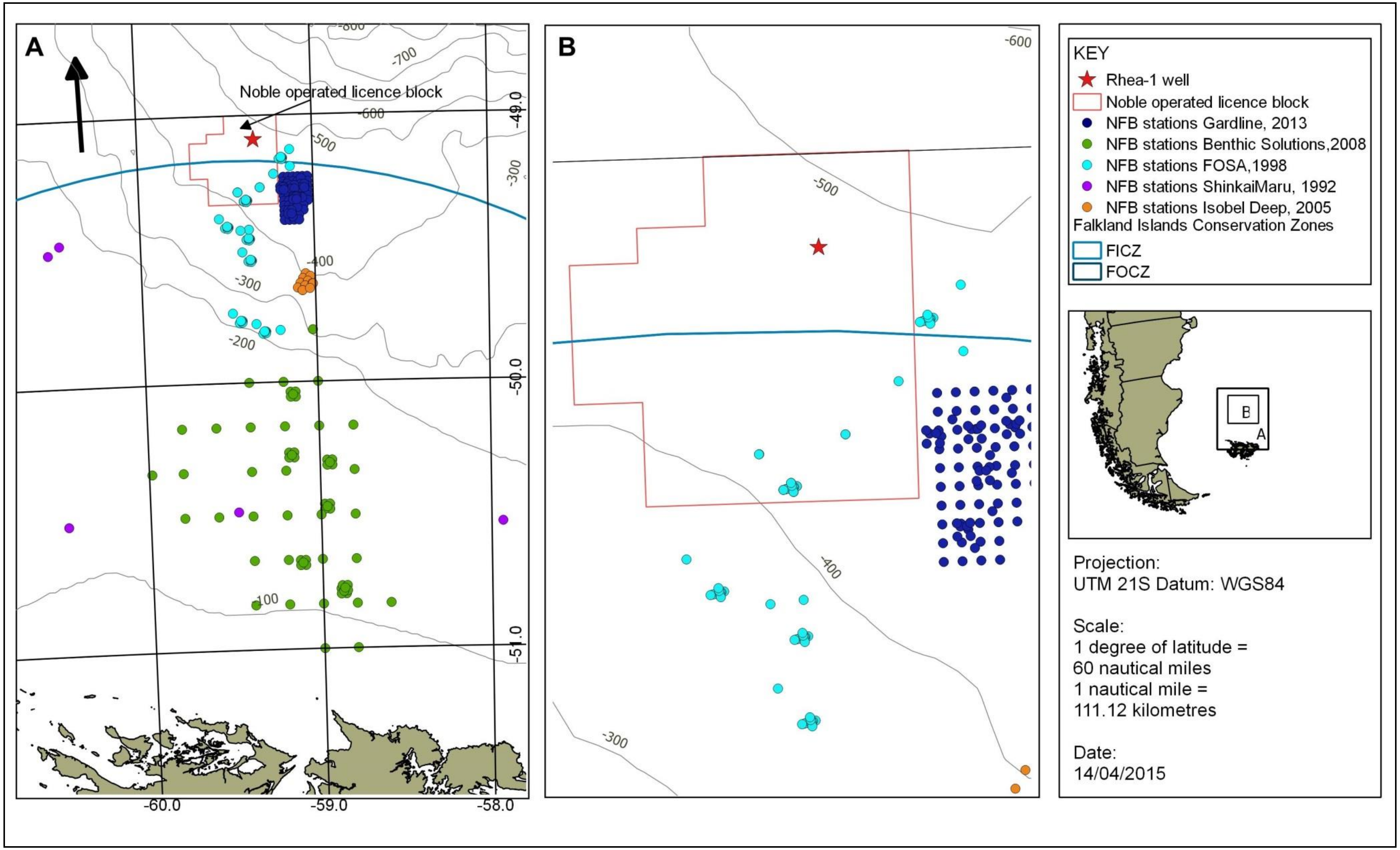


Figure 21: Environmental Survey Locations in the North Falkland Basin

5.3.1.2 North Falkland Basin FOSA Pre-Drilling Survey (1998)

Exploration drilling in the NFB was first conducted in 1998, by a consortium of licence holders under a joint operating agreement, FOSA (Falklands Offshore Sharing Agreement). Seven exploration wells were drilled in the NFB during the 1998 campaign. Prior to the drilling campaign, Gardline (1998a-g) (on behalf of FOSA) conducted an environmental baseline survey at each of the proposed well locations to describe the natural sediments and benthic communities prior to drilling activities and to provide a basis for future monitoring (Figure 20 and Figure 21). Twelve sample stations were positioned along a standard cruciform template, centred on each well location with the long axis aligned with the dominant current direction. Between one and three reference stations were sampled at >8,000 m from each of the proposed well locations. All stations were sampled using a Day grab, with three grab samples taken for macrofaunal analysis and one for physico-chemical analysis including granulometry, hydrocarbon and metal analysis.

The FOSA well sites and corresponding survey locations were generally located in a north-south orientation across the NFB, in water depths ranging from 215 m in the south to 482 m in the north. While these surveys were not undertaken in the direct vicinity of the Rhea_1 well site, the closest was approximately 13 km to the south east; the results provide information for indicative background sediment chemistry and wider faunal community for the area. Of the FOSA survey sites the ‘Sebald’ (B1) Block 14/05 well was located approximately 14 km southeast of Rhea-1, ‘Galapagos’ Block 14/09 is approximately 18 km south and the ‘Little Blue’ Block 14/09 is approximately 26 km to the south (Figure 21).

One of the historical well sites (‘Little Blue’) was re-surveyed post drilling activity to assess the impacts from drilling related discharges at the site (i.e. water based mud and cuttings). The survey concluded that there was no evidence from species composition to suggest that the area was polluted. While most physico-chemical sediment parameters had increased slightly since drilling, these did not fall outside the range indicative of uncontaminated sediments for the area. The report concluded that drilling activity had had little if any impact on the fauna at the site (Gardline, 1998i).

5.3.1.3 Sea Lion Pre-Development Environmental Baseline Survey and Post Drilling Survey (2013)

Nine wells were drilled in Licence Blocks PL032 and PL004 during the 2010-2011 NFB drilling campaign, which subsequently led to the discovery of the Sea Lion Field, which lies approximately 22 km southeast of the Rhea-1 well site. In 2012 Gardline Environmental Limited were commissioned to conduct an area wide environmental survey of the Sea Lion area to characterise the current environment prior to further drilling and field development being undertaken (Gardline, 2013a). In addition to the area wide pre-development survey, Gardline also conducted a post-drilling survey around five historic well locations within the licence area (four Rockhopper wells 14/10-2, 14/10-6, 14/10-9, 14/15-4a, and one Shell well 14/10-1) (Gardline, 2013b). The objective of the post-drilling survey was to assess the extent and severity of the impact of previous exploration drilling activities to the seabed sediments and associated benthic community.

The pre-development survey area was divided into a grid covering a total area of 140 km^2, with 54 sample stations positioned at 2 km intersections (Figure 21). Each post-drilling well site survey comprised 12-14 stations in a cross formation centred over the well site, with two stations positioned on each of the northwest and northeast arms of the cross and one station positioned on each of the southwest and southeast arms of the cross (Figure 21). Where possible, stations from the 2 km grid were used as additional post-drill stations and included in the post-drill survey report. Each station was sampled for a suite of environmental parameters including: CTD casts to profile the temperature, salinity, dissolved oxygen, turbidity and pH of the water column; chlorophyll, to measure primary productivity in surface waters; photographs of the seabed to identify potentially sensitive habitats; box core samples to identify macrofauna, sediment hydrocarbon, heavy metal concentrations and particle size. Table 14 summarises the samples collected from both the pre-development area and the post-drilling well sites.

Table 14: Summary of Environmental Sampling Parameters

Survey	Total No. Stations	CTD	Chlorophyll	Habitat Assessment	Box Core Sub-Sample			
					Fauna	Hydrocarbon	Metals and Organics	Particle Size
Pre-development Grid	54	16	10	54	54	54	54	54
Post-drilling well site	32	30	0	0	32	32	32	32

5.3.1.4 Southern North Falkland Basin (2008)

In August and September 2008, Desire Petroleum PLC, Rockhopper Exploration PLC and Arcadia Petroleum Limited commissioned Benthic Solutions Limited, to conduct an environmental survey over a regional area of the southern NFB in water depths ranging from 140 m to 285 m (Figure 20 and Figure 21). Benthic sampling was undertaken at a total of 77 stations relating to seven proposed exploration well sites. The survey design comprised 38 near-field stations around the well locations and 32 regional stations. The objective of the survey was to analyse and interpret physico-chemical properties of the sediments and macrofaunal communities to provide a regional baseline and context from which to later compare well-specific surveys. Sediments were collected using a double Van Veen grab (comprising two grabs within a single frame). Two grab deployments were made at each station to collect the required four samples, of which three were processed for macrofaunal analysis and one for physico-chemical parameters, including granulometry, hydrocarbon and metal analysis.

5.3.1.5 Other Surveys around the Falkland Islands

A number of environmental baseline surveys have been conducted around other areas of the Falklands Conservation and Management Zones in recent years.

- Benthic Solutions conducted well site environmental surveys in the Burdwood Bank area of the South Falkland Basin (SFB) on behalf of Boarders and Southern Petroleum, in 2008. Water depths over the survey area ranged from 1,200 m to 2,100 m.
- Environmental baseline surveys were conducted at three proposed well locations in the Falkland Plateau Basin (FPB) and one location on the SFB during 2009 and an additional three locations in the FPB and one in the south during 2011.
- Environmental baseline surveys took place from December 2013 to April 2014 using the MG3 survey vessel *Poseidon*. This survey covered the FISA12, FIST13 and FINA13 survey areas.

During 1978 and 1979, several exploration surveys were conducted throughout the Argentine Continental Shelf including the region around the Falkland Islands. Analyses of benthic samples from these surveys were used to describe the main faunal assemblages on the continental shelf from which three main biogeographic provinces were identified. The provinces comprised the Argentine, Patagonian and Malvinean province, the latter is primarily influenced by the Falklands Current (Bastida et al., 1992).

Detailed results of these surveys have not been considered in the baseline assessment of the NFB. The sampling stations on the Falkland Islands continental shelf were between 95 and 157 km from the northern Licence Blocks and located in <200 m of water and as such were not considered to be representative of the habitats and communities at 470 m at the Rhea-1 well site (Figure 20).

5.3.2 Benthic Soil Characteristics

The Falkland Islands are relatively immature in terms of oil and gas production and whilst 24 exploration wells have been drilled there is currently no oil and gas production underway in the region, hence typical background sediment chemistry datasets have not been formally characterised. However, 20 environmental surveys have been conducted within the three main Falklands basins (Appendix A). 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. These datasets have been used to provide comparative data for the campaign drilling area.

A summary of the mean chemical composition of sediments from around the Falklands continental shelf is presented in Appendix A, results indicated that sediments are comparable throughout the wider Falkland Islands waters. Full chemical analysis is available in the Environmental Baseline and Post-drilling Survey Report (Gardline, 2013a and b).

5.3.2.1 Sediment Types

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 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 (Gardline, 1998a).

The Rhea-1 well site lies in the northern sector of the NFB. During the 2012 environmental baseline area wide survey in the Sea Lion area (in water depths comparable with Rhea-1) , 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 was high (61.6 – 79.7%) at all stations across the Sea Lion area wide survey. These results were comparable to the sediment types recorded during the 1998 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) where fines accounted for 65.8% to 76.1% of sediment material (Gardline, 1998a, b). Results of the 1998 FOSA pre-drilling survey found similar proportions of gravel (0.0% to 3.1%) and suggested that the coarser material fraction was primarily attributed to pea sized sub-surface gravel originated from glacial drop-stones (Gardline, 1998a).

Post-drilling well site surveys across the Sea Lion region contained similar proportions of fines, sands and gravels to the 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, as 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 (Benthic Solutions, 2008).

According to the Rockhopper-1 site survey report (Britsurvey, 1998), seabed sediments at Rhea-1 are expected to consist of silty sand overlying very soft clay with no gravel.

5.3.2.2 Total Organic Matter and Organic Carbon Analysis

Organic matter in marine sediments is generally dominated by the flux of surface derived phytodetritus (decomposing phytoplankton and other plant material) to deeper water sediments. Terrestrial inputs from rivers and other marine biogenic material also contribute to the organic matter and composition of continental shelf sediments. Sediment total organic matter (TOM) and total organic carbon (TOC) were measured in samples from the Sea Lion area of the northern Licence Blocks as a percentage of total sample weight. Both parameters were generally found to be homogeneous, with measured mean TOM values of 5.6% ±0.5 SD, and mean TOC 0.9% ±0.1 SD (Gardline, 2013). Both TOM and TOC were found to positively correlate with particle size, with higher proportions of organic matter recorded at stations with 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, whereby lower concentrations of organic matter are generally found in sandier sediment where surface sediments indicate some mobility and consequently reduced percentage fines.

The level of organic matter showed low variation across post-drilling well site surveys with an overall TOM mean of 5.4% (±0.4 SD) and TOC mean of 0.9% (±0.1 SD) (Gardline, 2013b), which are comparable to the levels from the area wide survey. Both TOM and TOC were also found to positively correlate with the percentage fines, suggesting that organic matter content was associated with natural variation in the proportion of fines in the sediment.

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), which were the closest to the Rhea-1 well site and 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 (Benthic Solutions, 2008). Survey data from similar depths on the South Falklands Basin (SFB) at the proposed Toroa well site (571-702 m) indicated comparable levels of TOM and TOC (6.0 ±0.8 SD and 0.73% ±0.05 SD respectively) to the northern Licence Block area.

5.3.2.3 Seabed Chemistry

Total Hydrocarbon Concentrations

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.

Total Hydrocarbon Concentrations (THC) ranged between 4.7 $\mu g.g^{-1}$ and 15.5 $\mu g.g^{-1}$ (mean 9.7 $\mu g.g^{-1}$ ±2.7 SD) across all stations in the Sea Lion pre-development area wide survey. Samples collected during the post-drilling survey exhibited THC levels within a similar range as the area wide survey, ranging between 3.5 $\mu g.g^{-1}$ and 17.2 $\mu g.g^{-1}$ with a mean of 8.5 $\mu g.g^{-1}$ (±2.9 SD). Overall no spatial trends were observed and the survey report indicated that THC levels were considered to be within natural ranges exhibited by background variation (Gardline, 2013a, b).

When comparing the results from the Sea Lion 2013 surveys (mean 9.7 $\mu g.g^{-1}$ ±2.7 SD and 8.5$\mu g.g^{-1}$ ±2.9 SD) to the adjacent 'B1' 14/05 well and the 'Little Blue' 14/09 well from the FOSA 1998 pre-drilling baseline survey, (mean 0.3 $\mu g.g^{-1}$ ±2.9 SD, and mean 0.1 $\mu g.g^{-1}$ ±0.1 SD respectively), mean THC levels from the 2013 surveys were notably higher than those from the 1998 surveys (Gardline, 1998a, b). Post-drilling survey results for the 'Little Blue' 14/09 well indicated an increase in THC in comparison to pre-drilling baseline levels but mean values were also notably lower (0.6 $\mu g.g^{-1}$ ±0.4 SD) than those from the nearby Sea Lion survey.

Generally, the results from all seven FOSA survey locations exhibited 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 $\mu g.g^{-1}$ (±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 and the Rhea-1 well location (mean 4.3 $\mu g.g^{-1}$ ±1.4 SD) (BSL, 2008), although mean THC in both areas were low in comparison to Sea Lion.

Comparison of Sea Lion results to sediment means from other regions of the Falklands continental shelf, indicated that deeper (1,200-2,100 m), sandier sediments from the regional survey in the SFB recorded mean THC of 12.8 $\mu g.g^{-1}$ (±5.1 SD), and comparable water depths to Sea Lion (620 m) recorded a mean of 8.7 $\mu g.g^{-1}$ (±1.1 SD). Whilst mean THC ranging from 0.3 $\mu g.g^{-1}$ (±1.0 SD) to 5.4 $\mu g.g^{-1}$ (±1.0 SD) were recorded in sediments from the FPB in water depths of 1,300 m, suggesting that levels 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 survey 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, 2013).

Of the resolved hydrocarbon fraction, n-alkanes account for the largest proportion of material. n-alkanes are straight chained, single bond saturated hydrocarbons ranging from 10 to 35 carbon chain lengths. The distribution of n-alkanes can be indicative of the hydrocarbon origin, typically the small n-alkanes (nC_{10}-nC_{20}) are derived from petrogenic sources, whilst the larger n-alkanes (nC_{21}-nC_{35}) are derived from biogenic sources. Total n-alkane concentrations were within similar ranges across both the Sea Lion pre-development survey and the post-drilling survey with means of 0.55 $\mu g.g^{-1}$ (±0.1 SD) and 0.67 $\mu g.g^{-1}$ (±0.4 SD) respectively. These values were moderately high in comparison to all of the FOSA 1998 pre-drilling baseline survey locations, and in particular for the adjacent 'B1' 14/05 well and the 'Little Blue' 14/09 well (mean 0.3 $\mu g.g^{-1}$ ±0.03 SD, and mean 0.02 $\mu g.g^{-1}$ ±0.01 SD respectively). As with THC, the mean levels of total n-alkanes at across the Sea Lion survey area were more comparable to survey locations within deeper waters of the SFB (1.17 $\mu g.g^{-1}$ ±0.41 SD) and the EFB, which ranged from a mean of 0.25 $\mu g.g^{-1}$ (±0.06 SD) to 4.1 $\mu g.g^{-1}$ (±0.06 SD) in deeper water depths, whilst a mean of 0.65 $\mu g.g^{-1}$ (±0.09 SD) was recorded in similar water depths to Sea Lion and the Rhea-1 well location.

Individual n-alkanes were typically dominated by the heavier weight range (nC_{25} to nC_{37}), peaking in odd numbered carbon compounds nC_{29} and nC_{31}. Within the lower weight range (nC_{10}-nC_{21}), odd number n-alkanes were also dominant, albeit in lower concentration. This distribution suggests the presence of terrestrial derived n-alkanes from the wax layer covering the external surfaces of higher plants, which typically comprise the long-chain, odd carbon number n-alkanes (Eglinton et al., 1962); and a lower contribution of biogenic material from marine organisms (phyto- and zooplankton), which preferentially synthesize short-chain, odd number n-alkanes nC_{15} to nC_{21} (Blumer et al., 1971).

Sea Lion sediments exhibited a prevalence of odd over even numbered alkanes indicative of 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, such as the historic exploratory drilling activity in the area (Gardline, 2013b).

Polycyclic Aromatic Hydrocarbons

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 & 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 & Blumer, 1975), the burning of fossil fuels and, in the case of offshore oilfields, flare stacks, etc. The resulting PAHs, rich in the heavier weight 4-6 ring compounds, 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 survey area were 0.12 $\mu g.g^{-1}$ (±0.02 SD), whilst mean PAH ranged from 0.10 $\mu g.g^{-1}$ (±0.03 SD) to 0.15 $\mu g.g^{-1}$ (±0.01 SD) at the post-drilling survey stations. Mean total NPD concentrations across the Sea Lion survey area were 0.05 $\mu g.g^{-1}$ (±0.01 SD), and mean NPD ranged from 0.04 $\mu g.g^{-1}$ (±0.01 SD) to 0.065 $\mu g.g^{-1}$ (±0.01 SD) at the post-drilling survey stations.

When compared to the FOSA 1998 pre-drilling baseline survey, the 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 $\mu g.g^{-1}$ (±0.01 SD) and NDP of 0.2 $\mu g.g^{-1}$ (±0.01 SD). Comparison on a wider regional basis indicated that samples from the SFB Burdwood Bank and Toroa surveys both PAH and NPD 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 (Appendix A, Table 1).

Analysis of PAH composition in Sea Lion area sediments indicated that they predominantly comprised the heavier molecular weight 4-6 ring fraction (the mean ratio of NPD to 4-6 ring PAH ranged between 0.65-0.75) and suggesting that they primarily originate from pyrogenic sources (Gardline, 2013 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).

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 (Appendix A, Table 2). 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).

Conclusions

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 in the multivariate analyses 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).

5.4 Biological Environment

Information and data for this section came from a number of sources including scientific peer reviewed literature, scientific reports, grey literature and data provided by a number of organisations. In addition the Falkland Islands Marine Biodiversity Archive (FIMBAr) was consulted. FIMBAr was a collaboration between the Marine Biological Association (MBA), the

Shallow Marine Surveys Group (SMSG) and the South Atlantic Environmental Research Institute (SAERI). The project aimed to establish a marine biodiversity data archive for the Falkland Islands is supported by a Darwin Challenge Fund Award and ran from April 2012 until February 2013. By collating information from recent surveys and historical datasets it established a baseline dataset that can be used to map species distributions and inform future management of the marine environment (Davidson et al., 2013).

5.4.1 Marine and Inter-tidal Vegetation

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. It is necessary to determine whether there are any species present that may be at risk from any oil-related activities or pollution. As yet, the marine environment, marine habitats and species of flora and fauna that exist within Falklands waters are poorly described and understood. It is possible that there are new, endemic species yet to be discovered.

There are many seaweed species around the Falkland Islands, primarily in inshore waters. Seaweeds within the Falkland Islands fall into one of three categories: brown algae (Phaeophyta), green algae (Chlorophyta) and red algae (Rhodophyta). The red algae include coralline, or encrusting, algae that secrete calcium carbonate. The most common species of macro algae within the Falklands are the giant kelp (*Macrocystis pyrifera*) and the tree kelp (*Lessonia* spp.), both of which are classed as brown alga, and are common in inshore waters, between 0.5 m to approximately 40 m depth. 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 30 m).

5.4.1.1 Giant Kelp (Macrocystis pyrifera)

Giant kelp is one of the largest seaweeds, classed as a “brown algae”, and most abundant in the Falkland Islands forming extensive beds along the coastlines (Tussenbroek, 1989). It has been recorded as growing up to 60 m in length and commonly grows in “forests”, primarily found in more inshore waters, at depths between 3 – 6 m and usually within 1 km of the shore. Many marine invertebrate and fish species are known to use these forests for both habitat and food, it is thought to be particularly important habitat for the Peale’s dolphin (*Lagenorhynchus australis*), and spawning habitat for *Loligo* squid, which appears to preferentially lay eggs on solitary strands of kelp (Brown et al., 2010). Inshore waters are also important foraging grounds for many seabird species (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 then 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 (SMSG, 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. During the Environmental Baseline Surveys in the NFB in 2012, some algal litter believed to be giant kelp was observed on the seabed at some sample locations within the northern part of the Sea Lion area (Gardline, 2012). The kelp observed was quite deteriorated and undoubtedly drifted into these deeper waters from a near-shore area before settling onto the seabed.

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-petrel (*Garrodia nereis*) with an additional 21 seabird species also recorded as associating with free-floating patches of kelp (Gillon et al., 2001).

5.4.1.2 Tree kelp (Lessonia spp.)

There are four species of tree kelp that have been identified within Falklands waters: *Lessonia flavicans* (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*. Tree kelp is often found intertwined with giant kelp growing between 3 and 20 m. Broad blade tree kelp (*L. flavicans*) 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 (*L. vadosa*) inhabits depths between 0.5 to 2 m and grows in areas of harder substrate.

5.4.1.3 Other Algal Species

Many species of algae have been identified in the near-shore waters of the Falkland Islands, the vast majority of which will only grow in shallower waters. Table 15 (SMSG, 2013) provides a list of the most common algae found in the Falklands.

Table 15: Most Common Algae Species Found within the Falkland Islands Waters (SMSG, 2013)

Phylum	Common name	Latin name
Phaeophyta (brown algae)	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	*Desmerestia chordalis*
	Fur algae	*Desmerestia distans*
Chlorophyta (green algae)	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*
Rhodophyta (red algae)	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*

5.4.2 Plankton

5.4.2.1 Phytoplankton

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 via smaller fish and zooplankton up the food chain. The distribution of plankton therefore directly influences the movement and distribution of other marine species. The distribution and abundance of plankton 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 light for photosynthesis to occur) and are unicellular organisms, such as diatoms and dinoflagellates.

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 indicated that there were relatively few phytoplankton species and high diatom abundance south of 44°S, whilst the northern waters were comparatively dominated by dinoflagellates and ciliates and crustaceans (Hendley, 1937; Rodhouse et al., 1992).

5.4.2.2 Zooplankton

The oceanography and topography of the southern Patagonian Shelf, with the strong Falkland Current deriving from the ACC moving northwards both west and east of the Falkland Islands, creates an area of very high zooplankton productivity immediately to the north of the Islands and as such supports complex communities of zooplankton (Tarling et al., 1995; Boltovskoy, 2000), which in turn support complex pelagic and demersal ecosystems (Agnew, 2002).

A recent study by Padovani et al. (2012) examining the role of *Themisto gaudichaudii* on the Patagonian Shelf concluded that the species contributes greatly, both directly and indirectly, to supporting the fish community in the area. They proposed that *T. gaudichaudii* 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.

Also important to the Falkland Islands offshore ecosystem is the role of gelatinous zooplankton, such as jellyfish. Arkhipkin and Laptikhovsky (2013) found that gelatinous plankton occurred in diets of seven species, with two species, Patagonian rock cod (*Patagonotothen ramsayi*) and spur dogs (*Squalus acanthias*), having >10% ctenophores (comb jellies) in their diet. They found that the consumption of gelatinous plankton was important in rock cod but was extremely seasonal, with the greatest occurrence in late summer to autumn. Comb jellies were most abundant in rock cod of 25–34 cm total length, whereas salps (planktonic tunicates) were more frequent in larger individuals. In winter and spring, occurrence of gelatinous plankton in diets was reduced, reflecting their overall seasonal abundance in the ecosystem.

Other important components of the zooplankton community include the shrimp-like crustaceans, euphaudiids *Thysanoessa gregaria*, *Euphausia vallentini* and *E. lucens* (Tarling et al. 1995; Boltovskoy 2000). These coupled with the hyperiid amphipod *T. gaudichaudii* are important prey items to two of the Falkland Islands most abundant finfish species (hoki (*Macruronus magellanicus*) and southern blue whiting (*Micromesistius australis australis*)) and Argentine shortfin squid (*Illex argentinus*) (Mouat et al., 2001; Agnew, 2002; Brickle et al., 2009).

In contrast, the near-shore environment is dominated by the lobster krill, *Munida gregaria*. This is a very abundant species in the Falkland Islands near-shore environment and it is critical to this ecosystem (Agnew, 2002). It is also important in deeper water areas on the shelf where it forms important prey for seabirds, (Quillfeldt et al., 2011; Clausen et al., 2005; Michalik et al., 2010; Arata and Xavier, 2003) fish and baleen whales (Matthews, 1932; Arkhipkin et al., 2001; Laptikhovsky and Arkhipkin, 2003; Laptikhovsky, 2004; Brickle et al., 2009; Brickle, personal observation).

5.4.3 Benthic Flora and Fauna

Understanding the benthic fauna present within the NFB is crucial as drilling activity will directly impact on the benthos, and any drill cuttings and other potential pollutants may also have a detrimental effect on the species present. If there are any rare or protected species present within the area, this may also have an impact on potential drilling activities. Anthropogenic disturbances (such as from the oil industry) to the environment and the benthos can alter species diversity, abundance and even assemblage.

Although the historical results are useful in a broad sense, it is important to mention that historically there have been significant inaccuracies and inconsistencies with the survey design, sample processing, and species identification. Indeed this is a main feature of the current GAP Analyses

Project. Precision and quality control with regards to taxonomy is being developed in conjunction with the Natural History Museum, UK to ensure that inconsistencies are not an issue in the future. The GAP project will also work with companies to ensure adequate design methodologies for Environmental Baseline studies.

Seven baseline surveys were conducted by FOSA within the NFB licence blocks during 1998, and one post-drilling survey at one well location later in the year; a further survey was conducted by Benthic Solutions in 2008 in the southern NFB; and Gardline conducted an environmental baseline survey and post-drill survey within the Licence Blocks PL032, and PL04, in 2012. The methodology of each of these surveys is very similar, with sediment samples being collected with grabs and then sorted using a 0.5 mm mesh. All species found were generally sorted then preserved for taxonomic identification. As there are still many unknown and unidentified marine species within Falkland Islands waters, quite often the level of identification was not specific and often only to the Phyla level. It is also possible that the species resolution is greater in the later surveys than those conducted in 1998, as more species were identified in the interim period. Some surveys (for example, the Gardline surveys in 2012) removed specific taxonomic groups from the subsequent analyses (e.g. Copepoda, Mysidae, and Porifera) (Gardline, 2013a).

Isobel/Elaine (now called Isobel Deep) Survey (2014)

This survey was conducted on the Isobel/Elaine (now called Isobel/Deep) prospect area in blocks 14/20, approximately 65 km to the south of the Rhea-1 well location. The survey was conducted by MG3 Environmental Ltd on board the *MV Poseidon* between April and May 2014. Environmental and taxonomic expertise was provided by Benthic Solutions Limited. The Isobel/Elaine survey area was located in a polygon approximately 10 km x 7 km surrounding the potential prospect area. Ten sites were investigated with environmental sampling based on a pre-determined grid format. An additional location (ESL-09B) was also investigated using camera and grab sampling in order to ground-truth a channel feature for habitat information that was recorded during the acoustic survey. Another camera transect, undertaken at station ESL-01 in the north of the survey area to survey a similar feature (see MG3, 2014).

The water depths in the area vary from 330 m to 431 m. Habitat was assessed using a mix of acoustic and benthic ground truthing stations. The acoustic data was gathered using a ship mounted multibeam echo-sounder and a sub-bottom profiler. Benthic ground truthing was undertaken using a combination of high resolution imagery and a double grab sampler.

The survey revealed one general seabed type with two minor habitat variations recorded around relic ice modified features. The dominant sediment type was relatively homogeneous fine sediment with a Holocene sedimentary drape of sandy silt and occasional gravel. There were two variations with regards to seabed features which were interpreted to be iceberg groundings from the Pleistocene or older. These features comprised pronounced lay outcrops at the base of depressions with coarser material and boulders near the sides and shoulders of the features.

The noticeable biology in the area was the high densities of brittle stars; these were seen at all stations in the areas. Generally the survey area was fairly uniform and showed no evidence of habitats potentially considered as Annex I (European Habitats Directive). The presence of scleractinian (hard) corals in the form of an occasional cup coral over the softer sediments suggests a presence of some CITES Appendix II listed species in the area although these are not currently Red listed (IUCN). There were no records of geogenic or biological reefs or coral gardens, although isolated examples of octocorals are likely to be found on the larger individual drop stones located across the survey area.

5.4.3.1 Sea Lion Area Pre-Development Environmental Baseline Survey and Post Drilling Survey (2013)

These surveys were conducted in March and April, 2012 in Licence Blocks PL032 and PL04. In total, 90 stations were sampled: 54 in the environmental baseline survey, and 28 (four of which were replicated from the development survey) were conducted in areas where drilling had previously taken place, and eight random QA/QC stations. Samples were collected using a Box corer, and three sub-samples were collected at each sample location. The ten most dominant species were calculated, as were the Shannon-Wiener diversity index, Simpson's dominance index, and Pielou's evenness index (full results are presented in Gardline, 2013a).

The entire survey area in the baseline survey was considered to be rich in species assemblage, diversity and abundance, with a total number of taxa of 471 (minimum at any one station: 56; maximum at any one station: 144) (Gardline, 2013a). Of these 471 taxa, 81 were found at only one station. The total number of individual animals present was 41,527, with a range of 320 to 1,434 at each station. The results and analyses showed that the entire survey area was fairly homogeneous and the benthic community was typical of silt and mud benthic environments in the area. The community structure also indicates one that is undisturbed and unpolluted by anthropogenic activity.

Overall, polychaetes were the most abundant taxonomic group in terms of the number of taxa present, in most stations and overall, 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. The molluscs were the next most abundant group, followed by echinoderms. "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 and polychaetes made up 37% of the total. Molluscs were the next most abundant group. There appeared to be a slight degree of spatial differentiation, with slightly more crustacean species found in the southern part of the survey area.

In the post-drill survey, the benthic community was again found to be rich in species diversity, assemblage and abundance. No evidence of anthropogenic disturbance as a result of drilling activities was found, and the community was typical of those found in undisturbed/unpolluted medium to coarse silt environments. Species diversity and abundance was relatively uniform across the survey area. The number of taxa found in this survey was 468 (minimum at any one station: 104; maximum at any one station: 127). Of these taxa, 119 were found at only one station. The total number of individuals present was 26,280, with a range from 392 to 1,222 at one station.

As in the baseline survey, polychaetes were the most abundant taxonomic group in terms of number of taxa present, accounting for 43% of the total number of taxa found, followed by crustaceans, which made up 32% of the total number of identified taxa. These were followed by molluscs, then echinoderms, and the "other" taxonomic groups making up the remainder. In terms of numbers of individuals, however, crustaceans were again the most numerous, accounting for 39% of the total number of individuals, followed by polychaetes which were 43% of the total. Molluscs were the next most abundant group.

The ten most abundant species were almost exactly the same in both the environmental baseline survey and the post-drilling survey, with the only differences being the ninth and tenth most dominant species: the ninth was a different amphipod species in each survey and the tenth was a different gammarid amphipod species (Appendix B, Table 1). In the baseline survey, eight of the species present made up 41% of the total number of individuals found.

5.4.3.2 North Falkland Basin FOSA Pre-Drilling Surveys (1998)

In total, seven baseline surveys were conducted at different proposed well sites in the NFB in February/March 1998, and a post drill survey was conducted at the "Little Blue A" well in October 1998. Each sample station was considered to be rich in species diversity and abundance, with between 124 to 179 taxa being recorded at each site. It was also clear that they were undisturbed sites with taxonomic assemblages typical of undisturbed and unpolluted silts and muds (which were the sediment types found at each location). No clear spatial resolution was evident within the survey area; i.e. the stations sampled were fairly homogeneous with respect to the species present at each.

Consistently, across all survey locations annelids (polychaetes) were the most abundant group, followed by crustaceans, then molluscs, and echinoderms (Appendix B, Table 2). Only at the

“Minke” location were echinoderms more abundant than molluscs, and at location 14/23-A echinoderms and molluscs were present in equal numbers of species (Appendix B, Table 2). All of the species that were noted among the most dominant species at each survey site (Appendix C, Table 3) were all considered to be active or filter detrital feeders.

The Little Blue well (called “A” and “I” in Appendix B, Table 2) was surveyed both prior to- and post- drilling, with eight months between each survey. At the post drilling survey, ten more taxa were found (increasing from 144 to 154 (Appendix B, Table 2)). However, this increase in the number of taxa found is believed to be due to normal seasonal effects than as a result of any disturbance caused by drilling. Otherwise, the dominant species were exactly the same both pre- and post- drilling. Therefore, it is evident that the drilling activities did not cause any disturbance to the benthic community, and the location can still be regarded as “undisturbed and unpolluted”.

However, it should be noted that the lack of taxonomic resolution in these surveys may pose a problem when comparing with later survey data. It is also possible that some species were misidentified (Gardline, 2012a).

5.4.3.3 Rhea-1 Regional Environmental Habitat Assessment (RPS, 2015)

Based on the data available on the physical characteristics of sediments across the northern Licence Blocks, the consistency of occurrence of these sediments across the areas surveyed, together with the consistent seabed morphology across the northern Licence Blocks, the sediments present in the vicinity of the Rhea-1 well location are expected to be dominated by fines and comprise sandy muds with a low and varying proportion of gravel content.

According to the JNCC guidance on classification of deep sea habitats and biotopes (Parry et al*.,* 2015), the seabed habitats present within the NFB are considered to be most similar to the Atlanto-Arctic [Antarctic] upper bathyal mud (M.AAUB.Mu) habitat. This classification is considered appropriate due to:

- The mixing of cold Antarctic waters with the warmer waters of the south Atlantic;
- The depth of the Rhea-1 well site and northern Licence Blocks (i.e. within the upper bathyl depth band of 300-600 m); and
- The consistent muddy habitats, as defined by Long (2006), across the entire northern Licence Blocks.

Based on the similarity of the sediment type and water depths within the vicinity of Rhea-1 compared to the data reviewed within the wider NFB, it is concluded that the habitats will be dominated by a diverse array of infaunal polychaete species and amphipod species (i.e. deposit feeders) (RPS, 2015).

It is likely that the epifaunal communities recorded from seabed images in other studies (e.g. the Sea Lion survey area) in the northern Licence Blocks are also likely to be representative of the epifaunal communities at the Rhea-1 well location. Given the predominantly muddy nature of the sediments across the region, sea pen and echinoderm (urchin) communities could be patchily distributed across the area, although due to a lack of epifaunal data (compared to infaunal data) there is a degree of uncertainty associated with this conclusion (RPS, 2015).

Iceberg ploughmarks characterise the seabed across most of the NFB. These ice ploughmarks are probably formed by large icebergs drifting from Antarctica along the eastern branch of the Falkland Current during the Last Glacial Maximum approximately 20,000 years ago (Lopez-Martinez, 2011). No ice modified seabed features were identified with 500 m of the Rhea-1 well and although this is of interest generally for the area, is not significant for the Rhea-1 well (RPS, 2015).

No areas of coarse or hard substrates, which could be indicative of cold water coral habitats or sponge aggregations, were recorded during surveys and geomorphological mapping of the northern Licence Blocks, which strongly indicates that any such substrates are not present near the Rhea-1 well site (RPS, 2015).

5.4.3.4 Summary

The community throughout the areas surveyed to date, both pre- and post- drilling, is that of a typical silt/mud benthic environment, and also appears to be undisturbed and unpolluted. Drilling activities appear to have had no effect on the benthic community within the affected areas. One point of concern is that the lack of taxonomic resolution may make comparison between each data set more difficult and earlier work may have misidentified some species. However, both sets of surveys have brought new species to light and have led to more marine benthic species within Falkland Islands waters being identified. This work continues in collaboration with the Natural History Museum in the United Kingdom.

5.4.4 Fish Ecology (Commercial and non-commercial species)

This section provides a summary of the most abundant fish and squid species within Falkland Islands waters, describes their seasonal abundances in relation to the northern Licence Blocks, their seasonal spawning migrations and their principal diet. The wider area of continental shelf and slope in the vicinity of the Rhea-1 well site 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 proposed exploration well 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).

5.4.4.1 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. 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 (between two water masses) for feeding and back 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, and consequently species belonging to both temperate and sub-Antarctic taxa are found within the area.

The Falkland Islands Conservation and Management Zones (FICZ and FOCZ) delineate the extent of commercial fishing in 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:

- Inner Shelf (IS);

The outer shelf is subdivided into two habitats,

- North-Western Outer Shelf (NWOS);
- South-Eastern Outer Shelf (SEOS).

The upper continental slope partitioned at latitude 51° S into two habitats:

- Northern Slope (NS);
- Southern Slope (SS); and

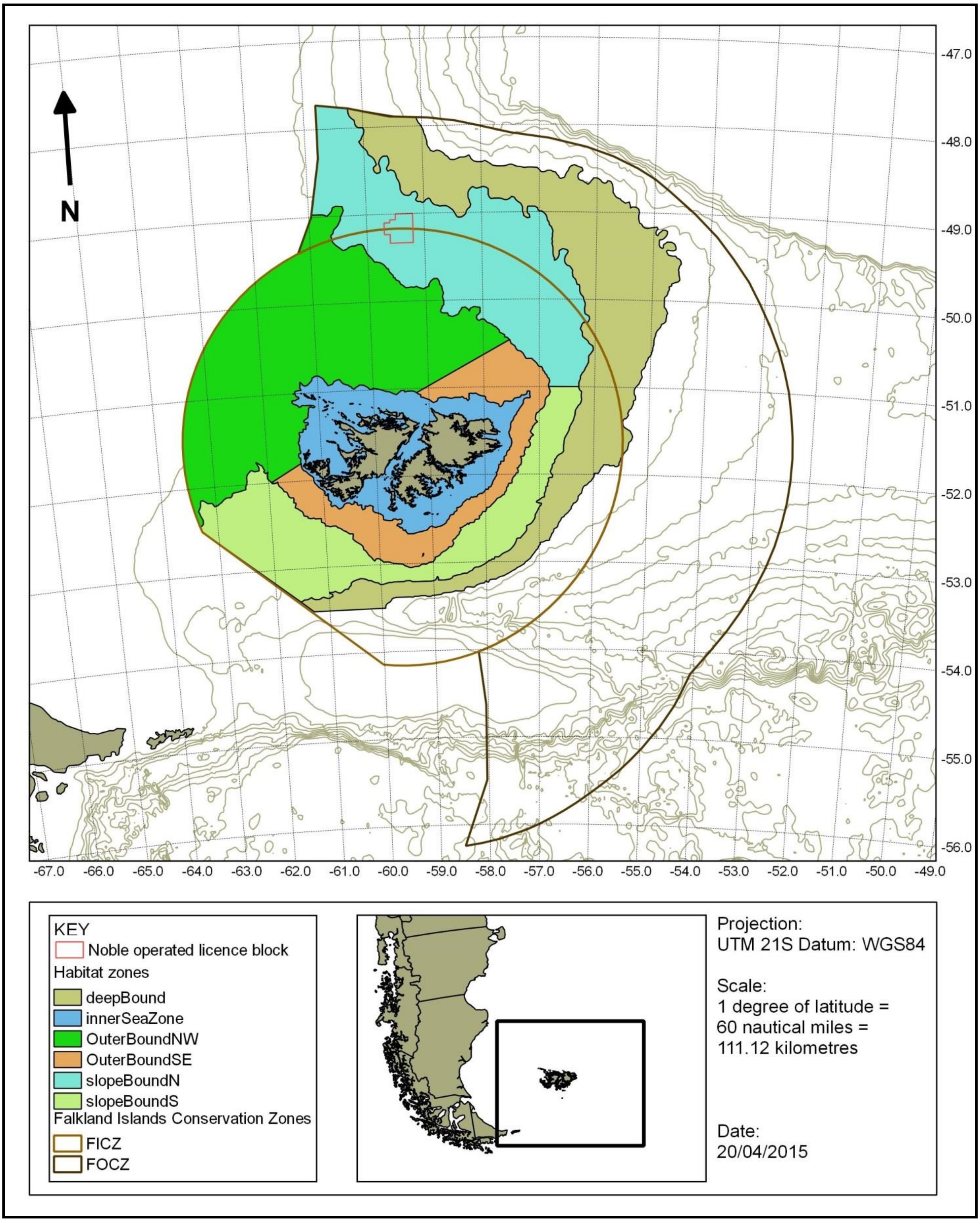
- Deepwater Slope (DS) at depths between 600 and 1,200 m.

The Rhea-1 well site sits in the North Slope area in the FICZ (Figure 22).

The NS covers an area of 50,686 km^2, with an average depth of greater than 400 m. The shallow-water area (250–350 m) of NS is mainly flat with sandy or muddy bottom topography and is 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. The shallower part of the NS is covered by the transition zone of Patagonian Shelf waters mixing with the SASW. There is only slight seasonal variation in temperature (4·8–5·5°C with the maximum observed in April to May) and salinity (34·06–34·11 ppt). The offshore deeper part of the NS is covered by the SASW mass with practically constant near-bottom temperatures (4·1–4·3°C) and salinities (34·1–34·2 ppt) (Arkhipkin et al., 2012a).

5.4.4.2 Seasonal abundances around the Falkland Islands

Despite the 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. Arkhipkin et al. (2012b) hypothesized that the high abundance of intermediate sized predators prevents most higher-trophic level predators (such as sharks, squid and tuna) from establishing spawning populations in the area, as their larvae and fry would be overwhelmed by predation. Instead, the higher-trophic level predators establish spawning and nursery grounds elsewhere and utilise resources in and around the Falkland Islands when they reach adulthood and therefore less vulnerable to predation.



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).

Figure 22: Map Delineating Habitat Zones within Falkland Islands Waters

5.4.4.3 Migration patterns around the Falkland Islands

This was summarised from Arkhipkin et al. (2012b). Data for this study were collected by Falkland Islands Government Fisheries Department (FIGFD) Scientists and Scientific Observers from 13,044 commercial bottom and pelagic trawls between 2000 and 2010 and from 1,272 research trawls between 1999 and 2011. Relative abundances were calculated as catch per unit effort (kg trawl-h^{-1}).

Sub-Antarctic fauna

Southern blue whiting is an abundant pelagic migratory species associated with sub-Antarctic waters. Its spawning grounds are to the southwest of the Falkland Islands where it congregates during the spring (Appendix E). 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 (*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 during the austral summer when it migrates to forage in the SEOS, North-West Outer Shelf (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., in press) (Appendix E).

Hoki or whiptail hake 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 (Appendix E). 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 (*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. The seasonal dynamics within habitat zones suggests that 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 Patagonian rock cod, moving back to the slope regions (mainly NS) in autumn (Arkhipkin et al., 2012a).

The greater hooked squid (*Onykia ingens*) is an abundant species throughout the Southern Ocean and feeds predominantly on fish species (Arkhipkin et al., 2012b). It is a relatively large squid (maximum reported mantle/body 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 Patagonian 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 (*Salilota australis*) is a relatively large demseral 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 (typical mantle length of 13–17 cm), locally known as loligo, is an important domestic commercial species that spends its whole life cycle in Falkland Islands waters (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. This small loliginid squid's abundance 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. 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.

Temperate fauna

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 the autumn and winter, common hake migrate to their main foraging grounds in the NWOS, and to a lesser extent in the NS, to feed on Patagonian 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) (Appendix E).

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 were found in the NWOS, SS and SEOS, which are the main foraging area of 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 Patagonian 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) (Appendix E).

The Patagonian 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 Patagonian rock cod has increased several fold in recent years and it is now the most abundant finfish on the Falkland Islands shelf and has become one of the most important finfish fisheries in the Falkland Islands (FIGFD, 2013). It is hypothesised that the regional decline in southern blue whiting is a factor in rock cod's increased abundance (Laptikhovsky et al., 2013). Patagonian 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 (up to 46% of stomach contents), reflecting their overall seasonal abundance in the oceans (Arkhipkin and Laptikhovsky, 2013). The abundance of rock cod declines, 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 (Appendix E).

The Argentine shortfin squid is medium-sized (typical mantle length of 35 cm), has an annual life cycle (Hatanaka, 1986) and is the most abundant squid species in the southwest Atlantic. It is mostly associated with the temperate waters of the Patagonian Shelf and highest abundances are recorded on the NWOS and NS during the 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).

The yellownose skate (*Zearaja chilensis*) is a relatively large skate that reaches 120 cm total length. It 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. 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.

The spur dog (*Squalus acanthias*) is a small shark that is associated with temperate waters of the Patagonian Shelf (Nakamura et al., 1986). The spur dog 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. 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).

The slender tuna (*Allothunnus fallai*) is a medium sized tuna growing to a maximum total length of approximately 100 cm. It has the most southerly distribution of tunas in the South Atlantic. This species 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).

5.4.4.4 Species sensitivity within the NS

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 around and out of these waters as food availability changes and to follow seasonal spawning migrations. The Northern Slope (NS) area, where the Rhea-1 well is located, is an important feeding area for a number of these species, whose abundance in the NS varies with season.

Table 16 summarises the relative abundance of the main fish species throughout the six main habitat zones over the four ‘seasons’. The habitats are identified in order of abundance of each species, and cell highlighting relates only the relative abundance within the NS, with darker turquoise highlighting indicating higher abundances, and pale blue indicating relatively lower abundances in the NS. The summary in Table 16 indicates that 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. 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 greater than 50% of the hoki population inhabits the NS over other areas (Arkhipkin et al., 2012b); similarly southern blue whiting predominantly inhabit the NS during summer, slender tuna during autumn and the yellownose skate during winter.

While the productive Falklands waters support the foraging of a diverse, abundant assemblage of fish and squid, a more unusual aspect of Falklands waters is the migration of the majority of higher trophic species to spawn elsewhere, like southern and common hake, hoki and kingclip. Only a few large predators such as red cod (SEOS), several skates and the loligo (IS) and greater hooked squid (DS) spend their entire life cycle in the shelf ecosystem (Arkhipkin et al., 2012b).

Table 16: Summary of Seasonal Abundance of Fish Species in Relation to Sea Lion Field in the Falklands Islands Northern Slope (NS) Habitat Zone

	Spring (Oct – Dec)	**Summer (Jan – Mar)**	**Autumn (Apr – Jun)**	**Winter (Jul – Sept)**
Sub-Antarctic species				
Southern blue whiting	SEOS / SS / NWOS	**NS**/ SS/ NWOS/ SEOS	**NS** / SS / DS	SEOS / SS / NWOS
Southern hake	SS/ NWOS/ NS/ DS	NWOS / SS / DS	SS / NWOS	SS / NWOS / **NS**
Hoki (whiptail hake)	**NS**/ NWOS/ SS/ SEOS			SS / **NS** / NWOS
Patagonian toothfish	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	IS / SS	IS / SEOS / SS	SEOS / IS	SS / SEOS / **NS**
Temperate species				
Common hake	NWOS / **NS**	NWOS / **NS**	NWOS / **NS**	NWOS / **NS**
Kingclip	NWOS/ SS/ **NS**/ SEOS	NWOS / SS / **NS**	NWOS / SS / **NS**	NWOS / **NS** / SS
Patagonian rock cod	NWOS / SEOS / **NS**	NWOS/ **NS**/ SS/ SEOS	NWOS / **NS** / SS	NWOS/ SS/ **NS**/ SEOS
Argentine shortfin squid	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

Note: High abundances in the NS highlighted in turquoise. Low abundances in NS highlighted in light blue.
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.

Based on data from Arkhipkin et al., 2012b.

5.4.4.1 Other Commercial and Non-commercial fish species on the Northern Slope

Although not commercial currently, grenadiers, particularly the Ridge scaled rattail (*Macrourus carinatus*), are abundant in the area and may be subject to a future fishery (Payá, 2009). Other species not mentioned above include a number of skate species (some examples are mapped in Appendix E), morid cods and psychrolutid fish. Lantern fishes (Myctophidae), the black smelts (bathylagids) and other bentho-pelagic fish also contribute to the fish community on the Northern Slope. 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). They were also evident in many of the drop down camera surveys undertaken in the region of the Sea Lion area (Gardline, 2013).

5.4.5 Marine Mammals

Marine mammal species comprise whales, dolphins and porpoises (cetaceans) and seals (pinnipeds). Cetaceans can be divided into two main categories: baleen whales (Mysticeti) such as the humpback whale (*Megaptera novaeangliae*), which feed by extruding plankton from seawater through baleen plates; and toothed whales (Odontoceti) such as killer whales (*Orcinus orca*) and dolphins, which have teeth for prey capture. Pinnipeds are fin-footed, semi-aquatic marine mammals that spend part of their time hauled out on land where they rest, moult and breed.

The Falkland Islands support a diverse range of marine mammal species. Much of the information regarding the status of species comes from anecdotal reports and records of stranded animals (Otley, 2008). However, there have also been a number of at-sea surveys. Over a three year period between 1998 and 2001, a team of Joint Nature Conservation Committee (JNCC) observers systematically surveyed the seabird distributions around the Falkland Islands (White et al., 2002). Although the methodology used was not specifically designed to survey the distribution of marine mammals, all animals sighted were recorded. White et al. (2002) remains the most comprehensive account of the at-sea distribution of marine mammals within Falkland Islands waters, however, the age of the dataset raises uncertainty as to how representative it is of present day populations. For instance, anecdotal observations suggest that the number of large baleen whales in Falklands waters has increased since these surveys were undertaken. In recent years, marine mammal observers on seismic vessels (Polacus, 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. The dispersion of marine mammals within Falklands waters remains poorly understood but the data available suggests that most of these species are present on a seasonal basis (see Figure 24).

Confirmed sightings and stranding records indicate that 25 species of cetacean occur within Falkland Islands waters. Many of these species are rare and inconspicuous, some are only known from stranded animals; however, from the available evidence it is possible to summarise the status of these species within Falkland Islands waters Appendix C, Table 1. Of the 25 species listed as occurring in the southwest Atlantic, two species are listed as Endangered on the IUCN Red List, fin *Balaenoptera physalus* and sei whales *B. borealis*, and one species, the sperm whale *Physeter macrocephalus*, is listed as Vulnerable.

At least, six pinniped species have been recorded in the Falkland Islands in recent years. There are three breeding species (South American fur seal (*Arctocephalus australis*), southern sea lion (*Otaria flavescens*) and southern elephant seal (*Mirounga leonina*); one seasonal visitor (Antarctic fur seal (*Arctocephalus gazella*); one occasional visitor (leopard seal, *Hydrurga leptonyx*) and one vagrant (Ross seal, *Ommatophoca rossii*). It is possible that other species from the Antarctic or sub-tropics occur as rare visitors or vagrants, for instance sub-Antarctic fur seal, *Arctocephalus tropicalis*. The 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.

The abundance and availability of prey, including plankton, fish and squid, can be of prime importance in determining the number and distribution of marine mammals. Although cetaceans are not tied to land to breed, many species return to specific areas to calve and reproduce each year. During the non-breeding period, many of the larger species make ocean-wide migrations to exploit specific feeding grounds, often at high latitude. It is believed that many of the cetaceans recorded within Falkland Islands waters are on passage through the area to and from these feeding/breeding grounds. Changes in the availability of principal prey species could result in local changes of marine mammal numbers (SMRU, 2001).

5.4.5.1 Mammals recorded during JNCC seabirds at-sea surveys

It is generally considered that there is insufficient data available for most marine mammal species in the Falkland Islands; in particular information on foraging and breeding areas, seasonal distribution and abundance and diet is particularly scarce (Otley et al., 2008). The JNCC seabirds-at-sea team (SAST) described the distribution of marine mammal species in Falkland Islands waters from the results of surveys conducted between February 1998 and January 2001 (White et al., 2002). The JNCC survey represents the most comprehensive visual survey of marine mammals in this area to date. Visual surveys were conducted during 91 cruises covering a total area of 20,907 km^2. Figure 23 shows the area covered and the total survey effort between 1998 and 2001, and the location of the Sea Lion area in the northern sector of the survey area. Although marine mammals were recorded whenever sighted, the methodology used in these surveys was not specifically designed to record marine mammals; it was designed to record seabird distribution. 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. To date, these datasets have not been collated and analysed as a whole.

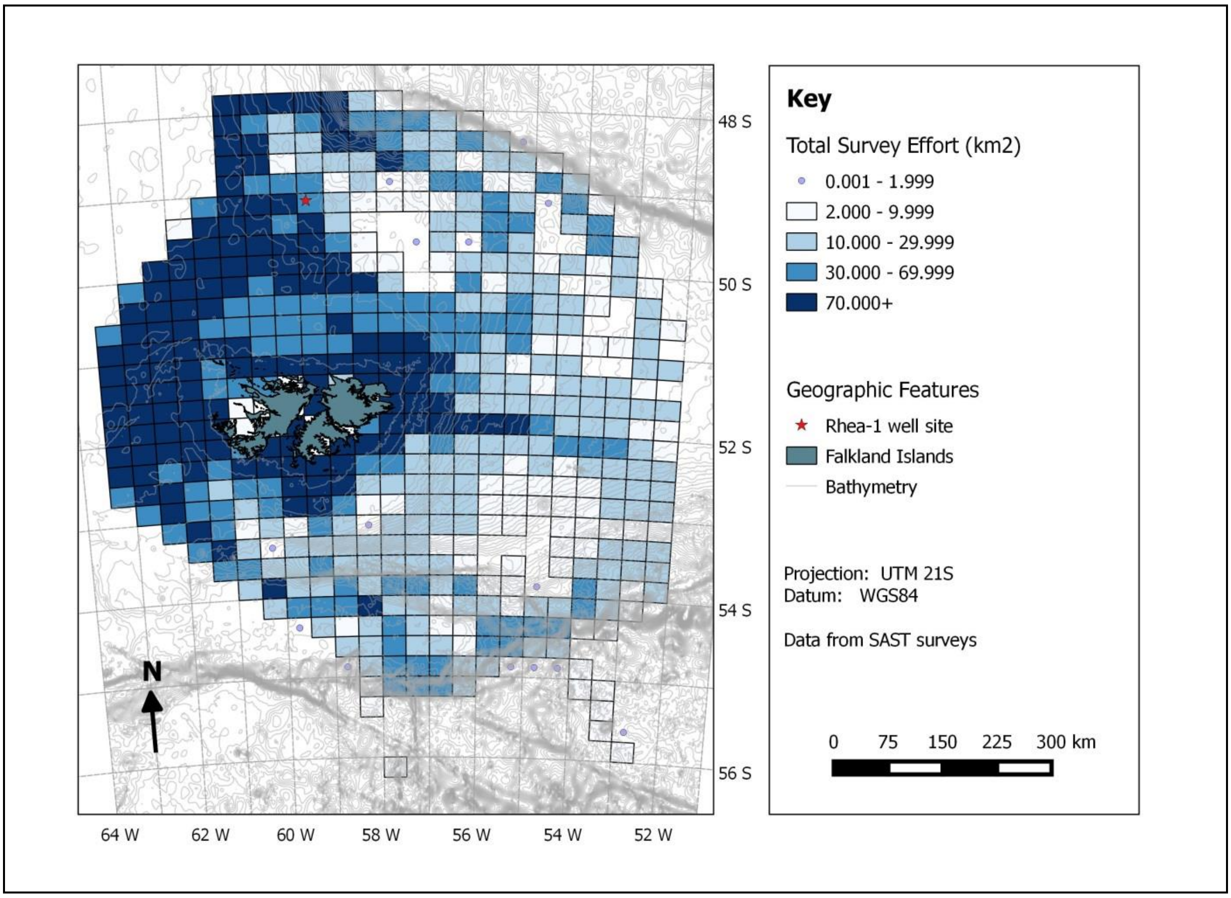


Figure 23: Total survey effort achieved during JNCC surveys between February 1998 to January 2001 (White et al. 2002)

The JNCC survey documented 6,550 individuals, identifying 17 species of marine mammal, including 14 cetacean and three pinniped 'species' (Appendix C, Table 1).

Survey effort was generally greatest during the summer months when daylight hours allowed for more surveying (the months of January, September and November, produced annual means of 817, 912 and 897 km^2, respectively). Lower survey effort was obtained during the autumn months when the survey bases (Fishery Patrol Vessels, FPVs) were required elsewhere. The lowest monthly effort was achieved in February, April, and May, with respective annual mean survey efforts of 448, 493 and 465 km^2. Figure 24 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 year-round (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 comparatively low between May and September, which is likely to be explained by the migratory behaviour of these species.

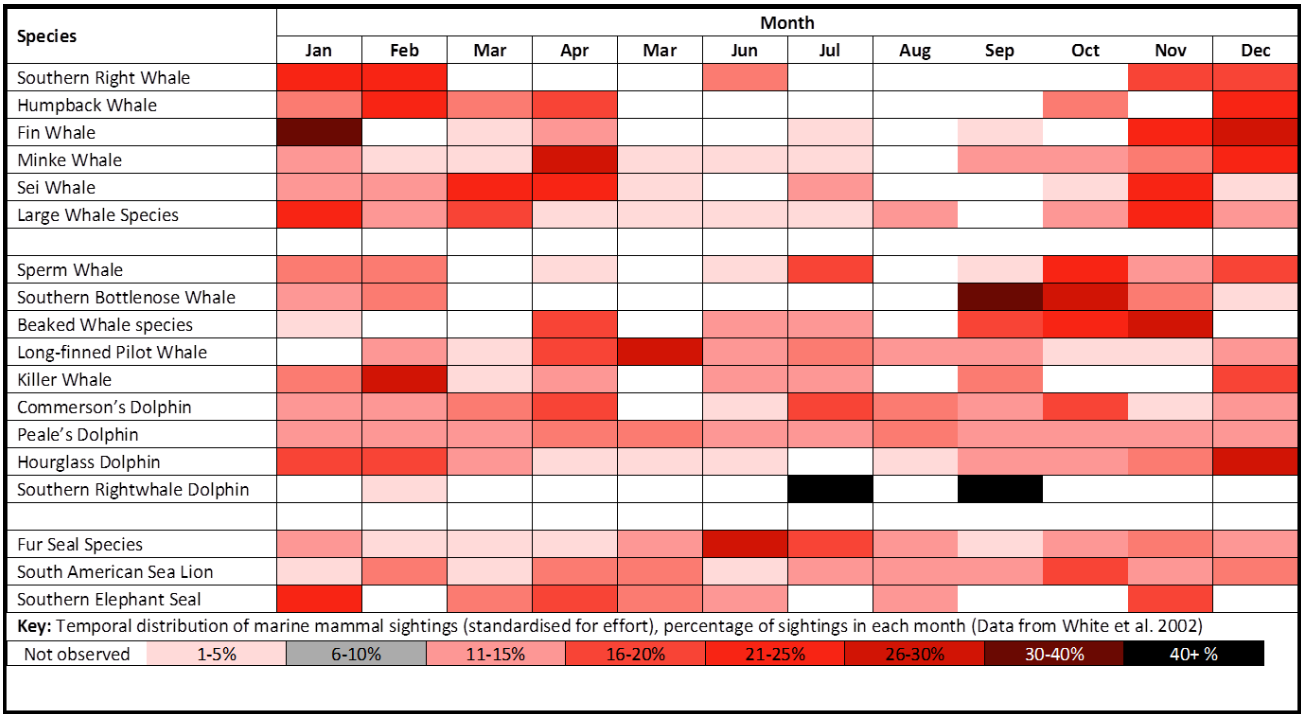


Figure 24: Relative incidence of marine mammal sightings, by species, adjusted for monthly survey effort (data from White et al. 2002).

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 while 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). There was evidence of seasonal variation in the dispersion pattern of hourglass dolphin.

The JNCC survey did not record all the species that are known or believed to occur around the Falkland Islands. Appendix C, Table 1 also lists species that have been found stranded in the Falkland Islands (Otley et al., 2012) but were not observed during the JNCC survey (White et al., 2002). In addition to seven beaked whale species (Otley et al., 2011), 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 are beaked whales. These animals 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 some limitations of visual surveys, which should be considered whenever using this data. Experienced and skilled observers are required and many species spend considerable periods of time below the surface, where they are undetectable. However, the use of multiple observers and distance sampling survey techniques can increase the reliability of the data. As previously stated, the JNCC methodology was not specifically designed to record the distribution of marine mammals and although the same three observers were used throughout the project they usually worked alone. Sea state and visibility will also affect the reliability of visual surveys. Acoustic methods may help to quantify the abundance of marine mammals but these methods also have some limitations. The vocal range of many of the species encountered within Falkland Islands waters is unknown and the audible range of vocalisations is dependent on frequency and the orientation of the animal, relative to the hydrophone. The combination of visual and static acoustic monitoring can provide a more rigorous survey methodology through amalgamation of both datasets.

5.4.5.2 Marine Mammal Surveys within the vicinity of the Drilling Campaign Area

Rockhopper Exploration conducted a one year static acoustic monitoring programme during 2012 and 2013 in the Sea Lion Field, using wideband acoustic recordings in order to examine the spatial and temporal distribution of resident and transitory marine mammal populations (Hipsey et al., 2013) from their vocalisations. Full details of the monitoring survey are described in Hipsey et al., 2013 and have been summarised in this report.

The acoustic survey was intended to significantly enhance the existing marine mammal dataset collected during a three-year JNCC visual survey of the Falkland Islands Conservation Zones and to provide a comprehensive dataset for assessing potential impacts from future 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 (rain and fog), 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 Rhea-1 well location is approximately 22 km from the Sea Lion field and consequently the data collected during the acoustic survey is relevant for the Rhea-1 well.

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 (

Table 17). 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.).

Table 17: Summary of the annual marine mammal activity detected by the AMARs from July 2012 to July 2013 (Hipsey et al., 2013).

Mooring	Recording Depth	Phase 1 Deployed 30 Jul 12		Phase 2 Deployed 01 Dec 12		Phase 3 Deployed 21 Mar 13	
		Record stop	Days Recorded	Record stop	Days Recorded	Record stop	Days Recorded
AMAR 1	399	18 Nov 12	109.9	19 Mar 13	108.2	26 Jul 13	Unreliable
AMAR 2	409	10 Oct 12	71.4	21 Mar 13	110	24 Jul 13	125.2
C-POD 1	181	01 Dec 12	123	21 Mar 13	110	05 Jul 13	106.4
C-POD 2	192	20 Nov 12	121	16 Mar 13	105	19 Aug 13	151
C-POD 3	192	01 Dec 12	123	21 Mar 13	110	19 Aug 13	151

The two AMAR moorings were spaced 9.6 km apart, and the three C-POD moorings 6.3 and 6.9 km apart (Figure 25).

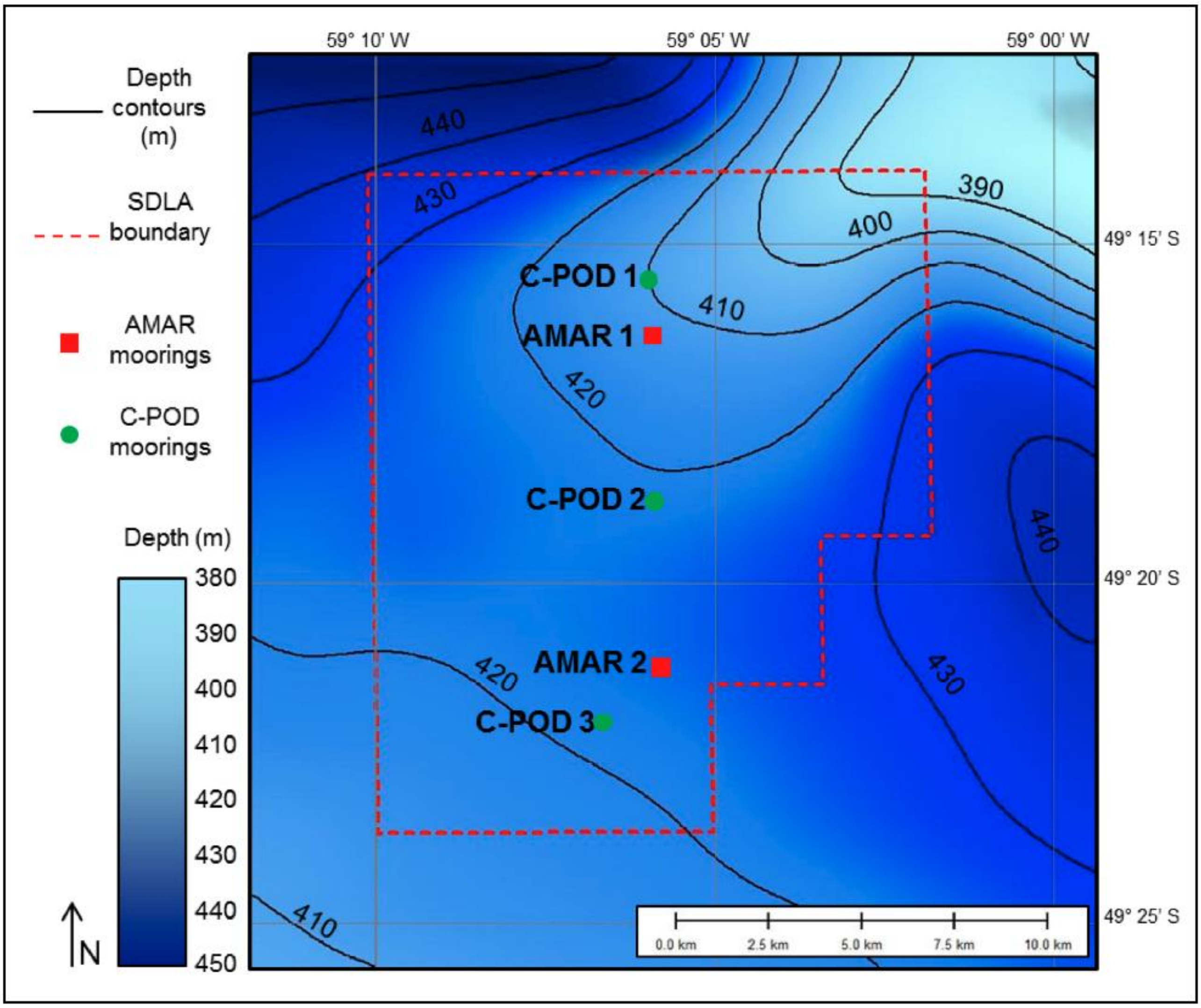


Figure 25: AMAR and C-POD Mooring Locations (Hipsey et al., 2013).

Whilst acoustic monitoring provides a number of advantages for marine mammal detection, there are also some limitations. Click detection instruments detect sounds that typically occur between

20 and 160 kHz and suffer a high degree of intensity attenuation in seawater (Hipsey et al., 2013). This results in relatively short detection ranges, especially at the higher end of this band. For instance, porpoise clicks between 120 and 140 kHz cannot usually be detected beyond 400 m and dolphin clicks are predominantly limited to ranges less than 1,000 m. Conversely, large baleen whales may be detected at ranges of hundreds of kilometres. As the Rhea-1 well is located approximately 22 km from the Sea Lion field clicks from porpoise and dolphin from the vicinity of the Rhea-1 well may not be represented in the acoustic survey. However, as these animals are highly mobile and the Rhea-1 well location is relatively close to the Sea Lion field in relation to typical foraging distances for these species, data from the acoustic survey is expected to give a good indication of their presence around Rhea-1.

Given the relatively short range of higher frequency clicks and the depth of water, there was a risk that a C-POD positioned close to the seabed would not capture higher frequency near-surface clicks. Conversely, at a very shallow deployment depth a C-POD would be more prone to effects of sea surface and weather noise and may not detect clicks from deeper-diving species, such as beaked whales. To optimise performance in this water depth, the C-PODs were therefore moored at a mid-water column depth. The expected detection capability of a mid-water column deployed C-POD. A near-seabed recording position for the two AMARs was chosen to minimise noise interference from the surface and potential multipath effects.

The effectiveness of click detectors and acoustic recorders is also limited by the highly directional nature of the clicks emitted by most delphinids. Horizontal and vertical beam-widths for these species are typically in the region of ±20° (Au and Hastings, 2010). Consequently, echo-location clicks will only be audible or detectable if the foraging mammal is ‘looking’ virtually at or very close to the instrument.

5.4.5.3 Acoustic Data Analysis

Data was uploaded from the retrieved AMARs and C-PODs on completion of each of the three recording phases. The AMAR data were auto-processed with JASCO’s Acoustic Analysis software suite to calculate ambient noise levels and to detect acoustic events and mammal vocalisations and clicks. 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).

Impulsive sounds indicative of distant seismic survey activity were recorded throughout the recording period, being detected on 37-38% of days. The greatest activity occurred during August 2012, December 2012 to February 2013 and June 2013. However, there are no seismic survey cruises planned to coincide with the 2015 Rhea-1 well drilling period.

5.4.5.4 Marine Mammal Observations during Seismic Surveys in the NFB and PL001

In addition to the year-long acoustic monitoring programme in the Sea Lion Field, Marine Mammal Observations (MMO) were conducted as mitigation to minimize the potential impacts of seismic surveys being conducted in the NFB. A seismic survey was conducted in the NFB between 11th January 2011 and 2nd May 2012 for Argos Resources and Rockhopper Exploration (Geomotive and MRAG, 2011); a second seismic survey was conducted in Licence Block PL001 between 25th

November 2010 and 5th May 2011 for Desire Petroleum and Rockhopper Exploration (Polarcus, 2011). MMO were made for 60 minutes at the start of each seismic activity, before the use of any airguns. A total observation effort of 1,310 hours and 11 minutes was recorded in the NFB during which there were 142 encounters of 12 different marine mammal species (Geomotive and MRAG, 2011); a total observation effort of 794 hours and 29 minutes was recorded in PL001 during which marine mammals were sighted on 109 occasions corresponding to 462 individuals representing 11 species (Polarcus, 2011). The data from these seismic surveys gives additional information relating to the presence of marine mammals in the NFB and PL001 during the austral summer and autumn, which complement the acoustic monitoring data for the Sea Lion Field. While both methods have recognised limitations in their data collection, referring to both datasets may provide a better overall picture.

5.4.5.5 Results of Marine Mammal Surveys within Falkland Islands waters

The results of the JNCC surveys are published in White et al. (2002), a summary of the number of individuals recorded by species can be found in Appendix C, Table 1, along with a number of marine mammal stranding's on the Falkland Islands (Otley, 2008).

Appendix C, Table 2 summarises the marine mammal sightings from MMO during the seismic survey campaigns in the NFB (Geomotvie and MRAG, 2011) and PL001 (Polarcus, 2011).

Appendix C, Figures 1-7 illustrate the number of call detections on each day during the year-long monitoring programme and indicate each species' relative seasonal abundance.

Acoustic surveys recorded six species of marine mammal; a summary of the results is presented in Table 18.

Table 18: Summary of the annual marine mammal activity detected by the AMARs from July 2012 to July 2013 (Hipsey et al., 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**	**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

5.4.5.6 Summary of Marine Mammal distribution in the North Falkland Basin

IUCN status is shown in parenthesis (DD=Data Deficient, LC=Least Concern, VU=Vulnerable, EN=Endangered).

Southern right whale *Eubalaena australis* (LC)

The JNCC surveys recorded southern right whales on four occasions over three years (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 (Geomotvie & 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 spring breeding grounds in Patagonia, 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).

Blue whale *Balaenoptera musculus* (EN)

Historically, blue whales would have been present within Falkland Islands waters, at present they are extremely rarely sighted and, to date, this species has not been recorded by visual or acoustic surveys. Whaling in the Atlantic sector of the Southern Ocean killed many thousands of blue whales (Moore et al., 1999). The paucity of blue whale sightings in the wider Scotia Sea indicates that the population of these animals has not yet recovered.

Fin whale *B. physalus* (EN)

Acoustic monitoring recorded fin whales in the Sea Lion area during late August 2012, and consistently in the late winter and early spring (August and September) period, but appeared to peak in March (early austral autumn) (Hipsey et al., 2013). Detections stopped abruptly in April and did not resume before the end of the monitoring period 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 in November, December, and January (White et al., 2002). Fin whales were sighted by MMO during both of the seismic surveys in the NFB, with greater numbers (12 individuals) recorded in waters adjacent to but south of the Rhea-1 well location (Geomotive and MRAG, 2011).

The acoustic monitoring program indicated that fin whales were present in the Sea Lion area from September until March, suggesting that past visual surveys (White et al., 2002) underestimated the occurrence of fin whales 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 are listed as Endangered on the IUCN Red List and are also afforded conservation status and management under CITES and 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 *B. borealis* (EN)

JNCC surveys recorded 45 sei whales; however, few of these came from waters to the north of the Falkland Islands, most 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). Analysis of the acoustic data from the Sea Lion area did not contain any confirmed sei whale calls. Due to the potential overlap in calls from sei and fin whales (Watkins, 1981, Baumgartner et al., 2008) and the absence of sei whale call description for the South Atlantic, it is possible that the fin whale detection records included some sei whale calls (Hipsey et al., 2013).

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, A. Black pers. comm., P. Brickle pers.

comm.). These animals are only present on a seasonal basis and are likely to pass through the NFB on migration. A project to survey the distribution of cetaceans in inshore waters is currently underway (Thomson and Munro, 2014). The preliminary results and anecdotal observations indicate that sei whales are frequently encountered in inshore waters during the summer and autumn months. 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 *B.bonarensis* (DD)

Antarctic minke whales 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).

Humpback whales *Megaptera novaeangliae* (LC)

Humpback whales have been rarely recorded within Falklands waters. JNCC surveys encountered seven animals, all between October and March, in Patagonian Shelf waters. 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 suggests that few of these whales pass through Falklands waters *en route*.

Sperm whale *Physeter macrocephalus* (VU)

This species was 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 and east of the Rhea-1 well location. While 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; Appendix C, Table 2). 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). 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, with highest numbers of detections recorded in May.

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 *Hyperoodon planifrons* (LC)

The JNCC surveys recorded southern bottlenose whales 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 *Mesoplodon* species (DD)

Beaked whales 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 southeast of the

Islands. Stranding records indicate that a number of *Mesoplodon* species could be present within Falkland Islands waters (Otley et al., 2011).

Killer whale *Orcinus orca* (DD)

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 between July and mid-October (Hipsey et al., 2013). The JNCC surveys recorded seven killer whale sightings over three years, primarily on the Patagonian Shelf, (White et al., 2002). 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 *Globicephala melas* (DD)

Long-finned pilot whale sightings primarily occurred between February and September during the JNCC surveys (White et al., 2000). 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).

The high number of pilot whale stranding's on the Falkland Islands (Otley, 2012) hints that there is a sizable 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, in particular, hourglass dolphin and to a lesser extent southern right whale dolphin were recorded in association with pilot whales.

Peale's dolphin *Lagenorhynchus australis* (DD)

Peale's dolphin 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 west and south-west of the Falkland Islands (Figure 26). Peale's dolphins were regularly recorded at the western boundary of the survey area, a strong indication that the distribution of the species is continuous between the Falkland Islands and mainland South America. There was no clear evidence of any seasonal changes in the abundance, distribution or behaviour of these animals.

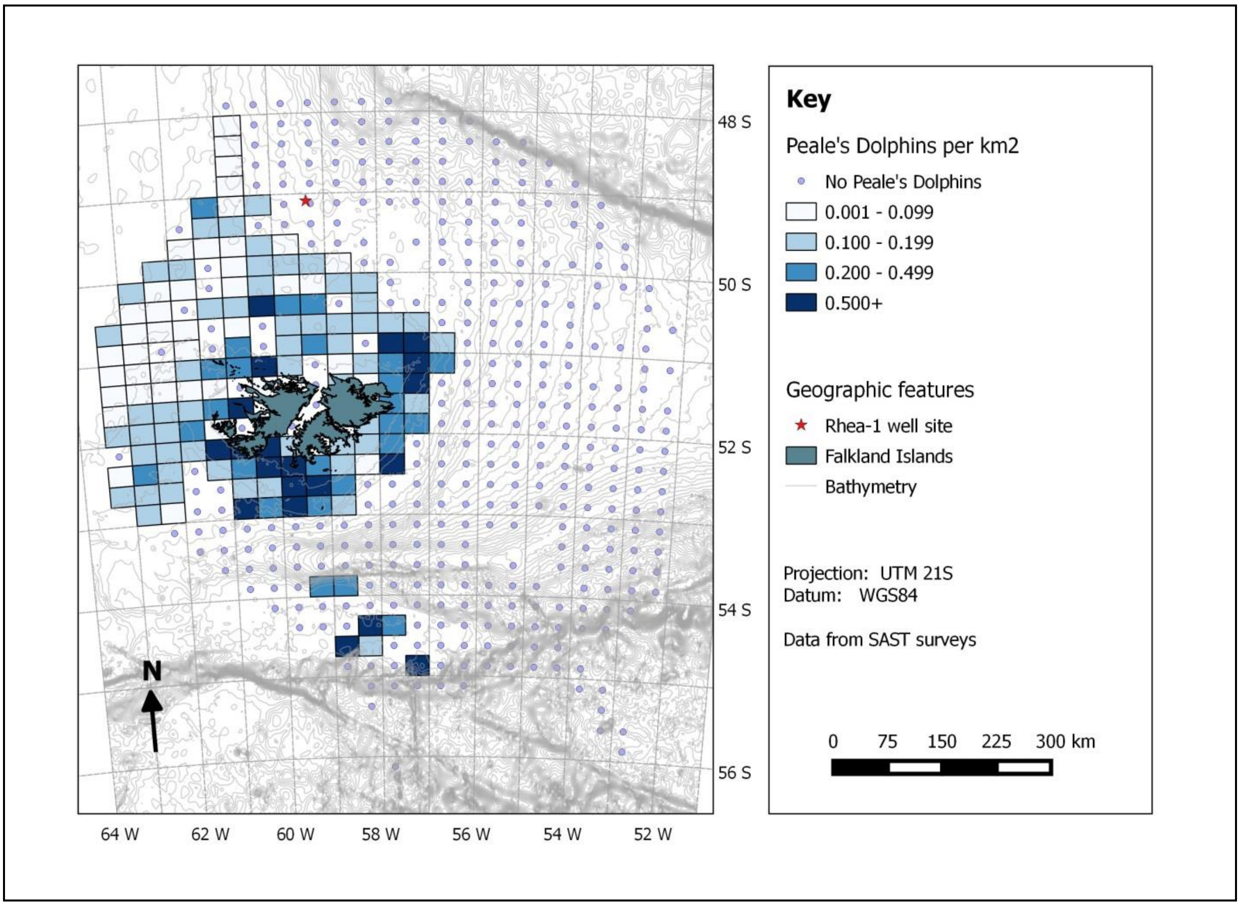


Figure 26: Peale's dolphin distribution recorded during JNCC surveys, all months

Peale’s dolphin was also the most frequently recorded marine mammal on both seismic vessel surveys (Geomotive and MRAG, 2011; Polarcus, 2011).

Hourglass dolphin *L. cruciger* (LC)

A total of 150 sightings of 792 animals was recorded, during 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 27). The JNCC surveys clearly identified spatial segregation between Peale’s and hourglass dolphins; there was 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 predominate in the deeper waters surrounding the Rhea-1 well location.

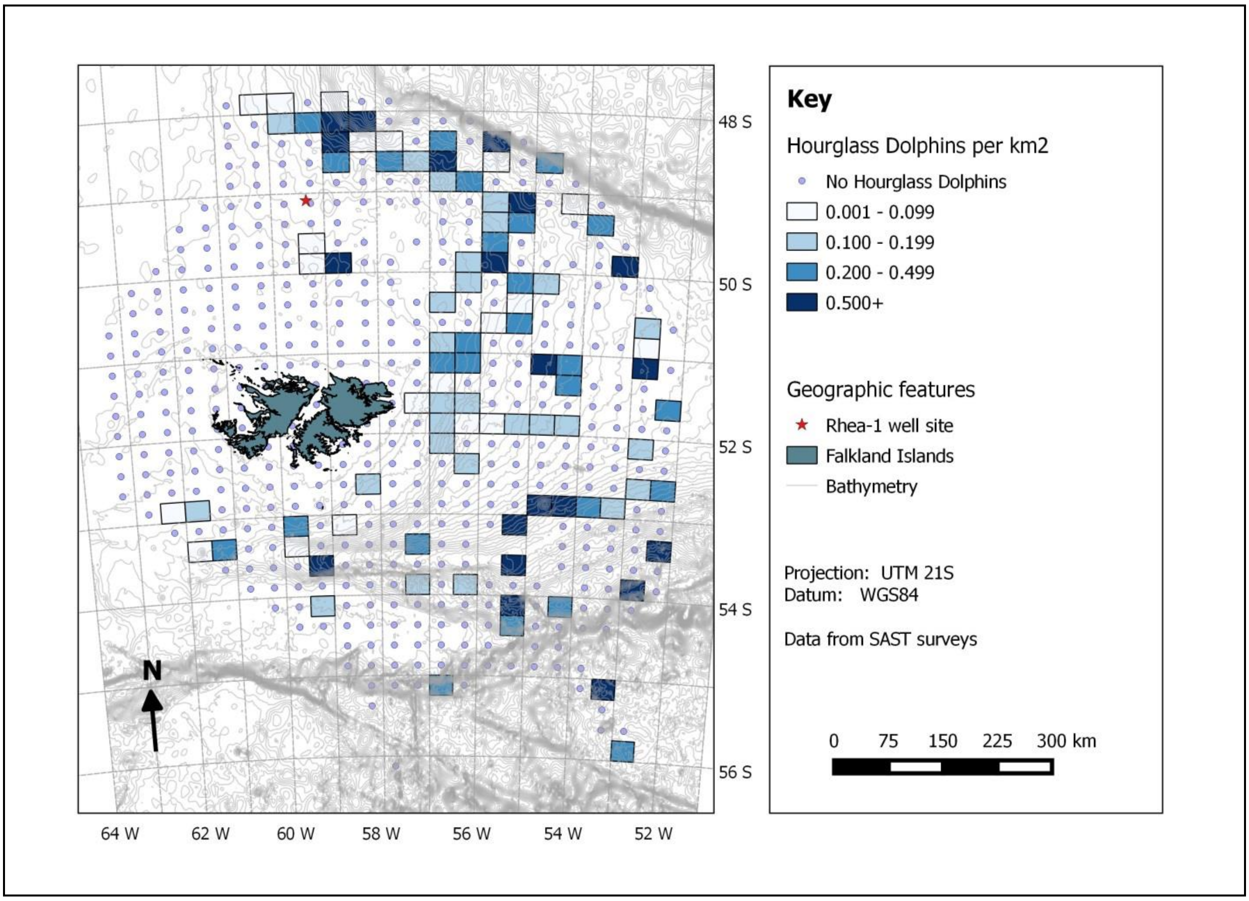


Figure 27: Hourglass dolphin distribution recorded during JNCC surveys, all months

Commerson's dolphin *Cephalorhynchus commersonii* (DD)

Commerson's dolphins were recorded during JNCC surveys in every month 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, and therefore it is unlikely that this species would occur near the Rhea-1 well location. This species was most frequently recorded from the waters within, or close to, the north and south entrances to Falkland Sound (Figure 28). There was no evidence of seasonal variation in the distribution or abundance of Commerson's dolphin - the apparent decreases in some months, for example May, is believed to be due to variation in the distribution of survey coverage rather than changes in the distribution of the dolphins.

Southern right whale dolphin *Lessodelphis peronii* (DD)

Southern right whale dolphins 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.

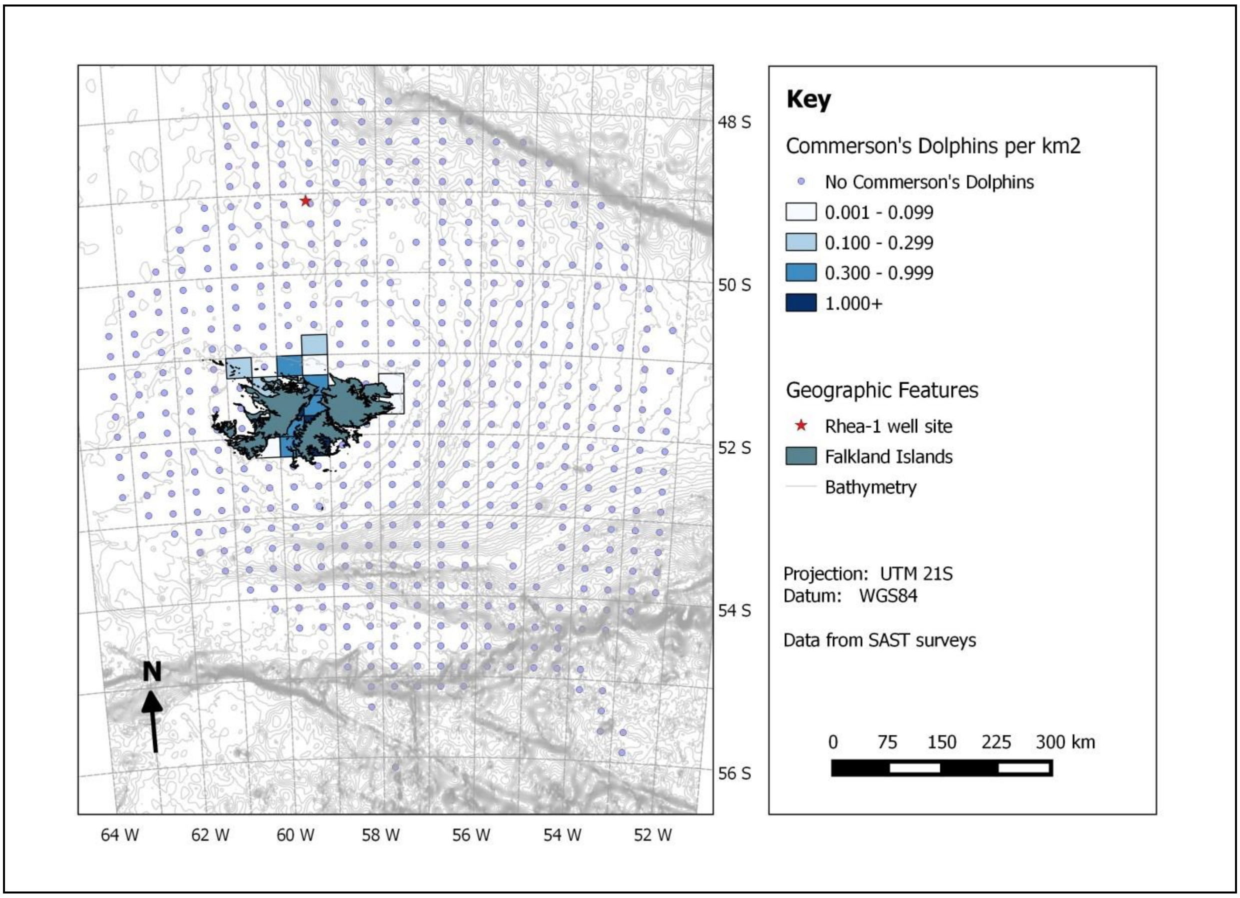


Figure 28: Commerson's dolphin distribution recorded during JNCC surveys, all months

South American sea lion *Otaria flavescens* (LC)

Sea lions 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).

Fur seal species *Arctocephalus* species (LC)

Fur seals 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 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 was thought that this marked an influx of Antarctic fur seals into Falklands waters from the South Georgia breeding population; this is supported by tracking data (Staniland et al., 2012).

Southern elephant seal *Mirounga leonina* (LC)

Southern elephant seals 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. No other surveys have recorded this species. Most of the records were clustered along the shelf break to the north of the Islands.

Leopard seal *Hydrurga leptonyx* (LC)

In total, Leopard seals accounted for the greatest number of detections throughout the acoustic monitoring study with the majority of leopard seal detections occurring in March and April (Appendix C, Table 6), 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).

5.4.6 Seabirds and Seabird Vulnerability

The waters around the Falkland Islands are highly productive and provide globally important feeding areas for significant aggregations of seabirds (White et al., 2002). The Islands themselves hold internationally important breeding populations of several seabird species and productive coastal and offshore waters support numerous species of non-breeding visitors (BirdLife International, 2014a). Of the 82 species of seabirds recorded in the Falkland Islands, 22/23 breed in the Islands, 24 are annual non-breeding visitors and the remainder are 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 population breeding in the Falkland Islands is a significant proportion of the global total. Approximately 33% and 36% of the global population of gentoo (*Pygoscelis papua*) and rockhopper penguins (*Eudyptes chrysocome*) breed in the Falkland Islands, respectively (Baylis et al., 2013 a and b). Furthermore, a significant proportion (possibly 10%) of the world population of Magellanic penguins (*Spheniscus magellanicus*) breed on the Islands (Woods and Woods, 1997). The small breeding population of king penguins (*Aptenodytes patagonicus*) is at the limit of the species' range in the Falkland Islands, and its population is almost entirely concentrated at Volunteer Point, on the east coast of East Falkland. 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 (Croxall et al., 1984; Woods 1988 and 1997; Strange, 1992; White et al., 2001 and 2002; Otley et al., 2008; BirdLife International, 2014b).

This section provides a summary of Falkland Islands seabird species; their abundance, distribution, feeding and breeding ecology and sensitivities. In addition to drawing on the papers listed above, identification of abundant seabird species within the region of the Rhea-1 well site has been based on at sea surveys conducted by Rockhopper Exploration and Desire Petroleum during seismic survey campaigns in licence area PL001 (Geomotive and MRAG, 2011) and NFB licence blocks (Polarcus, 2011).

5.4.6.1 Joint Nature Conservation Committee's (JNCC) Seabirds at-Sea Team (SAST)

In response to the impending start of exploratory 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, three dedicated observers were employed throughout this period. The project achieved over 20,900 km^2 of survey effort 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 should be considered as the baseline to which additional information can be added.

There are a number of advantages and disadvantages associated with visual at-sea surveys of seabirds, and marine mammals.

- The data is only as good as the observer, therefore, experienced highly skilled observers are required, and it is preferable to have two observers working in tandem.
- Some species are cryptic, their small size and/or behaviour make them difficult to see. For instance, penguins spend long periods out of sight, underwater. However, the data is recorded in distance bands and therefore it is possible to apply a correction factor to species that are less likely to be observed at distance.
- The distribution of survey effort is dependent on the survey base's activity. The majority of the SAST data was collected from FPVs and therefore effort is not evenly distributed. Following several years of work, some gaps in survey coverage were filled and all observations are standardised for survey effort, presented as the number of animals per unit of survey effort. However, it is difficult to detect seasonal and inter-annual variation in areas that are infrequently visited.
- In contrast to remote tracking, at-sea surveys record 'all' species of seabird and marine mammal encountered.
- The use of vessels of opportunity make at-sea surveys a relatively cheap monitoring tool.

With permission from Falklands Conservation (FC) and JNCC, the data was re-examined to highlight the species recorded in the vicinity of the northern Licence Blocks (PL001 and PL032). An imaginary 'box' (between 49-50°S and 58.5-59.5°W) was drawn. 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 19. 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. However, the age of the Seabirds-at-Sea dataset raises uncertainty as to how representative the data is of present day populations, and information relating to each species described below has been supplemented by more recent references on a species by species basis.

Table 19: Relative abundance of seabird species recorded in the vicinity of the Rhea-1 well location during each season (JNCC data)

	Autumn (M,A,M)		**Winter (J,J,A)**		**Spring (S,O,N)**		**Summer (D,J,F)**	
Rank	**Species**	**Birds/ km**	**Species**	**Birds/ km**	**Species**	**Birds/ km**	**Species**	**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	GBSP	0.007	AS	0.010	AS	0.008
16	WA	0.018	MDP	0.002	NRA	0.005	DP	0.006
17	AS	0.018	SS	0.002	WA	0.003	NRA	0.002
18	NRA	0.009	Dio Alb	0.001	SRA	0.003	CP	0.002
19	AtP	0.009	WCP	0.001	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						

Survey effort: Autumn 333.5 km, Winter 829.7 km, Spring 388.1 km, Summer 508.6 km

GPsp = giant petrel species, Dio Alb = *Diomedea* albatross species. The species codes in Table 19 are found in the text below.

A greater diversity of species was recorded during the autumn than during any other season. Below, a brief account is given for each species, ranked in order of autumn abundance. IUCN status is shown in parenthesis (LC=Least Concern, NT=Near Threatened, VU=Vulnerable, EN=Endangered).

Black-browed albatross (BBA) *Thalassarche melanophris* (NT)

The Falkland Islands are home to the world's largest breeding population of black-browed albatross. The most recent census in 2010 recorded 500,000 breeding pairs, which is equivalent to 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 northern Licence Blocks (Table 19) 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 higher than in other seasons. This period coincides with the fledging of young birds, which migrate northwards.

Great shearwater (GS) *Puffinus gravis* (LC)

Great shearwaters are largely a non-breeding visitor to Falkland Islands waters, although there is a very small local population (50-100 pairs, Woods and Woods, 1997). Virtually the entire global population, five million pairs, of this species breed on the Tristan da Cunha group (BirdLife International, 2014b). Following breeding, the population embarks on a circum-Atlantic migration, in a clockwise direction. It is these birds that are recorded within Falkland Islands waters.

Great shearwater was the second most numerous species recorded in the summer and autumn. The 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) *Procellaria aequinoctialis* (VU)

Like great shearwater, white-chinned petrel has a very small Falklands breeding population, estimated at 55-100 pairs (Reid et al., 2007). Most of the birds present within Falkland Islands waters come from the far larger South Georgian breeding population (Berrow et al., 2000; Phillips et al., 2006), which is estimated to be 900,000 pairs (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 PL001 area, except for the winter months, when their numbers are considerably reduced.

Cape petrel (CP) *Daption capense* (LC)

Cape petrels 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 and numbers start to decline in September and are virtually absent during the summer months (White et al., 2002).

Wilson's storm-petrel (WP) *Oceanites oceanicus* (LC)

Wilson's storm-petrels 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, the number of these birds observed during the winter months was greatly reduced. 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 northern Licence Blocks (White et al., 2002).

Antarctic fulmar (AF) *Fulmarus glacialoides* (LC)

Like Cape petrels, Antarctic fulmars 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.

Grey-backed storm-petrel (GBSP) *Garrodia nereis* (LC)

Like Wilson's storm-petrel, the Falklands support what is thought to be a small breeding population (1-5,000 pairs) of grey-backed storm-petrels (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 northern Licence Blocks.

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) *Pterodroma mollis* (LC)

Soft-plumaged petrels are regarded as summer and early autumn visitors to Falklands waters. 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 northeast of the Falklands.

Sooty shearwaters (SS) *Puffinus griseus* (NT)

Sooty shearwaters have an estimated breeding population of 10-20,000 pairs within the Falkland Islands (Woods and Woods 1997). Although present throughout the year, the majority of the breeding population are absent from Falklands waters from April to August (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.

Prion species (Pr) *Pachyptila* species (LC)

Several species of prion are known to frequent Falkland Islands waters, however, they are notoriously 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 drop in numbers during the autumn.

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 be 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 and one confirmed breeding site, on Beauchêne Island (Woods and Woods, 1997). Additionally, Antarctic prions (*P. desolata*) are likely to visit Falkland Islands waters.

Locally high densities of prions can be found close to the northern Licence Blocks in the summer months but generally densities of this ‘species’ are much higher elsewhere within Falklands waters, to the west and southwest of the Islands (White et al., 2002).

Southern and Northern royal albatrosses (SRA and **NRA)** *Diomedea epomophora* (VU) and *D. sanfordi* (EN)

Southern and northern royal albatrosses are both non-breeding visitors to the southwest Atlantic from their breeding sites in New Zealand. They are classed as Vulnerable and Endangered respectively under IUCN guidelines. Both species are recorded throughout the year in Falklands waters but the number of birds recorded was highest between March and June (White et al., 2002). At this time, 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) *Macronectes giganteus* (LC)

The Falklands support the largest breeding population of southern giant petrels 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 bred in higher latitudes move to Falklands waters during the winter (White et al., 2002).

Southern giant petrels were recorded in all months and were noted for being extremely persistent ship associates. 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. This species was not recorded in high numbers in the vicinity of the northern Licence Blocks 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) *Spheniscus magellanicus* (NT)

Magellanic penguins are regarded as summer breeding visitors to the Falkland Islands, which support approximately 10% of the global population (Woods and Woods, 1997). While breeding highest densities of Magellanic penguins were recorded in inshore waters, 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., 2002). They do not start to return to the Falklands until September. It is during these migrations that many birds will pass through the North Falklands Basin.

Grey-headed albatross (GHA) *Thalassarche chrysostoma* (EN)

Grey-headed albatross 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 later (ACAP, 2014).

The presence of this species within Falklands waters is highly seasonal, with the majority of birds recorded between May and September. At this time, 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) *Stercorarius longicaudus* (LC)

Long-tailed skuas 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 were recorded in the vicinity of the Falklands between December and March. As the Falklands lie towards the southern limit of this species' range, the majority of sightings took place 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 by White et al. (2002).

Wandering albatross (WA) *Diomedea exulans* (VU)

Wandering albatross are classed as Vulnerable under IUCN guidelines 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). 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 albatross 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 northern Licence Blocks but it is likely that many birds pass through this area during the course of a year.

Antarctic skua (AS) *Stercorarius antarctica* (LC)

The presence of Antarctic skuas within the study area is highly seasonal, with the vast majority of birds recorded between November and April. The density of birds recorded was highest over coastal 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) *Pterodroma incerta* (EN)

Despite a large breeding population of 1.8 million pairs, the breeding population of these birds is restricted almost entirely to Gough Island, Tristan da Cunha group, where the population is in decline due to mouse depredation (BirdLife International, 2014b). For these reasons, Atlantic petrel is classed as Endangered. This species was recorded in every month but there was a distinct peak in numbers during the spring, which corresponds to the post breeding period of this winter breeding species. Most encounters with Atlantic petrel came while surveying oceanic waters to the northeast of the Falklands.

Diving-petrel species (DP) *Pelecanoides* species (LC)

Two species of diving-petrel are regularly encountered within Falkland Islands waters; common diving-petrel *Pelecanoides urinatrix* and Magellan diving-petrel *P. magellanicus*, and a further species (Georgian diving-petrel *P.georgicus*) has 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 northern Licence Blocks.

Southern rockhopper and Macaroni penguins (RP, MAC, R/M) *Eudyptes chrysocome* (VU) and *E. chrysolophus* (VU)

The Falklands support approximately 40% of the global population of southern rockhopper penguins (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, it was at this time that the highest number of birds were recorded in the vicinity of the northern Licence Blocks. During the austral summer months, the distribution of rockhopper penguins was linked to the shallower waters of the Patagonian Shelf.

During the austral winter months, some macaroni penguins from the breeding population on South Georgia move into the oceanic waters of the Falklands Conservation Zones (White et al., 2002; Ratcliffe et al., 2014). 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.

Northern giant petrel (NGP) *Macronectes halli* (LC)

Northern giant petrels 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) *Puffinus assimilis* (LC)

Little shearwaters are rare non-breeding visitors to Falkland Islands waters, the nearest breeding population is 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 came while surveying waters to the north of the Islands.

Black-bellied storm-petrel (BBSP) *Fregetta tropica* (LC)

Black-bellied storm-petrels 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 northern Licence Blocks.

Two additional species were recorded during austral winter and spring surveys but not during the austral autumn.

King penguin (KP) *Aptenodytes patagonicus* (LC)

Although there is a small resident breeding population of king penguins 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. 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 penguin records within Falklands waters come from oceanic and shelf-break waters to the north of the Islands (White et al., 2002).

Kelp gull (KG) *Larus dominicanus* (LC)

Kelp gulls 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 northern Licence Blocks.

5.4.6.2 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. Appendix D (Table 1) summarises the tracking data collected to date. 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). 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 and periods outside of the breeding season. 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 limit the ability to obtain statistically meaningful and biologically relevant results. Work is ongoing to improve the scope of satellite tracking data in the Falklands.

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. However, there is no such repository for penguin data and consequently there is a need to review all the relevant data as a whole, this work is currently underway within the remit of the GAP project.

5.4.6.3 Seabird Surveys from seismic vessels within the vicinity of the Drilling Campaign Area during 2011

Seabird surveys were conducted from January 2011 until May 2011 during a 3D seismic survey in the licence area PL001, in which the Rhea-1 well is located (Geomotive and MRAG, 2011). A larger area wide seabird survey covering many of the NFB licence blocks was also conducted during the 2011 summer period, 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. The objective of these surveys was to increase 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 rank of species abundance from all three datasets. Table 20 lists the 20 most abundant seabird species recorded during the Geomotive and MRAG survey, the corresponding rank of abundance of those species recorded during the Polarcus survey, and their status on the IUCN Red List of threatened species. Details of all of the birds recorded during both surveys, their Falkland Islands and global breeding populations, and status under ACAP and IUCN Red List guidelines are listed in Appendix D, Table 1.

Table 20: Number of Seabird Sightings during the PL001 and NFB Surveys, including Status on the IUCN Red List and Population Trend

Bird Species Common name	PL001[1]			NFB[2]		IUCN Red List Category[3]	Population Trend[3]
	Rank	No. of Birds	No. of group sightings	Rank	No. of Birds		
Black-browed albatross	1	3118	1790	1	5043	**NT**	Decreasing
Great shearwater	2	2106	1325	3	1004	LC	Stable
Soft-plumaged petrel	3	1257	1000	6	318	LC	Stable
White-chinned petrel	4	1100	1011	2	1633	**VU**	Decreasing
Prion spp. (inc Blue petrel)	5	552	454	5	488	LC	Stable
Giant petrel species	6	411	370	4	574	LC	Increasing
Sooty shearwater	7	338	144	11	17	**NT**	Decreasing
Wilson's storm-petrel	8	229	213	7	262	LC	Stable
Atlantic petrel	9	173	161	23	2	**EN**	Decreasing
Southern royal albatross	10	172	138	12	16	**VU**	Stable
Cape petrel	11	170	105	20	4	LC	Stable
Manx shearwater	12	158	9	NR	NR	LC	Decreasing
Southern giant petrel	13	132	127	NR	NR	LC	Increasing
Northern giant petrel	14	125	111	NR	NR	LC	Increasing
Falkland Islands skua	15	78	62	NR	NR	LC	Stable
Large albatross species	16	65	49	13	14	n/a	n/a
Large skua	17	64	47	16	7	n/a	n/a
Wandering albatross	18	59	58	10	20	**VU**	Decreasing
Antarctic fulmar	19	52	42	9	22	LC	Stable
Grey-backed storm petrel	20	44	40	NR	NR	LC	Decreasing

Note: NR – not recorded. IUCN categories: LC – Least Concern, NT – Near Threatened, VU – Vulnerable, EN - Endangered

[1] Geomotive and MRAG 2011. 11/01/11 - 02/05/11.
[2] Polarcus 2011. 25/11/10 - 05/05/11.

During the survey of Geomotive and MRAG, a total of 242 individual surveys were conducted, comprising 308 hours and covering approximately 1,350 km. Over 7,300 sightings were made comprising 10,500 individual birds of 38 different species / species groups. There was little variation in species abundance over the four months of the survey period, with the same species present in similar numbers in each month (Geomotive and MRAG, 2011).

Throughout the Polarcus surveys, a total of 226 individual surveys were conducted over a period of 79 days and a total duration of 233 hours. Over 4,000 sightings were made comprising 9,638 individual birds of 30 different species / species groups. Some limitations were identified with the survey such as low vessel speed, high levels of seabird association with the vessel and seismic streamer array (Polarcus, 2011), which limit the comparison with other survey data.

The most abundant families of seabirds recorded during the surveys were albatross, shearwater, petrel, skua and fulmar (Table 20). Additionally, three species of penguin (Magellanic, gentoo and rockhopper) were recorded in low numbers during both surveys (Appendix D, Table 1). During both the PL001 and the NFB surveys, the black-browed albatross was the most commonly encountered species, with high-density rafts of birds recorded on the water during the NFB survey (Polarcus, 2011). The great shearwater, soft-plumaged petrel, white-chinned petrel and giant petrel species were also frequently encountered species; all of which are known to be attracted to and follow vessels (Polarcus, 2011).

Of the 20 most abundant seabirds, four are classified as Vulnerable or Endangered on the IUCN Red List, meaning that there is an increased risk of extinction. A further two species are in the Near Threatened category (Table 20). Of these six species, five are recorded as having a currently decreasing population trend, and one as stable.

The JNCC survey methodology is designed to record birds that are actually present at the time of the survey. The presence of a rig or platform and associated support vessels is likely to influence the distribution of birds in the immediate vicinity. Seabird densities have been recorded between 19 and 38 times higher in the immediate vicinity of a rig, when compared with surrounding waters (Wiese et al., 2001). Additionally, prey species may aggregate around the platform and influence the seabird assemblage in the immediate vicinity. Several species are known to persistently associate with ships (such as, black-browed albatross, giant petrels, Cape petrels and Antarctic fulmars), it is these species that are most likely to associate with the in-field infrastructure and supply vessels.

5.4.6.4 Seabird Ecology

Many seabird species are incredibly mobile, travelling thousands of kilometres across international waters and multiple Exclusive Economic Zones, and only return to land to breed. They face many serious conservation challenges throughout their migratory range and across all phases of the lifecycle and are now the most threatened group of birds (BirdLife International, 2014). Understanding seabird ecology is essential to assessing how marine and terrestrial operations may pose a threat to these species, and how these potential impacts may be avoided and mitigated. Table 21 and

Table 22 provide summaries of the key ecological characteristics of the most abundant seabird species, identified within the NFB and particularly the northern Licence Blocks.

Falklands Conservation conduct 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 population numbers, and southern giant petrels are monitored at one site (three colonies) (Stanworth, 2014). 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 population.

The estimated number of gentoo penguin breeding pairs at monitored sites decreased in the 2013/2014 season by 13% to 26,241 pairs from a high of 30,146 pairs during the 2012/2013 season. The largest drop in number was found at colonies in the southeast of the Islands, in the west and north, breeding numbers were stable or increasing. Overall, breeding success was below average at 0.84 chicks per pair.

The number of pairs of rockhopper penguin increased by 6.7%, in line with the trend recorded over past seven years. Breeding success declined slightly on the previous year to 0.48 chicks per pair, which is below the long-term average of 0.66 chicks per pair.

Estimated numbers of pre-fledged king penguin chicks varies considerably from one year to the next. The last count in 2013 recorded a little over 600 pre-fledged chicks, down 14.9% from the previous season (Stanworth 2014).

The estimated breeding pairs at three of the black-browed albatross colonies remained stable during the 2012/13 season, whilst the fourth colony declined by 11.5% following a severe storm during 2010 (Stanworth, 2013). In the 2013/2014 season, the number of breeding pairs increased at monitored sites to just below 3,000 pairs, close to the long-term (since 2005) average. Most of this increase is accounted for by the recovery in numbers at the site impacted by the storm.

The number of southern giant petrel breeding pairs at the monitored sites was stable, although breeding success was down by about 8% from the previous year (Stanworth, 2014).

It was noted that there was high variability in breeding success for gentoo and rockhopper penguins between and within monitoring sites and that local factors are also driving breeding success. Additionally the single monitoring site for Magellanic penguins is not considered to be representative of Island wide trends or the population as a whole owing to its proximity to Stanley and status as a popular tourist destination.

Data from the 2013/2014 seabird monitoring season and historic trends demonstrate the spatial and annual variability in seabird breeding success and the need for more detailed and widespread data to inform population trends and global breeding success.

Table 21: Key Ecological Characteristics of Some of the Most Abundant NFB Seabirds

Species	Migration patterns	Breeding cycle	Diet	Falkland breeding site	Falklands Population
Black-browed albatross (*Thalassarche melanophris*)	Out with breeding adults entirely at sea over Patagonian Shelf, between Drake Passage and 30°N (~100,000 km^2)	Start breeding at 7 yrs Annual breeder Adults return to nest Sept 1 egg laid mid Oct 70 day incubation Chicks brooded for 25 days Chicks fed mid Apr Chicks fledge after 122 days	Variety of prey, predominantly fish and squid, with some jellyfish, octopus, lobster krill and other crustaceans.	17 inland sites, large colonies on Jason Islands and Beauchêne Island.	500,000 breeding pairs. 76% global population
Great Shearwater (*Puffinus gravis*)	Most frequent between Dec and April over shelf slope and oceanic waters to east and north of Falkland Islands	Adults return Sept 1 egg laid end Oct Chicks and adults depart late April Most birds non-breeding visitors	Diving seabird foraging on squid, fish, crustaceans	Kidney Island and offshore tussac islands	20 pairs <0.1% global population
Soft-plumaged petrel (*Pterodroma mollis*)	Primarily in deep waters north of the Falkland Islands. Nov – Apr, peak Jan.	Non-breeding visitor	Primarily squid, also crustaceans and fish from surface	Tristan da Cunha, Gough Island	Non-breeder
White-chinned petrel (*Procellaria aequinoctialis*)	Widespread in shelf and oceanic waters in winter, shallower waters in spring summer	Adults return Sept 1 egg laid Oct/Nov 7 week incubation Chicks and adults depart April/May Most birds non-breeding visitors	Squid, fish and crustaceans from surface or by diving	Kidney Island, New Island, Bottom Island	55-100 pairs <0.1% global population
Southern giant petrel (*Macronectes giganteus*	Recorded in all months, highest densities March-June over Patagonian Shelf waters, west and south of Falkland Islands	Adults return Sept 1 egg laid Oct/Nov Chicks fledge Mar	Scavengers, of seals, seabirds and fishing discards	38 locations, primarily Falkland Sound, west of West Falkland	19,810 breeding pairs 41% global population
Northern giant petrel (*Macronectes halli*)	Recorded in all months with slightly higher density recorded from March to August, over Patagonian Shelf waters	Non-breeding visitor	Scavengers, of seals, seabirds and fishing discards	South Georgia	Non-breeder
Sooty shearwater (*Puffinus griseus*)	Migrate to northern hemisphere outside breeding season	Start breeding at 4 yrs Adults return Sept 1 egg laid late Nov Chicks fledge April Adults depart Mar	Squid, crustaceans, small fish and fishing discards	Kidney Island	100,000 pairs 0.1% global population
Wilson's storm-petrel (*Oceanites oceanicus*)	Migrate to northern hemisphere Apr-Aug, few remain	Adults return Nov 1 egg laid Nov-Jan 6 week incubation Chicks fledge Feb/Mar	Small shrimp, squid and fish offal from fishing discards	Jason Islands and Beauchêne Island.	No data
Atlantic petrel (*Pterodroma incerta*)	Recorded in all months, majority Oct – March during post-breeding dispersal. Deep waters to northeast, and southeast.	Non-breeding visitor	Primarily squid, some crustaceans and fish.	Tristan da Cunha, Gough Island	Non-breeder
Southern royal albatross (*Diomedea epomophora*)	High densities Patagonian Shelf northwest of Islands Mar-Jun. Locally high densities Jul-Sept, Low to moderate density	Biennial breeder. Non-breeding visitor	Primarily squid and fish, also salps, crustacea and carrion.	New Zealand	Non-breeder
Wandering albatross (*Diomedea exulans*)	Throughout the year in Falklands waters in small numbers offshore.	Biennial breeder. Non-breeding visitor	Squid and fish	South Georgia	Non-breeder

Source: BirdLife International, 2014b; Otley et al., 2008; White et al., 2002; Woods, 1988; Reid et al., 2007; Reid and Huin, 2005; Wolfaardt, 2012.

Table 22: Key Ecological Characteristics of Most Abundant NFB Penguins.

Species	Migration patterns	Breeding cycle	Diet	Falkland breeding site	Falklands Population
Gentoo penguin (*Pygoscelis papua*)	Resident, primarily within 10 km up to 300 km in winter	Nest building Sept 1-2 eggs laid late Oct 34 day incubation	Varies by location, primarily fish, also crustaceans and squid	Primarily West Falkland and outer islands	121,500 pairs, 39% global population
Rockhopper penguin (*Eudyptes chrysocome*)	Winter foraging between Straits of Magellan & 39°N (1,400km)	Mating Oct 2 eggs laid mid Nov Chicks fledge Mar Adults depart April	Crustacean, primarily krill. Squid.	Primarily outer islands of West Falkland	320,000 pairs 36% global population
Magellanic penguin (*Spheniscus magellanicus*)	Absent during winter, feeding Patagonian Shelf and shelf break, Argentine coast	Adults arrive Sept 2 eggs laid Oct 40 day incubation Chicks fledge Mar Adults depart Apr	Varying proportions of fish and squid, smaller amounts of lobster krill	Over 90 locations on the Falkland Islands	c.140,000 pairs 10% global population
King penguin (*Aptenodytes patagonicus*)	May-June migrate south of Polar Front	12 mo - Mating Oct 1 egg laid Nov-Mar 55 day incubation	Lantern fish and squid	Volunteer point	<1,000 pairs 0.04% global population

Source: BirdLife International, 2014b; Otley et al., 2008; White et al., 2002; Woods, 1988; Baylis, 2012

5.4.6.5 Threats to Seabirds within Falkland Islands Waters

Seabirds may be affected by anthropogenic factors in a number of ways, such as competition with commercial fisheries, scavenging fisheries discards, habitat modification, mortality resulting from fishing interaction and contamination from various forms of pollution. Within Falkland Islands waters, negative impacts on seabird productivity through competition for food with commercial fisheries was not identified in in the early years of the fishery (Thompson, 1992; Thompson and Riddy, 1995) and indeed to date there has been little further evidence gained to show this. However, mortality due to interactions with fisheries within Falkland Islands waters have been identified (Sullivan and Reid, 2003; Reid and Sullivan, 2004). Following the implementation of the National Plan of Action–Seabirds (NPOA-S) by the FIG in 2004, the introduction of effective mitigation measures significantly reduced the likelihood of incidental seabird mortality during longline fishing (FIG, 2007). In recent years, the trotline system has been adopted to prevent cetacean depredation but this method of fishing also reduces the risk of seabird mortality to virtually zero. Since 2007, there have been no reported seabird mortalities in the longline fishery (FIG, 2013).

Similarly, the FIG also adopted a NPOA-Tr for the trawl fishery in 2004, from which it was shown that there was significant levels of mortality in seabirds feeding off the offal discharge of the finfish fishery (FIG, 2007). Extrapolation of recorded seabird mortalities during 2012 estimates that 0.19 seabirds per day were killed in Falkland Islands waters, mostly black-browed albatrosses, equating to a total of 621 birds killed each year (FIG, 2013).

In recognition of the threats 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 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 (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 (Appendix II) to conserve them over their entire range, such as ACAP.

Currently, ACAP covers 30 species, which comprise 22 albatrosses, seven petrels and one shearwater. Of these species, 12 were recorded within Falklands waters during JNCC surveys (White et al., 2002), three of which have breeding populations. Table 23 lists the species listed under ACAP that occur within Falkland Islands waters. 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.

Of the species recorded during the PL001 and NFB seabird surveys at-sea eight are listed under ACAP. No species are currently listed on CMS Appendix I as threatened with extinction.

Table 23: ACAP species found within Falklands waters

Common name	***Scientific name***	**Local status**	**IUCN status**
Black-browed albatross	*Thalassarche melanophris*	Common breeder	NT
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

5.4.6.6 Area Vulnerability Scores

To date, reports of oiled seabirds in the Falkland Islands are rare; however, globally millions of seabirds have been killed by oil pollution (García-Borboroglu et al., 2006 and 2008; Wolfaardt et al., 2009). With the development of the oil and gas industry in the Falkland Islands, the risk posed to seabirds is an important consideration due to the global importance of this area to seabirds and the logistical challenges associated with responding to an oil spill.

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 (National Research Council, 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 more at risk from the effects of surface pollution; for example, penguins are 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. Additionally, the potential reproductive rate of a species will influence the time taken for a population to recover following a decline. Other factors such as natural mortality rate, migratory behaviour, species abundance and conservation status (e.g. globally threatened) will also determine the effects of an oil spill on seabird populations.

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 was the production of an Oil Vulnerability Atlas (White et al., 2001).

This analysis scores each species on four factors to produce an Oil Vulnerability Score (OVS). The OVS is applied to the density of that species recorded within each ¼ ICES square, 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. The results of the original analysis were published in White et al. (2001) and the vulnerability maps for each month are presented in Figure 29 to Figure 34. These maps place the areas of oil exploration into the wider context of Falkland Islands waters.

Throughout the year, the highest areas of seabird vulnerability are generally found in coastal and Patagonian Shelf waters. 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 breeding populations of seabirds that spend the winter elsewhere, which results in the very high vulnerabilities. Generally, seabird density and consequently Area Vulnerability Scores decreased with increasing water depth.

In the austral autumn (March to May), the immediate area around the Rhea-1 well site 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), the area of the vicinity of the Rhea-1 well is classed as an area of moderate vulnerability. A patchy distribution of species typical of the Patagonian Shelf in winter, were 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), recorded relatively lower densities of seabirds than at other times of the year. The area of the Rhea-1 well is therefore classed as moderately vulnerable, although the adjacent, shallower waters, to the west have high vulnerability status. The seabirds present include; rockhopper/macaroni penguins, prion species, Wilson's storm-petrels, black-browed albatrosses and Magellanic penguins.

During the austral summer (December to February), the vulnerability of the area in the immediate vicinity of the Rhea-1 well 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 Rhea-1 were low and moderate respectively, however, an area of very high vulnerability was identified to the southeast in January.

5.4.6.7 Data Limitations with Seabird Distribution and Vulnerability Data (White et al. 2001, 2002)

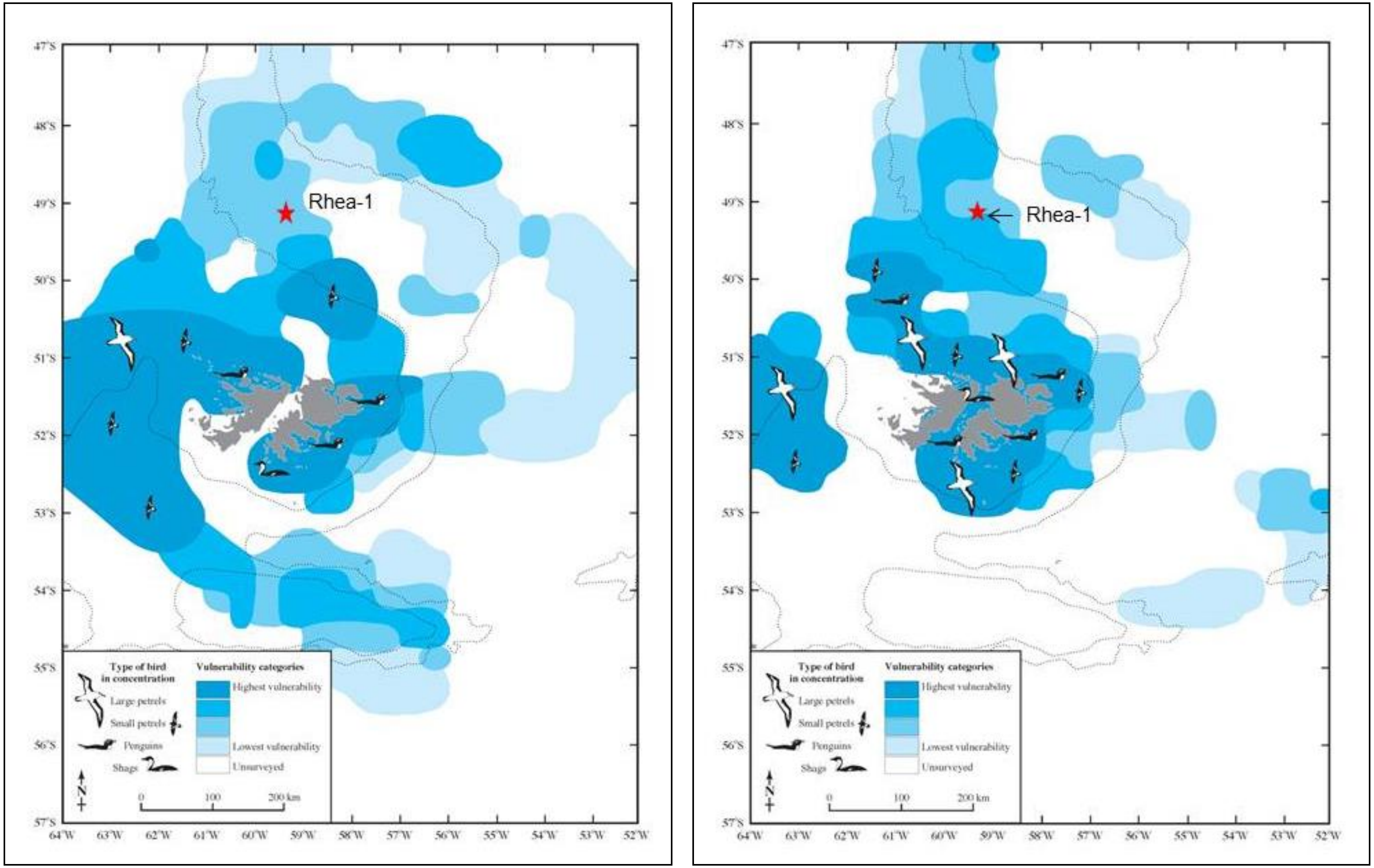
There are a number of limitations associated with the SAST surveys, which must be taken into consideration when interpreting the data. The SAST surveys were conducted opportunistically; therefore distribution of survey effort was closely linked to the activity of patrol vessels. Occasionally, some vessel 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 Rhea-1 well site 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 and 2002). Additional penguin tracking has been carried out in subsequent years (see Appendix D).

Now in 2015, the SAST data was 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; however, the study covered a relatively short time frame.

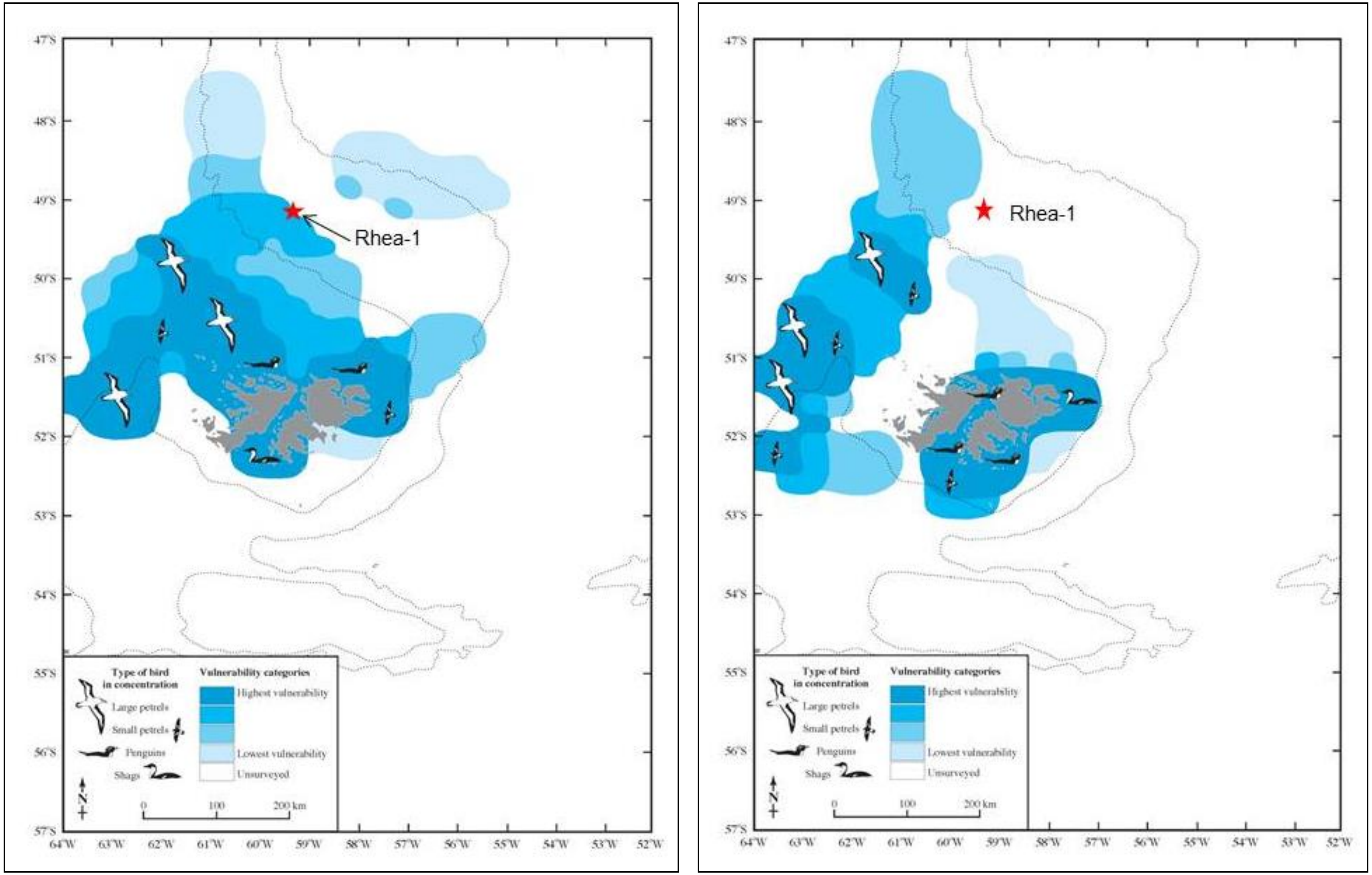
One of the great advantages of at-sea surveys is that all species are recorded. Therefore, it is possible to assess the risk to species that have not been tracked. None of the smaller species of petrel have been tracked, yet they are vulnerable to oiling and light induced bird strikes.

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., in prep). 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 on the Falklands. A combination of satellite tracking and at-sea observations is likely to give the best overview of seabird distribution within Falklands waters.



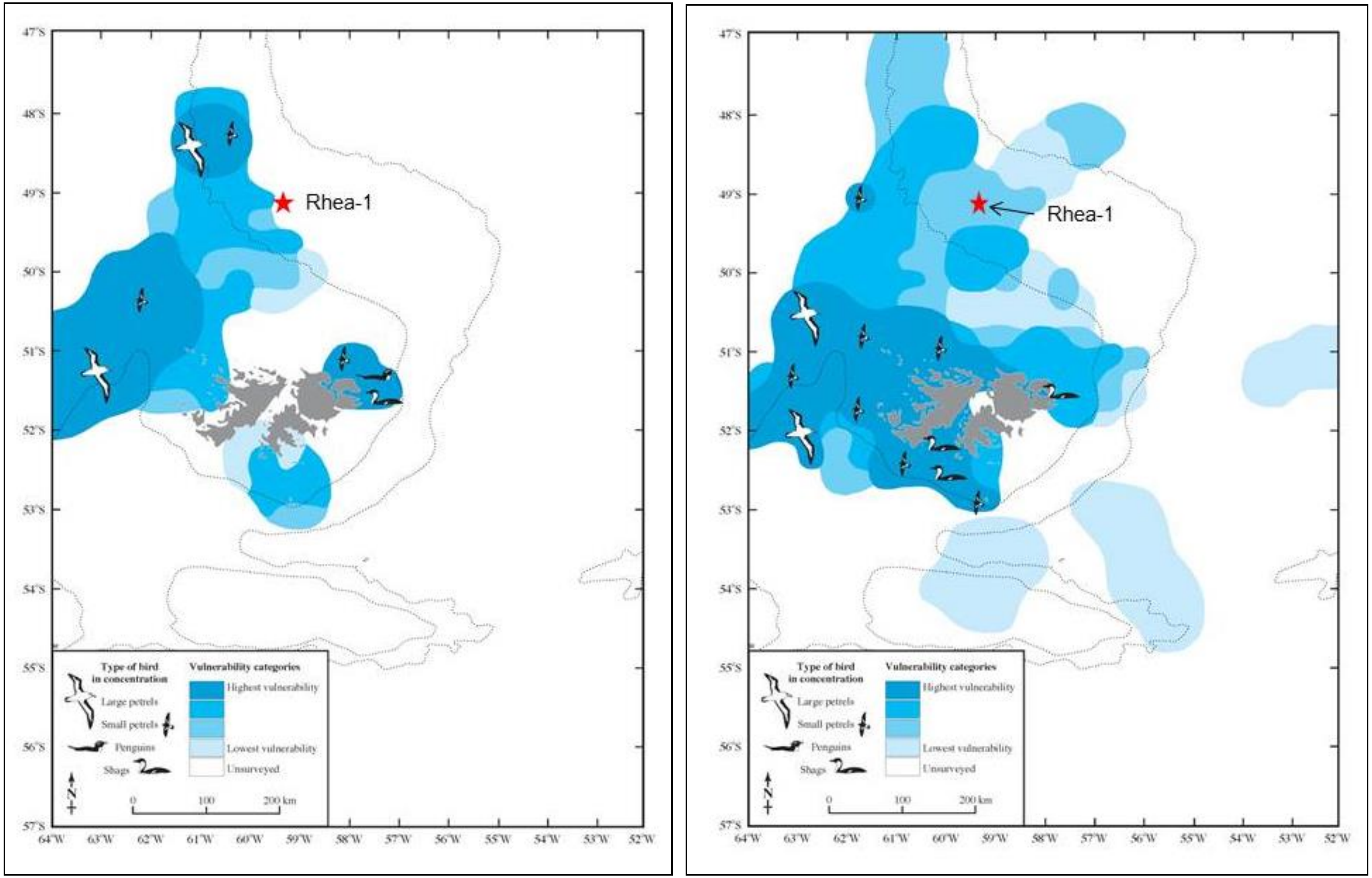
*Red star indicates the position of the Rhea-1 well site

Figure 29: Seabird Vulnerability Maps for January (left) and February (right), from White et al. (2001)



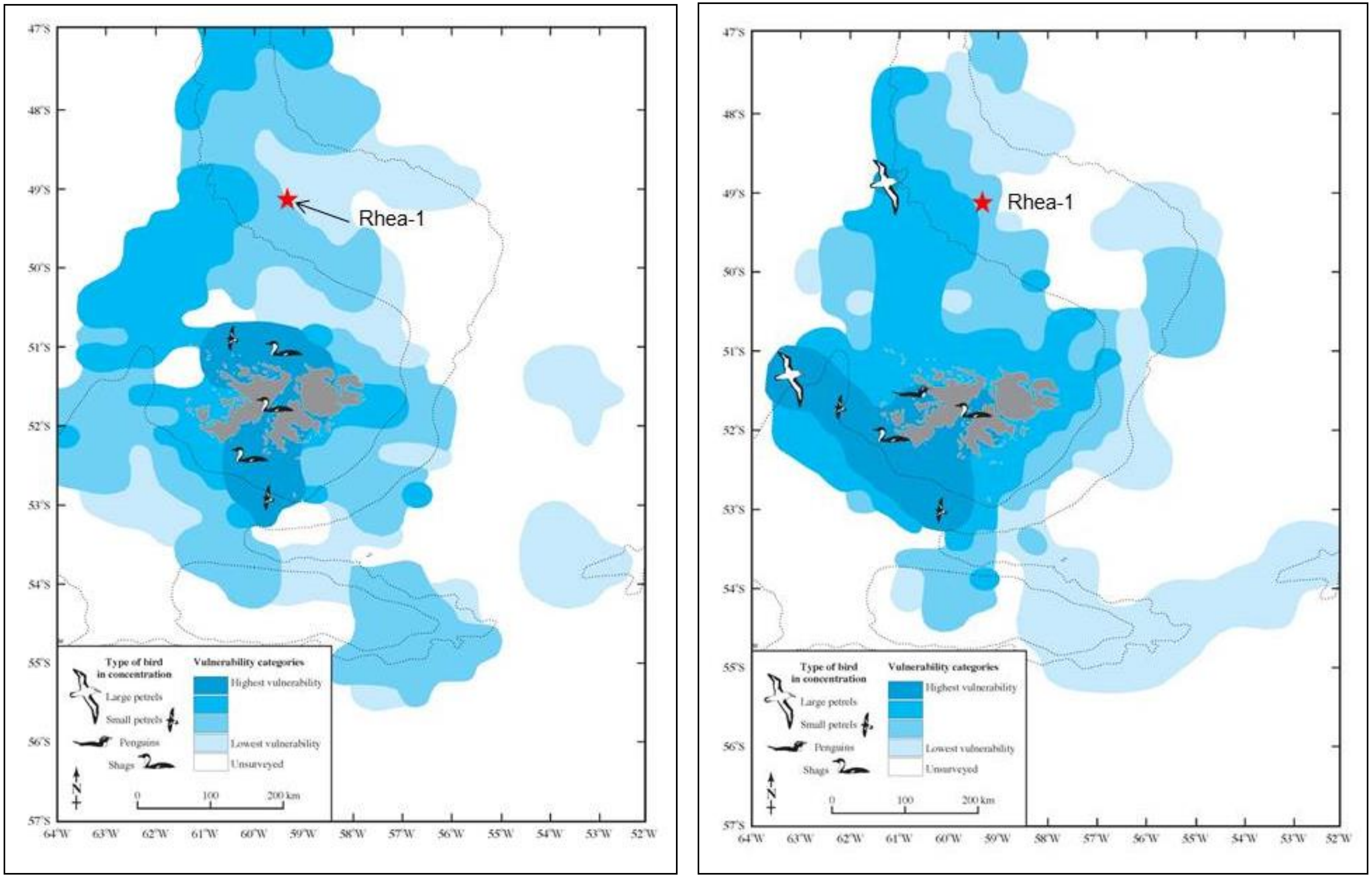
*Red star indicates the position of the Rhea-1 well site

Figure 30: Seabird Vulnerability Maps for March (left) and April (right), from White et al. (2001)



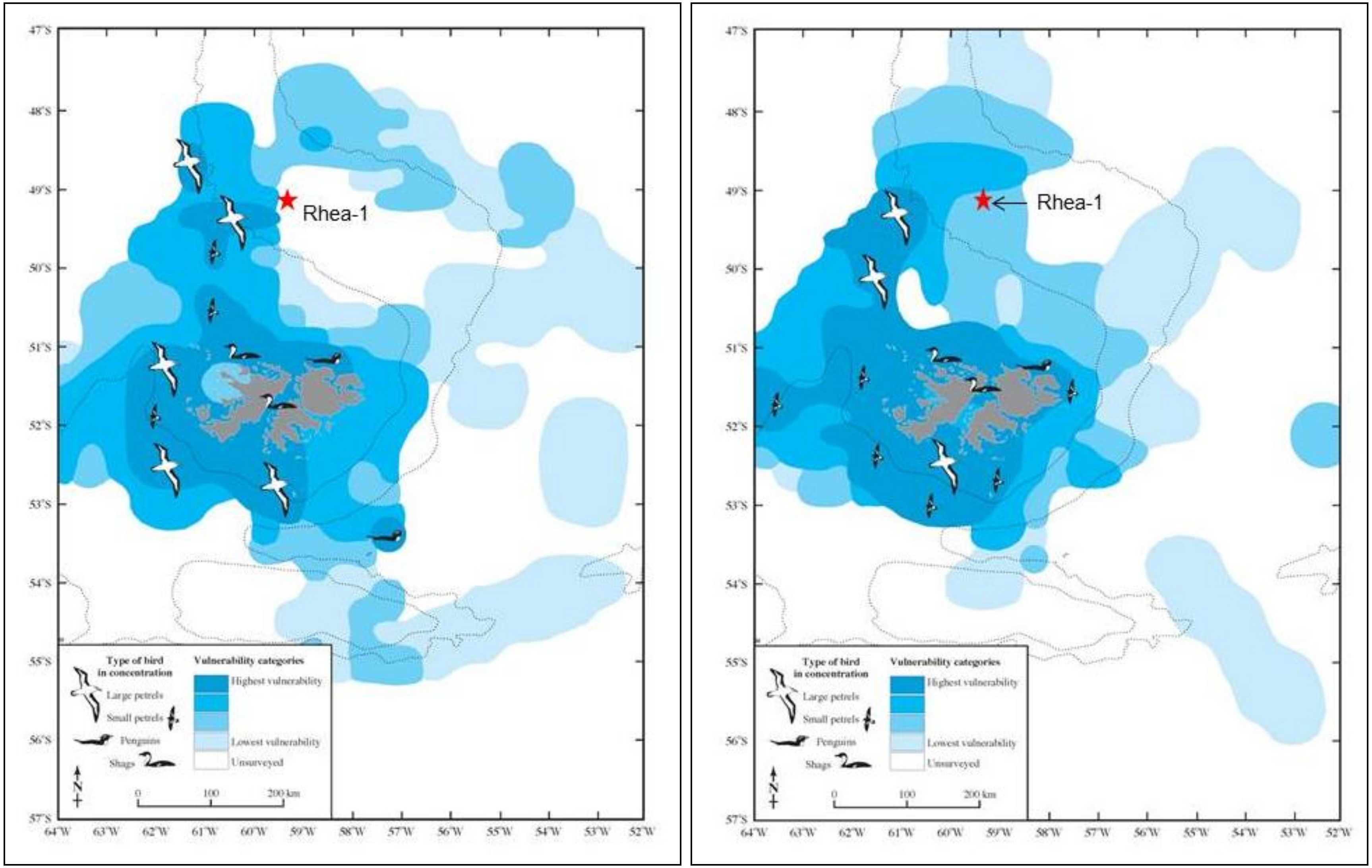
*Red star indicates the position of the Rhea-1 well site

Figure 31: Seabird Vulnerability Maps for May (left) and June (right), from White et al. (2001)



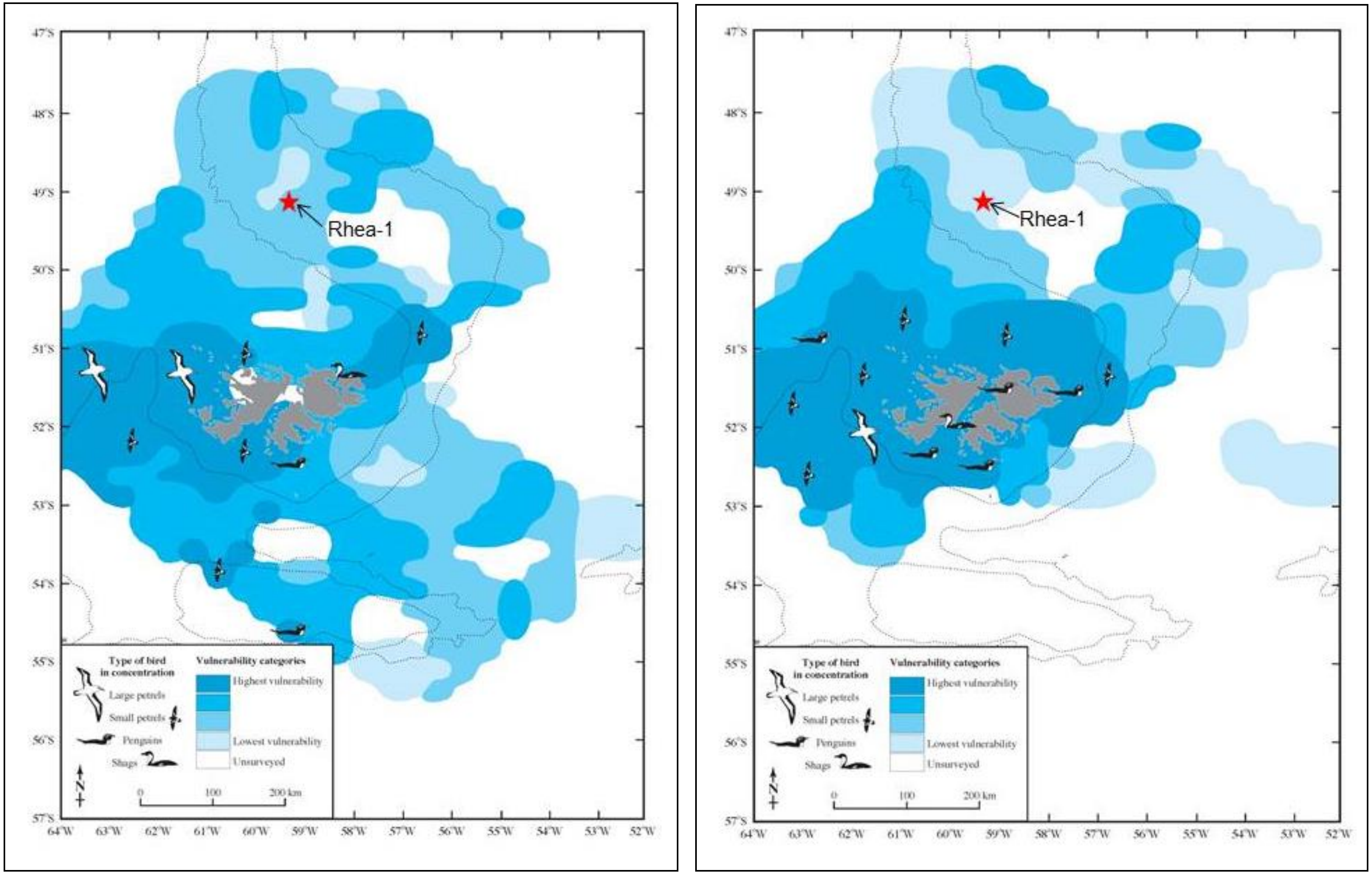
*Red star indicates the position of the Rhea-1 well site

Figure 32: Seabird Vulnerability Maps for July (left) and August (right), from White et al. (2001)



*Red star indicates the position of the Rhea-1 well site

Figure 33: Seabird Vulnerability Maps for September (left) and October (right), from White et al. (2001)



*Red star indicates the position of the Rhea-1 well site

Figure 34: Seabird Vulnerability Maps for November (left) and December (right), from White et al. (2001)

5.4.7 Threatened Habitats / Species

5.4.7.1 Protected bird species

The majority of native wild birds are protected under the Conservation of Wildlife and Nature Ordinance, which was put in place in 1999. The exceptions include: 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). 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 n miles offshore).

The Fisheries Ordinance 2005 provides a framework for the management of fisheries resources within the Falklands EEZ in a sustainable manner. It also extends the influence of the Conservation of Wildlife and Nature Ordinance (1999) to 200 nautical miles offshore, which protects all wild birds and animals.

5.4.7.2 Protected plant species

Under the Conservation of Wildlife and Nature Ordinance (1999), there are 19 plant species that are under protection, six of which are endemic to the Falkland Islands and are vulnerable to extinction, mostly due to their small population sizes and restricted ranges: Antarctic cudweed (*Gamochaeta antarctica*), Falkland rock-cress (*Phlebolobium maclovianum*), false plantain (*Nastanthus falklandicus*), the hairy daisy (*Erigeron incertus*), Falkland nassauvia (*Nassauvia falklandica*), and Moore’s plantain (*Plantago moorei*) (Upson, 2012). Surveys conducted in the 1980s and 1990s show the distribution of these plant species to be 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; the 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).

5.4.7.3 Vulnerable terrestrial habitats

There are five threatened terrestrial habitats: bluegrass acid grassland, bluegrass dune grassland, native Boxwood scrub, Fachine scrub, and mainland Tussac. However, this list of threatened habitats is only preliminary as it is based on the current, limited knowledge of these habitats and their extent and degree of threat that they face. A variety of wetland sites may also be under threat, however this requires further investigation. The main threat to and degradation of certain terrestrial habitats has been through the introduction of grazing herbivorous animals for farming (RPS Energy, 2009; Upson, 2012).

5.4.7.4 Vulnerable marine species and habitats

There exists a reasonably high level of legal protection to the marine species and the marine environment through legislation, such as the Marine Mammal Ordinance 1992 and the Fisheries (Conservation and Management) Ordinance 2005.

The Marine Mammal Ordinance 1992 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 three cetacean species that occur within Falkland Islands waters that are Endangered; sei, fin and blue whales and one Vulnerable species; sperm whale.

The Fisheries Ordinance 2005 includes the use of closed areas (to protect spawning sites), a three mile no-take zone around the entire coastline (Figure 38) and mitigation measures to prevent the incidental capture of seabirds in longline and trawl fisheries.

There is little specific protection for benthic marine species or marine habitats within Falkland Islands waters. Partly the issue is that the marine environment and species assemblage is relatively poorly described. Work is on-going in order to address this. Surveys conducted within the northern Licence Blocks by Gardline (2012) found that the habitats and species found within the area were of no conservation concern when compared with the UK's Offshore Marine Conservation (Natural Habitats, &c.) (Amendment) Regulations 2010. However, there could be localised populations of sensitive species that have not been encountered by previous surveys. A pre-drilling ROV survey of the benthic environment will be vital to determining whether the proposed well site is free from protected species and habitats.

5.4.7.5 Protected Habitats

There are currently four levels to designate areas of environmental and wildlife significance within the Falkland Islands: NNRs (through the Conservation of Wildlife and Nature Ordinance (1999); Important Bird Areas (IBAs), Important Plant Areas (IPAs), and Ramsar sites.

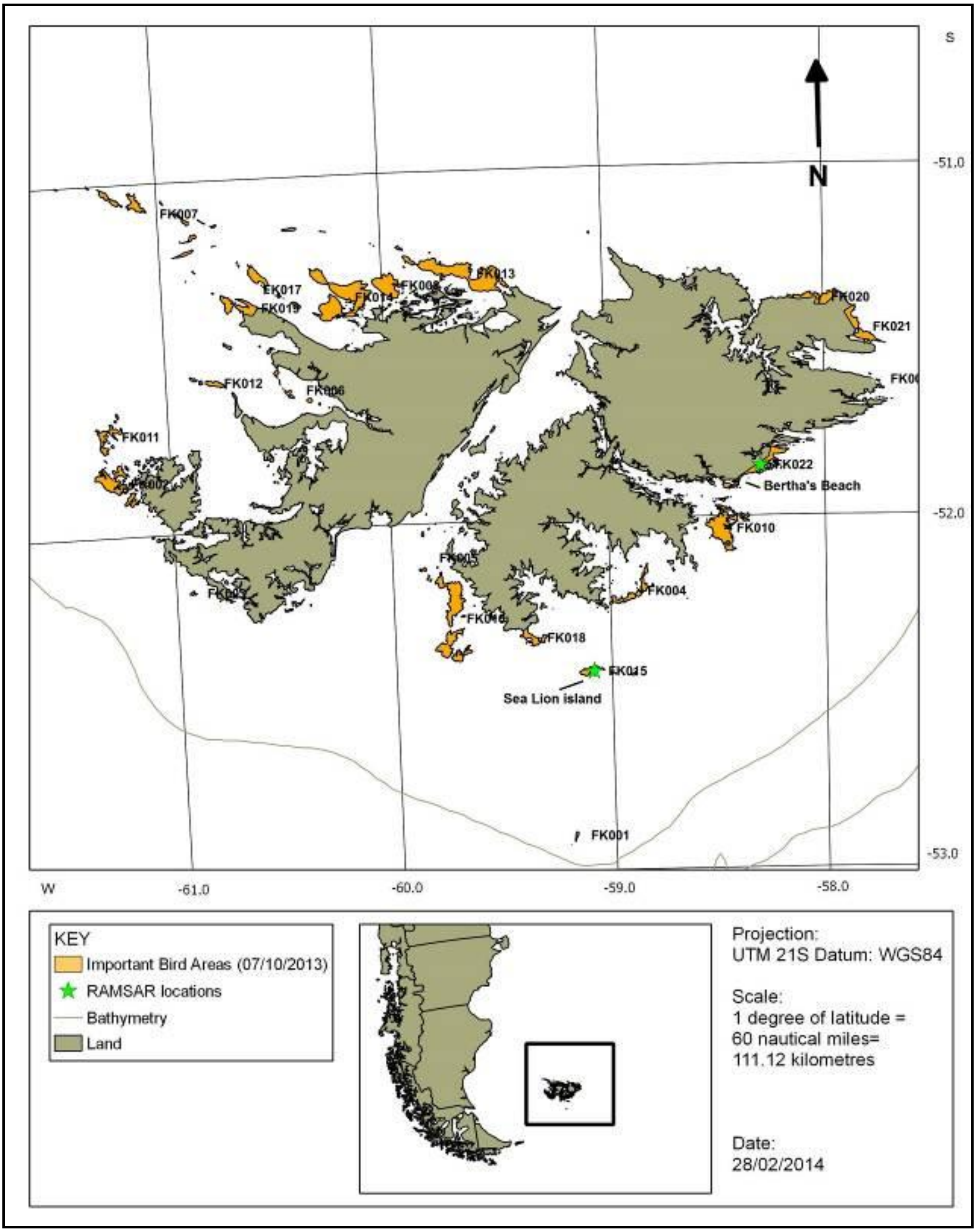
Important Bird Areas

Important Bird Areas (IBAs) are a global directive that was introduced and created by BirdLife International, an international consortium of conservation organisations. They were introduced as a means of protecting and conserving bird species that are becoming threatened by anthropogenic activities, such as habitat destruction and therefore fragmentation. IBAs are created based on a set of criteria that apply globally. Within the Falkland Islands, Falklands Conservation is responsible for describing and cataloguing IBAs. Currently within the Falkland Islands, there are 22 IBAs, 17 of which are islands or island groups, and the other five are found on the mainland of East or West Falkland (Table 24; Figure 35). Any terrestrial based IBA may be extended by 15 nautical miles into the offshore environment. However, there are currently no marine IBAs established, though there are 17 candidate marine IBAs that are currently being considered (Table 25; Figure 36). The level of legal protection associated with IBAs varies from country to country. In the Falklands, IBA status does not infer any legal protection.

Table 24: Confirmed Important Bird Areas - Breeding

IBA Code	Site Name	Area (km^2)	IBA trigger seabird Species, life-cycle	Distance from Rhea-1 well site (km)
Confirmed IBA – Terrestrial breeding areas				
FK001	Beauchêne Island	1.7	MC, GP, RP, BBA, FP, SS: breeding	422
FK002	Beaver Island Group	59.6	GP, MP, SGP: breeding	331
FK022	Bertha's Beach, East Falkland	33.0	GP, MP: breeding	318
FK003	Bird Island	1.2	RP, BBA, TBP, SS - breeding	361
FK004	Bleaker Island Group	21.5	GP, RP, MP, SGP, IS – breeding	341
FK018	Bull Point, East Falkland	15.0	GP, MP - breeding	362
FK005	Elephant Cays Group	2.5	MP, SGP – breeding	329
FK019	Hope Harbour, West Falkland	17.6	GP, RP, MP, BBA – breeding	269
FK006	Hummock Island Group	6.7	RP, IS – breeding	292
FK007	Jason Islands Group	33.7	MC, RP, MP, BBA, SGP – breeding	250
FK008	Keppel Island	36.3	GP, RP, MP, BBA – breeding	249
FK009	Kidney Island Group	0.4	MP, WCP, SS - breeding	304
FK010	Lively Island Group	67.9	GP, MP, SGP - breeding	326
FK011	New Island Group	25.5	GP, RP, MP, BBA, TBP, WCP, IS - breeding	317
FK012	Passage Islands Group	8.8	GP, RP, SGP – breeding	294
FK013	Pebble Island Group	109.6	MC, GP, RP, MP, SGP, SS – breeding	242
FK014	Saunders Island	124.0	GP, RP, MP, BBA – breeding	253
FK015	Sea Lion Islands Group	10.3	GP, RP, MP, SGP, SS – breeding	371
FK020	Seal Bay, East Falkland	31.0	GP, RP, MP, SS – breeding	271
FK016	Speedwell Island Group	0.9	GP, MP, SGP, SS – breeding	342
FK021	Volunteer Point, East Falkland	40.6	GP, MP – breeding	280
FK017	West Point Island Group	35.0	GP, RP, MP, BBA - breeding	257

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, 2014a.



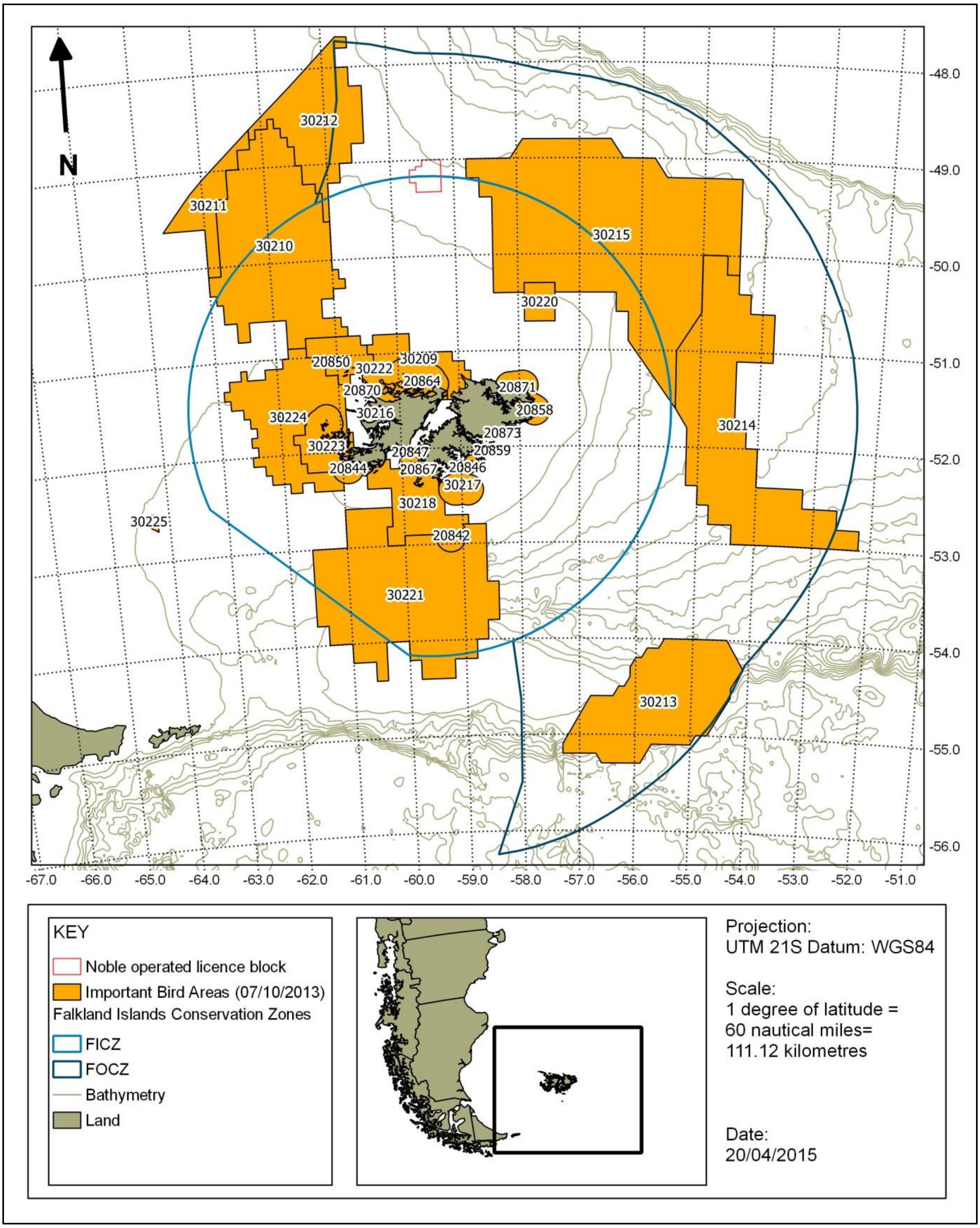
Source: BirdLife International, 2014a.

Figure 35: Confirmed Important Bird Areas and RAMSAR Sites around the Falkland Islands

Table 25: Candidate Marine Important Bird Areas.

Site Name	Area (km^2)	M-IBA ID	IBA trigger seabird Species, period, life-cycle	Distance from Rhea-1 well site (km)
Candidate IBAs – Marine				
Atlantic, Southwest 1 - Marine	26,250	30210	BBA: Oct-Jan, incubation, non-breeding	131
Atlantic, Southwest 2 - Marine	28,259	30214	WA: Dec-Jun, sabbatical, juvenile	329
Atlantic, Southwest 3 - Marine	51,316	30215	GHA & NGP: Jan-Oct, Dec, non-breeding	39
Atlantic, Southwest 4 - Marine	29,221	30221	SS: Dec-Jan, pre-egg, incubation	394
Atlantic, Southwest 5 - Marine	12,013	30224	BBA: Jan-Feb, brood-guard	254
Atlantic, Southwest 7 - Marine	1,578	30220	BBA: Jan-Jun, post-guard	169
Atlantic, Southwest 9 - Marine	18,139	30213	WA: Jan-Apr, incubation	606
Atlantic, Southwest 11 - Marine	11,886	30212	BBA: May-Aug, non-breeding	85
Atlantic, Southwest 13 - Marine	4,388	30211	NRA: Jan-Dec, non-breeding	212
Atlantic, Southwest 38 - Marine	324	30225	BBA: Jan-May, post-guard	511
Atlantic, Southwest 49 - Marine	2,942	30209	BBA: Jan-Dec, incubation; SS: Jan-Dec breeding	192
Beauchêne Island - Marine	7,041	30218	BBA: Jan-Dec, post-guard SS: Jan-Dec, breeding, incubation	325
Bird Island / New Island Group - Marine	3,849	30223	BBA: Jan-Dec, brood-guard, post-brood WCP & SS & IS: Jan-Dec, breeding	299
Bleaker Island Group / Sea Lion Islands Group - Marine	1,912	30217	SS & IS: Jan-Dec, breeding	336
Hummock Island Group - Marine	293	30216	IS: Jan-Dec, breeding	280
Kidney Island Group - Marine	1,686	30219	WCP & SS: Jan-Dec, breeding	251
Pebble Island Group - Marine	5,998	30222	BBA: Jan-Dec, incubation, brood-guard SS: Jan-Dec, breeding	210

Marine IBA trigger species: BBA – black-browed albatross, GHA – grey-headed albatross, IS – imperial shag, NGP – northern giant petrel, NRA – northern royal albatross, SS – sooty shearwater, WA – wandering albatross, WCP – white-chinned petrel.
Source: BirdLife International, 2014a.



Source: BirdLife International, 2014a.

Figure 36: Candidate Marine Important Bird Areas around the Falkland Islands

Ramsar sites

The Ramsar convention was established in 1971 in an international summit in Ramsar, Iran (www.ramsar.org). It allows 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 (www.ramsar.org). There are currently two Ramsar sites within the Falkland Islands: Sea Lion Islands and Bertha's Beach, both of which are also designated as IBAs and 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.

National Nature Reserves (NNRs)

As previously mentioned, the NNRs are established under the Conservation of Wildlife and Nature Ordinance (1999). There are currently 19 NNRs within the Falkland Islands (Table 26, Figure 37), which are either owned by FIG, are privately owned, or are owned by Falklands Conservation. It has been agreed throughout the Falkland Islands community that solely using legislation to protect these areas is ineffectual; therefore management plans are agreed upon and implemented by both the FIG and landowners/stakeholders. The FIG are able to designate marine NNRs but there are none established to date, though there are some sites currently under review. Terrestrial NNRs may also be extended out by 15 miles offshore from the coast.

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 (Upson, 2012). Figure 37 shows the NNRs and IPAs around the Falkland Islands. The NNRs range between 208 km and 389 km from the Rhea-1 well location, and the IPA range between 221 km and 332 km from the Rhea-1 well location.

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 (Figure 38). 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 Strategy 2008-18 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*'. Under this plan the main threats to local biodiversity are prioritised and mitigation measures identified. However, the lack of integrated land/sea zoning and management was 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".

SAERI and partners have recently been awarded a Darwin Plus grant to redress this. The project started in April 2014 and will include a series of reviews, stakeholder meetings and workshops together with creating a Geographic Imaging System (GIS) for data analysis and visualisation relating to habitats, coastlines, fauna/flora, fisheries and hydrocarbon resource extraction. The outcome will be to provide 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.

Table 26: Falkland Islands National Nature Reserves

Date	Order	Designated Area	Landowner	IBA/IPA Ramsar Status	Distance from Rhea-1 well site (km)
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	250
1964	The Twins Islands	51º 15'S 60º 38'W Northwest of Carcass Island	Falklands Conservation	IBA	257
1964	Low Island	51º 19'S 60º 27'W Southeast of Carcass Island	Private	IBA	262
1966	Middle Island	51º 38'S 60º 20'W King George Bay, West Falkland	FIG	IBA	292
2009	Chartres Horse Paddock	51º42'S 60º 03' W East of Chartres Farm Settlement, West Falkland	Private	IPA	295
1998	Narrows	51º 41'S 60º 19'W Narrows Farm, West Falkland	Private	-	296
1998	East Bay	51º 48'S 60º 13'W East Bay Farm, West Falkland	Private	-	305
1993	New Island South	51º 43'S 61º 18'W	Private	IBA	326
1978	Sea Dog Island	Sea Dog Island 52 00'S 61 06'W	FIG	-	348
1969	Bird Island	Bird Island 52º 10'S 60º 54'W	FIG	IBA	361
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	-	356
1964	Beauchêne Island	52º 54'S 59º 11'W	FIG	IBA	422
1970	Bleaker Island	52º 18'S 58º 51'W Bleaker Island north of Long Gulch	Private	IBA	341
2012	Sea Lion Island	Sea Lion Island 52º25'S 59º 05'W	Private	IBA Ramsar	371
1973	Stanley Common	51º 43'S 57º 49'W	FIG	IPA (Cape Pembroke)	309
1964	Kidney & Cochon Islands	Cochon Island 51º 36'S 57º 47'W Kidney Island 51º 38'S 57º 45'W	FIG	IBA	304
1968	Volunteer & Cow Bay	51º 29'S 57º 50'W East Falkland	Private	IBA	280
1968	Cape Dolphin	51º 15'S 58º 51'W	Private	-	242
1996	Moss Side	51º 23'S 58º 49'W, Pond and sand-grass flats behind Elephant Beach	Private	-	256

Source: Falkland Islands Government, 2014.

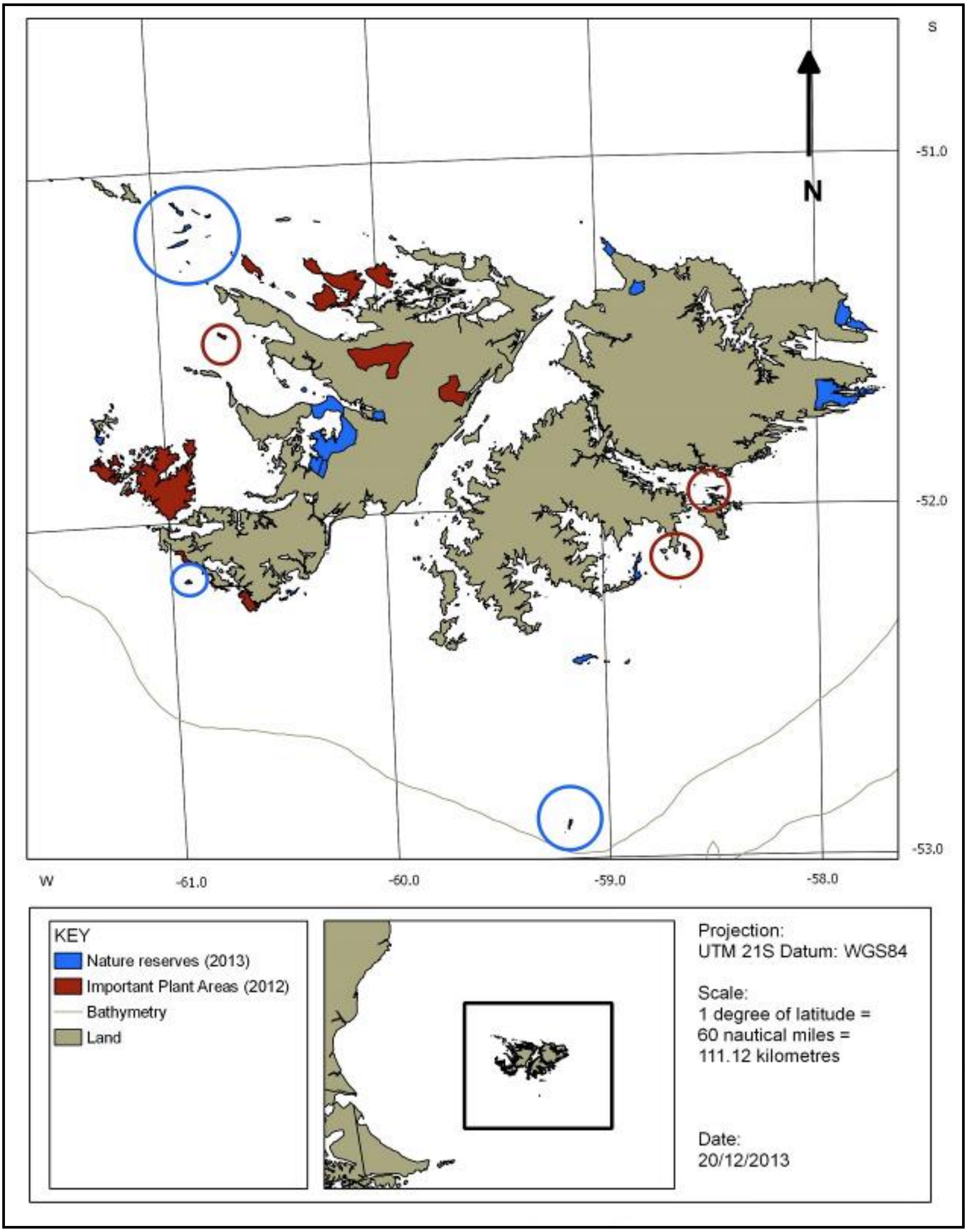


Figure 37: Falkland Islands National Nature Reserves and Important Plant Areas

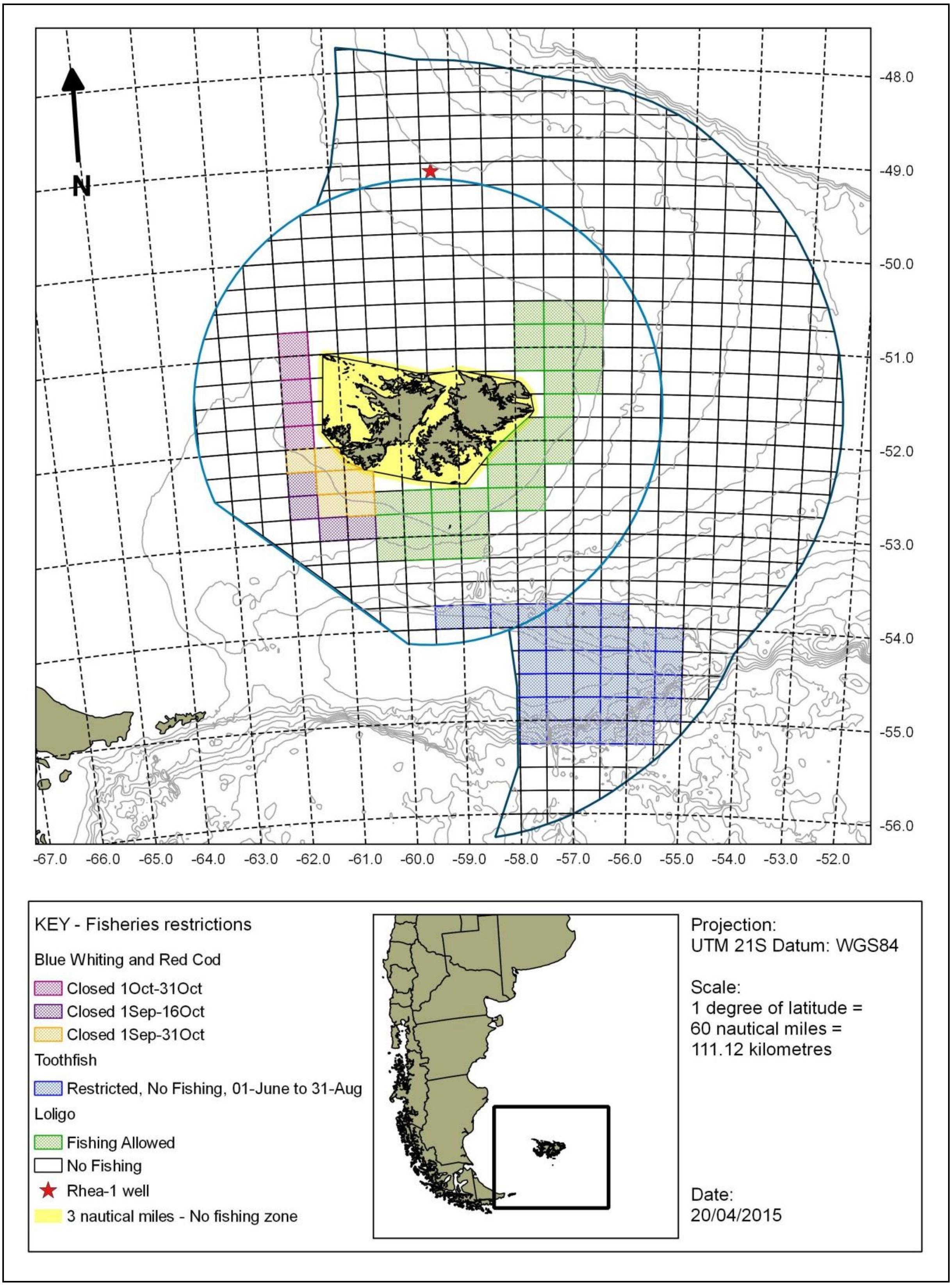


Figure 38: The Falkland Islands Conservation Zones showing permanent and seasonal no-take zones

5.4.7.6 Coastal Sensitivity

Premier Oil completed a study of the north Falklands coastline to ascertain, using industry developed techniques the environmental sensitivity along the coastline to a spill of hydrocarbons (Premier Oil, 2014). Table 27 shows the coastline classifications used in the analysis. This work was initiated following conceptual oil spill modelling studies for the Sea Lion Development, which modelled the potential distribution of oil in the unlikely event of a worst-case oil spill from the proposed Development location, 220 kilometres north of the Falkland Islands. This modelling showed a risk of oil beaching in along the NFB.

For the Rhea-1 exploration well, site-specific oil spill modelling has been conducted. Results are presented in Section 12. Although some risk to the north Falklands coastline is also predicted by the Rhea-1 exploration well spill modelling, potential volumes of beached oil are much lower than those predicted for the Sea Lion Development and Sea Lion exploration wells, due to the lower predicted flow rates from the Rhea-1 well.

Nevertheless, despite the lower predicted risk of coastal impact, the Falklands Coastline Environmental Sensitivity study is relevant as it highlights the most sensitive sites along the north Falklands coastline in the event that a shoreline oil spill response operation does needs to be initiated.

The exploration modelling predicts that following a loss of well control (for a 15 day period), under worst-case metocean conditions during the period simulated, the highest probability of Sea Lion crude reaching the shoreline is less than 5% with a worst-case mass of 6.5 tonnes reaching the shoreline after 60 days at sea. The model was also run with a lighter crude but this would not reach the shore.

The average mass predicted to reach the shore is a much lower value of 0.15 tonnes – any hydrocarbons would also arrive at the coast in a highly dispersed state. In the event of a Sea Lion type crude (which has been modelled) the resultant solid waxlets are predicted to be non-adhesive and non-cohesive and will present a relatively low risk of direct impacts to avifauna. The model predicts that standed oil would be centred on East Falkland with a lower probability of waxlets beaching than islands to the west. The most northerly headlands of Cape Dolphin, Cape Bougainville and Seal Bay / McBride Head showing the highest overall probabilities, less than 5% under the worst-case scenario. To the east and south of McBride Head, towards Volunteer Point and Cape Pembroke, the likelihood of waxlets beaching declines.

Table 27: Adaption of the Gunlach & Haynes (1978) and IPIECA (2011) coastline classification of ESI for the Falkland Islands.

ESI	Estuarine	Lacustrine	Riverine
1A	Exposed rocky shores	Exposed rocky shores	Exposed rocky banks
1B	Exposed, solid man-made structures	Exposed, solid man-made structures	Exposed, solid man-made structures
1C	Exposed rocky cliffs with boulder talus base	Exposed rocky cliffs with boulder talus base	Exposed rocky cliffs with boulder talus base
2A	Exposed wave-cut platform in bedrock/mud/clay	Shelving bedrock shores	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)	Eroding scarps in unconsolidated sediment	Exposed, eroding banks in unconsolidated sediments
3C	Tundra cliffs		
3D	Scarps / steep slopes in bedrock or flat rocks		
4	Coarse-grained sand beaches	Sand beaches	Sandy bars and gently sloping banks
5	Mixed sand and gravel beaches	Mixed sand and gravel beaches	Mixed sand and gravel bars and gently sloping banks
6A	Gravel beaches Gravel beaches (granules and pebbles)*	Gravel beaches	Gravel bars and gently sloping banks
6B	Riprap Gravel beaches (cobbles and boulders)*	Riprap	Riprap
6C*	Riprap		
7	Exposed tidal flats	Exposed tidal flats	
8A	Sheltered scarps in bedrock, mud, or clay Sheltered rocky shores (impermeable)*	Sheltered scarps in bedrock, mud, or clay	
8B	Sheltered, solid man-made structures Sheltered rocky shores (permeable)*	Sheltered, solid man-made structures	Sheltered, solid man-made structures
8C	Sheltered riprap	Sheltered riprap	Sheltered riprap
8D	Sheltered rocky rubble shores		
8E	Peat shorelines		
8F			Vegetated, steeply-sloping bluffs
9A	Sheltered tidal flats	Sheltered sand/mud flats	
9B	Vegetated low banks	Vegetated low banks	Vegetated low banks
9C	Hypersaline tidal flats		
10A	Salt- and brackish-water marshes		
10B	Freshwater marshes	Freshwater marshes	Freshwater marshes
10C	Swamps	Swamps	Swamps
10D	Scrub-shrub wetlands; Mangroves**	Scrub-shrub wetlands	Scrub-shrub wetlands
10E	Inundated low-lying tundra		
* A category or definition that applies only in Southeast Alaska. ** In tropical climates, 10D indicates areas of dominant mangrove vegetation			

The classification does not quantify the exact level of impact but within each habitat considers the potential vulnerability to oil spill damage based upon shoreline interaction with the physical processes controlling oil deposition, observed persistence of the oil in that environment, ease of cleaning operations, and the extent, duration of and recovery from likely biological damage. Exposed rocky shores are considered the most robust to oil impacts whilst sheltered coastal mudflats are considered the most vulnerable to longer-term impacts.

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, Smylies Inlet, Inner White Rock Bay, Inner Tamar Pass (N&S), Inner Port Purvis, Victor Creek (Pebble Island), Justice Inlet (Keppel), NE Bay Saunders, Brett Harbour (Saunders), Penguin Island (Saunders) (Figure 39 and Figure 40). On top of the general sensitivity of the coastline there are a range of IBAs, IPAs, NNRs and Ramsar Sites that were considered along with sites of known environmental importance with significant concentration of wildlife. Whilst a range of taxa may be impacted by an oil spill, the assessment was predominantly based upon colonial seabirds for which census data is available.

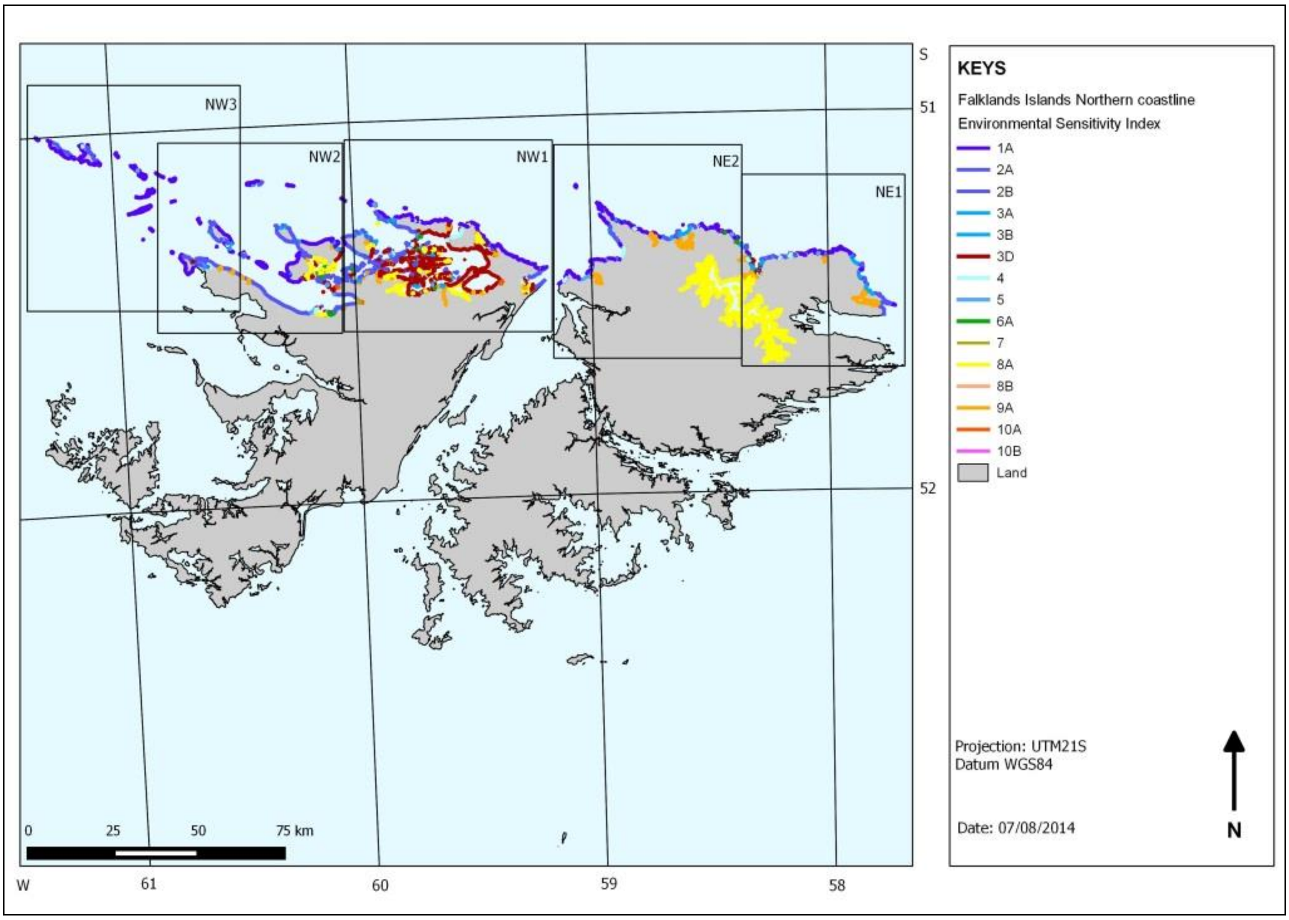


Figure 39: ESI North Falklands Coastline. Oil Spill Vulnerability categorized by Environmental Sensitivity Index 1-10 [from Gunlach & Haynes (1978) & IPIECA (2011)].

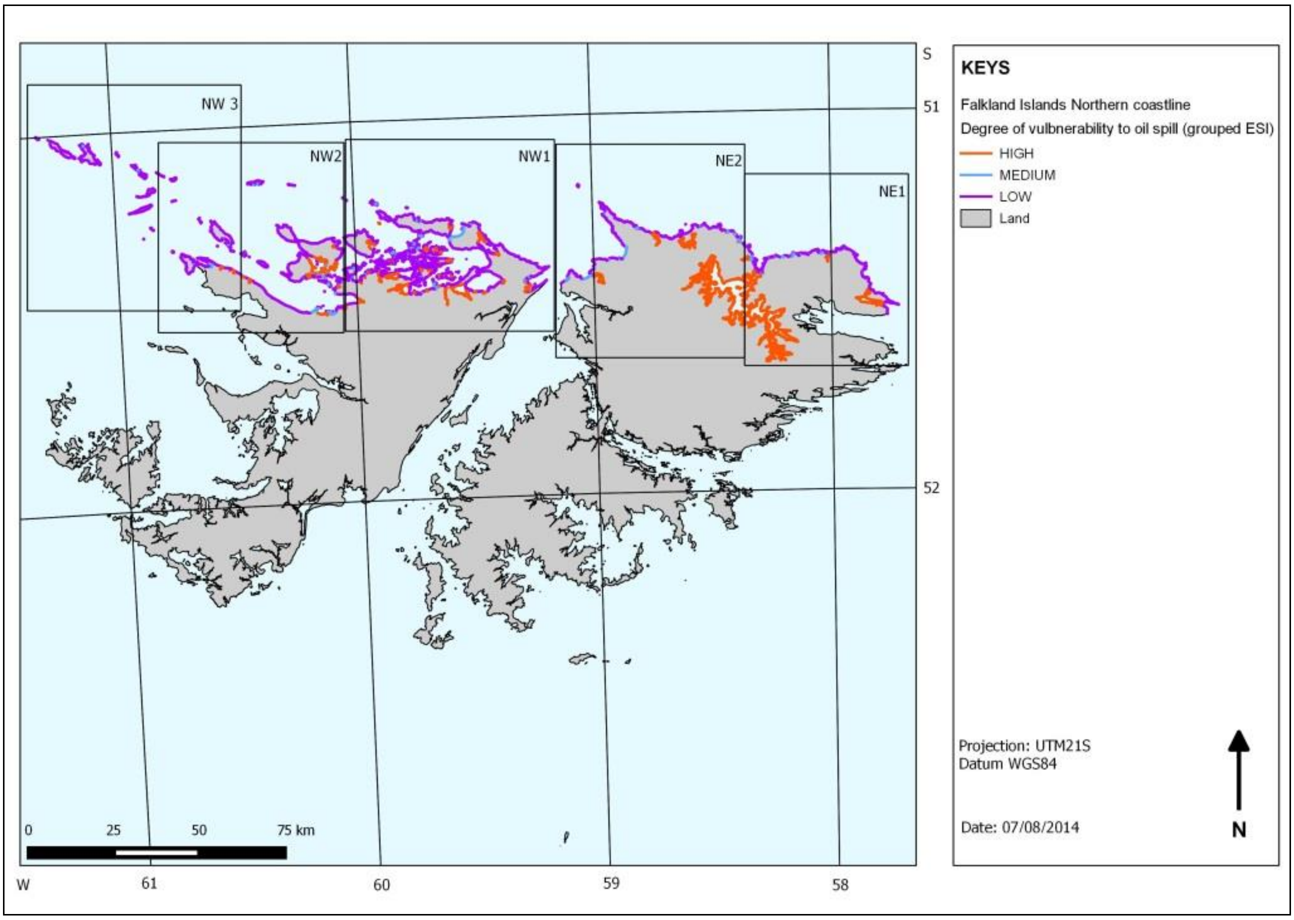


Figure 40: North Falklands Coastline. Environmental Sensitivity Mapping (ESI) categorized as Low (ESI 1-3), Moderate (ESI 4-7) and High (ESI 8-10) Vulnerability to Oil Spill.

A review of the colony locations with respect to coastline type, the seasonality of occurrence and the Oil Vulnerability Index (OVI) of the species would suggest that gentoo penguin 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.

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 (ESI 3).

The study also investigated and 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 ramps), ports, airstrips, settlements and out-houses was detailed and mapped, along with their condition where appropriate. This will enable NEFL to define the level of resources required to affect an appropriate response.

Due to the spatial extent of the North Falkland Islands coastline and the associated issues with regards to access, response time etc. will mean that some prioritisation is required. This will 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 impact. A pragmatic compromise must be reached that balances the importance of a site with the level of resources that must be committed. This may mean that some important sites that would lead to over commitment of resources 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 listing of sites for priority response was determined based on; the coastal ESI, location of notable scenic beaches, occurrence of gentoo penguins, overlap with an environmental land designation and relative level of tourism activity.

The highest ranked sites for prioritised response are located at;

- Volunteer Point;
- Pebble Island;
- Saunders Island;
- Carcass Island.

Important and secondary ranked sites for response are located at;

- Swan Pond & Seal Bay coastline;
- Brazo del Mar and entrance to Salvador Waters;
- Bougainville, Concordia & Limpet Creek coastline;
- Cape Dolphin Swan Pond Beach;
- Smylies Inlet and Paloma Beach;
- Grave Cove, Dunbar;
- 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 & Concordia;
- Cape Dolphin and Elephant Beach;
- Paloma Beach, Smylies and Race Point;
- Pebble Island;
- 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.

5.5 Social and Economic Environment

5.5.1 Falkland Islands Socio-economic Description

To date, oil and gas exploitation within the Falkland Islands has been limited to exploration and appraisal drilling. However, following the recent commercial discovery in the Sea Lion area, planning to develop the field for oil production is currently underway. Supporting an oil and gas development and production operation will be new to the Falkland Islands, and consequently there may be significant impacts on the local community and the socio-economic landscape of the Islands.

In 2012, Rockhopper Exploration commissioned an independent socioeconomic impact assessment to identify potential impacts and mitigation measures to minimise any negative impacts that could be associated with the project (Plexus Energy, 2012). The FIG also recently commissioned an independent socio-economic study of oil and gas development in the Falkland Islands (Regeneris, 2013). This section outlines the current socio-economic baseline for the Falkland Islands and draws on both of the above reports as well as FIG data, including the recent 2012 Falklands Census.

5.5.1.1 Administration and Governance

The Falkland Islands are one of 14 British Overseas Territories under the British Overseas Territories Act 2002. The Basic Law is the 2008 Constitution, which deals with all aspects, with the exception of defence and foreign affairs, which are the responsibility of the UK. The UK is also responsible for internal security, the public service and the offshore financial sector. In other areas, executive power is exercised at island level. The Falkland Islands are located almost 8,000 miles from the United Kingdom, its primary economic partner (Regeneris, 2013).

The Falkland Islands enjoy almost crime free status with an annual police detection rate of over 95% on average.

5.5.1.2 Population

The Falkland Islands were first inhabited in 1764, and the current permanent population of the Islands stands at 2,840 (FIG Policy Unit, 2012). The majority of the Falkland Islands population (74.7%) live in the capital Stanley, which is the only town on the Islands and is based on East Falkland.

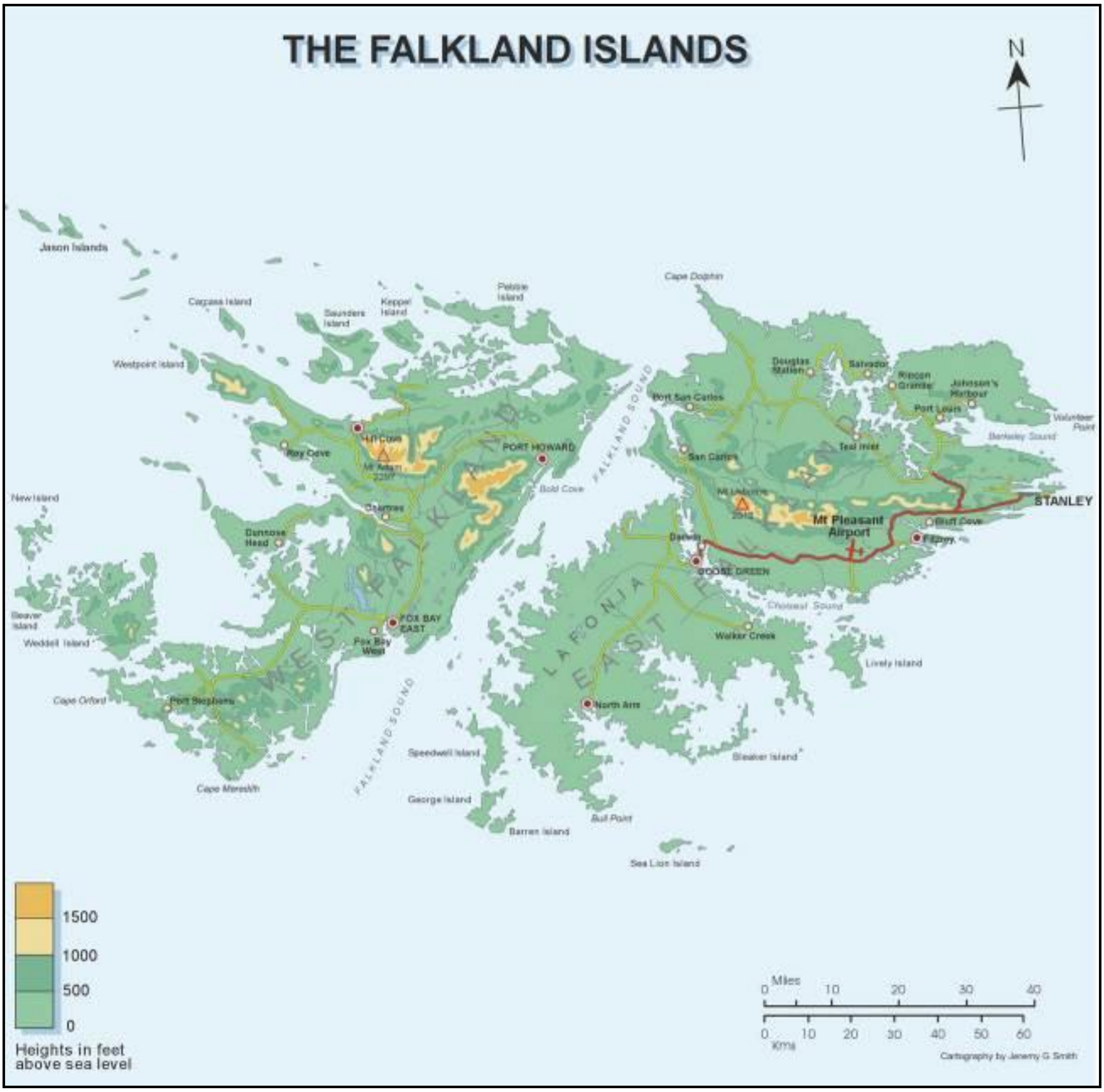
Outside Stanley, in what is referred to as Camp (the local term for the countryside derived from the Spanish word Campos); there are a number of smaller settlements. According to the 2012 Falkland Census, the total population of Camp stood at 351, representing 12.4% of the total resident population of the Falkland Islands. The economic pull of Stanley has led to depopulation in Camp settlements in recent decades. Although this trend has reduced over the last ten years, Camp depopulation remains a significant local concern (Regeneris, 2013).

There are three main Camp settlements on West Falkland (Fox Bay, Port Howard and Hill Cove) and three on East Falkland (Goose Green, North Arm, and Fitzroy). In total, there are 84 mostly family owned farms across the Islands, 38 of which on East Falkland, 35 on West Falkland and a further 11 on the outer islands (Figure 41) (Plexus Energy, 2012).

The Ministry of Defence base at MPC towards the centre of East Falkland is a largely self-contained community, but provides the main airport base for international flights (Regeneris, 2013). The remaining 12.9% of the population are civilian contractors working at the MPC (FIG Policy Unit, 2012).

The majority of the population is British by birth or descent, with many tracing their family origins in the Islands back to the early nineteenth century. In addition to the Falkland Islanders, there is a significant minority of resident Chileans and St. Helenians who work on the Islands. Most the remaining population comprises people from the UK and other countries working under contract or in certain government positions that require specialist skills (Plexus Energy, 2012, Falkland Census, 2012).

There are over 1,200 homes on the Islands, with around 1,000 of these in Stanley. On average only 20 new houses are being built each year, largely detached houses in their own plots. Around three quarters of homes are detached houses and development is fairly low density. There are currently very few empty homes (Regeneris, 2013). A new development in the west of the town, at Sappers Hill, and an extension to Murray Heights have helped to ease the pressure on housing recently.



Source: Plexus Energy, 2012.

Figure 41: Main Settlements and Roads within the Falkland Islands

5.5.1.3 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 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 trawlers 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, 2014).

There are around 290 registered businesses on the Falkland Islands, of which it is estimated that around 130 are active. Analysis by GDP and employment highlights that public services, fisheries, agriculture, tourism and construction are all key sectors of the local economy. These five sectors account for around 85% of GDP and around two thirds of all jobs (Regeneris, 2013).

This contrasts markedly with the percentage breakdown of annual employment (Falkland Census, 2012). In particular, fisheries employment accounts for only 3% of total employment, compared with 50-60% of economic output. This is largely because fishing revenues are from the sale of fishing licences to foreign fishing fleets, not from the Falkland Islands-based fishing activities. In contrast, FIG accounted for 25.4% employment, compared with just 13% of economic output (Plexus Energy, 2012). Similarly, agriculture's 9.9% share of employment is much higher than its 2% share of economic output (Plexus Energy, 2012).

The employment rate for working age people (those aged 16-64) is 89.5%, with only 1.4% unemployed and seeking work. This is an exceptionally high level of employment by international standards, and means that there is virtually no spare capacity in the labour market (Regeneris, 2013).

- The majority of workers in the Falklands undertake a ~45 hour working week, and around half of Camp residents report working a 50+ hour week.
- The mean income level in Stanley is £23,300, making it around 10% lower than the mean level for the UK. Around a quarter of Falkland Islanders supplement the income from their primary job with a second job.

5.5.1.4 Agriculture

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).

5.5.1.5 Tourism

The role of tourism in the Islands' economy has increased in recent years (FIG, 2014). Tourist numbers continue to grow, with many attracted by the Islands' pristine environment and its diverse wildlife. According to the Falkland Islands Government (FIG, 2014), approximately 60,000 tourists visit the Islands by cruise ship each year, and a further 1,600 'land-based' tourists arrive by air annually to enjoy the Islands' unique wildlife and unspoilt environment. The tourism sector is the second largest contributor to the Islands' economy and contributes approximately £4m to annual GDP (FIG, 2014).

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.

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 (FIG, 2014).

5.5.1.6 Education

There are approximately 380 school children between the ages of 5 and 16 in the Falkland Islands. Their education, which follows the English system, is free and compulsory (Plexus Energy, 2012). Primary education is available in Stanley where there are boarding facilities; at RAF Mount Pleasant for children of service personnel; and at a number of rural settlements where remote learning is supported by the Stanley-based Camp Education Unit. The Government funds qualified students to study A-levels or vocational qualifications, and higher education within the UK.

5.5.1.7 Health

The Falkland Islands Government Health Service is responsible for the provision of all health care services in the Islands, including dental care, social and benefits services (Plexus Energy, 2012). Primary and secondary health care facilities are based at the King Edward VII Memorial Hospital (KEMH) in Stanley, the only hospital in the Islands. The hospital is run jointly by FIG and the UK MoD, specialist medical care is provided by visiting ophthalmologists, gynaecologists, ENT surgeons, orthopaedic surgeons, oral surgeons and psychiatrists from the United Kingdom. Patients requiring emergency treatment are airlifted to the United Kingdom or to Santiago, Chile.

Healthcare in remote Camp farm settlements is provided by the KEMH's GPs via telephone consultations and six weekly visits by doctors who will visit residents' homes as needed. In an emergency situation the patient can be evacuated to Stanley using the Falkland Islands Government Air Service (FIGAS).

The realisation of a major accident hazard associated with the joint NEFL and Premier Oil drilling campaign could result in multiple fatalities / serious casualties and in such a scenario it is highly unlikely that KEMH's existing acute / general bed capacity could handle the rapid influx of injured patients. NEFL's strategy for medical response is to have fully trained medics with advanced trauma life support (ATLS) or equivalent qualifications both on the rig and SAR helicopter. Patients will be medevac'd initially to Stanley and stabilised for onward medevac to South America. In the event of multiple casualties, patients would have to undergo triage to prioritise treatment. Pressure on bed space at KEMH in this unlikely scenario is inevitable.

5.5.1.8 Infrastructure

There is a network of roads linking the main settlements in the Falkland Islands (Figure 41). Outside of Stanley the road to MPC is partially tarred, but all other roads are gravel all-weather surfaced. The absence of capping on some of the roads leads to significant erosion, especially during the winter, making all types of road travel difficult and increases safety risk during those periods (Plexus Energy, 2012). The road between Stanley and MPC will be used on crew change days.

The availability of accommodation in Stanley is limited and will be augmented with temporary accommodation (Section 10.8). This will be reliant on the existing power and water supply, although the temporary accommodation may be equipped with its own generators for emergency power.

Freshwater supply

The town of Stanley is currently reliant on one source of freshwater at Moody Brook. The availability of freshwater varies seasonally, according to rainfall, with supply lowest during the summer months. Reliance on a limited supply leaves the residents of Stanley vulnerable to periods of extreme dry weather and potential contamination. Currently, infrastructure for a second source of freshwater for the town (Murrell River) is being put in place. However, this will not be on line before the start of the 2015 Drilling Campaign but will cover all eventualities in the future.

Residents of Stanley and local businesses, such as the Falkland Islands Meat Company (FIMCO), rely on the Stanley freshwater supply. However, previous shortages have only occurred during unusually dry summers (November to January). The vast majority of drilling operations will be conducted outside of this period.

During a previous drilling campaign, in January 2011, demand did become stretched due to factors such as; lower than average rainfall in Nov/Dec 2010 and January 2011, higher demand by Stanley residents due to warm dry weather (i.e. watering gardens), FIMCO operations commencing and demand by the drilling campaign (C. Paice pers. comm.).

It is not possible to predict the quantity of freshwater that will be required during the drilling campaign. However, it is anticipated that it will not exceed that of previous campaigns.

Unlike previous campaigns, the TDF is fitted with a freshwater reservoir with a capacity of one million litres. This reservoir will be trickle fed to avoid excessive peaks in demand on the local supply.

5.6 Shipping

5.6.1 Falkland Islands Fisheries

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, 2014).

It is therefore important to understand current fishing activity within the area of the Rhea-1 well site in order to determine to what extent the exploration and potential future development of the area might interfere with fishing activities. For example; as a result of exclusion of fishing vessels from around the field, and whether this could translate into loss of revenue for the fishing fleet or the FIG as a result of licence sales.

This section provides an understanding of the fishing activities and intensity in the region of the Rhea-1 well in order to evaluate the potential impacts associated with the proposed exploration. This area is known to support very low fishing activity. These low levels of fishing activity are likely for two reasons: the depth of the area is greater than the normal maximum depths at which the bottom trawlers fish, and; the area is denoted by rough fishing grounds and therefore there is a high risk of bottom trawlers losing fishing gear.

This review is based on the Summary Report of fishing activity over the Sea Lion development area, conducted by Pale Maiden Consultancy (April 2013), and FIG Fisheries Department Catch Report Database from 2008 to 2012. Some information is also taken from the Fishing and Trawling Risk Study conducted by Jee on behalf of Premier Oil (2013).

The Falkland Islands EEZ contains rich fishing grounds, particularly for the two important squid species, Argentine shortfin squid and Loligo (Patagonian squid). Table 28 presents total catch (tonnes) data for the main target species in the Falkland Islands fishery between 2008 and 2012 (FIGFD, 2008-2013). This illustrates that the Argentine shortfin squid, is consistently the most important (in terms of catch) fishery (with the exception of 2009 where the species was virtually absent from the EEZ), accounting for 53.8% catch by weight in 2013, followed by Loligo squid which accounted for 15.2% of the catch by weight in 2013.

Patagonian rock cod has increased in importance over recent years, experiencing 20-30 fold increase in catches (Laptikhovsky et al., 2013), and is currently the third most important fishery accounting for 12.3% of catch by weight in 2013 (Table 28). The rise in this fishery followed the decline in the blue whiting fishery in 2007 (Laptikhovsky et al., 2013).

Fisheries of considerably smaller magnitude also operate for the main finfish species, such as; whiptail hake (hoki) (6.4%), hake (4.6%), red cod (2.0%) kingclip (1.5%), blue whiting (1.0%) and

Patagonian toothfish (0.5%). Additionally, skates and rays account for a small 2.2% of the catch (Table 28).

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, Directorate of Natural Resources, Fisheries Department 2012).

Table 28: Annual Fishing Catch by Target Species in the FICZ/FOCZ

Target Species	Catch (Tonnes)						% Catch
	2009	2010	2011	2012	2013	2014	(2014)
Argentine shortfin squid	43	12,110	79,389	86,981	142,405	306,148	67.63
Loligo squid	31,477	66,532	34,663	70,888	40,177	48,702	10.76
Patagonian rock cod	58,246	76,451	55,707	63,512	32,418	56,589	12.50
Hoki	23,396	19,226	22,980	15,866	16,845	7,390	1.63
Hake	13,056	13,604	9,903	10,477	12,284	14,861	3.28
Skates and Rays	5,880	5,894	6,975	6,650	5,910	5,553	1.23
Red cod	5,119	3,120	4,202	4,625	5,162	3,464	0.77
Kingclip	3,386	3,631	3,864	3,515	3,960	2,880	0.64
Southern blue whiting	10,395	6,469	3,944	1,596	2,697	3,612	0.80
Patagonian toothfish	1,408	1,396	1,550	1,309	1,420	1,297	0.29
Others	1,225	700	2,616	818	1,331	152	0.03

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 gird squares are the same as the ¼ ICES squares used for Seabird data (Section 3). 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 2012 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 (FIGFD, 2008-2013).

5.6.1.1 Fisheries Operating within the vicinity of the Rhea-1 well

The Rhea-1 well location is in FIFD grid square XEAK, 20 to 37 nautical miles northeast of the 200 m depth contour line, with depths of approximately 470 m. This grid square has been fished by licenced vessels for either for the Argentine shortfin squid, or for skates, or finfish. The licence types which are issued by FIFD for these grid squares are:

B: Argentine shortfin squid and sevenstar flying squid (*Martialia hyadesii*)

G: Argentine shortfin squid and restricted finfish

A: unrestricted finfish

F: skates and rays

S: blue whiting and hoki

W: restricted finfish

Data extracted from the Fisheries Department database (Table 29) 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 (Table 29). Throughout the period between 2009 and 2013, total fishing effort by jigging vessels was only 63 hours, resulting in a catch of slightly under 17 tonnes of Argentine shortfin squid. However, during the first six months of 2014 the effort and catch rate increased, with 161 hours of jigger fishing effort resulting in over 478 tonnes of squid caught. When compared with the total catch in Falklands waters during 2014, this represents approximately 0.16% of the total catch taken by the jigger fleet, which highlights that this area is not an important fishing ground. A trawler was also present for one day in 2014 but only took a modest catch (Table 29).

Table 29: Total Annual Catch and Effort in Grid Square XEAK (data from FIFD daily catch reports)

Species	2009	2010	2011	2012	2013	2014 (Jan-Jul)	
	N/A	Jigger	N/A	Jigger	N/A	Jigger	Trawler
Catch (tonnes)							
Argentine shortfin squid	0	5.76	0	10.971	0	478.670	1.180
Rock cod	0	0	0	0	0	0	0.213
Hoki	0	0	0	0	0	0	0
Common hake	0	0	0	0	0	0	0.214
Rays	0	0	0	0	0	0	0.432
Kingclip	0	0	0	0	0	0	0
Patagonian toothfish	0	0	0	0	0	0	0
Total	0	5.76	0	10.971	0	478.670	2.039
Effort (jigger night, trawler day)							
XEAK	0	33 hrs	0	30 hrs	0	161 hrs	6 hrs

The vast majority (97.8 %) of all bottom trawl fishing for finfish and skates in the Falkland Islands was conducted in waters less than 350 m in depth (Pale Maiden, 2013).

5.6.2 Marine Archaeology

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 n miles radius of the Rhea-1 well site; the two closest of these wrecks are both located approximately 40 n miles from the field (Table 30, Figure 42). There are no recorded wrecks within the vicinity of the Rhea-1 well site.

Table 30: Recorded Wrecks within 100 miles of the Rhea-1**.**

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).

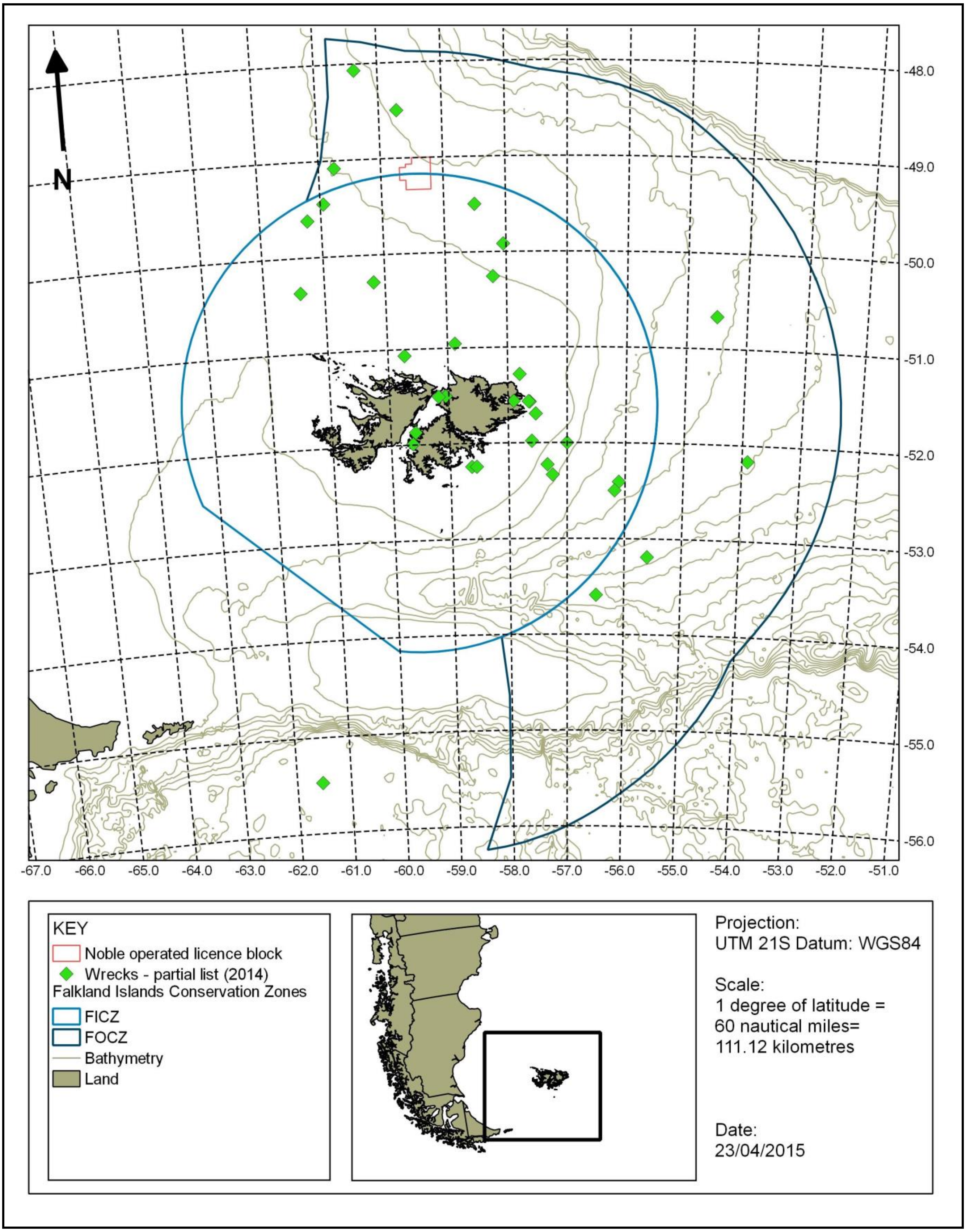
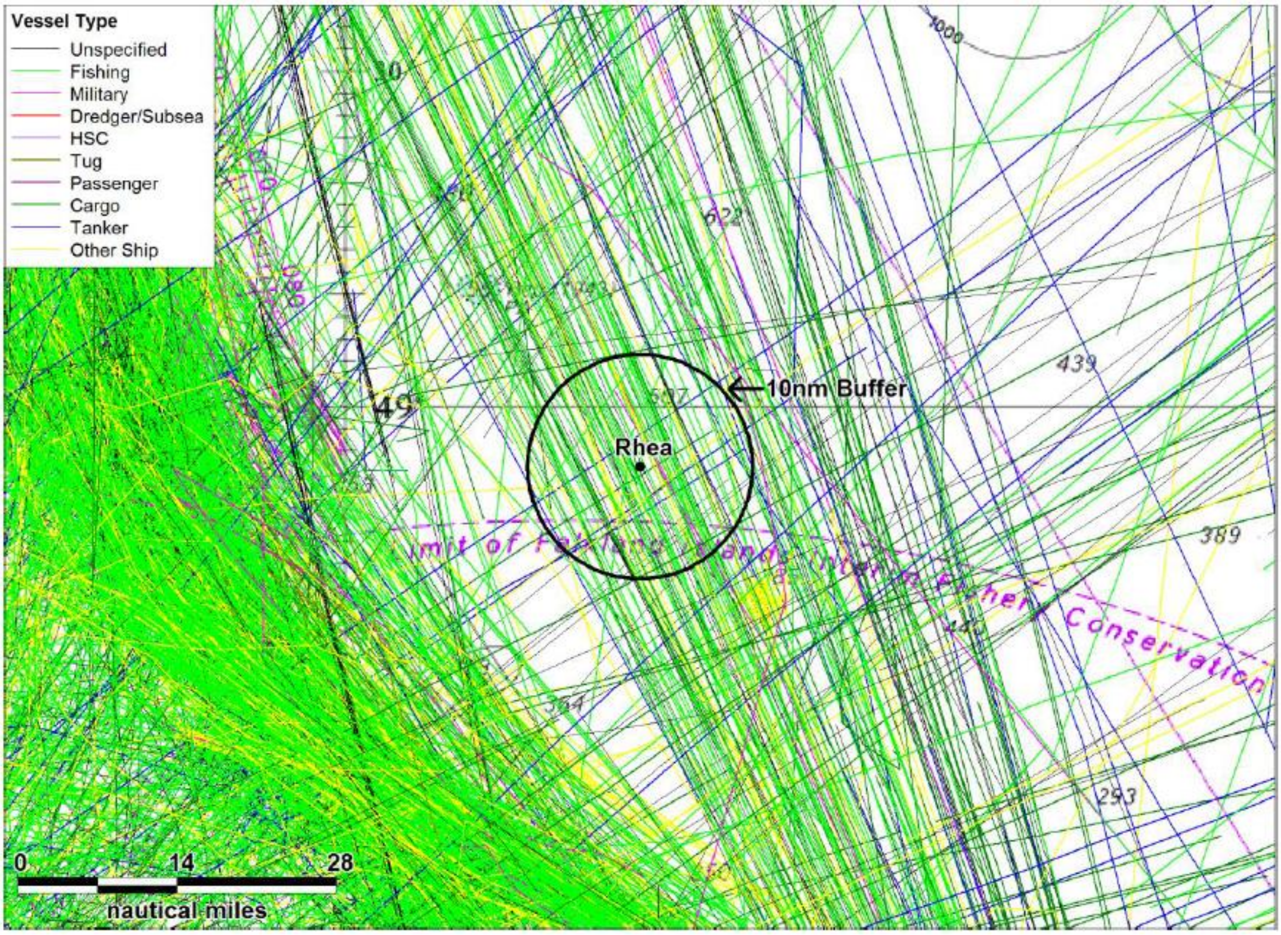


Figure 42: Known Shipwrecks within the Falklands' Continental Shelf

5.6.3 Navigation and Maritime Transport

NEFL commissioned Anatec to identify the shipping routes passing the Rhea-1 location in the NFB. Details of all of the shipping routes passing close to the Rhea-1 location were identified using detailed analysis of Automatic Identification System (AIS) data (Anatec, 2015). AIS is an automated tracking system used on ships and by vessel traffic services for identifying and locating vessels by electronically exchanging data (such as unique identification, position, course and speed) with other nearby ships, AIS base stations and satellites. The International Maritime Organisation's International Convention for the Safety of Life at Sea requires AIS to be fitted onboard international voyaging vessels with gross tonnes of 300 or more. Figure 43 illustrates a composite of AIS tracking data in the vicinity of the Rhea-1 location, indicating that it is located in an area of low shipping activity (Anatec, 2015). The nearest area of high-density shipping activity passes the Sea Lion area approximately 20 n miles to the southwest (Figure 43).



Source: Anatec, 2014.

Figure 43: Overview of AIS shipping data for the Rhea-1 Location

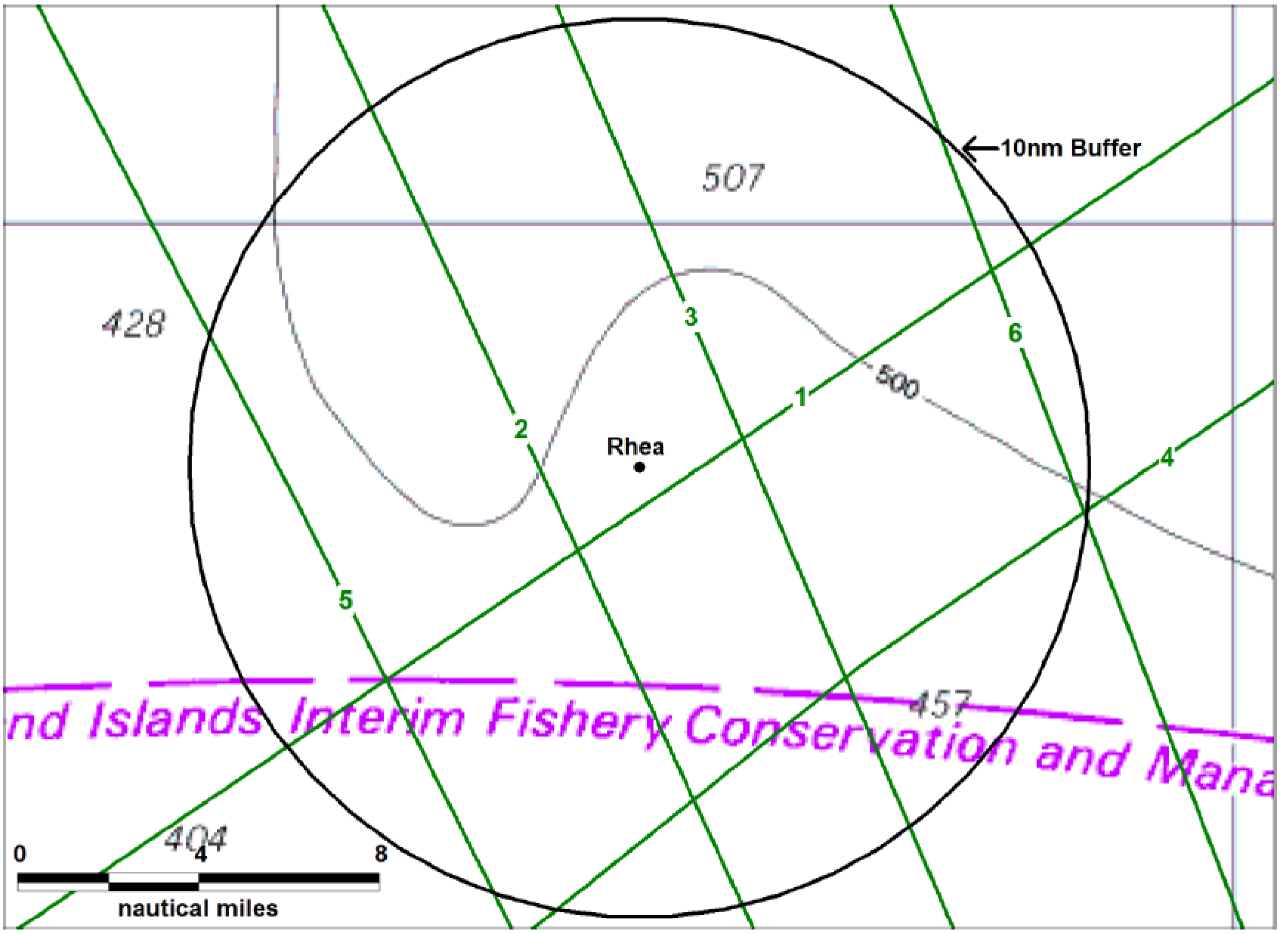
There are six shipping routes that pass within 10 n miles of the Rhea-1 location, with a total of 289 ships per year travelling through these shipping routes (Table 31, Figure 44), equating to 1 vessels passing every 1.2 days.

Table 31: Ship Routes Passing within 10 nautical miles of the Rhea-1 location

Route No.	Description	CPA (nm)*	Bearing (°)	Ships per year	% of Total
1	N. America West Coast-West Africa*	0.7	145	16	6%
2	Berkeley Sound-Fishing Grounds*	2.0	245	70	24%
3	Berkeley Sound-Montevideo B*	2.7	67	84	29%
4	West Africa-N. America West Coast A	6.5	142	5	2%
5	Berkeley Sound-Puerto Madryn*	7.1	242	64	22%
6	Berkeley Sound-Montevideo A*	9.2	70	50	17%
TOTAL				**85**	**100%**

* 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.

Source: Anatec, 2015.



Source: Anatec, 2015.

Figure 44: Shipping Route Positions within 10 nautical miles of the Rhea-1 location

There are six shipping routes trafficked by an estimated 289 ships per year passing within 10nm of the Rhea location.

It is noted that this is route-based traffic and there will also be additional, non-routine shipping in the area such as fishing, cruise, research and military vessels.

As previously noted fishing vessels have been modelled as other vessels passing the location, given their regular routeing through the area.

The majority of the traffic passing within 10nm of Rhea location is fishing vessels travelling to fishing grounds. It can also be seen that over 80% of vessels are below 5,000 DWT.

There are an estimated 289 ships per year passing within 10nm of the proposed Rhea-1 location, corresponding to an average of 1 vessel per day.

Based on installing the *Eirik Raude* Semi-submersible drilling rig at the Rhea-1 location, the annual collision frequency is estimated to be 3.9 x 10^{-04}, corresponding to a collision return period of 2560 years.

From the review of the area, the vessels have ample room to pass the drilling location with limited impact on navigation.

5.6.4 Military

It is important to be aware of the other users of the licence area, and whether the development and production of the field will have the potential to interact with areas used by the military for naval exercises.

There has been a substantial military presence in the Falkland Islands since 1982, which provides air, land, and sea coverage. In particular;

- A Castle Class offshore patrol vessel was based in the Falkland Islands on a full time basis (RPS Energy, 2009); however, this has recently been replaced with a River Class vessel (M. Jamieson, pers. comm.).
- A Royal Fleet Auxiliary tanker is also based permanently within the Falkland Islands (M. Jamieson, pers. comm. 2013).
- A destroyer or frigate Guardship also visits the Falkland Islands on a regular basis throughout each year.

It is possible that the military vessels residing in the Falkland Islands will pass close to the Rhea-1 well site as there are no restrictions on their movements within Falkland Islands waters, however, it is understood that this does not happen with any frequency (M. Jamieson, pers. comm. 2013). It is also possible that the visiting Guardships may pass through or close to the well site *en route* to or from the UK and the Falkland Islands (M. Jamieson, pers. comm. 2013).

The MoD has provided the military vessels, flights and helicopters that are in operation around the Falklands with maps of wildlife avoidance areas within the Falklands and Falklands' waters. However, these areas of avoidance are all in more coastal or terrestrial areas and are primarily in place for helicopters and planes. The wildlife avoidance areas will also be in force for helicopters moving to and from oil and gas installations based further offshore.

5.6.5 Other sea users

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 pass through, or close to, the northern Licence Blocks. Also, several yachts and pleasure craft may travel close to the Rhea-1 well either *en route* to or from the Falkland Islands or other locations, such as South Georgia. However, this is difficult to ascertain given that VMS is only for Falklands registered vessels, and yachts do not have AIS (M. Jamieson, pers. comm. 2013).

6.0 Environmental Impact Assessment Methodology

6.1 Introduction

The EIA process provides a framework for assessing the environmental consequences of a project during the planning stages, such that favourable alternatives may be considered, and mitigation measures may be proposed to minimise impacts to acceptable levels prior to the decision for project sanction.

The purpose of this section is to describe the impact and risk assessment methodology that has been used to identify potential impacts and risks resulting from the Rhea-1 element of the 2015 Exploration Drilling Campaign. The methodology has been prepared based on the Falkland Islands Government's Department of Mineral Resources (FIG DMR) *Field Developments Environmental Impact Statements Guidance Notes* (2012) and international best practice for EIA (IEEM, 2010; Horvath (IAIA), 2013; Morris and Therivel, 2009; Glasson et al., 2013).

6.2 Environmental Impact Assessment Process

The activities associated with the proposed drilling campaign have the potential to affect the environment in a number of different ways.

Project activities can be categorised into a sequence of **planned activities** that must occur for the project to be successfully completed. During the course of any project execution there is a risk that, if project activities do not occur as planned, an **accidental event** may occur. Planned activities give rise to **environmental impacts,** while unplanned or accidental events pose a risk of environmental impacts *if* they occur.

The environmental impacts of unplanned or accidental events are evaluated by taking the likelihood of the event occurring into consideration in an **environmental risk assessment**.

Therefore with regard to assessing the overall impact of the Rhea-1 well operation:

- Planned events are subject to an environmental impact assessment only
- Unplanned / accidental events are subject to the same environmental impact assessment followed by a secondary assessment of the likelihood that the unplanned / accidental will occur at all

The International Standard for Environmental Management (ISO 14001:2004) defines an environmental impact as any change to the environment, whether adverse or beneficial, wholly or partially resulting from a project's environmental aspects. The project's environmental aspects are defined as project activities or outcomes that could present an environmental impact.

The evaluation of impacts and risks follows a structured methodology (Figure 45) that systematically:

- Identifies and assesses the planned **environmental aspects** that could lead to an **environmental impact** *and* the potential unplanned or accidental environmental aspects that carry the risk of environmental impact;
- Assesses the value or **sensitivity** (Section 6.2.0) of the environmental receptor;
- Assesses the **severity** (Section 6.2.0) of the environmental effect caused by the aspect prior to implementing mitigation measures;
- For planned activities the **significance of the impact** (Section 1.1.1) is evaluated based on the sensitivity of the receptor and the severity of the effect;
- For accidental or unplanned events the **significance of the risk** (Section 1.1.1) is evaluated based on the sensitivity of the receptor, the severity of effect and the likelihood of the unplanned or accidental event occurring;
- Assesses the degree of **confidence** (Section 6.2.2) in the impact or risk assessment based on the definition and certainty of project activities; understanding of the sensitivity of the receptor, nature of the impact; and criticality in the number of data gaps;

- Identifies any **mitigation measures** (Section 6.2.3) required to reduce the identified environmental impact or the likelihood, and thus risk, of an unplanned event occurring;
- Evaluates the residual impact (Section 6.2.4) or risk once mitigation measures to reduce the impact or likelihood of unplanned or accidental events occurring have been accounted for;
- Evaluates the potential for **cumulative** or **in-combination impacts**; and
- Describes the **environmental management plan** (Section 6.2.5) that will be used to systematically implement measures to manage the environmental impacts and risks during project execution.

Figure 45 illustrates the environmental impact and risk assessment process as described above.

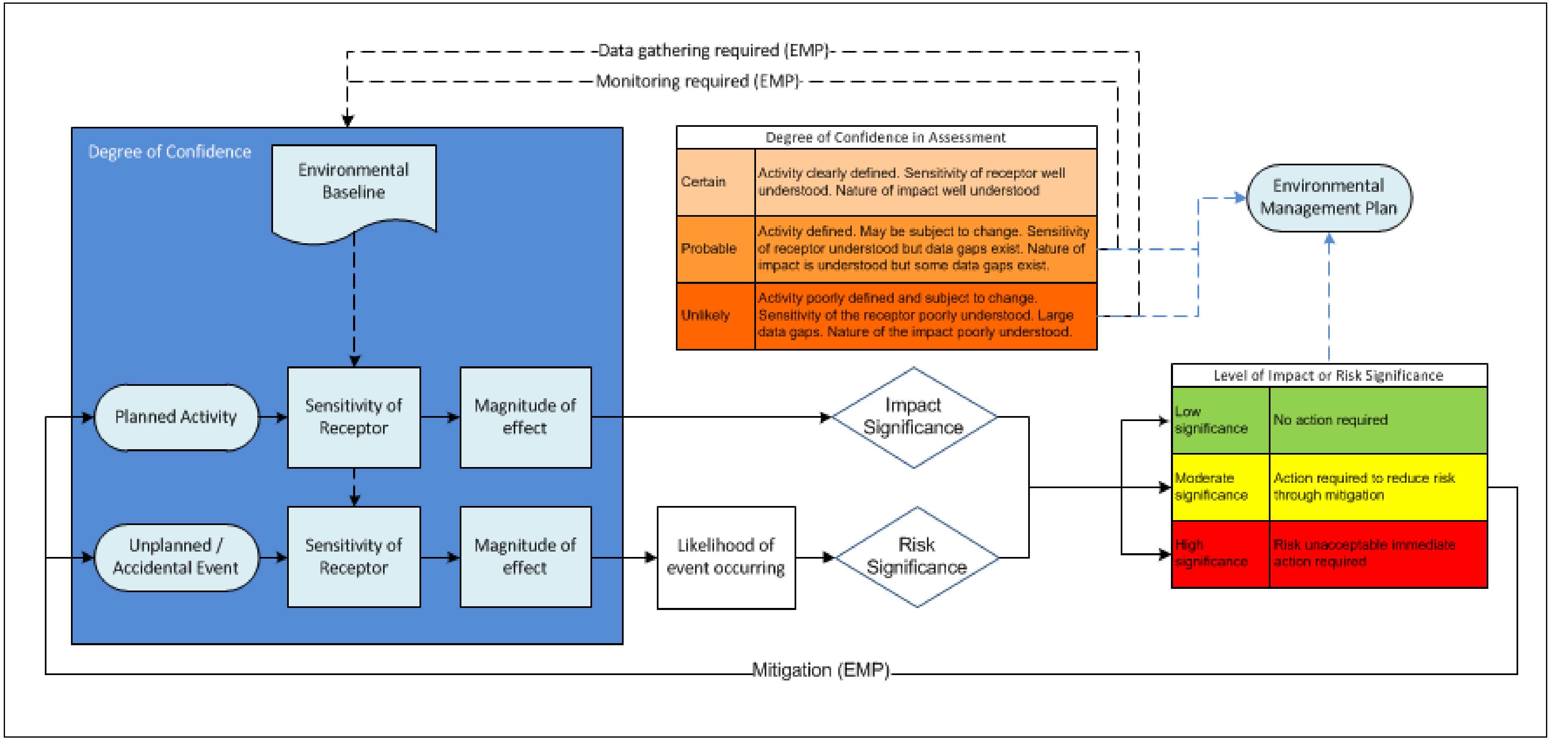


Figure 45: Overview of the Environmental Impact and Risk Evaluation Process

6.2.1 Impact and Risk Assessment Methodology

Environmental aspects were identified by systematically stepping through the different phases of the Rhea-1 exploration drilling activities to determine which project activities or outcomes could present an impact or risk to the identified environmental components. The environmental components considered to be relevant to this project include:

- Air quality (local);
- Climatic factors;
- Soil (including the seabed);
- Water quality;
- Benthic (animals living on or in the seabed), terrestrial ecology;
- Plankton (plant or animals which live in the water column and drift with the ocean currents);
- Fish ecology;
- Seabirds;
- Marine mammals;
- Commercial fisheries;
- Human population;
- Landscape and seascape;
- Waste landfill resource:
- Architecture and archaeology:
- Designated sites;
- Transboundary impacts;
- In-combination and cumulative impacts; and
- Stakeholder and or regulatory concern.

Planned events

The drivers for evaluating environmental or social impacts of planned events are:

- The *sensitivity of the receptor to the environmental or social impact* (IEEM, 2010; Morris & Therivel, 2009)*;* and
- The *severity of the effect* (IEEM, 2010; Morris & Therivel, 2009).

Sensitivity of the receptor has particular significance in the Falkland Islands, as the Falkland Islands and the surrounding waters support a diverse and important assemblage of species that live within, or rely on, the marine environment for survival.

The sensitivity of the receptor considers a number of factors including the relative importance of the local population size, the conservation status of the habitat or species, the seasonal migrations or abundance, and species sensitivities. Project specific definitions have been developed to describe the '*sensitivity of the receptor to the environmental aspect*' (Table 32). The definitions were based on the criteria for assigning value to ecological features as described in IEEM (2010). Effects on the human population as a result of the identified environmental impacts were assessed using the descriptors in Table 33, which are based on types of social impacts described in IAIA (2003) and Morris & Therivel (2009).

The severity of the effect on the receptor considers whether the effect is positive or negative, the magnitude, spatial extent, duration, reversibility and the timing, and frequency of the effect. The definitions for the '*severity of the effect on the receptor*' are based on the Oil and Gas Industry Standards and are presented in (Table 34).

The significance of an environmental impact can be 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

Each impact was evaluated and a measure of significance of the impact on the receptor determined using the impact assessment matrix in Table 35 (sensitivity vs. severity). Impacts were categorised as very low, low, medium, high and very high significance as defined in Table 38.

The impact assessment results are used to determine where mitigation measures are required to reduce the impact to as low as reasonably practical (ALARP). For this project, it is considered necessary to implement mitigation measures for impacts of Moderate significance and above. Impacts of Low significance and lower are considered to be acceptable and do not require any further control measures. Table 38 provides a list of definitions for the categories of environmental impacts from Very Low to Very High.

Table 32: Project Specific Definitions for the Sensitivity of Environmental Receptors (adapted from IEEM, 2010)

Level	Category	Environmental Receptor Sensitivity Definition
5	Very High	Population size of international importance (1% of global population) during period of project activity: Habitat / site of international value - protected under international designation: Species IUCN status Critically Endangered: Endemic species: and/or Large populations of animals considered under wider threat, present during period of project activity.
4	High	Population size of regional importance (1% of biogeographic population) during period of project activity: Habitat / site national value - protected under national designation: Species IUCN status Endangered: and/or Locally distinct sub-populations of a species present during period of project activity.
3	Moderate	Population size of national importance (1% of Falkland Island population) during period of project activity: Habitat / site regional value - containing viable areas of threatened habitats: and/or Species IUCN status Vulnerable.
2	Low	Population size of little geographical importance during period of project activity: Habitat / features which are undesignated but are considered to appreciably enrich the local habitat resource: and/or Species IUCN status Near Threatened.
1	Very Low	Population size of no geographical importance during period of project activity: Habitat / site undesignated and of low grade and widespread nature.: and/or Species IUCN status Least Concern.

Table 33: Project Specific Definitions for the Sensitivity of Human / Social Receptors

Level	Category	Human / Social Receptor Sensitivity Definition
5	Very High	The receptor has little or no capacity to absorb change without fundamentally altering its present character. For example, changes to the following: • Population size, temporary and permanent; • Health and wellbeing - physical, mental, social, spiritual; • Local services – educational, health services, social support, recreation, transport, housing availability; • Lifestyles / quality of life, community stress and conflict, integration, community character, crime, culture, way of life; and • Environment – air quality, water, noise, food availability etc.
4	High	The receptor has low capacity to absorb change without fundamentally altering its present character.
3	Moderate	The receptor has moderate capacity to absorb change without significantly altering its present character.
2	Low	The receptor is tolerant of change without detriment to its character.
1	Very Low	The receptor is resistant to change.

Table 34: Project Definition for the Severity of Effect

Level	Impact level	Description
1	Slight	Negligible environmental effect. No habitat / population effects. No breach of permit / non-regulatory reportable.
2	Minor	Minor, localised short-term, reversible environmental effect. Barely detectable impact on species / habitat / ecosystem. Rapid on site clean-up. Delayed regulatory notification for information.
3	Moderate	Moderate effect in small area e.g. small chronic / moderate short-term release. Temporary and rapidly reversible impact on species / habitat / ecosystem. Site / local response required. Immediate regulatory report required.
4	Major	Major effect away from facility e.g. uncontrolled spill, large gas release. Serious and long lasting (multi-year) but eventually reversible impact on species / habitat / ecosystem. Full Business Unit response required (with corporate support). Immediate and on-going regulatory reporting / interface required.
5	Extensive	Extensive effect over large (regional) area e.g. major well blow-out. Permanent loss / irreversible damage to species / habitat / ecosystem. Full company corporate response. Immediate and on-going regulatory interface.

Table 35: Environmental Impact Assessment Matrix

Impact			Severity of Effect				
			1 Slight	2 Minor	3 Moderate	4 Major	5 Extensive
Sensitivity of Receptor	Very high	5					Very High
	High	4				High	
	Moderate	3			Moderate		
	Low	2		Low			
	Very low	1	Very Low				

Unplanned or Accidental Events

Should an unplanned or accidental event occur, it might result in unintended harm to the environment, therefore, unplanned or accidental events that have the potential to arise from planned project activities pose a risk to the environment. A distinction is made between planned and unplanned events in the assessment methodology in recognition of the potentially high consequence but generally very low likelihood of these types of impact.

Environmental risks must be controlled throughout the project. An environmental risk assessment (ERA) process is used to identify potential unplanned or accidental events that could arise from project activities and to determine steps that could be implemented to prevent or reduce the risk of the event occurring. The ERA process takes into account the environmental impact [sensitivity of receptor (Table 32 and Table 33), severity of the effect (Table 34)] and the likelihood of an unplanned or accidental event occurring (Table 36) (Morris & Therivel, 2009).

The significance of the environmental risk can therefore be 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

Environmental risks were therefore evaluated in two steps:

1. By assessing the level of environmental impact which would result from the unplanned / accidental event occurring.

2. By assessing the likelihood that the unplanned or accidental event will occur.

The risk was then ranked using the assessment matrix (Table 37) (impact vs. likelihood) to determine the overall level of risk the proposed activity could pose to receptors in the receiving environments. The overall significance for a particular risk was determined by taking the highest level of risk associated with the project activity against any one of the receptors/attributes. Risks were categorised as low, medium and high significance and are defined in Table 38.

Table 36: Guidelines for assessing the likelihood of an unplanned / accidental event occurring

Level	Likelihood	Frequency of an unplanned or accidental event occurring and impacting receptors during the project lifetime
A	Improbable	Impact almost never observed, few if any events in the industry
B	Remote	Has occurred previously in the industry however, breach of numerous controls would be required
C	Rare	Likely to occur less than once per year and more than once in 10 years
D	Possible	Likely to occur more than once per year
E	Frequent	Likely to occur at more than once per operation

Table 37: Environmental Risk Assessment Matrix

Risk			Likelihood				
			1 Improbable	2 Remote	3 Rare	4 Possible	5 Frequent
Impact	Very high	5	(yellow)	(yellow)	(red)	(red)	High (red)
	High	4	(green)	(yellow)	(yellow)	(red)	(red)
	Moderate	3	(green)	(yellow)	Moderate (yellow)	(yellow)	(red)
	Low	2	(green)	(green)	(yellow)	(yellow)	(yellow)
	Very low	1	Low (green)	(green)	(green)	(green)	(yellow)

Table 38: Definition and Implication of Significance Categories to the Project

Project Significance Level	Impact Significance Level	Impact Definition (planned events)	Risk Definition (accidental events)
High Significant	Very High Significance	• Serious concerns from consultees which cannot be resolved • Non-compliance with environmental legislation and company policy ➢ Impact unacceptable: Immediate action required to reduce impact to an acceptable level.	• Substantial environmental or socio-economic risk which cannot be reduced with the resources available to the project. ➢ Risk unacceptable: Immediate action required to alter project design to reduce risk to an acceptable level.
	High Significance		
Moderate Significant	Moderate Significance	• Concerns expressed by consultees which can be adequately resolved ➢ Impact acceptable: Identify opportunities for improvement through mitigation and controls.	• Risk-reduction measures available, which generally have a history of successful use and acceptance. • Evidence of adequate contingency planning and response capabilities for hydrocarbon spills or other emergencies. ➢ Risk should be reduced: Identify opportunities for improvement project controls.
Non-Significant	Low Significance	• No concerns from consultees ➢ Impact acceptable: No additional actions required beyond industry standard measures and controls.	• No or negligible environmental, socio-economic or technical risks ➢ Risk acceptable: Risk-reduction measures not required, or are industry standard.
	Very Low Significance		
Benefit	Beneficial	• Have a positive environmental or social impact. ➢ Impact acceptable	N/A

6.2.2 Uncertainty and Confidence in 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 adequacy of available data, knowledge, and understanding about the environmental component being assessed;
- The proposed technology;
- The nature of the project-environment interaction; and
- The efficacy of proposed mitigation (IAIA, 2013).

It is important to understand the level of confidence in the assessment so that where low to moderate levels of uncertainty exist appropriate monitoring may be determined, or, in the case of significant levels of uncertainty, additional analysis may be undertaken to more fully characterize the potential risk.

The level of confidence in the impact and risk predictions (in terms of the nature of the impact and its level of significance) is evaluated in each of the following impact assessment chapters and takes into account key characteristics of the impact (e.g. magnitude, extent, reversibility, duration, frequency and sensitivity of the receptor) (IAIA, 2013). For the purposes of this EIA, the degree of confidence that the impact will occur as predicted by the assessment (e.g. with regard to project description, sensitivity of receptors and nature of the impact is well understood, without large data gaps) was evaluated using the qualitative scale: *Certain, Probable, Unlikely* (IEEM, 2010). Project specific definitions have been developed for the degree of confidence in the assessment as described in Table 39.

The limitations in the baseline data have been described in the environmental baseline description (Chapter 5.0) and the implications for the confidence in the impact predictions has been evaluated in each of the following impact assessment chapters

Table 39: 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 in the monitoring data from previous projects. The status and sensitivity of the environmental 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.
Unlikely	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 environmental receptor is poorly understood and large data gaps exist.

6.2.3 Mitigation Measures and Monitoring

If the impacts and risks are deemed of moderate significance or above, they should be removed or reduced through design or the adoption of operational measures (mitigation). Following mitigation, there may be residual impacts that must be described. Where there are uncertainties concerning the significance of impacts or the effectiveness of proposed mitigation measures, monitoring should be undertaken.

Mitigation

Mitigation measures aim to avoid, reduce, remedy or compensate for the predicted significant adverse impacts of the project (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, options to avoid and reduce should be considered or implemented before those to remedy or compensate the impact. Mitigation measures can be classified by the mitigation hierarchy (e.g. project alternatives, physical design measures, management measures or deferred mitigation) and by different project phases. It is important that mitigation measures are designed with monitoring in mind to ensure that the effectiveness of the measures can be evaluated.

Monitoring

Opportunities for monitoring will be identified throughout the impact assessment process. Where measuring and recording physical variables, and the occurrence and magnitude of impacts associated with the predicted exploration impacts could improve impact understanding and / or mitigation measures, monitoring should be carried out. Monitoring the appropriate variables can 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). Additionally, where there are data gaps, monitoring could provide additional information relating to the nature of the impact. Monitoring activities will be focused on the environmental aspects that are considered to pose a moderately significant environmental impact, or those activities, which have been highlighted as a particular concern by stakeholders.

Monitoring is also essential for effective environmental impact auditing, which involves comparing the impacts predicted in the EIA with those that actually occur during the project execution phase.

6.2.4 Residual Impacts

Mitigation measures are proposed where environmental impacts and risks are assessed to pose an unacceptable risk or impact level to the receiving environment. The purpose of the measures is to reduce the impact to an acceptable level for the project to go ahead. It is therefore necessary to re-evaluate the environmental impact or risk following the application of the mitigation measure. The project activities that have been identified as posing a significant impact or risk to the environment are considered in detail in the following chapters. Where appropriate mitigation and monitoring measures are recommended, an assessment of the residual (post-mitigation) environmental impact (i.e. risk following application of the mitigation measures) are performed using the methodology and criteria described above. Effective mitigation measures should reduce the level of environmental impact or risk.

6.2.5 Project Environmental Management Plan

The monitoring and mitigation measures identified during the EIA process will form the basis of a Project Specific Environmental Management Plan (EMP; NEFL, 2015a) that will be implemented throughout the various phases of the project. The EMP sets out the actions that are needed to manage the environmental risks associated with the lifecycle of the project, identifies what is needed, when they should be implemented, the achievement criteria, and who is responsible for the delivery (IEMA, 2008).

The basis for the NEFL EMP is detailed in Section 14.2 and incorporates the actions identified in the preceding Sections.

6.3 Outcome of the Evaluation of Potential Impacts

This section presents the results from the identification and scoping of environmental impacts from the proposed Rhea-1 well drilling campaign. The identification of potential impacts and risks and the determination of their significance have been undertaken using the methodology outlined in Section 6.2.

An environmental impact identification workshop (ENVID) was undertaken involving specialists from a variety of disciplines. The objective of the ENVID was to identify the environmental aspects associated with the drilling campaign and their possible environmental impacts and risks, and to discuss control and mitigation measures. The activities associated with the Rhea-1 well can be grouped into the following categories to summarise the main groups of activities:

- Rig and vessel operations (including logistical support vessels / standby tugs / offshore supply vessel)
- Helicopter operations
- Shore based operations
- Drilling operations
- Accidental and emergency events

The project activities and unplanned or accidental events that were identified through the environmental impact and risk assessment process as requiring further consideration in the EIA are listed below:

- Generation of underwater noise (Chapter 6.0);

- Generation of atmospheric emissions (Chapter 8.0);
- Generation of light offshore, attracting seabirds and marine life (Chapter 9.0);
- Onshore and inshore impacts (Chapter 10.0);
  - Interference to other users of the sea from increased vessel traffic in Stanley Harbour;
  - Collisions between support or supply vessels and marine mammals;
  - Introduction of marine invasive species;
  - Disturbance to wildlife, livestock and local population onshore from helicopter noise;
  - Introduction of terrestrial invasive species with cargo imports;
  - Disturbance to wildlife and local residents from shore base light and noise;
  - Demands for accommodation in Stanley;
- Waste management (Chapter 11.0);
- Discharge of drilling mud and cuttings (Chapter 12.0); and
- Accidental events (Chapter 13.0)
  - Significant loss of containment from an uncontrolled release or from rig failure to maintain location on DP;
  - Loss of rig or vessel resulting from collision.

Where impacts or risks were identified as having a moderate, or higher, level of significance they are taken forward for a more detailed assessment, including identification of mitigation measures, evaluation of residual risk or impact, level of confidence in the assessment and potential cumulative impacts. In addition to the impact and risk assessment process, aspects were automatically taken forward for detailed assessment if they were identified as:

- Being of concern by consultees; and/or
- Identified in Falkland Islands Government *Field Development Environmental Impact Statement Guidelines* (DMR 2012).

Chapter 14.0 provides a summary of the assessment justification for all aspects identified in the ENVID, in particular this includes activities that were screened out from further assessment as they were determined to have low impact or risk. This information informs the development of the project EMP.

Table 40: Summary of Pre-Mitigation Environmental Impact and Risk Evaluation of Activities Associated with Rhea-1 Drilling Campaign

Lilac	Benefit
Green	Non-significant impact
Yellow	Moderate significant impact
Red	High significant impact
Blue	Subject of separate EIA

Environmental Aspect	Air quality (Local)	Climatic Factors (GHG's)	Soil (including the seabed)	Water quality	Benthic & terrestrial ecology	Plankton	Fish ecology	Seabirds	Marine mammals	Commercial fisheries	Human Population	Landscape and seascape	Waste landfill	Architecture and archaeology	Designated Sites	Transboundary impacts	Cumulative impacts	Stakeholders	Regulatory
Rig and vessel operations offshore																			
Underwater noise and vibration from DP thrusters during rig and vessel movements						Green	Green	Green	Yellow								Green		
Temporary placement of rig clump weight and transponders on the seabed			Green		Green														
Physical presence of the rig and vessels										Green								✓	
Generation of light on rig and support vessels offshore						Green	Green	Green	Green									✓	
Atmospheric emissions from power generation during rig and vessel movements	Green	Green		Green							Green						Green		✓
Discharges of vessel drainage, firewater, sewage and galley waste from rig and vessels				Green		Green	Green	Green											
Discharge of closed drains following separation, and firewater foam to sea during system test				Green		Green	Green	Green											
Drilling Operations																			
Discharge of drill cuttings, WBM, cement and chemicals to marine environment			Green	Green	Green	Green	Green		Green										✓
Generation of non-hazardous and hazardous waste for disposal in UK/FI													Green						✓
Use of Stanley domestic water supply for preparation of drilling mud				Green														✓	
Intake of seawater to make potable water on the rig				Green		Green	Green												
Discharge of heated seawater from heating /cooling medium or Reverse Osmosis unit				Green		Green	Green												
Generation of noise and vibration during drilling, cutting casing and well plug & abandonment							Green	Green	Green										
Generation of noise and vibration during Vertical Seismic Profiling (VSP) operations						Green	Green	Green	Yellow										

Table 40 continued: Summary of Pre-Mitigation Environmental Impact and Risk Evaluation of Activities Associated with Rhea-1 Drilling Campaign

Lilac	Benefit
Green	Non-significant impact
Yellow	Moderate significant impact
Red	High significant impact
Blue	Subject of separate EIA

Environmental Aspect	Air quality (Local)	Climatic Factors (GHG's)	Soil (including the seabed)	Water quality	Benthic & terrestrial ecology	Plankton	Fish ecology	Seabirds	Marine mammals	Commercial fisheries	Human Population	Landscape and seascape	Waste landfill	Architecture and archaeology	Designated Sites	Transboundary impacts	Cumulative impacts	Stakeholders	Regulatory
Activities Onshore and Inshore																			
Atmospheric emissions from power generation during vessel movements	Green	Green									Green						Green		✓
Physical presence of shore base and use of land resource			Green		Green						Green			Green	Green				
Generation of light during 24hr operations								Green			Yellow								
Generation of noise during 24hr operations								Green			Green								
Generation of waste for transportation to landfill in UK/FI													Green						
Use of local electrical and water resources for operation of the shore base	Green	Green		Green							Green							✓	
Demands for temporary accommodation in Stanley											Blue							✓	
Physical presence of vessels interfering with other users of Stanley Harbour										Yellow	Green							✓	
Introduction of marine invasive species from existing marine growth on rig and support vessel			Green	Green	Yellow														✓
Introduction of marine invasive species from rig and vessel ballast water (including Stanley Harbour)			Green	Green	Yellow														✓
Collision between support or supply vessel with marine mammals									Yellow										✓
Introduction of terrestrial alien species at shore base via equipment import from UK			Yellow		Yellow						Yellow								✓

Table 40 continued: Summary of Pre-Mitigation Environmental Impact and Risk Evaluation of Activities Associated with Rhea-1 Drilling Campaign

Lilac	Benefit
Green	Non-significant risk
Yellow	Moderate significant risk
Red	High significant risk
Blue	Subject of separate EIA

Environmental Aspect	Air quality (Local)	Climatic Factors (GHG's)	Soil (including the seabed)	Water quality	Benthic & terrestrial ecology	Plankton	Fish ecology	Seabirds	Marine mammals	Commercial fisheries	Human Population	Landscape and seascape	Waste landfill	Architecture and archaeology	Designated Sites	Transboundary impacts	Cumulative impacts	Stakeholders	Regulatory
Crew Presence and Transportation																			
Gaseous emissions from engine power generation for charter flight and minibus transfer	Green	Green									Green						Green		✓
Generation of noise, flight path over sensitive seabird colonies, livestock grazing areas and local communities								Yellow			Yellow								
Presence of oil industry workers in Stanley impacting availability of temporary/hotel accommodation											Blue								
Presence of oil industry workers in Stanley could result in antisocial behaviour by transitory workers											Blue								
Presence of oil industry could have adverse effect on Falkland Islands as a tourist destination											Green							✓	
Charter flights potentially supporting local freight options											Lilac								
Unplanned event																			
Dropped objects			Green		Green														✓
Accidental minor spill of diesel/oil/ chemical during loading operations				Green		Green	Green	Yellow										✓	✓
Storm water overwhelming rig deck drains resulting in discharge of contaminated water				Green		Green	Green	Green											✓
Unplanned discharge from rig open or closed drain system				Green		Green	Green	Green											✓
Accidental Events																			
Vessel collision in Stanley Harbour				Green	Green	Green	Green	Green	Green	Green								✓	✓
Emergency situation leading to significant loss of containment	Green		Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow			Green		Green	Green		✓	✓
Loss of containment of drilling mud from riser due to rig failing to maintain station			Green	Green	Green	Green	Green											✓	✓
Major rig incident resulting in loss of rig			Green	Green	Green	Green	Green	Green	Green	Green								✓	✓
Major vessel incident resulting in collision with rig or another vessel and loss of diesel inventory				Green	Green	Green	Green	Yellow	Yellow									✓	✓

7.0 Underwater noise

7.1 Introduction

The properties of sound in water (range and speed) are exploited by many marine animals. 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. Marine animals have evolved to use sound as a means of communication, navigation and detecting prey or predators. Specifically, the toothed whales have developed sophisticated bio-sonar capabilities to feed and navigate; the large baleen whales have developed long-range communication systems using sound in reproductive and social interaction; and the pinnipeds (seals) make and listen to sounds for critical communicative functions (OSPAR, 2009a). Man-made noise in the marine environment can interfere with these processes and is recognised as having potentially serious consequences for marine animals. Despite growing awareness, this is still an area that has received little dedicated research, largely due to the difficulties of observing and measuring the impact on animals in the marine environment.

In recent years, there have been a number of comprehensive reviews written that investigate the sources of underwater noise generated by the oil and gas industry (Genesis, 2011) and the implications of anthropogenic noise on marine animals (OSPAR, 2009a; NOAA, 2013). These reviews provide much of the information that forms the basis of this impact assessment. It should be stated that currently this is an area that is poorly understood, however, it is clear that excessive exposure to anthropogenic underwater noise has the potential to cause harm to marine animals. In these cases, underwater noise should be regarded as a form of pollution. Very little is known about the long-term implications of anthropogenic noise in the marine environment and therefore a precautionary approach is required.

This chapter provides an assessment of the potential impacts of underwater noise generated during the Rhea-1 well drilling campaign. The assessment identifies and characterises the sources of underwater noise that will be generated during the exploration drilling (much of the noise will be generated as a consequence of vibrating machinery); and identifies the sensitive environmental receptors within the zone of influence.

7.2 Sources of Underwater Sound during the Drilling of the Rhea-1 Exploration Well

7.2.1 Description of Sound Characteristics

The field of underwater acoustics is full of technical terminology; Table 41 provides definitions of the terms used in this Chapter.

7.2.2 Ambient Sound in the northern Licence Blocks

Between July 2012 and July 2013, an array of hydrophones was deployed within the region of the northern Licence Blocks (see Hipsey et al., 2013 for full details). Along with the vocalisations of marine mammals, ambient noise both natural (for example, wind, waves and rain) and anthropogenic (shipping) were 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.

Noise events assessed as being caused by vessel traffic were infrequent and sporadic, except during the second half of February. During this period an increased but still small number of detections were made. This corresponds broadly with the findings of the White et al. (2002), who only recorded fishing vessels in the area between February and June, and then in very small numbers.

In overall ambient noise terms, the NFB was relatively quiet compared to five other locations where similar projects have been conducted elsewhere in the world (Hipsey et al., 2013).

Table 41: Definitions of terms found in the text

Term	Definition
Hz	Hertz; measurement of sound frequency (cycles per second).
TTS	Temporary Threshold Shift, A temporary, reversible increase in the threshold of audibility at a specified frequency or portion of an individual's hearing range
PTS	Permanent Threshold Shift; a permanent, irreversible increase in the threshold of audibility at a specified frequency or portion of an individual's hearing range
dB (re. 1μPa)	deciBel; An expression of sound pressure (Newtons m^{-2}) on a logarithmic scale, re. 1μPa indicates a reference pressure for underwater sound.
dB_{ht} (generic)	The generic (for all species) hearing threshold, the detectable sound intensity. These values are frequency specific and are expressed as an audiogram.
Source level	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	Intensity of a sound at any given point, expressed in dB re. 1 μPa.
Transmission Loss	The change in signal strength as a sound wave spreads from a source. A combination of geometrical spreading and attenuation.
Perceived Sound	The sound level perceived by a receptor. Expressed as: Sound Pressure Level – dB_{ht} (generic)
Sound Exposure Level	A measure of the energy of a sound, and is therefore related to Sound Pressure Level and time (exposure)

7.2.3 Characterising the Sources of Anthropogenic Sound during the Rhea-1 Campaign

The main sources of noise associated with the operations and activities during the 2015 exploration drilling campaign have been identified as:

- Coasters transiting from the UK to Stanley;
- OSVs/PSVs transporting materials and equipment to and from the field;
- ERRV providing support to the drilling rig in the field throughout the campaign;
- Rig transit to the site and between well locations, and maintaining position during drilling operations;
- Drilling operations;
- Vertical Seismic Profiling.

Supply and Coaster vessels

Shipping is a widespread and common source of low frequency sound in the marine environment. The nature of the sounds produced depends on a vessel's type, size, mode of propulsion, speed and a range of operational characteristics. It has been estimated that while steaming 85% of a vessel's noise is due to propeller cavitation (Barlow and Gentry, 2004). When alongside the rig, OSV/PSVs will maintain their position with the aid of dynamic DP thrusters. Vessels operating on DP generate considerably more noise than when using conventional forms of propulsion (stern propellers).

Coaster vessels will transit from the UK to Stanley prior to the start of drilling operations. The rig will also be serviced by two OSV/PSVs as the well is drilled, these vessels generally produce low frequency noise (<1 kHz) in the range of 136-190 dB (re. 1μPa) depending on the vessel's size and activity (Genesis, 2011). The range of frequencies produced overlap with those utilised by many marine animals, particularly baleen whales and pinnipeds (Figure 46) but also fish.

The vessels will run between Stanley and the rig on a rotational basis, on average an OSV/PSV will visit the rig every five to seven days.

Emergency Response and Rescue Vessel (ERRV)

An ERRV (standby or guard vessel) will be on station, in close proximity to the rig, at all times to be able to assist in the case of emergencies and maintain a 500 m exclusion zone around the rig. These vessels are often dedicated to the task and are relatively small and inactive compared with the rig, therefore, the level of sound produced by ERRV is generally lower than the rig. However, the age and condition of a vessel will also influence frequency and intensity of sounds produced.

An ERRV will be on station, near the rig, at all times. Periodically (every 4-6 weeks), the ERRV will steam to Stanley to bunker fuel, take on stores and change crew members. At these times, one of the supply vessels will replace the ERRV on standby.

Rig positioning

The drilling operations will be conducted from the *Eirik Raude*, a semi-submersible drilling rig, which is supported by pontoons that are partially submerged in the water. The rig will be held on station by DP thrusters and will not be anchored to the seabed.

There are few published data to indicate the intensity of sound produced by semi-submersible rigs under varying conditions. One of the few documented examples is presented in Nedwell and Edwards (2004), who took measurements of the semi-submersible drilling rig, *Jack Bates*, in deep water northwest of the Shetland when the rig was drilling and on location. During both drilling and non-drilling periods there was a peak noise level at about 10 Hz with other low frequency tonal signals being detected in the range 10 - 600 Hz. It was found that the use of DP thrusters, and the associated cavitation noise, caused a significant elevation of the low frequency sounds from 3 - 30 Hz by about 30 dB (Table 42). There was significant variation in the broadband noise during non-drilling periods this was attributed to the operation of specific types of machinery.

The drilling schedule is outlined in Chapter 3.0. In summary, the Rhea-1 well will take approximately 38 days to complete, (20 drilling days). Throughout this time the rig will be maintained on station by DP thrusters. Drilling of the well is currently expected to take place in August and September (the rig has been operating in the NFB since March 2015 and will continue working in the Falklands until November 2015. The *Eirik Raude* is self-propelled and will transit between wells under its own power.

Drilling operations

Underwater sound is generated from drilling rigs through the transmission of vibrations from machinery and drilling equipment (such as; pumps, compressors and generators) that are operating on the rig. Additionally, the action of the drill on the substrate creates additional vibration and sound, which is dependent on the substrate type.

The few published examples indicate that drilling will increase the sound source pressure level. For example, sound from the semi-submersible rig *Ocean General* in the Timor Sea was measured during periods when the rig was drilling and not drilling (McCauley, 1998; reviewed in Genesis 2011). During non-drilling periods the typical broadband level encountered was ~113 dB re 1µPa@125m with various tones from the machinery observable in the noise spectra. During drilling periods the broadband noise level increased to the order of 117 dB re1µPa@125m. An approximate 4 dB increase at 125 m would equate to an approximate increase of 42 dB in Source Level. The frequency of sound generated by semi-submersible rigs is primarily in the range of 10 – 500 Hz.

Vertical Seismic Profile (VSP)

Underwater sound is generated during a VSP by the release of high-pressure air from devices called airguns. The air forms an expanding bubble; the rapid expansion of this bubble generates the seismic wavefront.

An array of 3-4 airguns (totalling less than or equal to 1,000 cubic inches in volume) will be used during VSP operations. The peak in sound pressure generated is likely to be in the region of 240 dB (re. 1µPa), focused between 10–150 Hz but also includes a higher frequency component. The survey consists of a number of shot points, approximately 75 m apart. At each point, a series of 3-5 shots are made before the geophones are relocated to the next spot point. It takes about 15 minutes to complete each shot point; take the shots, record the data and move onto the next point. It is estimated that this procedure will take 12-15 hours (1.6-2.5% of the campaign). This procedure is standard working practice within the oil and gas industry around the world.

Genesis (2011) present recorded sound pressure levels from a range of different sized airguns. The sound intensity is related to the volume of the airgun, array configuration and air pressure.

Well abandonment

Exploration wells are usually abandoned once the quality and quantity of any hydrocarbons found has been evaluated, or drilling is complete. There is currently no intention to flow or suspend the wells for future use. At the end of the drilling operations, it is therefore intended that the wellhead will be severed and sealed. This will entail the cutting of the well casing approximately three metres below the seabed. The cutting process will introduce another source of anthropogenic sound into the marine environment; however, this is anticipated to be a low intensity sound source and the operation should only take 20 minutes.

Table 42 gives representative examples of the sound sources generated by the type of activity proposed during the Rhea-1 Campaign. Where appropriate, a range of values is given to reflect values cited in the literature, (see Genesis, (2011) and OSPAR, (2009a) for further examples).

Table 42: Characterisation of anthropogenic sounds associated with the Rhea-1 Campaign

Sound source	Source sound pressure level (dB re 1µPa)	Range of highest sound pressure (Hz)	Total Bandwidth of source sound (Hz)	Duration (ms)	Directionality	Source
OSV/PSV steaming	164	<1,000	6->30,000	Continuous	Omnidirectional	Genesis 2011
OSV/PSV on DP	184-190	<1,000	6->30,000	Continuous	Omnidirectional	Genesis 2011
ERRV	136-180	<1,000	6->30,000	Continuous	Omnidirectional	Genesis 2011
Rig on DP, not drilling	160	<100	10-10,000	Continuous	Omnidirectional	Nedwell and Edwards 2004
Rig on DP, drilling	188	<100	10-10,000	Continuous	Omnidirectional	Nedwell and Edwards 2004
VSP	230-240	10-120	10-100,000	30-60	Vertically focused	Genesis 2011

7.3 Environmental Receptors in the NFB

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, navigate and detect potential prey or predators.

There has also been some research into the impacts of noise directed at marine fish and cephalopods. Most of the fish species studied are able to emit and detect sounds that are less than 1 kHz. Some cephalopods are known to be sensitive to infrasound (<20 Hz) with an upper hearing limit of 200 Hz (OSPAR, 2009a). These ranges fall within the scope of anthropogenic sounds produced during oil and gas related activities. Several studies have been undertaken to consider any potential effects of seismic surveys on marine fish species, and the results show that harm to individual fish and increased mortality from firing airguns can occur at distances up to 5 m, with most frequent and serious damage within 1.5 m. Fish in the early stages of life are most vulnerable (OSPAR, 2009a), however, so far only a few fish and cephalopod species (and sometimes only a few individuals of these species) have been investigated. Consequently, our knowledge in this field is still very limited. In comparison to the impact of commercial fisheries on fish and cephalopod species in Falklands waters, the impact of sound during the drilling of the Rhea-1 well is considered to be negligible.

Although there is also limited information regarding the effect of anthropogenic sound on marine mammals, their protected status and known presence in the area around the Rhea-1 well site mean that a thorough assessment of the potential impact on these animals is required. On this basis, the following impact assessment will focus on marine mammal species.

7.3.1 Marine Mammals in the NFB

At least 14 species of cetacean and at least three species of pinniped were recorded by White et al. (2002) within Falkland Islands waters. An additional 12 species of cetacean (mostly species of beaked whale) are known from strandings and rare sightings within Falklands waters (Otley et al., 2011, Falklands Conservation, 2013). Marine mammal observations from seismic vessels in early 2011 (Geomotive and MRAG, 2011; Polarcus, 2011) add to and confirm earlier at-sea observations. In order to improve the knowledge of cetacean distribution and abundance in the NFB, an array of hydrophones were deployed in the area between July 2012 and July 2013 (Hipsey et al., 2013). Combined, these sources provide a good indication of the seasonal abundance of marine mammal species in the region (see Biological Description chapter, Section 5.4.5).

In the Falkland Islands, all marine mammals are protected by law under the Marine Mammal Act 1992 and internationally under the Convention on Migratory Species. Fin and sei whales, two regularly observed species in the NFB, are both classified as Endangered by the IUCN (Reilly et al., 2008; Reilly et al., 2013). Although the Rhea-1 well will coincide with the period with lowest marine mammal abundance in Falklands waters (in August during the austral winter), some species, particularly long-finned pilot whale and fur seals, are most numerous at this time (Section 5.4.5).

7.3.2 The Hearing Thresholds of Marine Mammals

Cetaceans are known to emit sound over a large range of frequencies from 10 Hz in the blue whale to 200 kHz in some dolphins (OSPAR, 2009a). However, the hearing range of species is likely to extend beyond the emitted sound range. Different species of marine mammal are sensitive to different ranges of frequencies (graphical descriptions of a species' range are shown in Figure 46). Therefore, the range of frequencies utilised by an assemblage of marine mammal species can be very extensive. The auditory range of species can only be determined through field observations, which are extremely difficult in the marine environment. Consequently, the full range of vocalisations used by many species encountered in the southwest Atlantic is poorly understood (Hipsey et al., 2013).

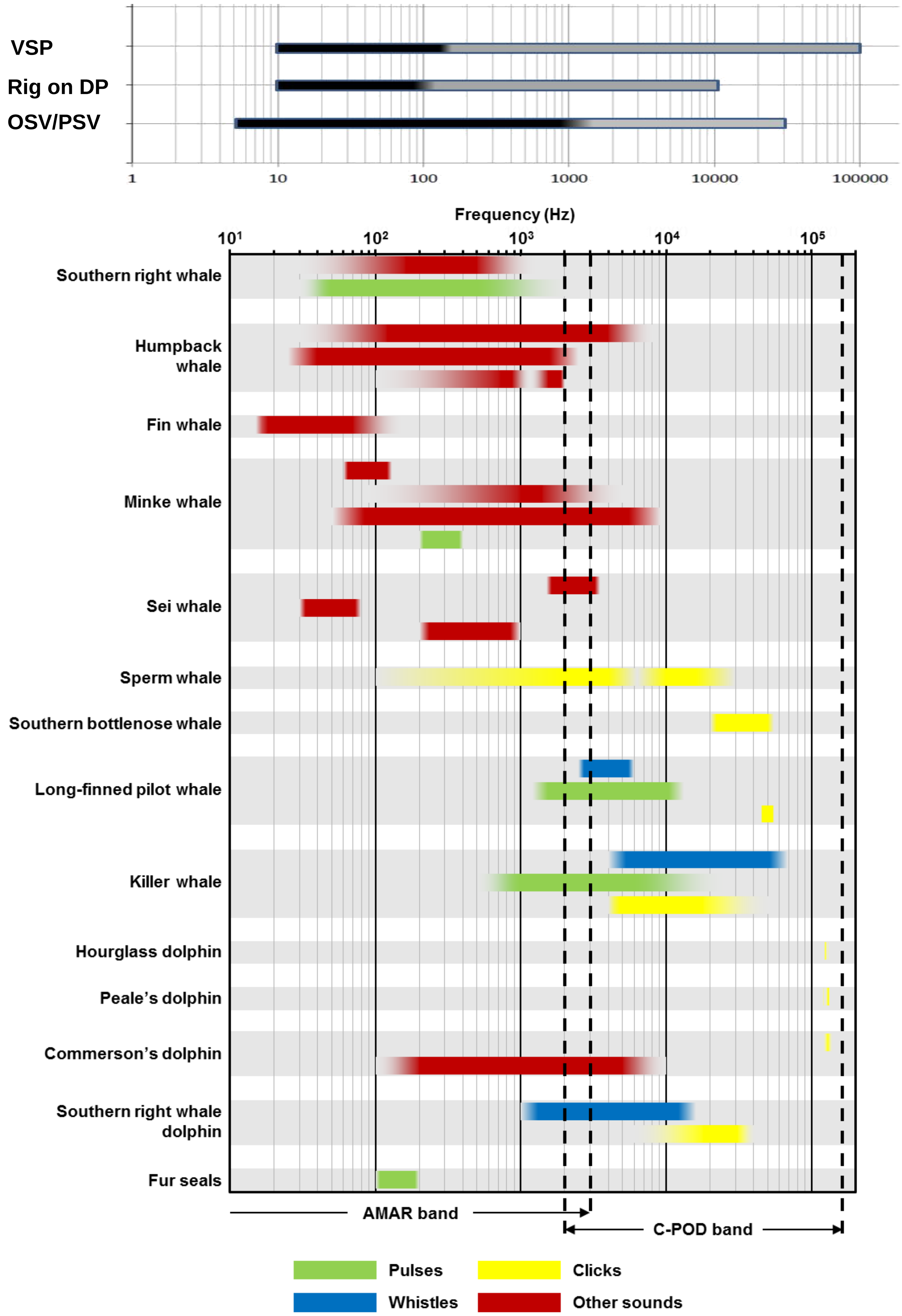


Figure 46: Frequency bands of species' vocalisations with AMARs and C-POD click operating bands (from Hipsey et al., 2013) and anthropogenic sounds associated with the Rhea-1 Campaign

Figure 46 also shows the range of frequencies emitted by anthropogenic activities. Although these sounds may cover a wide range of frequencies, peak sound pressure (loudness) occurs over specific parts of the frequency scale (usually in the region of 100 Hz). These sounds overlap with those utilised by baleen whales and pinnipeds, such as fur seals, and to a lesser extent with toothed whales, which use higher frequencies. In order to help classify marine mammals according to the frequency ranges that they employ, the National Oceanic and Atmospheric Administration (NOAA, 2013) have proposed five functional hearing groups (Table 43).

Table 43: Marine mammal functional hearing groups (from NOAA, 2013)

Functional Hearing Group	Functional Hearing Range*	Range of highest sensitivity
Low-frequency cetaceans (baleen whales)	7 Hz to 30 kHz	500 Hz to 1 kHz
Mid-frequency cetaceans (dolphins, toothed, beaked and bottlenose whales)	150 Hz to 160 kHz	20 kHz to 40 kHz
High-frequency cetaceans (true porpoise, Commerson's, hourglass and Peale's dolphin)	200 Hz to 180 kHz	30 kHz to 40 kHz
Phocid pinnipeds (true seals)	75 Hz to 100 kHz	500 Hz to 20 kHz
Otariid pinnipeds (sea lions and fur seals)	100 Hz to 40 kHz	500 Hz to 6 kHz

*Represents frequency band of hearing for entire group as a composite, individual hearing ranges are typically not as broad.

7.3.3 Sensitivity of Marine Mammals to Anthropogenic Sounds

There are a number of potential effects of underwater noise on marine mammals, they can broadly be classified as; masking, behavioural disturbance, hearing loss, discomfort/stress, tissue trauma and; in extreme cases, death. The strength of the effect depends on the intensity of the sound experienced by the receptor, which is related to the sound source intensity, distance of the receptor from the sound source, sound frequency and length of exposure. If a sound source is sufficiently powerful to impact on marine mammals the distance between the source and the receptor is a key factor.

Masking

Masking occurs when anthropogenic sounds impair the ability of marine mammals to detect biologically significant sounds, such as communication calls, echo-location clicks or passive environmental sounds used in navigation or prey detection.

Behavioural disturbance

Behavioural disturbance is usually detected by changes in activity due to sound; these can range from strong avoidance behaviour 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 motivational state. For example, animals that are engaged in feeding may be more reluctant to change behaviour, move away from a food source, when subjected to noise.

Hearing loss

In more extreme cases, underwater noise may result in hearing loss, which could have severe consequences for animals, through impaired communication, navigation and abilities to detect prey and predators. Hearing loss is likely to be over a specific range of frequencies and can be classified as either; TTS (Temporary Threshold Shift) or PTS (Permanent Threshold Shift). Recovery from TTS can occur over a relatively short period, hours or days, PTS results in tissue or structural damage and is permanent. Attempts have been made to set threshold values for TTS and PTS in different species (see below). It is likely that behavioural changes will occur at thresholds below the TTS.

Discomfort / stress

There is limited information regarding stress in marine mammals as it is very difficult to measure. However, Rosalind et al. (2012) have recently published results that correlate changes in stress related hormones with changes in the density of shipping traffic. The long-term impacts of noise induced stress are unknown.

Tissue damage

Like many areas of marine mammal science, research on the non-auditory effects of sound on marine mammals is in its infancy (OSPAR, 2012). However, there is evidence of damage to non-auditory swim-bladder and muscle tissue in fish, and enhanced gas bubble growth and traumatic brain injury in fish and marine mammals (see Richardson et al., 1995; Hastings and Popper, 2005 for review). It has been proposed that avoidance 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, 2009a).

7.4 Characterising and Quantifying the impact of underwater sound on marine animals

By comparing the auditory range of each species with the range of anthropogenic sounds generated during the Rhea-1 drilling campaign (Table 42), it is possible to identify the species that are potentially at risk of disturbance (see Table 43 and Figure 46). The anthropogenic sounds that will be generated during the campaign are of low frequency (most anthropogenic sounds in the marine environment peak at around 100 Hz; OSPAR, 2009a; Hipsey et al., 2013) and overlap with the auditory range of low-frequency cetaceans (baleen whales) and pinnipeds, therefore these species are most likely to be impacted.

Impact assessments are generally concerned with those man-made activities that overlap in frequencies with the hearing range of marine organisms in question. An exception has to be made for very loud sounds. In these cases, the peak sound pressure is decisive and the frequency becomes less relevant. The source sound pressure level of a VSP airgun falls into this category.

Using a precautionary approach, worst-case scenario, with the data available, it is possible to broadly assess whether an impact is likely to occur from the proposed activities.

Within their auditory range, each species of marine animal shows different sensitivity to different sound frequencies. A species' sensitivity to each sound frequency can be determined through experimentation and is plotted as an audiogram. The hearing sensitivity of very few individuals of few species, of marine animals, has been measured and therefore it is not possible to assign an audiogram to any of the species that are likely to be present in the NFB. For instance, to date there are no audiograms for baleen whales. Comparative studies on humans indicate that there is considerable variation in the hearing sensitivity of individuals and it is likely that the same applies to marine animals (David, 2011). With these considerations in mind and taking a precautionary approach, it is possible to take all of the available data to produce a generic audiogram (as described by David (2011)). This approach uses the minimum hearing sensitivities of a range of marine species and also takes into account ambient environmental noise levels (Figure 47).

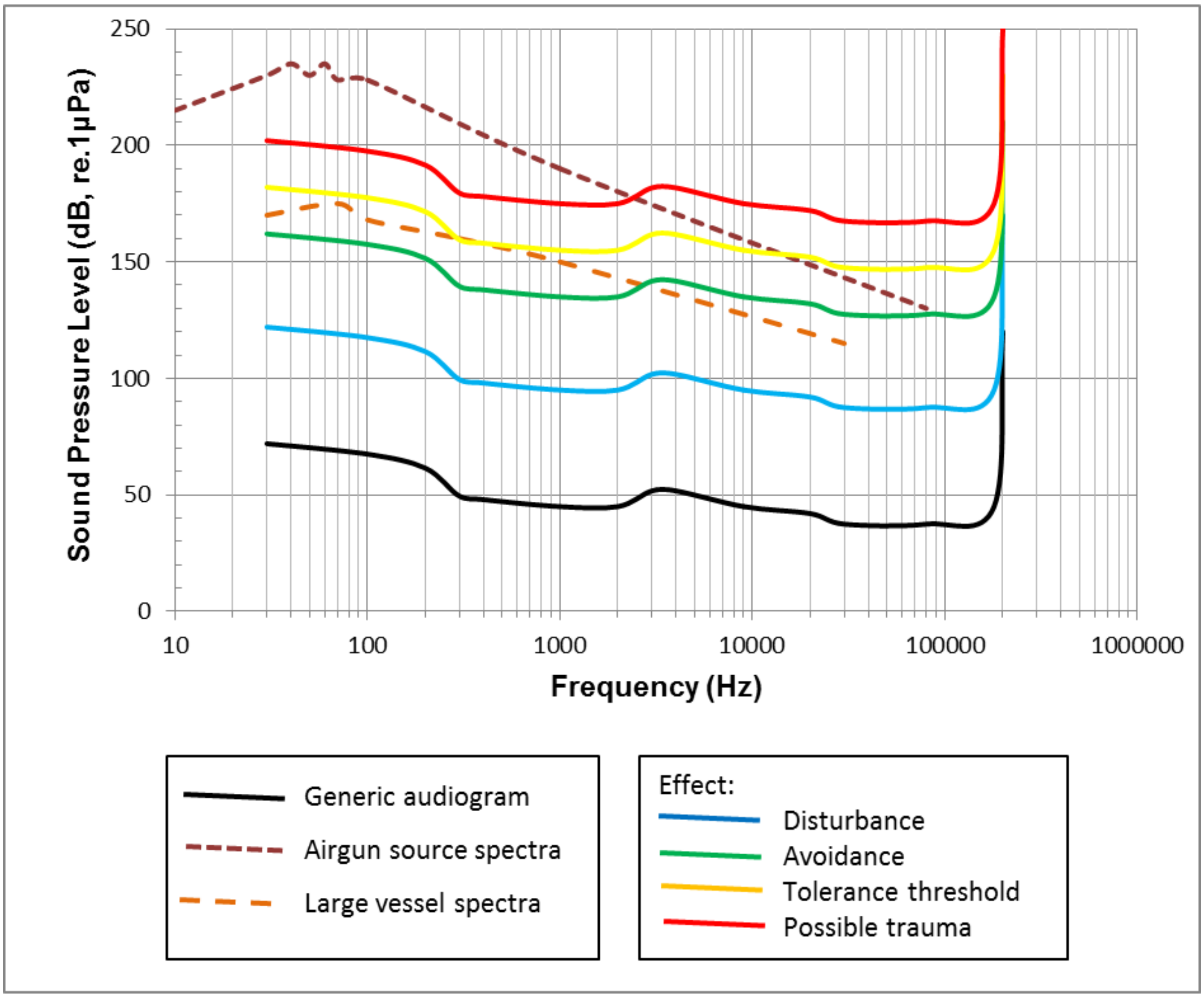


Figure 47: A generic audiogram for marine animals (adapted from David 2011) indicating increasing sound effect levels (from Nedwell et al., 2007), and anthropogenic sound pressure levels at source.

The intensity of a perceived sound by a particular species (known as dB_{ht}(*Species*)) is a function of the emitted sound level (dB, re.1µPa) and the species' hearing threshold at that particular frequency (perceived sound is the intensity above the hearing threshold). For example, in Figure 47 the generic hearing threshold at 100 Hz is approximately 70 dB, therefore an animal exposed to a sound with frequency of 100 Hz and intensity of 120 dB, re.1µPa will effectively be exposed to a perceived sound intensity of 50 dB_{ht} (*generic*). Any sound that falls below the dB_{ht}(*generic*) line on the generic audiogram will not be heard, sounds above the line will be perceived as increasingly louder noise.

Nedwell et al. (2007) reviewed the available literature and defined broad categories describing the response of individuals to different sound levels, which are described in Table 44 and illustrated on Figure 47. The recorded source sound profiles for airguns, used in VSP operations, and large vessels are also illustrated on Figure 47 to give an indication whether the sound levels associated with the Rhea-1 well will elicit behavioural responses or exceed the limits of tolerance and possible trauma for the animals present.

The generic audiogram and source sound pressure levels indicate that if a marine mammal were adjacent to the airgun when it was fired it would be likely to experience traumatic hearing damage, as the peak sound pressure level for the airgun exceeds the 'Trauma' threshold. Similarly the presence of vessel sound is also likely to result in avoidance behaviour. However, these examples illustrated in Figure 47 do not account for the distance that a marine mammal may be from the source sound, the attenuation of sound with distance from source is described in Section 7.4.

Table 44: Behavioural and Physiological Response by Marine Mammals to Increasing Perceived Sound Levels, suggested by Nedwell et al. (2007)

Perceived Sound Level (dB_{ht} (*Species*))	Behavioural and Physiological Effect
Less than 0	None; sound imperceptible
0 to 50	Mild reaction in minority of individuals, probably not sustained
50 to 90	Stronger reaction by majority of individuals, but habituation may limit effect
90 and above	Strong avoidance reaction by virtually all individuals
Above 110	Tolerance limit of sound; unbearably loud
Above 130	Possibility of traumatic hearing damage from single event

7.4.1 Methodology to Estimate the Perceived Sound Level with Distance from Source

In order to provide an objective and high-level quantitative assessment of the degree of environmental effect, it is necessary to estimate the sound level as a function of distance. The propagation of sound in water is complicated by a number of factors. The sound from a source can travel through the water both directly and by means of multiple bounces between the surface and seabed. Sound may also travel sideways through the rocks of the seabed, re-emerging back into the water at a distance. Refraction and absorption (influenced by salinity, temperature and pressure) further distort the impulse, leading to a complex sound wave arriving at a distant point, which may bear little resemblance to the sound wave in the vicinity of the source.

Accurately predicting the level of sound at a point away from a source is therefore extremely difficult, and use is generally made of simple models or empirical data, based on measurements, for its estimation. Here we follow the procedure outlined in OSPAR (2009a) for calculating transmission loss and therefore Sound Pressure Level at the receptor:

$$\text{Sound Pressure Level at receptor} = \text{Source pressure Level} - \text{Transmission Loss}$$

Where:

- the Source Level, is the pressure level of sound generated by the source, and
- the Transmission Loss, is the rate at which sound from the source is attenuated as it propagates.

Transmission Loss is estimated by the equation:

$$\text{Transmission Loss} = N_{log}(r) - \alpha r$$

Where:

N = a coefficient relating to geometrical spreading (20 assuming spherical spreading OSPAR, 2009a)
r = range in metres
α = absorption coefficient, which is frequency dependant.

For low frequency sounds (<1,000Hz), such as those predicted during the exploration drilling campaign, the absorption coefficient is negligible at ranges less than 10 km and will be therefore treated as zero here (OSPAR, 2009a).

Obtaining accurate measures of the anthropogenic sound sources under investigation is not straight forward. There are relatively few published records of the sounds generated by semi-submersible rigs and OSV/PSVs in different operational modes (see Genesis, 2011 for review).

The data presented here was selected to be generally representative of the types of vessel and rig operating during the campaign (Table 42).

There is a little more information available regarding the source pressure levels of airguns, where the size (ranging between 20 - 800 cubic inches for single airguns) and air pressure (generally 2,000 - 2,500 psi) influences the source sound. Additionally, airguns are directional; most of the energy is focused vertically downwards, although there is also some horizontal spreading of higher frequencies. Therefore, it is very difficult to model the potential impact with a high degree of certainty. To reflect this, this assessment uses the precautionary principle throughout, which should result in a degree of built in safety.

It should be noted that, due to the logarithmic decibel scale the cumulative sound pressure level of more than one source at the same location is not simply the sum of the two sources (for example, two vessels emitting sound at the same sound pressure level will result in a combined sound level that is 6 dB above the individual sources). If the difference between two sound sources is more than 20 dB, the stronger source dominates and the weaker source does not increase the overall sound pressure (Erbe, 2011).

Exposure Duration

The categories of behavioural and physiological responses developed by Nedwell et al. (2007) for marine mammal exposure to increasing sound pressure level must also be considered in relation to the duration of time that the animal is exposed to such sound levels. Nedwell et al. (2007) suggests marine mammals have a maximum tolerable exposure time to sounds exceeding 90 dB_{ht}(*Species*), beyond this time duration the animal is likely to experience hearing loss. Sound exposure over time follows the ‘equal energy rule’, whereby an increase in sound level leads to a decrease in the tolerable exposure time. Nedwell et al. (2007) suggest that hearing loss may occur when animals are exposed to sounds greater than 90 dB_{ht}(*Species*) for a period of eight hours, above 130 dB_{ht}(*Species*) traumatic injury could occur regardless of exposure time. Figure 48 indicates the exposure time at different sound exposure levels (above dB_{ht}(*Species*)) that would induce TTS (from Nedwell et al., 2007).

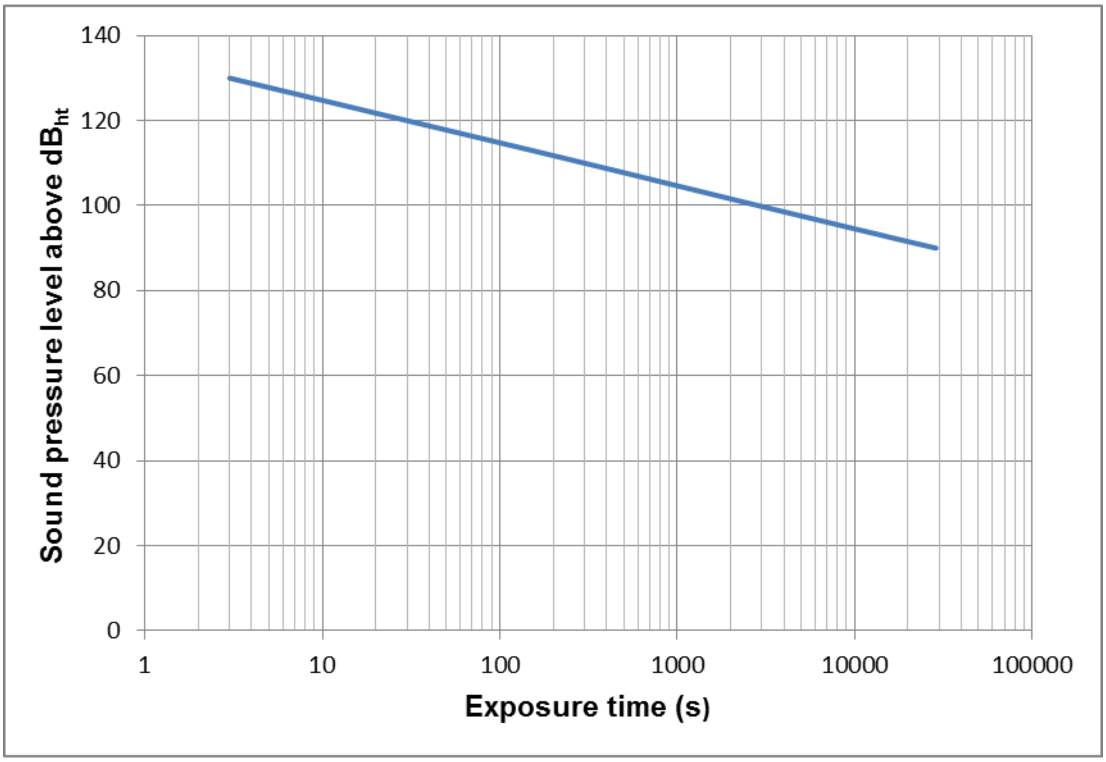


Figure 48: Comparison of sound pressure level and duration for the same cumulative noise dose (from Nedwell et al., 2007)

It is assumed that marine mammals exposed to sound levels that elicit an avoidance response will move away from the sound source, effectively reducing the sound level experienced by the receptor. At times, the response of the receptor may also be influenced by other factors such as feeding or social behaviour, which may result in a reluctance to change behaviour, for example move away from a food source when subjected to noise. In some cases, an individual subjected to high sound pressure levels may not be able to move to an area of lower sound pressure quickly enough to avoid a high sound exposure.

7.4.2 Predicted Impacts of Anthropogenic Sounds Generated during the 2015 Exploration Campaign

The perceived sound pressure levels for the activities identified as generating underwater noise during the drilling of the Rhea-1 well have been calculated using the methodology described in Section 7.4. The calculated perceived sound pressure levels at various distances, ranging from 1 to 5,000 m, from the source are shown in Table 45.

The calculations of perceived sound levels in Table 45 are based on the peak source sound pressure level for each activity, as the worst-case.

Where the perceived sound levels exceed the thresholds for disturbance, avoidance behaviour, tolerance limit of sound and the threshold for hearing damage (based on the generic audiogram for marine animals (David, 2011; Figure 47, indicating a dB_{ht} of 67.5 dB re.1µPa at 100 Hz)), cells have been highlighted blue, green, yellow or red respectively. It is clear that most sources of sound will stimulate a reaction at close range but it is only the VSP that has the potential to induce threshold shifts and potentially auditory damage.

Note that the VSP is directed vertically downwards and therefore distances of 500 m and above are not applicable as maximum water depth in the area is 470 m. The degree of horizontal transmission from the VSP is not known but animals in the immediate vicinity of the airgun are probably at risk.

Here we assume that the prolonged exposure to sound levels greater than 90 dB_{ht}(*Species*) could result in auditory damage. The results presented in Table 45 indicate that a marine mammal would need to spend a period of eight hours within 50 m of the loudest source of continuous noise (Supply vessel on DP) before exceeding the cumulative noise dose described by Figure 48. Although the noise generated by the VSP is louder the sound is delivered in pulses lasting 30-60 ms. Therefore, a marine mammal, exposed to perceived sound levels less than 130 dB_{ht}(*Species*), would have to experience multiple exposures to surpass the cumulative noise dose indicated in Figure 48.

Table 45: The sound pressure levels (dB re.1μPa) at a range of distances from the source and the perceived sound pressure (assuming a dB_{ht} (generic) at 100 Hz of 67.5 dB re.1μPa).

Activity	Sound Pressure Level (dB re.1μPa) at increasing distance from source (m)										
	Source	10 m	20 m	30 m	40 m	50 m	100 m	200 m	300 m	500 m	1000 m	5000 m
OSV/PSV steaming	164	144	138	134.5	132	130	124	118	114.5	110	104	90
OSV/PSV on DP (low)	184	164	158	154.5	152	150	144	138	134.5	130	124	110
OSV/PSV on DP (high)	190	170	164	160.5	158	156	150	144	140.5	136	130	116
ERRV (low)	136	116	110	106.5	104	102	96	90	86.5	82	76	62
ERRV (high)	180	160	154	150.5	148	146	140	134	130.5	126	120	106
Rig, not drilling no DP	160	140	134	130.5	128	126	120	114	110.5	106	100	86
Rig, drilling on DP	188	168	162	158.5	156	154	148	142	138.5	134	128	114
VSP (low)	230	210	204	200.5	198	196	190	184	180.5	N/A	N/A	N/A
VSP (high)	240	220	214	210.5	208	206	200	194	190.5	N/A	N/A	N/A

Disturbance
Avoidance behaviour
Above tolerance threshold
Potential hearing damage

Although the methodology used here is precautionary and relies on many assumptions, the predicted impacts broadly agree with assessments made by other authors, as summarised in Table 46 (Southall et al., 2007; OSPAR, 2009a). Southall et al. (2007) suggest a peak pressure of 230 dB (0-peak, re: 1 μPa) for cetaceans and 235 dB (0-peak, re: 1 μPa) for pinnipeds would be required to cause TTS, which is higher than the precautionary limit used here.

Table 46: The potential for oil and gas activity to have adverse impacts on marine mammals

Activity	Activity Description	Southall Exposure Criteria (2007)				EU Task Group indicator thresholds (OSPAR, 2009a)
		Injury PTS cetaceans	Injury PTS pinnipeds	TTS cetaceans	TTS pinnipeds	
Airguns (single shot)	Single airgun 40 cubic inches	N	N	N	N	N
	Single airgun 100 cubic inches	N	Y	Y	Y	Y
	Array 280 cubic inches and above	Y	Y	Y	Y	Y
Drilling and production	Semi-submersible	N	N	N	N	N
	Platforms	N	N	N	N	N
	Drillships	N	N	N	N	N
Shipping	Cargo ship 25,550 tonnes (on passage)	N	N	N	N	N/A
	Tug (on passage)	N	N	N	N	
	Anchor handling vessel	N	N	N	N	

N = No adverse impact
Y = Potential for adverse impact

7.5 Impact Assessment Summary

The drilling of the Rhea-1 well will introduce a number of sources of underwater sound into the marine environment. A summary of the impact assessment of underwater sound on marine animals is shown in Table 47, page 221.

7.5.1 Severity and Receptor Sensitivity

Rig and vessel engine noise

Operations during the 2015 Campaign will add considerably to the ambient noise levels in an area that normally experiences little anthropogenic sound. These activities produce predominantly low frequency (<1,000 Hz) continuous sounds that are less than 190 dB re.1μPa at source. Sound of this intensity could induce avoidance behaviour of marine animals at close range (<50 m), and disturbance over several hundred metres range, hence impacts would be predominantly localised in their effects and this impact would be extremely short-lived, as the distance between the source and animal will increase rapidly. A small increase in vessel noise to animals that are already subject to, and possibly accustomed to, vessel noise may disrupt feeding and cause short-term stress, however, these impacts are very hard to measure. It is expected that any negative impact would be readily reversible once the well has been completed (as found by Rosalind et al., 2012), therefore, it is considered unlikely that this would have any long-term negative impact. The Rhea-1 well will be drilled over a short period of time (approximately 38 days in total) during the months when the densities of potential receptors are relatively low. Therefore, the severity of this impact has been assessed as **'Minor'**.

Within the Falklands, all marine mammals are protected under the Marine Mammals Ordinance 1992. Additionally, some of the species at potential risk are classified as Endangered under IUCN guidelines. Therefore, under the definition outlined in Chapter 6.0, the sensitivity of the receptors is assessed to be **'High'**.

VSP airguns

The sound source of greatest concern associated with the Rhea-1 well is the impact of high intensity, low frequency (10-150 Hz) pulsed sounds of VSP airguns. The source pressure of these devices is in the region of 230-240 dB re.1µPa, which is above the limit of tolerance and possible trauma used in this analysis. The results of this analysis indicate that marine mammals within 100 m of the airgun could experience hearing loss, however in relation the NFB this is an extremely localised area. The duration of potential impact from VSP will be short-lived, as the airguns will only be in operation for 12-15 hours, and on this basis the severity of the impact has been assessed as **'Moderate'**.

A large number of marine mammal species are at potential risk from underwater noise associated with the Rhea-1 well activities. In terms of seasonal abundances Hipsey et al. (2013) recorded nine times lower fin whale activity in the area between April and July than during the summer months (December to March). The Rhea-1 well campaign coincides with the period of lowest marine mammal abundance in the area during August in the austral winter. However, there are some exceptions, Hipsey et al. (2013) frequently recorded sperm whales throughout the year and long-finned pilot whales were most numerous between April and August. Visual surveys have encountered more fur seals in the exploratory area during the winter months than at other times of the year (White et al., 2002). Despite the potential for presence of sensitive receptors in close proximity to the rig, previous surveys have only recorded low numbers of marine mammals in the austral winter months. As a worse-case scenario, it is assumed that the Endangered fin whale, known to be in the area year-round (Hipsey et al., 2013), and sei whale, known to be seasonally abundant (Geomotive and MRAG, 2011; Polarcus, 2011), are the receptor species. Therefore the sensitivity of the receptors is assessed as **'High'**.

7.5.2 Significance

The significance of the disturbance created by the loudest mechanical sounds (engine and DP noise) produced by the rig and vessels has been assessed as **'Moderate'**. However, the static nature of the rig and relatively slow movement of the vessels means that animals are not subjected to sudden bursts of noise. As the vessels or animals move through the water the sound intensity will increase, or decrease, gradually. The behaviour of the animals is a form of self-regulation. Nonetheless, animals will alter their behaviour to avoid vessels and the long-term implications of stress due to underwater noise are not known, it is currently not possible to mitigate further.

The most noteworthy source of potential impact from underwater noise is VSP, which is assessed as **'Moderate'**. The pulsed nature of airguns means that animals can be suddenly exposed to high sound levels that could result in TTS or PTS. Therefore, mitigation measures will be put in place to reduce the significance of the impact of VSP airguns on marine mammals.

7.5.3 Degree of Confidence

The model used here relies on many assumptions regarding the sound source levels of oil and gas related activity and auditory sensitivity of receptors. 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 forthcoming exploration campaign provides an opportunity to quantify the intensity of sound produced by the rig and associated vessels under a range of operational conditions using acoustic recording devices. During VSP activities a hydrophone will be deployed, which will record the sound level of the airguns and background rig and vessel sounds. The deployment of a MMO will provide an opportunity to investigate the interactions between oil and gas related activity and marine animals. This information would help to better inform future exploration and development activities.

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**' and the data gaps are not considered to have the potential to significantly change the outcome of the assessment.

7.5.4 Cumulative Impacts

Acoustic recordings indicate that the campaign drilling area is subject to low ambient anthropogenic noise and therefore there will be little cumulative impact near the well sites. Vessels travelling to and from Stanley will add to the existing vessel noise in the area. Premier Oil will be drilling four exploratory wells in the Sea Lion area in the months before the Rhea-1 well is drilled. The Rhea-1 well will prolong the period of anthropogenic activity in the northern Licence Blocks by 38 days.

7.6 Mitigation Measures

It is generally regarded that a single exposure to vessel noise is unlikely to cause any physical damage. The most likely impacts resulting from low frequency sounds produced by vessels are masking and disturbance, though the long-term implications of this are unknown (OSPAR, 2009a). The species most at risk are baleen whales, seals, sea lions and fish, although the lowest social sounds of toothed whales are also in the spectrum of sounds generated by medium sized vessels (50-100 m in length).

An increase in vessel/rig noise within the area covered by the 2015 Campaign is inevitable, although this is likely to be of '**Minor**' severity. There are currently no guidelines governing anthropogenic noise that does not exceed the TTS. These include vessel/rig noise and sound generated from drilling operations. No specific mitigation measures are proposed for these activities.

The significance of underwater noise resulting from VSP activity on marine mammals has been assessed here as '**Moderate**' and therefore measures must be taken to reduce the risk to these animals. In line with JNCC guidance, a Marine Mammal Observer (MMO) will be deployed to search for marine mammals within a mitigation zone (500 m radius, standard for UK operations) for a period of 60 minutes prior to firing of airguns, soft-start procedures will be followed and VSP activity will commence during daylight hours. These measures will further reduce the risk of marine mammals being exposed to intense low frequency pulses.

JNCC guidelines, Section 3.3.1 (JNCC, 2010)

The operator should whenever possible implement the following best practice measures:

- If marine mammals are likely to be in the area, only commence seismic activities during the hours of daylight when visual mitigation using MMOs is possible.
- Only commence seismic activities during the hours of darkness, or low visibility, or during periods when the sea state is not conducive to visual mitigation, if a Passive Acoustic Monitoring (PAM) system is in use to detect marine mammals likely to be in the area, noting the limitations of available PAM technology (seismic surveys that commence during periods of darkness, or low visibility, or during periods when the observation conditions are not conducive to visual mitigation, could pose a risk of committing an injury offence).
- Provide a trained MMO to implement the JNCC guidelines.
- Use the lowest practicable power levels to achieve the geophysical objectives of the survey.

- Seek methods to reduce and/or baffle unnecessary high frequency noise produced by the airguns (this would also be relevant for other acoustic energy sources).

Soft-start

There are three means of performing a soft start:

- The standard method, where power is built up slowly from a low energy start-up (e.g. starting with the smallest airgun in the array and gradually adding in others) over at least 20 minutes to give adequate time for marine mammals to leave the vicinity.
- As the relationship between acoustic output and pressure of the air contained in the airgun is close to linear and most site surveys / VSP operations use only a small number of airguns a soft start can be achieved by slowly increasing the air pressure in 500 psi steps. From our understanding the minimum air pressure which the airgun array can be set to will vary, as this is dependent on the make and model of the airgun being used. The time from initial airgun start up to full power should be at least 20 minutes.
- If neither of the above techniques can be used, over a minimum time period of 20 minutes the airguns should be fired with an increasing frequency until the desired firing frequency is reached.

7.6.1 Residual Impact

The activity of vessels and the rig during the drilling campaign will cause localised disturbance to marine mammals, this is unavoidable and therefore there will be some residual impact.

The deployment of a dedicated MMO to conduct 60 minute observations prior to the commencement of soft-start procedures will lead to greater detection and tracking of marine mammals, especially deep diving species. With these measures in place, the likelihood of marine mammals being within 500 m of airguns discharging at full power is greatly reduced and therefore the severity of the impact is also reduced. With mitigation measures in place the significance of the impact of VSP noise on marine mammals is **‘Low’**.

Table 47: Summary of the impacts of underwater noise on marine animals

Activity	Aspect	Potential Impact	Type of Activity	Likelihood	Sensitivity	Severity	Significance		Certainty	Mitigation / Prevention / Control
							Pre-mitigation	Post-mitigation		
OSV/PSVs	Engine/thruster noise	Disturbance to marine life	Planned	N/A	High	Minor	Moderate		Probable	None proposed
Rig presence	Maintaining station	Disturbance to marine life	Planned	N/A	High	Minor	Moderate		Probable	None proposed
Drilling Operations	Mechanical boring and machinery noise	Disturbance to marine life	Planned	N/A	High	Slight	Low		Probable	None proposed
Vertical Seismic Profile (VSP)	Airgun discharge	Disturbance - physical injury to marine life	Planned	N/A	High	Moderate	Moderate	Low	Probable	Following JNCC Guidelines (MMO, mitigation zone and soft-start). Start operation in daylight hours.
Plug and abandonment	Noise and vibration from cutting casing	Disturbance to marine life	Planned	N/A	High	Slight	Low		Probable	None proposed

** See Section 6.0 for definitions of sensitivity, severity, likelihood and significance.*

8.0 Generation of Atmospheric Emissions

8.1 Introduction

Activities associated with the exploration drilling operation will generate atmospheric emissions as a result of power generation on the rig, rig transportation, vessel transportation of equipment and supplies and crew transportation to and within the Falkland Islands.

At the local, regional and transboundary levels, gaseous emissions may impact air quality. At the global level, it is generally accepted that anthropogenic gaseous emissions are amplifying the natural atmospheric greenhouse effect, leading to global warming and climate change (Cubasch *et al*., 2013). Some gases have a direct effect by radiative warming, whilst other gases have an indirect impact on the abundance of greenhouse gases through chemical reactions in the atmosphere (Cubasch *et al*., 2013). At the regional level, atmospheric emissions have the potential to cause acid rain and to increase the presence of particulate matter.

In addition, research suggests that the absorption of anthropogenic CO_2 is causing acidification of seawater with potential impact on the shells and skeletons of marine organisms (Doney *et al*., 2005).

The use of ozone depleting substances is also known to impact upon the stratospheric ozone layer.

This chapter provides an assessment of the potential impacts of atmospheric emissions generated during the Rhea-1 well drilling operation. The assessment identifies and characterises the sources of emissions that will be generated during the exploration drilling operation and identifies the sensitive environmental receptors within the zone of influence.

8.2 Sources of Atmospheric Emissions

The main sources, and potential sources, of emissions generated by the operations and activities during the proposed drilling operation will be:

- Drilling rig transit to well location and maintaining position during drilling operations;
- Power generation during drilling operations (e.g. use of gas turbines, diesel engines, generators);
- OSV/PSV transporting materials and equipment to and from the rig;
- ERRV providing support to the drilling rig in the field throughout the operation;
- Coaster vessels delivering cargo to and from the UK;
- Transportation associated with crew change, including charter flights to and from the UK, minibus transfer from MPC to Stanley and helicopter flights between Stanley and the rig;
- Power generation for non-operational activities e.g. in accommodation block;
- Refrigeration, heating, ventilation, air conditioning on the rig and vessels i.e. use of ozone depleting substances (ODS) and fluorinated gases (F-Gas); and
- Operation of the onshore supply base.

Combustion of fuels and the use of ODS and F-Gases during the above activities all have the potential to impact upon the global and regional atmosphere and/or the marine environment.

F-Gases and ODS are not released to the environment. The environmental impacts of combustion emissions can be estimated by predicting the quantity of the emissions associated with each activity based upon:

- The volume of fuel used (e.g. by vessels during transit, power generation by the drilling during operations);
- The overall duration of the activity (e.g. engine/turbine running hours); and
- Standard data on the composition of emissions from the combustion of different fuels.

8.3 Potential Environmental Receptors

Potential receptors of the impacts of atmospheric emissions include the global and local atmosphere and water quality and all those that rely on these environmental elements e.g. human populations, marine and terrestrial flora and fauna.

8.3.1 Atmosphere

Global Warming

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.

The two main components of the Earth's atmosphere are nitrogen (78%) and oxygen (20%), both of which have poor thermal absorption properties. The gases that make up the remaining 2% of the atmosphere have sufficient thermal absorption to capture energy from the sun and thus make the Earth habitable. These gases are referred to as 'greenhouse gases' because they absorb and effectively trap heat within the Earth's atmosphere.

The presence of greenhouse gases is one of the key factors that govern the temperature of the Earth's atmosphere, and therefore as greater quantities of greenhouse gases are generated by human activities, the more the planet warms.

Certain greenhouse gases are more effective at warming than others. The two most important characteristics of a greenhouse gas, in terms of climate impact, are how well the gas absorbs heat energy (preventing it from immediately escaping to space), and how long the gas stays in the atmosphere. The combination of these two factors is known as the Global Warming Potential (GWP), which is a relative measure of the total heat energy that a gas absorbs over a standard period of time (usually 100 years) in comparison to the total heat energy that carbon dioxide absorbs over the same period. The larger the GWP, the more warming the gas causes. For example, methane's 100-year GWP is 21 (IPPC 1995). This means that methane will result in 21 times as much global warming as an equivalent mass of carbon dioxide over a 100-year time period. As the GWP is a ratio of the warming potential of a gas relative to that of carbon dioxide, when it is applied to the estimated emissions for different gases the result is expressed as the carbon dioxide equivalent (CO_2e) i.e. how much CO_2 would have to be produced to give the same warming potential for a given gas emission.

Greenhouse gas emissions are governed by the legally binding international treaty known as the Kyoto Protocol, which came into force in 2005. Under the first commitment, industrialised countries that were party to the protocol agreed to reduce GHG emissions by an average 5.2% (compared to 1990 levels) by 2012. Under the second commitment (the 'Doha Amendment'), the remaining participants agreed to cut emissions by an average of 18% (compared to 1990 levels) by 2020. As a British Overseas Territory, the Falkland Islands remain party to the Kyoto Protocol.

The primary greenhouse gases identified within the Kyoto protocol which are considered to have the greatest potential contribution to global climate change, and which are relevant to the oil and gas industry, are:

- Carbon dioxide (CO_2) - has a GWP of 1 and serves as a 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. Typically, CO_2 is emitted through fuel combustion during oil and gas exploration and production activities.
- Methane (CH_4) - has a GWP of 21 (i.e. more than 21 times that of CO_2 for a 100-year time scale). CH_4 emitted today lasts for only about a decade in the atmosphere, on average. However, CH_4 absorbs more energy than CO_2, making its GWP higher. CH_4 is typically emitted through fuel combustion during oil and gas exploration and production activities.

- Nitrous oxide (N_2O) - has a 100-year GWP of 310. N_2O emitted today remains in the atmosphere for more than 100 years, on average. N_2O is typically emitted through fuel combustion during oil and gas exploration and production activities.
- Fluorinated gases (F-Gases) - F-Gases are man-made gases which were designed to replace ozone depleting gases for use within refrigerants, solvents, foam blowing agents, firefighting fluids and heating, ventilation and air-conditioning (HVAC). They do not deplete the ozone layer, are energy efficient and safe due to their low levels of toxicity/flammability and are relatively rare in the atmosphere. While F-Gases are not emitted during the course of normal operations, they are very powerful greenhouse gases with very high GWP's[1]. The 100-year GWP for F-gases have the following ranges:
  - Sulphur hexafluoride (SF_6): 23,900
  - Hydrofluorocarbons (HFCs): 140-11,700
  - Perfluorocarbons (PFCs): 800-50,000

Additionally, there are four gases that have an indirect 'greenhouse gas' effect by producing increased ozone (O_3) concentrations in the lower atmosphere (i.e. the tropospheric layer which comprises the lower 5-10 miles of the atmosphere). Ozone gas is produced when nitrogen oxides (NO_X), carbon monoxide (CO), non-methane volatile organic compounds (NMVOC) and sulphur dioxide (SO_2), react with sunlight. In the lower atmosphere, ozone gas contributes to the greenhouse gas effect by its thermal absorption properties.

Table 48 summarises the GWP of the Kyoto and indirect greenhouse gases that will be emitted during the operation. To ensure consistency with the Kyoto reporting requirements, the GWP for the Kyoto (direct) greenhouse gases are taken from the Intergovernmental Panel on Climate Change (IPCC)'s second assessment report (SAR) (IPCC 1995). The GWP's for indirect greenhouse gases depend upon numerous variables. As such, there is significant uncertainty in the GWP's for these and they are often updated. The indirect greenhouse gas GWP's in Table 48 are taken from the more recent IPCC Fourth Assessment Report (AR4) (IPCC 2007).

Table 48: Summary of Global Warming Potential (GWP) Factors

	Ratio of Gas$_X$ Required to Create the Equivalent Warming to 1 Tonne of CO_2						
	Kyoto GHG's (Direct)[1]			Indirect GHG's[2]			
	CO_2	CH_4	N_2O	NO_x	SO_2	CO	NMVOC
GWP Factor	1	21[3]	310	40	-	1.9	3.4

[1]IPCC Second Assessment Report: Climate Change 1995 to ensure consistency with Kyoto reporting requirements. [2]IPCC Fourth Assessment Report: Climate Change 2007. [3] The GWP for methane includes indirect effects of tropospheric ozone production and stratospheric water vapour production.

Ozone Layer

Ozone is present throughout the Earth's atmosphere. The highest concentrations, which form the 'ozone layer', exist in the upper atmosphere (i.e. in the stratospheric layer which is 15 - 25 miles above the Earth's surface). This ozone layer intercepts much of the harmful ultraviolet (UV) light produced by the sun. Ozone Depleting Substances (ODS) (e.g. the man-made chlorofluorocarbons (CFC's), hydrochlorofluorocarbons (HCFC's) and Halon) contribute to the breakdown of ozone into oxygen in the upper atmosphere, and consequently break down the ozone layer allowing these harmful rays to pass through the Earth's atmosphere. It is suspected that a variety of biological consequences such as increases in skin cancer, cataracts, damage to plants, and reduction of plankton populations in the ocean's photic zone may result from the increased UV exposure due to ozone depletion.

[1] Ozone depleting substances also have greenhouse gas effects and are also assigned a global warming potential. However, these are being phased out under international legislation and are thus not included within the Kyoto "basket" of greenhouse gases.

The use of ODS is subject to:

- The Montreal Protocol - an international agreement, which introduced control measures to eliminate the production and use of ODS;
- MARPOL 73/78 Annex VI - providing Regulations for the prevention of Air Pollution from ships;
- EU regulation - Ozone Depleting Substances (ODS) Regulations (1005 / 2009); and
- UK legislation - Environmental Protection (Controls on Ozone Depleting Substances) Regulations 2011

Prior to the Montreal Protocol, ODS's were commonly used in refrigerants, solvents, foam blowing agents, firefighting fluids and HVAC, all of which are required during oil and gas exploration and production activities.

Under the Montreal Protocol (and the aligned MARPOL 73/78 Annex VI), the use of ODS's is being phased out. The phase-out of most ODS's is now complete. Notwithstanding critical use exemptions where applicable, the use of virgin and reclaimed/recycled Halon and CFC's in new equipment and during maintenance is now prohibited. Following the last meeting (the nineteenth meeting) of the parties to the Montreal Protocol in 2007, the phase out of HCFC's was accelerated such that the use of new HCFC's is prohibited and the use of reclaimed/recycled HCFC's must be phased out by 1st January 2020. The Montreal Protocol requires ships (including drilling rigs) to be surveyed and issued with an International Air Pollution Prevention (IAPP) Certificate to ensure that MARPOL Annex VI is complied with.

EU and UK regulations enforce stricter controls and require the use of reclaimed/recycled HCFC's to be phased out by 1st January 2015 unless the use is for maintenance within existing systems and can be actively justified.

Regional Air Quality

At the local, regional and transboundary levels, gaseous emissions may impact air quality. Key issues include the formation of acid rain from oxides of sulphur (SO_X) and nitrogen (NO_X) and direct impacts on human health from particulate matter (formed by chemical reactions involving NO_X, SO_X, and volatile organic compounds (VOCs) as pre-cursor gases) (EEA, 2012).

Particulate Matter (PM) comprises small particles that are suspended in the atmosphere which are small enough to be inhaled and have the potential to impact upon health. Some PM is generated naturally from forest or grassland fires, sea spray etc., whilst human activities such as burning fossil fuels or releasing aerosols may also generate significant quantities of particulates. Of particular concern is the class of particles known as fine particulate matter or PM2.5 (< 2.5µm in diameter) that can penetrate deep into the lungs although larger particles, PM10 (<10µm in diameter) and ultrafine particles PM0.1 (<0.1µm in diameter) may also be inhaled and are also of concern.

8.3.2 Water Quality

Ocean Acidification

Carbon dioxide is highly soluble in water and consequently the oceans absorb carbon dioxide from the atmosphere by direct air-sea exchange. The exchange process equilibrates surface water CO_2 to atmospheric levels with a timescale of approximately one year (Doney *et al*., 2005). While the absorption of CO_2 could be beneficial with regard to global warming, there is an associated cost. When carbon dioxide dissolves in seawater it forms carbonic acid (H_2CO_3) and as more carbon dioxide is taken up by the oceans' surface, the pH decreases, moving the ocean towards a less alkaline and therefore more acidic state. One well-known effect of ocean acidification is the lowering of calcium carbonate saturation states, which impacts shell-forming marine organisms from plankton to benthic molluscs, echinoderms, and corals (Doney *et al*., 2009). Many calcifying species exhibit reduced calcification and growth rates in laboratory experiments under high-CO_2 conditions.

8.4 Characterising and Quantifying the Impact

8.4.1 Greenhouse Gas Emissions From Combustion

Quantification of atmospheric emissions can be estimated on the basis of total fuel consumption and published emissions factors for the unit amounts of various gases emitted when fuel is burnt, as described below.

Emissions (gas_x) (tonnes) = Emissions factor (tonne gas_x / tonne fuel) x Fuel consumption (tonnes)

The fuel consumption data used to calculate emissions associated with transportation and vessel and drilling operations have been summarised in terms of the duration and frequency of each activity (Table 49). Fuel consumption during the transit of the drilling rig from West Africa to the Falklands is excluded from this EIA, as associated emissions were included in the NEFL EIS for the FPB drilling campaign (NEFL, 2015). Helicopters are planned to fly to and from the rig on a daily basis with an additional four to eight journeys every two weeks to accommodate crew change requirements. The helicopter transportation data provided in Table 49 are based on the assumption that approximately 45 flights (including five emergency response test flights) are expected to occur over the 38 day drilling period.

In this assessment, emissions factors have primarily been sourced from:

- The UKOOA (now Oil and Gas UK) Environmental Emissions Monitoring System (EEMS);
- Atmospheric Emissions Calculations (2008);
- The National Atmospheric Emissions Inventory; and
- The Exploration and Production Forum (1994).

These emissions factors have been summarised in Table 50. The total fuel consumption for the operation (i.e. rig transit and operation, vessels, charter flight, minibus etc.) was calculated based on the number and type of vessels or vehicle, the duration and type of operations and the average daily consumption of the relevant fuel type (e.g. helifuel, aviation fuel, diesel). The total fuel consumption estimates (Table 49) are multiplied by the appropriate emissions factor from Table 50 to estimate the total atmospheric emissions, as summarised in Table 51. To account for the varying efficiency of different greenhouse gases in warming the Earth, the Global Warming Potential (GWP) is applied to the atmospheric emissions to calculate the CO_2 equivalent (CO_2 e).

Table 49: Summary of Fuel Consumption During Activities that will Generate Atmospheric Emissions during the Operation

Source of Emissions	Frequency	Duration (days or hours)	Fuel Consumption
Drilling rig (transit to well location)	1	1 day	120 (t/d)
Drilling rig operations (*Eirik Raude*) Driilling, evaluation, P&A	1	38 days	50 (t/d)
Coaster supply vessel from UK	3	60 days	15 (t/d)
Charter flight from LGW UK to MPC	3	36 hrs	5.3 (t/hr)
Helicopter - crew change from rig to Stanley	40	3 hrs	0.51 (t/hr)
Helicopter – emergency response test flight	5	3 hrs	0.51 (t/hr)
OSV/PSV – from Stanley to rig	45	1.25 days	15 (t/d)
ERRV - standby vessel alongside rig	1	38 days	0.8 (t/d)
Onshore minibus transport – crew change support between MPC and Stanley (15 minibus's x 3 crew changes)[3]	45	-	15 (litres / round trip)
Electricity demand for onshore supply base	-	38	Unknown

[1] Charter flight duration is based on current return flight duration between Brize Norton and MPC. Fuel consumption based on the current Airbridge Aircraft Airbus A330-200 operating between Brize Norton and MPC (Airberlin 2014). [2] Aviation diesel factors from Institute of Petroleum, 2000. [3]Falkland Islands Tours and Travel pers com.

Table 50: Summary of Emissions Factors

Source of Emissions	Tonne Gas$_x$ / Tonne Fuel Consumed						
	CO_2	CH_4	N_2O	NO_x	SO_2	CO	VOC
Diesel consumption (Engines)[1]	3.2	0.00018	0.00022	0.0594	0.004	0.0157	0.002
Diesel consumption Helicopter[2]	3.2	8.7×10^{-5}	0.00022	0.0125	0.008	0.0052	0.0008
Charter flight aviation fuel[3]	3.15	3×10^{-5}	0.018	0.0001	0.0013	0.0056	0.0003
Diesel consumption [3] (Onshore coach)	3.16	1.1×10^{-5}	0.012	8.8×10^{-5}	1.5×10^{-5}	0.0032	0.0005

[1] Data from OGUK EEMS Atmospherics Calculations Guidance, 2008. [2] E&P Forum, 1994. [3] Defra National Atmospherics Inventory.

Table 51: Summary of Atmospheric Emissions from Vessels, Transportation and the Drilling Operation

Source of Emissions	Combustion Emissions (Tonnes)							F-Gas Emissions
	CO_2	CH_4	N_2O	NO_x	SO_2	CO	VOC	
Drilling rig (transit to well location)	384	0.02	0.03	7.13	0.48	1.88	0.24	0
Drilling rig operations (*Eirik Raude*) Drilling, evaluation, P&A	6,080	0.34	0.42	112.86	7.60	29.83	3.80	0
Coaster supply vessel from UK	8,640	0.49	0.59	160.38	10.80	42.39	5.40	0
Charter flight from LGW UK to MPC	1,803	0.02	10.30	0.06	0.74	3.21	0.17	0
Helicopter - crew change from rig to Stanley	196	0.01	0.01	0.77	0.49	0.32	0.05	0
Helicopter – emergency response test flight	24	0.00	0.00	0.10	0.06	0.04	0.01	0
Platform Supply vessel – from Stanley to rig	2,700	0.15	0.19	50.12	3.38	13.25	1.69	0
ERRV - standby vessel alongside rig	97	0.01	0.01	1.81	0.12	0.48	0.06	0
Onshore minibus transport – crew change support between MPC and Stanley (15 minibus's x 3 crew changes)	2	0.00	0.01	0.00	0.00	0.00	0.00	n/a
Electricity use shore base	Unknown							n/a
Total Emissions	19,926	1.03	12	333	24	91	11	0
GWP (CO_2e)	19,926	22	3,582	13,328	-	174	39	n/a
GWP Total (CO_2e)	**37,071**							

8.4.2 Use of F-Gases

The release of F-gases to the atmosphere is prohibited such that zero emissions will occur (Table 51). During the course of normal operations it is necessary to ensure that 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.

NEFL audited the *Eirik Raude* prior to accepting the rig on hire for the previous exploratory drilling operation in the FPB and was provided with evidence that:

- International standards on management and reporting of F-Gas use are being met; and
- Operational controls are sufficient to ensure that all F-Gas containing equipment is appropriately maintained.

8.4.3 Ozone Depleting Substances

The only ozone depleting substance used on the *Eirik Raude* is an HCFC (R22) used in hermetically sealed domestic appliances (e.g. refrigerators) with an inventory <3kg. In accordance with the Montreal protocol and MARPOL Annex VI, no HCFC will be released to the environment in the course of normal activities as the relevant systems are contained and fully operational.

As described above, NEFL has audited the *Eirik Raude* and was provided with sufficient evidence that all standards and controls with regard to the use of ODS are sufficient.

The *Eirik Raude* is therefore in compliance with the Montreal Protocol and MARPOL Annex VI. Nonetheless, in order to comply with the stricter requirements of the EU and UK regulations, the *Eirik Raude* is currently undergoing modification to ensure that the use of R22 (HCFC) onboard is phased out within 2015 and that only F-Gases, which do not deplete the ozone layer, are used.

8.5 Impact Assessment Summary

The main environmental effects as a result of the emissions of gases to the atmosphere are:

- Contribution to greenhouse gases (direct CO_2, CH_4, N_2O, indirect NO_x, SO_2, CO, VOCs)
- Contribution to local air quality (via photochemical pollution formation (NO_x, SO_2, VOCs))
- Contribution to ocean acidification (CO_2)

A summary of the impact assessment of atmospheric emissions is shown in Table 53, page 234.

8.5.1 Severity and Receptor Sensitivity

Global Warming Potential

Atmospheric emissions statistics for the Falkland Islands (provided by the EPRD 2014) indicate that total FI emissions of CO_2e in 2012 were 0.16 million tonnes CO_2e. Approximately 78% of emissions were generated as a result of agricultural farming, with domestic combustion (10.6%), power generation (4.8%) and road transport (4.2%) accounting for the majority of remaining emissions. Emissions statistics for 2012 did not account for air or shipping transport from the UK to the FI, which has been included in some previous years statistics, where on average, air transport from the UK to the Falkland Islands accounted for less than 8% emissions and shipping less than 1% between 1990 and 2010. Emission statistics for the period 1990-2012 do not account for emissions arising from previous oil and gas exploration campaigns. It should also be noted that the emissions statistics for the Falkland Islands are not directly comparable to those calculated for the campaign, as they do not include emissions of NO_x, SO_2, CO, VOC.

To consider the emissions on a comparable basis, 2012 Falkland Islands emissions can be compared to the Rhea-1 operation emissions excluding NO_x, SO_2, CO, VOC. Based on a comparison of CO_2e calculated from CO_2, CH_4 and N_2O, the Rhea-1 well operation emissions would account for an additional 23.2% of Falkland Islands 2012 annual emissions. Therefore, the emissions generated from the Rhea-1 well operation result in a significant increase in annual emissions in Falkland Islands waters.

It is also necessary to compare the emissions in the context of the oil and gas industry as the Falkland Islands currently does not have any on-going oil and gas operations. Additionally, as the Falkland Islands emissions are incorporated under the United Kingdom's emissions inventory for reporting under the Kyoto Agreement, the impact on UK emissions must also be considered. UK national statistics of estimated greenhouse gas emissions indicate that total UK net emission of CO_2 in 2012 was 474.1 million tonnes CO_2 (581.1 million tonnes CO_2e) (DECC, 2014). Energy supply from power stations accounted for the greatest proportion of 2012 emissions i.e. one third of UK emissions at 159.52 million tonnes CO_2e. Exploration and production of oil and gas accounted for 0.24 million tonnes CO_2e, and flaring of oil and gas 3.58 million tonnes CO_2e.

In this context the total emissions generated from the Rhea-1 well operation would represent 0.01% of total UK CO_2e emissions. In isolation this project would therefore have a negligible effect on the global concentrations of greenhouse gases and subsequent climatic impacts. At a UK national level the operation will have negligible impact on emissions targets, whilst in the Falkland Islands the campaign will have a high impact on annual emissions.

Under the first commitment period of the Kyoto Agreement (2008-2012), the Falkland Islands were not required to reduce emissions or place a ceiling on emissions due to the relatively very small level of greenhouse gas emissions. The same applies under the Doha Amendment for the second

Kyoto commitment period (2103 – 2020). Therefore, emissions arising from the Rhea-1 well operation will not compromise Falkland Islands commitments under the Kyoto Agreement. Nonetheless, the Falkland Islands are expected to introduce policies in line with the objectives of the UK Climate Change Programme in driving energy efficiencies. In relation to the UK Kyoto commitments and Climate Change Programme, emissions from the Rhea-1 well operation will contribute a small amount to the UK emissions total, and thus require that NEFL consider equipment and technologies that improve the energy efficiency of all aspects of the operation.

Following consideration of the estimated operation emissions in the context of annual Falkland Islands and UK emissions, and considering both countries' commitments to the Kyoto Agreement, the overall severity and sensitivity of this impact has been assessed as '**Low**'.

To further put the operation emissions into context of activity in the regional area, there are areas of high-density shipping approximately 30 nautical miles to the west of the exploration area (Section 5.6.3), which primarily result from fishing, tanker and other non-specified vessels. The severity of the effect is therefore considered to be '**Slight**' resulting in a negligible environmental effect, whilst the sensitivity of the receptor is considered to be '**Low**'.

Ozone Depleting Substances

During the rig and vessel audit at the start of the joint NEFL and Premier Oil 2015 drilling campaign, NEFL was provided with sufficient evidence that operational controls in place (e.g. maintenance procedures, reporting protocols) were sufficient to ensure compliance with international legislation and thus zero emission.

Regional air quality

The primary contributions to the atmospheric PM generated from the drilling operation would result from the transit and operation of the drilling rig, OSV/PSV's and the return charter flights from the UK to the Falkland Islands.

These activities will either take place in the offshore environment over 200 km from the nearest land or along the flight path from the UK to the Falkland Islands. The offshore conditions in the NFB would rapidly dissipate any effects on air quality, which would therefore be relatively temporary and localised in nature. The drilling operations are scheduled to be conducted over a 38 day period and are therefore of a short-term duration, with the local air quality being expected to rapidly return to background conditions.

The main sources of PM arising from the drilling operation that could be detrimental to human health would be road transportation from the airport at MPC to Stanley during crew change, the crew transfer flight as it comes into land and the OSV/PSV's when they come in to refuel and resupply in Stanley Harbour. It is expected that there will be one flight every two weeks with a requirement for fifteen minibuses to transport offshore workers to and from Stanley to MPC. Currently there are three flights per week landing in Stanley and due to the exposed nature of the airport at MPC and road to Stanley, and the relatively low traffic levels (compared to many global towns and cities) the particulate matter is rapidly dispersed by local winds and changes in air quality rapidly return to background conditions. It is expected that emissions of PM arising from the additional charter flight and crew transfer to Stanley for the drilling operations would result in comparable levels of pollution to the existing flight activities and would therefore be within acceptable levels. Emissions of PM arising from the OSV/PSV transit from the rig and time spent in Stanley Harbour is not expected to have significant adverse effects to the population of Stanley as a whole due to the distance between the site and the TDF and most homes. Additionally the prevailing wind direction is westerly which would transport any pollutants away from Stanley.

Any impacts to the local air quality from offshore and onshore operations are considered to be minimal, and would only have a very low level and short-term effect on local air and marine life (severity '**Slight'**), with no expected effects on Falkland Islands' communities (sensitivity '**Very Low**').

Ocean Acidification

The principal combustion product of the proposed Rhea-1 drilling activities is CO_2, which is directly related to the rate of ocean acidification. The amount of CO_2 generated as a result of the proposed drilling operation is finite and very low in relation to overall UK emissions and would therefore have a negligible effect on the oceans' pH. For example, in 2012 UK net emissions of CO_2 were estimated to be 474.1 million tonnes and the CO_2 emissions generated by the drilling operation would account for 0.004% of UK emissions. The severity of the impact is therefore considered to be '**Slight**' and the sensitivity of the receptor is '**Very Low**'.

Assessment of the significance of carbon dioxide and other greenhouse gases generated as a result of the drilling campaign is considered on a global scale, as appropriate for impacts that contribute to global processes such as global warming and ocean acidification. Generated emissions released into the atmosphere will behave in different ways; some gases persist in the atmosphere for only short periods before decaying and would therefore have only a short-lived effect, whilst some gases such as carbon dioxide persist for centuries and have a long-lived effect. Given the short duration of the operation, the resulting quantity of greenhouse gases is relatively low in comparison to similar exploration and oil and gas activity in the rest of the world and the emissions in isolation would have a barely detectable effect. Therefore, emissions generated during the drilling operation will have a negligible effect on both global warming and ocean acidification and hence have been assessed of '**Low**' significance.

Impacts associated with regional air quality are considered to be of '**Low**' significance due to the remote location, the dispersive effects of the offshore environment and the relatively low level of emissions generated from waste incineration in Stanley.

There will be no emissions of ozone depleting substances during the drilling campaign and therefore this aspect is also considered to be of '**Low**' significance.

8.5.2 Degree of Confidence

The duration of the drilling operation 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 data have been used to calculate the emissions arising from the project activities. While, the energy requirements of the shore base are currently unknown, 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. 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 report.

The relationship between the generation of greenhouse gases and the subsequent global warming and ocean acidification potential are both well researched and documented. The level of confidence in the impact predictions (in terms of the nature of the impact and its level of significance) for atmospheric emissions is considered to be '**Certain**' as the activity is clearly defined, the sensitivity of the receptor and the nature of the impacts are well understood.

8.5.3 Cumulative Effects

NEFL and Premier Oil will both be conducting exploration drilling operations in Falkland Islands waters during 2015, sharing both the drilling rig and the onshore base. The Premier Oil drilling campaign will involve drilling four potential wells in the NFB. NEFL are drilling a single well in the FPB as described in the NEFL EIS for Exploration Drilling Offshore in the Falkland Islands (March 2015 Rev 08, Document number: 050-14-EHSR-ESH-PA-T4) as well as the Rhea-1 well, which is the subject of this EIS.

The estimated atmospheric emissions from the NEFL FPB well are taken from the previous NEFL EIS (March 2015 Rev 08) (Table 52). Premier Oil has calculated its estimated atmospheric emissions from the 2015 campaign, based on power generation by the drilling rig, OSV/PSV's, helicopters and contingency well testing as summarised in Table 52.

The combined NEFL drilling operations (Humpback-1 in the FPB and proposed Rhea-1 in the NFB) and Premier Oil (four well campaign) will result in total emissions of 249,099 tonnes CO_2e. The Rhea-1 well therefore contributes 15% of the emissions generated during the combined 2015 drilling operations.

The proposed Rhea-1 exploration project has the potential to contribute to the future development and production of oil and gas production in the Falkland Islands, should the drilling prove successful, and therefore the subsequent generation of atmospheric emissions associated with it. The emissions arising from any future development and production will be accounted for in detail in separate EISs.

Overall the cumulative impact associated with the drilling campaign is considered to be of '**Low**' significance due to the very small incremental effect and the relatively short duration of the drilling campaign.

The potential for the exploration drilling campaign to contribute to cumulative regional air quality impacts is negligible. The drilling activities will be located over 200 km from the nearest land and whilst there will be other vessels, such as fishing vessels, in the area the weather conditions in the offshore NFB would rapidly dissipate the emissions.

Table 52: Estimated total atmospheric emissions resulting from 2015 Falkland Island drilling activities

Emissions Sources	Emissions (Tonnes)						
	CO_2	CH_4	N_2O	NO_x	SO_2	CO	VOC
Premier Oil Campaign							
Rig, vessels and transportation for four wells	83,234	4.40	36	1,431	101	388	49
NEFL Exploration Drilling							
Rig, vessels and transportation for FPB well	33,952	2	2	607	42	161	21
Rig, vessels and transportation for proposed Rhea-1 operations	19,926	1.03	12	333	24	91	11
Total Cumulative Emissions	**137,112**	**7**	**50**	**2,371**	**167**	**640**	**81**
GWP (CO2e)	137,112	156	15,500	94,840	-	1,216	275
Cumulative GWP Total (CO2e)	**249,099**						

8.6 Mitigation Measures

Whilst atmospheric emissions associated with the drilling operation are considered to have a low environmental significance, they contribute to a global cumulative effect and as such are governed by International Treaties, such as the Kyoto Protocol for greenhouse gases, and consequently a number of industry standard mitigation measures will be implemented. These include:

- All vessels, including the *Eirik Raude*, employed during drilling and installation activities will comply with the Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2008, which controls the levels of pollutants entering the atmosphere. All combustion equipment will be subject to regular monitoring and inspections and an effective maintenance regime will be in place, ensuring all combustion equipment runs as efficiently as possible.
- Vessels will be audited as part of selection and pre-mobilisation (Chapter 14.0).
- The time spent drilling the well is the predominant factor in overall emissions and this is minimised through the careful planning of the well and by executing the well with a robust drilling platform, using state of the art combustion plant.

- MARPOL controls on the quality of diesel, which limits the sulphur content of fuel to low levels, thereby controlling acid gas emissions in the form of sulphur dioxide. Certain areas have been identified as Emissions Control Areas (ECA) where sulphur emissions are limited more stringently; the Falkland Islands does not fall within an ECA. Marine diesel available to the Falklands region can vary in sulphur content from 0.008%-0.20% (Stanley Services pers com.), which is well within the current limit for sulphur content both within (1.00%) and outside (3.5%) ECA. The sulphur limit inside ECA is due to change in January 2015 to 0.1%, whilst outside ECA it will remain 3.5% until January 2020, when it will reduce to 0.5%.

8.6.1 Residual Impacts

The impacts associated with atmospheric emissions are considered to be of low significance prior to mitigation measures. It is acknowledged that generation of emissions contribute to a cumulative global effect, albeit on a very small scale, and consequently emissions are subject to International Treaties that provide a framework to reduce global emissions. To this end standard industry and international recommended mitigation measures will be employed during the operation, but as the pre-mitigation impacts were assessed to be of '**Low**' significance, there will be no change in assessment of the residual impacts, which are also of low significance.

Table 53: Summary of the impacts of atmospheric emissions arising from the Rhea-1 Well Operation

Activity	Aspect	Potential Impact	Type of Activity	Likelihood	Sensitivity	Severity	Significance		Confidence	Mitigation / Prevention / Control
							Pre-mitigation	Post-mitigation		
Power generation associated with rig and vessel movements, crew change transportation, onshore supply base	Generation of atmospheric emissions (CO_2, CH_4, N_2O, indirect NOx, SO_2, CO, VOCs)	Global warming	Planned	N/A	Low	Slight	Low		Certain	All vessels will comply with the Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2008 Vessels will be audited as part of selection and pre-mobilisation Optimisation of drilling schedule and efficient execution to minimise time spend on operations. Apply MARPOL controls on sulphur content of fuel
	Generation of atmospheric emissions (via photochemical pollution formation (NOx, SO_2, VOCs))	Contribution to local air quality	Planned	N/A	Very Low	Slight	Low		Certain	
	Generation of atmospheric emissions (CO_2)	Contribution to ocean acidification	Planned	N/A	Very Low	Slight	Low		Certain	

* *See Section 6.0 for definitions of sensitivity, severity, likelihood and significance.*

9.0 Generation of Artificial Light Offshore

9.1 Introduction

The level of anthropogenic light in the night-time sky has increased dramatically in recent decades. 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 can affect the natural behaviour of animals in several ways; for instance, disturbance to activity patterns and hormone-regulated processes, such as the internal clock. A more obvious affect is attraction and disorientation of animals to man-made light sources; this is known as positive phototaxis.

This behaviour has been exploited to catch species of squid (FAO, 2014), with approximately 63-89% of the global catch being made by light-fishing vessels (jiggers).

It has long been known that seabirds are attracted to lights at-sea (Murphy, 1936), which has 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 (Montivecchi, 2006), although quantitative studies are few in number. NEFL have instigated a Bird Strike Management Plan (BSMP; NEFL, 2015b) to monitor, record, report and mitigate (if required) bird strikes on the rig and other vessels associated with the 2015 campaign (NEFL, 2015).

This chapter assesses the potential impacts from anthropogenic light arising from the drilling of the Rhea-1 exploration well, which include:

- Attraction of marine life, e.g. plankton, fish and squid; and
- Attraction of seabirds and subsequent collision risk with the rig or vessels.

9.2 Artificial Light Sources

Offshore operations associated with the campaign will introduce several sources of artificial light into the offshore waters of the NFB, including OSVs/PSVs, the ERRV and the drilling rig. Drilling, and other rig activities, will operate for 24 hours a day and to do this safely, all working areas will have to be well illuminated. Sources of light on the vessels will include navigational lights, illuminated living spaces within the ships and rig, and floodlighting to provide a safe working environment on the decks of ships and rig.

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 don't appear to pose a great risk (see Poot et al., 2008).

Living Spaces

Light can be emitted from living spaces (accommodation, mess rooms etc.) through uncovered portholes and windows on the rig and other vessels.

Deck Lights

Deck lighting is required to provide a safe working environment. These lights are usually very bright flood lights, designed to illuminate a wide area.

Ambient Light Levels

Under natural conditions, the only sources of light at-sea are moonlight, starlight and bioluminescence. Currently, there are several other sources of anthropogenic light in the wider area of the NFB. The finfish trawl fleet operate along the edge of the continental slope (200 m depth contour) to the south and west of the Rhea-1 well site. These vessels often stop fishing at night, so there is little deck lighting, but are an additional source of light. A limited number of cargo vessels pass within a few kilometres of the well sites (see Section 5.6.3). However, the most significant source of artificial light in the southwest Atlantic is the *Illex* jigging fleet. These vessels use powerful arrays of lights (up to 150 bulbs totalling 300 kW per vessel) to attract squid to jigging lures. Jiggers fish in fleets, the size of the fleet and distribution of fishing effort are related to squid abundance, which can vary considerably from year to year. Over recent years, the number of jiggers fishing within the Falklands EEZ has peaked at about 100 vessels (FIG FIFD, 2013 and 2014). 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; the licence period extends from February to June (FIG FIFD, 2014). Therefore, jigger fishing vessels will not be present in Falklands waters at the time when Rhea-1 is drilled.

9.3 Potential Environmental Receptors

9.3.1 Zooplankton and Fish

It is well known that marine zooplankton is attracted to artificial light (Davies et al., 2014); aggregations of zooplankton attract small fish, which in turn attract larger predatory fish. The affect appears to be more pronounced with static light sources. Experimental trials to investigate the abundance and behaviour of fish in response to artificial light indicate that, artificial nocturnal lighting created conditions that potentially benefitted larger, piscivorous (primarily fish diet) fish through both the concentration of prey and an enhanced foraging environment for visual predators (Becker et al., 2013). There are relatively few pelagic fish species in the deeper waters of the NFB; catch statistics indicate that hoki is the most abundant species in the area (FIG FIFD, 2014). Hoki are known to feed on plankton (Brickle et al., 2009).

9.3.2 Squid

It is well known that pelagic squid are attracted to light; this behaviour is exploited to catch Argentine shortfin squid in the Falklands' jig fishery. The fishery generally starts in the extreme north of the Falklands EEZ and moves southwards as the season (February to June) progresses (for example see FIG FIFD 2013 and 2014). The spread of catches indicates that there is considerable inter-annual variation in the distribution of this species (Waluda et al., 2008). However, the migratory nature of this species means that it is unlikely to be in the vicinity of the *Eirik Raude* during August and September.

9.3.3 Seabirds

Seabirds have evolved to live in an environment that is essentially dark at night, except for moonlight and sources of bio-luminescence. Seabirds take advantage of natural sources of light to find prey and navigate. Light generated by the oil and gas industry, and other marine users, has the potential to negatively impact seabirds in a number of ways, these include: direct mortality from the impact of a collision, resulting loss of feather condition and hypothermia (due to contact with the rig deck) or incineration in rig flares.

Not all species of seabird are equally vulnerable to light induced effects, diurnal albatrosses and petrels seem less likely to be involved in bird strikes than smaller petrels (Wiese et al., 2001; Black, 2005), although fledglings 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 procellariiform seabirds (petrels, shearwaters and storm-petrels) that remain active at night. It is unclear what exactly attracts the birds but there are several theories; these 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 also be a navigational cue for some species of seabird (Montivecchi, 2006). In the absence of celestial light, on overcast nights, Poot et al. (2008) postulate that artificial lights interfere with a bird's magnetic compass. Whatever the reason, it is clear that many small petrels collide with anthropogenic structures at-sea and die as a consequence (for examples see Ryan, 1999; Wiese et al., 2001; Black, 2005; Merkel, 2010).

In the South Atlantic there are a few documented accounts of bird strikes on vessels at-sea, although it is known to occur in Falkland Islands waters, South Georgia and elsewhere in the world (A. Black pers. obs.; Wiese et al., 2001; Merkel, 2010). Generally, the scale of these events is small but occasionally a far larger incident (bird-strike) is recorded, involving hundreds of birds on a single night (for example Ryan, 1991; Black, 2005).

During the 2011 exploratory campaign, observations from the ERRV recorded birds associating with the rig but did not record any negative interactions (Munro, 2011). However, most observations were made at a distance of 500 m from the rig. In order to be able to detect small petrels at night, observations would ideally be carried out from on board the rig. Statistically, significantly more birds were recorded during the morning than the afternoon, it was suggested that this was due to attraction to lights during the night (Munro, 2011).

9.3.4 Marine Mammals

Literature reviews for this assessment have found no evidence that marine mammals would be attracted to artificial light directly. Munro (2011) did not observe any marine mammals in the vicinity of the rig drilling in the NFB during 14 days of observations in June 2011.

9.4 Characterising and Quantifying the Impact of Artificial Light

The episodic nature of light induced effects is linked to light use, seabird abundance and weather conditions on any given night and is therefore difficult to quantify. It can be safely assumed that lights will be used and vulnerable species of seabird will be present (if only in low numbers). Therefore, poor visibility due to (snow or fog in particular) is likely to be a key variable.

9.4.1 Quantifying sources of artificial light

Measuring Light Intensity

Until recently, light bulbs were classified in terms of Watts (or kiloWatts = 1,000 Watts), which is the unit of electrical input power required to light a bulb. However, the intensity of light output from a bulb is measured in lumens. Different light sources could have the same power requirements, but vastly different light output, as not all the energy is converted to light (for example, some energy will be lost as heat). 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. There is a positive relationship between the power consumption of a light source and the amount of light emitted, which is known as ‘luminous efficacy’ and has units of lumens per watt (lm/W). Luminous efficacy varies between light sources, although it is still common to refer to light intensity in terms of Watts (see examples below).

The potential impact of offshore light on marine life is related to the length of the drilling campaign, the intensity of light sources, wavelength of light and orientation of light sources.

Duration of Light Exposure

The drilling of the Rhea-1 well will last a total of 38 days, in August and September. The rig will operate 24 hours a day and will be permanently lit.

Intensity of Light

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 54 shows the power consumption of different lights on the gas production platform L5; 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 lights influence extended 3-5 km from the rig. 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 Falklands waters, with more fishing in Argentine waters.

The lights used on the *Eirik Raude* are likely to differ from those on the L5; however, it has been used as an example as information regarding the specific lighting specifications of the *Eirik Raude*, are not available.

Table 54: Examples of the power required by different light sources on gas production platform L5

Source	Source power consumption (kW)
Navigational lights (red and green)	3.0
Sodium floodlights of crane	1.5
Helicopter platform	0.16
Landing lights	0.148
Platform total	30.0

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 54). Helicopter platform and landing lights also face outwards, or upwards, to guide incoming aircraft. These are usually of relatively low intensity (Table 54).

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 rig and can vary in orientation if following a moving load suspended on the crane.

Location of Light Sources

The rig will be based offshore within the northern Licence Blocks (see Section 3.1 for well location). The two OSV/PSVs will travel between Stanley and the rig on a five to seven day rotation. While working cargo, the supply vessels will have to use deck lighting; however, when steaming light should be limited to navigation lights.

9.4.2 Weather Conditions and Moon Phase

Virtually every reported bird strike associated with artificial light at-sea is linked to weather conditions (for instance; Ryan, 1991; Black, 2005; Merkel, 2010). When visibility is reduced due to snow or fog, bird strikes are far more likely and events tend to affect greater numbers of individuals. The probability that snow will fall on any given day is presumed to be higher during the winter than the summer months, which coincides with the proposed drilling campaign. Fog is generally related to wind direction and is more frequently observed during periods of north or north easterly winds, which can be experienced at any time. The influence of artificial light appears to be greatest on moonless nights when there is limited ambient natural light (Montivecchi, 2006). The longer nights and poorer weather experienced during the winter months are conducive for bird strikes, although the density of vulnerable species is also lower in the winter.

9.5 Impact Assessment Summary

A summary of the impact assessment of artificial lights to wildlife offshore is shown in Table 55, page 242.

9.5.1 Severity and Receptor Sensitivity

Attraction of Marine Life (plankton, fish and squid)

Any impact of the Rhea-1 campaign on zooplankton, fish and squid is expected to be very small and localised. These animals may be attracted to the lights of the rig but there is nothing to suggest that this should be regarded as a significant risk to these species, although there could be some indirect impacts on these animals. Squid and fish may be attracted to the rig to feed on zooplankton and may in turn be an easier target for larger squid, fish, seabirds or marine mammals. Attraction of these animals to the rig may also increase the likelihood of other impacts, such as; those associated with underwater noise or accidental spills (discussed in Sections 6.0 and 13.0).

Vessels in transit should only be displaying navigation lights, which are of low light intensity. Additionally, relatively slow moving plankton, fish and squid would be unable to maintain position alongside a moving vessel.

Given the relatively modest intensity and power of lights used on the rig (30 kW), the severity of the impact from the rig is considered to be relatively small, short-term (38 days), extremely localised and fully reversible once the rig has been removed and is therefore assessed as '**Minor**' severity. The sensitivity of these receptors is considered to be '**Very Low**' as the population under the influence of the rig will be of no geographic importance.

Seabird Strikes / Collision with the Rig or Vessels

Bird strikes tend to be episodic events that are related to a number of factors. Along with excessive light use; reduced visibility due to mist, fog or snow, the presence of a large number of birds (for instance, close to a breeding site) are important factors. When all of these factors align, hundreds of birds could collide with a vessel on a single night.

Bird strikes reported by Black (2005), Ryan (1991) and observations on vessels in Falklands waters (A. Black pers. obs.) indicate that the most vulnerable species groups in the South Atlantic are; prions, blue petrel, storm-petrels, diving-petrels, gadfly (*Pterodroma*) petrels and shearwaters. Most of these birds are migratory or widely dispersed during the non-breeding season, which coincides with the Rhea-1 campaign. These species generally have very large population sizes, are found over extensive ranges and are mostly regarded as Least Concern by IUCN; however, some of the gadfly petrels (such as Atlantic petrel) are regarded as Endangered, due to a restricted breeding distribution and land-based threats.

All of these species show seasonal patterns of distribution and abundance within Falkland Islands waters and, more generally, within the northern Licence Blocks (see Section 5.4.6).

It is not possible to quantify the number of birds at risk from bird strikes, caused by artificial lighting, during the drilling campaign for the Rhea-1 well. However, from experience gained on vessels that operate in Falkland Islands waters and on oil and gas 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 drilling campaign. Although the species concerned have large population sizes, a collision with a vessel or the rig is likely to result in injury and death of the individual. However, it is considered that the impact would be barely detectable on the size of any species' population, as the impact is localised and short-term. Therefore the severity of offshore light has been assessed as '**Minor'**. The proportion of the local populations that are at risk is considered to be of little geographical importance, (less than 1% of the local population). Consequently the sensitivity of seabird species involved has been assessed as '**Low**'.

Indirect Effects on Diurnal Species of Seabird

Other species of seabird and land birds will be attracted to the rig but this is not necessarily due to excessive light. Some of these species may exploit feeding opportunities associated with the rig; however, there is also a risk of these birds colliding with the structure and close association increases the risk of contamination from any minor oil spills (see Section 13.3 for further discussion).

Several land birds migrate between South America and the Falkland Islands and these may be attracted to the rig (for example, snowy sheathbill *Chionis albus*). Of particular note, every autumn a large number of cattle egrets (*Bubulcus ibis*) arrive in the Falklands, and further south, however, these birds are essentially lost and die soon after arriving due to starvation. It is likely that groups of birds will arrive on the rig during the austral autumn in poor condition and die of starvation but this should not be regarded as an impact caused by the rig.

9.5.2 Significance

Overall, the significance of the impact of offshore artificial light on plankton, fish, squid and seabirds is considered to be '**Low**', as it poses a negligible risk to the populations of receptor species. However, concerns have been raised by stakeholders regarding artificial light at-sea, and good housekeeping measures would help to further reduce the impact.

9.5.3 Degree of Confidence

While the duration of the drilling campaign is known and the locations of the light sources during the campaign have been confirmed, the intensity and orientation of lights on the rig are not quantified, and an example has been used in this assessment. Flaring will not be undertaken and therefore the impacts associated with flaring have not been considered in this assessment. The nature of the impact on the environmental receptor is understood, however, the scale of the potential impact is difficult to predict due to its episodic nature. Some monitoring data exists from previous Falklands' campaigns, although short-term this did not directly record an issue with bird strikes. While some specific survey data exists for seabirds in the NFB and the area around the Rhea-1 well site, 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.

The use of deck lighting, occurrence of potentially vulnerable species (albeit in low numbers) and the likelihood of poor weather conditions (reduced visibility) combined suggest that some incidents of bird strike are likely to occur during the drilling of the Rhea-1 well. NEFL's BSMP will help to determine the accuracy of this assessment and inform future EIAs. 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 oil and gas industry are an issue in the Falklands and prompt 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.

9.5.4 Cumulative Effects

Several of the species of fish and squid that may be attracted to the rig are subject to fisheries in the Falklands EEZ (light fisheries in the case of Argentine shortfin squid); by comparison to the fishing fleet the influence of the rig on these species is insignificant.

The drilling of the Rhea-1 well coincides with the second fishing season within Falklands waters. At this time, there will be approximately 40 trawlers fishing within the Falklands' EEZ; however, there will not be any jiggers fishing here at this time. Many of the trawlers will fish on the edge of the continental shelf to the south and west of the Rhea-1 well site. There are occasional bird strikes on trawlers (A. Black pers. obs.) but these go largely unreported.

Premier Oil is also drilling exploratory wells in the NFB during 2015, approximately 26 km from the Rhea-1 site. Although Premier and NEFL will not be drilling simultaneously, the Rhea-1 well will prolong activity in the northern Licence Blocks.

The additional light of the drilling rig and supporting vessels will add to light emitted by other vessels in the NFB but is not expected to result in a significant cumulative effect.

9.6 Mitigation Measures

Although the significance of the impact of artificial light has been assessed as Low, this is in part due to the season and location of the Rhea-1 well site. Good working practice will help to limit the amount of light pollution and further reduce the risk of bird strikes.

Season and Location

The vulnerable seabird receptor species all show seasonal patterns of abundance and distribution within Falklands waters. Although potentially vulnerable birds are present in all months, the timing of activity around the Rhea-1 site coincides with the period of lowest abundance for these species.

Reducing Light Pollution

For safe working practices, all working areas have to be well illuminated. Additionally, the risks of explosion and corrosion mean that it is not always possible to switch lights on and off on drilling rigs. However, there are means of limiting the horizontal and vertical spread of light, which will help to reduce the risk of light induced bird strikes.

Some of the guidelines that are applied to ships operating in the region would be appropriate for use on OSV/PSVs, the ERRV and the rig, these include:

- The use of blackout blinds/curtains will eliminate light from living spaces; and
- The majority of lights on the rig will be directed inwards to allow safe working conditions; however, outward facing lights are necessary for navigation and safety so cannot be reduced.

9.6.1 Residual Impact

The impacts associated with artificial light offshore are considered to be of low significance prior to 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. However, as the pre-mitigation impacts were assessed to be of ‘**Low**’ significance, there will be no change in assessment of the residual impacts, which are also of ‘**Low**’ significance.

Table 55: Summary of the impact of offshore light generated during the drilling of Rhea-1 on marine life

Activity	Aspect	Potential Impact	Type of Activity	Likelihood	Sensitivity	Severity	Significance		Certainty	Mitigation / Prevention / Control
							Pre-mitigation	Post-mitigation		
OSV/PSV/ERRV vessels	Vessel, navigation lights	Seabird strikes	Planned	N/A	Low	Minor	Low		Probable	NEFL have developed a Bird Strike Management Plan to monitor, record, report and mitigate (if required) any interactions between seabirds and vessels. Minimise light emission from accommodation with blackout blinds. Direct deck lighting inboard and shade/deflect horizontal spreading where practical and possible
OSV/PSV/ERRV vessels	Vessel, accommodation	Seabird strikes	Planned	N/A	Low	Minor	Low		Probable	
OSV/PSV/ERRV vessels	Vessel, deck lights	Seabird strikes and attraction of other marine life	Planned	N/A	Low	Minor	Low		Probable	
Drilling operations	Rig, accommodation	Seabird strikes	Planned	N/A	Low	Minor	Low		Probable	
Drilling operations	Rig, deck lighting	Seabird strikes and attraction of other marine life	Planned	N/A	Low	Minor	Low		Probable	

** See Section 6.0 for definitions of sensitivity, severity, likelihood and significance.*

10.0 Inshore and Onshore Impact

10.1 Introduction

Logistical support for the 2015 drilling campaign will be based in Stanley. Cargo has been delivered and stored at the shore base in preparation for transport to the rig by Offshore Supply Vessels (OSV/PSVs). At times, this activity will potentially have an impact on the local environment and community. Inshore and onshore impacts cover a range of activities associated with the operation of vessels, on the TDF and at the shore base. These include:

- Interference to other sea users due to increased vessel traffic in Stanley Harbour;
- Collisions between support or supply vessels and marine mammals;
- Introduction of marine invasive species by support or supply vessels;
- Disturbance to wildlife and the human population onshore from helicopter noise;
- Introduction of terrestrial invasive species with cargo;
- Disturbance to Stanley residents and wildlife from inshore and onshore light and noise sources; and
- Demands for accommodation in Stanley.

The range of activity is so varied that each of these subjects will be treated separately below.

10.2 Interference to Other Sea Users due to Increased Vessel Traffic in Stanley Harbour

10.2.1 Introduction

Stanley Harbour and Port William are utilised by a wide range of vessels; including fishing vessels, reefers, cruise ships and cargo vessels. Peaks in usage are associated with the timing of fishing seasons (particularly at the start when vessel licences are issued and at the end, when catch may be offloaded) and the summer cruise ship season. Space for vessel manoeuvres in Stanley Harbour and through the passage into Port William (The Narrows) can be tight (see Figure 11: Location of the Temporary Dock Facility, Section 3.4.10) and there is history of vessel collisions and groundings within these areas (M. Jaimeson pers. comm.). The Harbour Master is accustomed to different types of vessels and crews from a range of nationalities entering, and exiting, Stanley Harbour and vessels are required to report intended movements within the Harbour. A system is also in place to record the entry, and exit, of vessels into Port William and Berkeley Sound.

Interference with other sea users due to increased traffic in Stanley Harbour has already been covered under the TDF specific ESHIA (NEFL/RPS, 2013) and a Harbour Management Plan (HMP; PMO/NEFL, 2014), including the TDF, is in place for the duration of the 2015 exploration campaign. This section describes the potential impacts that are specific to the Rhea-1 phase of the campaign.

10.2.2 Sources of Interference to Users of Stanley Harbour

A number of different vessels associated with the Rhea-1 exploration drilling campaign will be using Stanley Harbour. These include;

- Coaster cargo vessels have travelled between Aberdeen (Scotland) and Stanley to deliver all the equipment required for the drilling campaign. On arrival, coasters moored alongside the TDF and cargo was transferred ashore.
- The two OSV/PSVs will travel between the drilling rig and Stanley on a five to seven day rotation throughout the drilling campaign. On arrival in Stanley Harbour, these vessels will moor alongside the TDF to facilitate the transfer of cargo.

- At the end of the drilling campaign, coaster vessels will return to Stanley as part of the campaign demobilisation, to return equipment and cargo to Aberdeen.
- The rig ERRV will spend the majority of the time offshore, close to the position of the rig; however, it will return to Stanley occasionally (on a 4-6 week basis) to refuel and change crew.

These vessels will be passing through Port William and The Narrows before docking at the TDF. The TDF is not equipped with fuel bunkering facilities and it is intended that vessels will move to FIPASS for refuelling during each visit to Stanley Harbour.

10.2.3 Environmental Receptors within Stanley Harbour

Any disruption to third-party vessels has the potential to impact fishing and cargo operations, which could result in a loss of business revenue, due to the additional time and fuel needed to complete their activities.

There is a system of reporting for vessels entering/leaving Stanley Harbour and Port William, which enables information regarding ship movements to be passed to arriving/departing vessels. However, additional traffic in a confined space will increase the risk of collisions between vessels.

The key area restricting shipping activity in Stanley Harbour is the lack of berth space at FIPASS. At times, demand outstrips available space and vessels may have to leave FIPASS and anchor to create space for other vessels, or wait for a berth to become available. Due to the necessity to transfer cargo to and from lay-down yards onshore, the oil and gas industry have been heavy users of FIPASS in previous campaigns. However, not all vessels use FIPASS as licensing inspections, passenger transfers, fuel bunkering and transhipment of fish to reefers can all be achieved at anchor.

Other users of the Harbour include:

Fishing vessels

At the start and end of fishing seasons (see Section 5.4.4), fishing vessels tend to arrive in Stanley Harbour for licensing. Not all these vessels go alongside FIPASS, instead many will anchor in Port William or Stanley Harbour.

Fishery Patrol Vessels

The Falkland Islands and South Georgia and the South Sandwich Islands Governments' Fishery Patrol Vessels are regular visitors to Stanley Harbour throughout the year and go alongside FIPASS when space is available.

Cargo vessels

Cargo vessels visit Stanley on a regular basis and require a berth at FIPASS to transfer cargo onshore.

Cruise ships

All but the smallest cruise ships anchor in Port William, from where they ferry passengers onshore (to the Public Jetty) in tenders. Some of the smaller cruise vessels will go alongside FIPASS. The vast majority of cruise ship visits occur between October and April, and will therefore not coincide with the Rhea-1 well campaign, which is scheduled in August and September.

Reefers

Reefers are refrigerated vessels that tranship catch from fishing vessels and deliver it to market. Most of these vessels anchor in Port William or Berkeley Sound and rarely enter Stanley Harbour. The activity of reefers reflects the timing of the fishing seasons and catch rates in any given year.

Tankers

Tankers will visit FIPASS occasionally to transfer fuel (less than 20 visits per year, Harbour Master pers. comm.). At other times, tankers may be anchored in Berkeley Sound to bunker fishing vessels.

Yachts and pleasure craft

A number of locally owned yachts are moored at The Canache, the inlet to the east of the TDF. Most visiting yachts moor at jetties in the town or anchor in front of the town.

10.2.4 Characterising and Quantifying the Impact of Increased Traffic in Stanley Harbour

The TDF could potentially be operational 24 hours a day seven days a week, and therefore, vessels could arrive or depart at any time.

The Number of Vessels Visiting FIPASS

Statistics regarding the number of vessels visiting FIPASS are only available on an annual basis (Harbour Master pers. comm.). Figure 49 shows the number of visits by vessel type over the period 2008 to 2013.

The number of visits for 'fishing' and 'all other vessels' were reasonably consistent between 2008 and 2013; however, supply vessel visits varied considerably, reflecting oil and gas exploration activity. Exploration campaigns were ongoing throughout most of 2010, 2011 and into 2012. The necessity to move cargo through FIPASS resulted in a considerable increase in demand for this facility. For instance; during 2011, supply vessels accounted for over 39 % of all vessel visits to FIPASS.

During the 2015 campaign each OSV/PSV is expected to refuel once a week, the ERRV will refuel every 4-6 weeks and coasters will refuel prior to departure, therefore over the 38 day Rhea-1 drilling campaign this equates to approximately six refuelling visits to FIPASS.

In addition to their own requirements, OSV/PSVs will be transporting fuel to the drilling rig. Refuelling is achieved at a rate of 35-40 m^3/hr and the maximum capacity of the supply vessels is in the order of 800 m^3. From empty, refuelling could take approximately 20 hours.

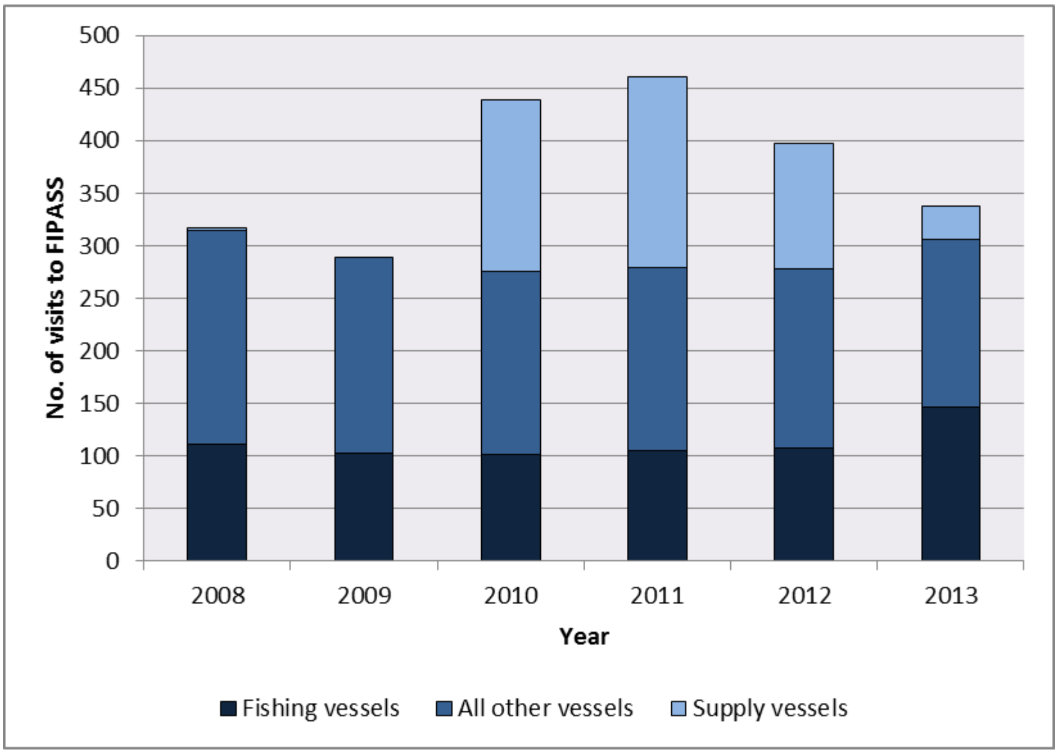


Figure 49: The recorded number of vessel visits to FIPASS between 2008 and 2013 (Data from Harbour Master)

10.2.5 Impact Assessment Summary

A summary of the impact assessment is shown in Table 59, page 271.

10.2.5.1 Severity and Receptor Sensitivity

Disruption to Other Users of Stanley Harbour

Facilities and space within Stanley Harbour are limited, which means that during busy periods, vessels may not be able to obtain a berth at FIPASS when required. This can lead to delays and additional costs, in fuel and launches. Any additional pressure from the oil and gas industry will exacerbate the issue. However, utilising the TDF will alleviate much of the pressure placed on facilities by the drilling campaign, although refuelling will still take place at FIPASS.

The TDF is situated in an area that is not usually used as an anchorage so the disruption to other users of Stanley Harbour, who wish to anchor, will be minimal. Along with the localised and short-term nature of the impact the severity of disruption to other users of Stanley Harbour is assessed as '**Minor'**.

With the TDF in place, there is moderate capacity to absorb the added pressure from the oil and gas industry without significant alterations to present working practices. There will however be some disruption to other users of Stanley Harbour, which may have economic implications. Therefore the sensitivity of the receptors involved has been assessed as '**Moderate'**.

10.2.5.2 Significance

Disruption to Users of Stanley Harbour

There is the potential for economic impact on other users of Stanley Harbour, through competition for berths at FIPASS. The construction of the TDF should reduce the amount of time that supply vessels are alongside FIPASS and help to allay any concerns of other users of the Harbour. However, the significance of disruption to other users of the Harbour has been assessed as '**Moderate'**. Measures will be put in place to help to reduce the significance. The risk is believed to be acceptable but the situation will be continually reviewed.

10.2.5.3 Cumulative Impacts

There are peaks and troughs in the number of vessels using the Stanley Harbour throughout the year. Most of these fluctuations are associated with the start or end of fishing seasons when demand for berths at FIPASS is at its highest. During previous campaigns, OSV/PSVs contributed considerably to the amount of traffic within Stanley Harbour, resulting in a large cumulative impact. Although the Rhea-1 exploration activity does coincide with the 'second season' of fishing in the Falklands, late August and September are not busy months for vessel traffic in Stanley Harbour.

10.2.6 Mitigation measures

As part of standard working procedures, measures will be in place to limit the level of disruption to other users of Stanley Harbour. These measures include:

- The appointment of a Marine Superintendent to liaise with the Harbour Master, FIPASS management, Stanley Services and other users will help to keep everyone well informed and promote good working relationships;
- Notes to Mariners will be issued to inform all masters of vessels of the presence of a new shoreline facility;
- A navigational risk assessment was completed prior to the start of the 2015 campaign to inform the preparation of a Stanley HMP. This Plan has been prepared in close collaboration with the Harbour Master and covers the following as a minimum: pre-notification protocols associated with the entry of vessels in Stanley Harbour; pre-defined passage routes within Stanley Harbour; procedures associated with vessel collision and emergency response;
- Marine night-time lighting will be required and procedures will be put in place for periods of poor weather;

Alternatives

- Critical to the disruption to other users of Stanley Harbour is the need to use FIPASS for refuelling. There are alternative means of vessel bunkering from tankers at anchor in Berkeley Sound and while this has been considered, it is safer and more efficient to use the facilities at FIPASS. Currently, Stanley Services are extending the bunkering capabilities on FIPASS to allow vessels to refuel on the western most berth; this will further reduce the pressure on FIPASS.

10.2.6.1 Residual Impact

The employment of a Marine Superintendent and the development of a Stanley HMP will help to coordinate activities thus reducing the severity of the impact. With severity reduced to '**Slight**', the significance of interference with other sea users becomes '**Low**'. Oil exploration activity has been ongoing since the end of 2014, to date no major issues have arisen. Some minor issues regarding the areas used by vessels waiting to go alongside the TDF have been raised but these have been simply dealt with by asking vessels to wait elsewhere.

10.3 Collisions Between Support or Supply Vessels and Marine Mammals

10.3.1 Introduction

It is believed that collisions between cetaceans and vessels are more frequent than previously suspected (WDCS, 2006). An increase in the risk of collisions is linked to a general increase in the density of shipping traffic and in particular the number of large fast moving vessels (Silber et al., 2009). Globally, this has become an increasingly important issue (WDCS, 2006). In particular, the threat to northern right whales has received attention, as the impact of collisions with vessels is threatening the survival of this Critically Endangered species (NMFS, 2005). Off the east coast of the US and Canada, several mitigation measures have been put in place, including closed areas and speed limits, to reduce the risk of collisions (NMFS, 2005). Interactions between fin whales and ships in the Mediterranean Sea are also causing concern (Vaes and Druon, 2013).

Small cetaceans (dolphins) are fast moving and agile enough to avoid vessels travelling at moderate speed and are not considered further. In the following section, the risk of collisions between cetaceans and vessels associated with the Rhea-1 campaign is assessed.

10.3.2 Sources of Shipping Traffic

Like any area where cetaceans and shipping coexist, there is the potential for whales and vessels to collide in Falkland Islands waters. Coaster and OSV/PSVs will be steaming through Falkland Islands waters on a regular basis throughout the drilling campaign. It is anticipated that the two supply vessels will travel from Stanley to the drilling rig and back on a five to seven day rotation. Coasters arrived in the Islands at intervals of 10-14 days in the early months of 2015 and will again at the end of the 2015 campaign, and the ERRV will visit Stanley on a monthly basis.

10.3.2.1 Degree of Confidence

There have been three previous exploratory drilling campaigns in the Falklands (since 1998) and therefore the nature of the potential impact of increased vessel traffic is well understood. This drilling campaign will run for a fixed, relatively short period and the number and frequency of ship visits are understood. Therefore confidence in the assessment is '**Certain**'.

10.3.3 Environmental Receptors in the Exploration Campaign Area

A wide range of cetacean species are found within Falkland Islands waters, most of these have clear spatial and temporal patterns of distribution (see Section 5.4.4.1).

Sensitivity of Environmental Receptors

The available evidence suggests that, the risk of collisions is highest in waters where high densities of cetaceans and shipping are found in the Falklands these are coastal waters, particularly near Berkeley Sound and Port William.

A range of factors relating to cetacean behaviour are thought to influence the likelihood of a collision, these include:

- ***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.
- ***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.

Two species that are encountered in the coastal waters of the Falklands are likely to be the most vulnerable due to their behaviour (southern right whale) or abundance (sei whale).

Right whales

Globally the distribution and behaviour of right whales appears to make them particularly vulnerable; they have a coastal distribution, spend prolonged periods near the surface and are slow moving. In the Falklands, southern right whales are occasionally seen in inshore waters; including Stanley Harbour (A. Black pers. obs.). Although right whales may be present within Falklands waters throughout the year acoustic and visual surveys indicate that their number is highest in the spring and summer months.

Sei whales

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,) but are also found throughout the inshore waters of the entire archipelago (Thomsen and Munro, 2014). Anecdotally, there is evidence that the number of sei whales within Falklands waters, and more generally within the southwest Atlantic (Iñíguez et al., 2010), is increasing, although the occurrence of this species has been erratic in the past. However, sufficient survey data to determine a population estimate is currently unavailable.

Sei whales appear to respond to approaching vessels and are relatively fast swimmers; however, they tend to swim just below the surface leaving a clear trail of 'fluke prints' in their wake (Sea Watch Foundation, 2012). There are many records from around the world of collisions between sei whales and vessels (IWC database, 2014).

Sei whales are listed as Endangered on the IUCN Red List and are also afforded conservation status and management under CITES and CMS.

10.3.4 Characterising and Quantifying the Impact of Vessel Collisions with Cetaceans

This is a global issue that requires further research in order to better understand and model the potential impact on cetacean species (IWC/ACCOBAMS, 2011). The International Whaling Commission (IWC) encourages mariners to report collisions with cetaceans, although many collisions go unobserved or unreported. 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, to allow better modelling of risk factors (for example, vessel type, speed and size), and to identify high risk or unsuspected problem areas.

Any incidents of collisions with marine mammals should be reported to the International Whaling Commission (www.iwc.int\ship-strikes or shipstrikes@iwc.int) and FIG.

The probability of a collision between a cetacean and a vessel is related to the density of shipping traffic and cetacean density in the same area (see Vaes and Druon 2013). The outcome of the collision is related to the size and speed of a vessel.

Vessel traffic

The penultimate round of exploratory drilling in the Falklands was underway throughout 2011. During this year, there were 1,515 vessel movements reported in Berkeley Sound, Port William and Stanley Harbour (Harbour Master pers. comm.). Of these, 314 (20%) were OSV/PSVs for the exploration campaign.

Vessel size and speed

The size and speed of a vessel clearly influences the force and outcome of any collision between a cetacean and a ship. The specifications of vessels used during the Rhea-1 exploration campaign are given in Table 56. The identity of the vessels used to demobilise is unknown at the time of writing but it is assumed that they will be similar to those used at the start of the campaign.

Table 56: Specification of vessels used during the Rhea-1 exploration campaign

Vessel Name	Date launched	Type	Length (m)	GRT (tonnes)	Max. speed (kn)	Last port	Country of registry
Pacific Leader	2014	OSV/PSV	97	5,179	14	Aberdeen	Singapore
Pacific Legend	2014	OSV/PSV	97	5,179	14	Aberdeen	Singapore
Fastnet Sentinel	2015	ERRV	61	1,944	13	Cape Town	UK
*HHL Congo***	2011	Coaster	138	9,616	14	Aberdeen	Antigua and Barbuda

** Several different vessels from the HHL (Hansa Heavy Lift) fleet have been chartered; *HHL Congo* is shown as an example here

The available evidence suggests that collisions occur between cetaceans and vessels of all sizes but most fatal collisions are on vessels greater than 80 m in length (Laist et al., 2001). Larger vessels clearly have more momentum than smaller vessels travelling at the same speed. Additionally, they are less able to manoeuvre to avoid a collision and visibility of animals near the bow may be restricted.

The outcome of a collision is related to speed, whales struck at speeds greater than 14 knots are more likely to die whereas whales struck at speeds lower than 14 knots are more likely to survive (Laist et al., 2001). The faster a vessel is travelling the less likely it is that a cetacean will be observed, ahead of a collision. The transit speed for an OSV/PSV is likely to be approximately 12 knots, as this is the most economical speed for vessels of this type (Mærsk, 2014).

Cetacean detectability is a function of vessel speed and breathing rate, although a range of environmental factors, location of the bridge and observer experience are also important. The faster a vessel is travelling, the less likely it is that a cetacean will be observed ahead of the ship.

10.3.5 Impact Assessment Summary

A summary of the impact assessment is shown in Table 59, page 271.

10.3.5.1 Severity and Sensitivity of Receptors

Wherever high densities of cetaceans and shipping coexist there is the potential for collisions. There are anecdotal reports of collisions or near misses between vessels and cetaceans in the southwest Atlantic but little information that can be used to give a quantitative assessment of the issue. However, there are many examples of collisions between a wide range of cetacean species and vessels from elsewhere in the world, many of these species are also found within Falklands waters (IWC database, 2014).

The available evidence suggests that the size and speed of a vessel are key factors determining the outcome of a collision. The OSV/PSV and ERRV used during the campaign are 97 m and 61 m long respectively and have maximum speeds of approximately 13-15 knots (Table 56), although they are likely to operate at lower speeds. The likelihood of survival following a collision is directly related to the size and speed of the vessel concerned. Also, cetaceans are better able to avoid vessels travelling at low speed and mariners will be better able to detect and avoid cetaceans.

The conservation status and life history of large cetaceans (sei whales are Endangered) mean that the sensitivity of the receptor has been assessed as ‘**High**’. Any collision that could result in mortality would have a moderate short-term impact on the species. For this reason the severity of collisions between ships and cetaceans has been assessed as ‘**Moderate**’. Therefore, the impact is assessed as ‘**Moderate**’.

10.3.5.2 Likelihood

Collisions between cetaceans and shipping are often unreported or unobserved. Post-mortem examinations of carcasses found elsewhere in the world indicate that the number of reported incidents under-estimates the scale of the issue. However, there are no known records of collisions or beached carcasses, with signs of ship-strike injury, from the Falkland Islands. The Rhea-1 well will result in additional shipping traffic in coastal waters off East Falkland and within the NFB during August and September 2015. However, the density of shipping around the Falklands will remain relatively low, compared with elsewhere in the world, and there is no indication that there is currently an issue around the Falklands.

Large cetaceans, albeit at lower densities, can be encountered anywhere within Falklands waters (see Section 5.4.4.1 and White et al., 2002). The number of large cetaceans encountered within Falklands waters is lowest over the winter and, therefore, Rhea-1 well will be drilled during the period with lowest cetacean abundance. Therefore, it is assessed that the risk of collisions between cetaceans and vessels associated with the Rhea-1 well is very low. The likelihood of a collision has been assessed as '**Remote**'.

10.3.5.3 Significance

The risk of collisions between shipping and cetaceans is of great concern in specific locations around the world where high densities of cetaceans and shipping coexist. Although it is not thought that a significant problem exists in the Falklands at present, further investigation to establish the causes, consequences and provisions for risk management are required. The overall significance of the risk has been assessed as '**Moderate**' and therefore opportunities to reduce the risk are proposed.

10.3.5.4 Degree of 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. 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 assessment is '**Probable**'.

10.3.5.5 Cumulative impact

There is already a reasonable amount of fishing and cargo vessel traffic using Berkeley Sound, Port William and Stanley Harbour. It is estimated that the Rhea-1 well will increase the amount of vessel traffic in and out of Stanley by about 6%. As a worst-case it has been assumed that this could translate to a similar relative increase in the risk of cetacean strike.

10.3.6 Mitigation Measures

Cetaceans could be encountered during any month throughout Falklands waters. A number of common sense precautions should be taken to reduce the likeliness of collisions with cetaceans:

- Mariners should be made aware of the issue and how it relates to the Falkland Islands (see IFAW (2013) leaflet).
- Along with the usual duties of a watch keeper, additional vigilance is required to detect cetaceans in inshore waters.

10.3.6.1 Residual Impact

Increased awareness and vigilance should reduce the risk of collisions between vessels and marine mammals, leading to a barely detectable risk to these species. With mitigation in place the likelihood of collisions will be reduced to '**Improbable**' and therefore the overall significance will be '**Low**'. Vessels will be requested to report any incidents, which will help to quantify the scale of the impact and better inform future impact assessments.

10.4 Introduction of Marine Invasive Species by Support or Supply Vessels

10.4.1 Introduction

The IUCN has identified the introduction of non-native species as one of the major threats to native biological diversity. Not all non-native species that arrive in the Falklands are able to survive, reproduce and spread, to the point that they become invasive. However, the impact of species that do become invasive can be immense and often irreversible (Hilliard, 2004; Otley et al., 2008). The impact of invasive species on island ecosystems like the Falklands, where native species have evolved in biological isolation, can be particularly harsh. Over the last two hundred years, or so, human trade and travel has introduced alien species to areas like the Falklands where the native species are not adapted to the new threat.

Around the world, there are many documented cases of invasive species and their impact on native biodiversity, along with associated economic impacts in many cases (Lowe et al., 2004). In particular, OGP/IPIECA (2010) provides an excellent review of the risks that the oil and gas industry pose regarding the introduction of non-native species.

On the central Patagonian coast, most ecosystems have been modified by invasive species (Orensanz et al., 2002). In the Falklands, until recently there was no baseline, so determining those species that are native and those that are invasive is not always straight forward. However, it is clear that there are several invasive species already established within Stanley Harbour and Mare Harbour, such as, the tunicate (*Ciona intestinalis*) and the parchment worm (*Chaetopterus variopedatus*) (SMSG, 2011). Both species have the potential to out compete and smother native species.

In this Section, an assessment is made of the potential for the Rhea-1 well drilling campaign to introduce non-native species to the Falklands' marine environment that, in time, could become invasive. The risk of introducing non-native species in association with the rig, *Eirik Raude*, from West Africa to Falklands waters has already been covered in a previous EIS (NEFL, 2014).

10.4.2 Sources of Non-native Species Introductions to the Falklands

Globally, shipping routes cross many biogeographical boundaries and vessels have the potential to transport 'hitch-hiking' organisms from one region to another. All vessels that travel to the Falklands for the purpose of the drilling campaign have the potential to introduce non-native species to the Islands.

- Supply vessels and coasters associated with the 2015 exploration campaign have travelled between Aberdeen, Scotland, or West Africa and the Falklands, passing through various international waters on route.

10.4.3 Sensitivity of Environmental Receptors to Invasive Species

The marine ecosystem of the Falklands has evolved in isolation and the introduction of alien species is likely to have serious impact on biodiversity, through competition or predation on native species. There are many examples from around the world where this not only impacts on biodiversity but also has serious economic impact (OGP/IPIECA, 2010). However, at present there is no discernible economic impact from marine invasive species in the Falkland Islands. Once established, marine invasive species are extremely difficult to remove.

10.4.4 Characterising and Quantifying the Impact of Marine Invasive Species

There are two main pathways by which non-native marine species are transported; through ballast water and biofouling on the hulls of vessels. Both routes are recognised as serious issues by the International Maritime Organisation (IMO), who have developed guidelines to guard against such introductions.

Ballast water

Planktonic organisms, larval stages, eggs and micro-organisms can all be transported from one location to another in ballast water, and associated sediments. Ballast is taken on-board to trim and stabilise a vessel, ballast exchange practices are specific to each vessel.

There is an international convention governing the exchange of ballast water, however, the UK is not a signatory. The Falklands may well adopt the legislation without adopting the Convention but have not done so yet (M. Jamieson pers. comm.). However, all international shipping is obliged to follow the Convention's guidelines under International Law.

IMO guidelines for ballast water exchange

Key to the safe and effective exchange of ballast water is a Ballast Water Management Plan. The Plan is specific to each ship and includes a detailed description of the actions to be taken to implement the Ballast Water Management requirements and supplemental Ballast Water Management practices. The Plan includes;

- The duties of key shipboard control personnel undertaking ballast water exchange at sea. Such personnel should be fully conversant with the safety aspects of ballast water exchange and in particular the method of exchange used on-board their ship, and the particular safety aspects associated with the method used;
- Ships must have a Ballast Water Record Book to record when ballast water is taken on board; circulated or treated for Ballast Water Management purposes; and discharged into the sea. It should also record when Ballast Water is discharged to a reception facility and accidental or other exceptional discharges of Ballast Water.

In terms of environmental effectiveness, ballast water exchange should take place in offshore oceanic waters, which will minimise the probability that harmful aquatic organisms and pathogens be transferred in ships' ballast water. The exact specifications vary between countries and regions, however, a general standard is for ballast water exchanges to take place at least 200 nautical miles from the nearest land in waters over 200 m deep (IMO, 2004).

All vessels associated with the 2015 drilling campaign require ballast to maintain trim. NEFL developed a biosecurity plan (NEFL, 2015), which states that all vessels will exchange ballast water at least 12 n miles offshore (in line with IMO guidelines) and all OSV/PSVs are required to maintain a ballast exchange log.

Biofouling

Biofouling is the growth of marine organisms on man-made structures. Once established, biofouling species can be transported to colonise environments that they would not be able to reach through natural dispersal. Figure 50 outlines the stages that lead to the introduction of invasive species from one location to another via biofouling.

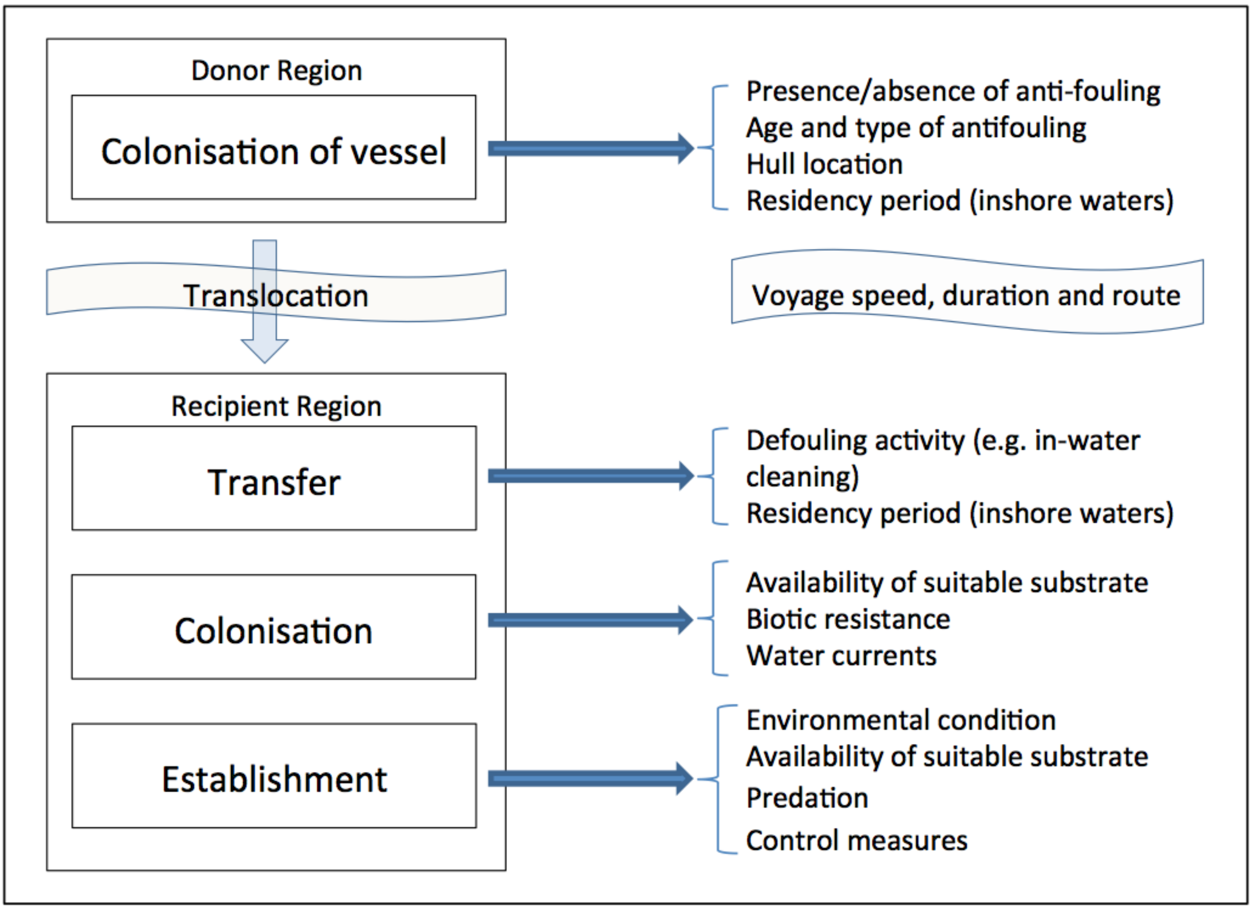


Figure 50: The process of invasive species introduction (from Lewis and Coutts 2010)

- ***Colonisation*** - Whether biofouling organisms become established on the hull of a vessel, or not, largely depends on the condition of anti-fouling treatment and the residence period in inshore waters, where biofouling organisms are most abundant.
- ***Translocation*** - Once established, particularly in niches in the hull like sea chests, organisms can be transported across oceans and biogeographic boundaries. The movement of the vessel through the water, changes in temperature and salinity may help to remove some organisms. However, this is no guarantee that biofouling organisms will be killed or removed from a vessel's hull. For instance, Lee and Chown (2007) found that biofouling organisms can survive multiple voyages between South Africa and Antarctica.
- ***Transfer*** - Once in the recipient region, biofouling organisms still have to transfer to the marine environment to become invasive. This can happen naturally over time or due to mechanical processes such as hull cleaning.
- ***Colonisation and Establishment*** - Once released into the marine environment of the recipient region, a potentially invasive species must become established and reproduce, which will require suitable conditions. This is more likely if the donor and recipient regions are ecologically similar. If an introduced non-native species becomes established it can be regarded as invasive and will impact the native biodiversity and may also result in long-term economic impact.

IMO guidelines to control and manage biofouling

There is an International Convention governing anti-fouling on ships, and all vessels associated with the campaign will adhere to the requirements of the Convention.

In 2011, the Marine Environment Protection Committee of the IMO introduced guidelines for the control and management of ship biofouling to minimise the transfer of invasive aquatic species (MEPC, 2011). The guidelines recommend the use of a vessel specific Biofouling Management Plan and the maintenance of a Biofouling Record Book. The purpose of the Plan is to outline measures used to control and manage a vessel's biofouling to minimise the transfer of invasive aquatic species. Such a Plan should address the following;

- Details of the anti-fouling systems 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 anti-fouling systems;
- Details of the recommended operating conditions suitable for the chosen anti-fouling systems and operational practices;
- Details relevant for the safety of the crew, including details on the anti-fouling system(s) used; and
- Details of the documentation required to verify any treatments recorded in a Biofouling Record Book (see MEPC, 2011 - Appendix 2).

Vessels employed during the Drilling Campaign

The majority of vessel movements associated with the 2015 campaign have been between Aberdeen, Scotland, and the Falklands; except for the ERRV that travelled from western Africa. Table 56 (page 250) provides details of the vessels involved in the 2015 exploration campaign. Northern Scotland and the Falklands are both temperate regions and species from one of these regions are likely to survive in the other. Vessels travelling from Aberdeen to the Falklands will pass through the Tropics, which will help to remove most biofouling organisms, although there is no guarantee of removing all of them (Minchin and Gollasch, 2003).

It is not anticipated that the rig will move into inshore waters at any time during the 2015 exploratory drilling campaign, the risk of biofouling organisms transferring to and becoming established in the Falklands is greatly increased when vessels are inshore, as most species require hard substrates to attach to. Therefore, coaster and OSV/PSVs that will travel to and from Stanley Harbour pose the greatest risk. However, there is still a small risk that organisms growing on the rig could be transferred to OSV/PSVs and then transported to inshore waters.

10.4.5 Impact Assessment Summary

A summary of the impact assessment is shown in Table 59, page 271.

10.4.5.1 Severity and Sensitivity of Receptors

Most marine invasive species impact inshore benthic communities of native species, which is difficult to detect and monitor. If invasive species were introduced during the drilling campaign the impact on the benthic ecology of the Islands may not be evident for a number of years. However, the long-term implications for the Islands' ecology could be severe and irreversible. Currently, the number of invasive species in the Harbour is apparently small but the species present are able to out-compete native species (SMSG, 2011). Elsewhere in the world, the impact of invasive species can be 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 loss of native biodiversity, and can greatly impact crab and shellfish industries (CABI, 2014). At present, there is limited exploitation of inshore resources and aquaculture in the Falklands but this could develop in the future. Given the potential for marine invasive species to spread, there is potential to have an impact on a regional scale and therefore the sensitivity of receptors has been assessed as '**High**'. The introduction of parasites, disease, competitors or predators could impact these industries. The severity of the impact will be species specific but following the precautionary principle (worst-case scenario) the severity has been assessed as '**Major**'. Therefore, the impact is assessed as '**Moderate**'.

10.4.5.2 Likelihood

There are International conventions regarding ballast water and biofouling management but the Falklands are currently not signatories. However, vessels registered in the UK (and elsewhere) or operating in International waters will be following the requirements of the ballast water and biofouling conventions. The guidelines produced by the IMO are widely accepted within the shipping industry and have been adopted by NEFL for this campaign (NEFL, 2015). When followed, the IMO's guidelines on exchanging ballast water and managing biofouling organisms will greatly reduce the likelihood of introducing non-native species.

Vessels will be visiting Stanley Harbour on a regular basis throughout the drilling campaign. All vessels associated with the Rhea-1 phase of the 2015 campaign have been operating in Falklands waters for a number of months. Each vessel underwent ballast water exchange when it first entered Falkland waters and will therefore be using water of southwest Atlantic origin. These vessels now pose a minimal risk of introducing non-native species in ballast water.

If vessels were harbouring biofouling organisms when they arrived, the risk of transferring these species to the Falklands increases the longer the vessels are working in the Islands. Over time, organisms may be dislodged or mature and reproduce in situ.

Given the number of vessels that visit Stanley and the apparently few invasive species in the Harbour (SMSG, 2011), the introduction of invasive species appears to be an uncommon event. However, introduction of invasive species has happened in the Falklands, and by the industry elsewhere, and therefore the likelihood of invasive species becoming established as a result of the drilling campaign has been assessed as '**Remote**'.

10.4.5.3 Significance

The environmental and economic impacts posed by the introduction of non-native marine species are well documented. However, many of the factors that lead to this are vessel specific; such as, anti-biofouling maintenance, previous location and activity. There are risk-reduction measures available that are widely used and accepted by the shipping industry. Although vessels will be following these measures to reduce the likelihood of an introduction, the precautionary approach used throughout this assessment assumes the worst-case scenario, in terms of severity. Therefore, overall significance of the risk of introducing non-native marine species has been assessed as '**Moderate**'. Additional mitigation measures are required to reduce the significance.

10.4.5.4 Degree of Confidence

The nature of the impact of invasive species on the marine environment will depend on the species involved but it is understood that the introduction of any non-native species is detrimental to the environment. The likelihood of vessels to be harbouring potentially invasive species is vessel specific and depends on a number of factors; including, anti-fouling maintenance and location prior to travelling to the Falklands. However, the practices proposed here are used internationally and all vessels involved in the campaign will be well maintained and were vetted before contracts were awarded. Confidence in the assessment is therefore '**Probable**'.

10.4.5.5 Cumulative Impacts

Numerous vessels arrive in Stanley Harbour from all over the world. There is the potential for any of these vessels to be harbouring non-native species. Vessels associated with the 2015 drilling will add slightly to the potential for the introduction of non-native species.

10.4.6 Mitigation Measures

Ballast water

At present, the FIG regard ballast water management as an issue but there is no policy or legislation in place. NEFL have adopted a project specific biosecurity plan, which follows IMO guidelines (described in Section 10.4.4 above) with regards to ballast water exchange (NEFL, 2015).

Biofouling

Biofouling is harder to mitigate than introduction through ballast water, and consequently the risk of each vessel introducing invasive species to Falkland Islands waters should be assessed on a case by case basis.

- All vessels employed during the drilling campaign will follow IMO guidelines on marine biofouling.
- The OSV/PSV and ERRV vessels are all recently commissioned vessels and should be in close to pristine condition

10.4.6.1 Residual Impact

Following the standard application of the IMO guidelines, the risk of introducing non-native marine species should be reduced but not eliminated entirely, as such the likelihood of the impact will still be '**Remote**' and therefore the overall significance will remain '**Moderate**'.

The IMO guidelines should minimise the risk of the introduction of non-native marine species. However, if non-native species were introduced their detection would be difficult without monitoring in place. In order to provide an early warning system, PMO and FIG are in the process of deploying settlement plates on the TDF and elsewhere in the Harbour. The plates will be in place by the start of the Rhea-1 drilling program. Maintenace and checking of the plates will be conducted regularly as part of a Shallow Marine Survey Group (SMSG) project. NEFL will have access to the results to help review biosecurity measures, as appropriate.

10.5 Disturbance to Wildlife, Livestock and the Human Population Onshore from Helicopter Noise

10.5.1 Introduction

There has been considerable concern regarding the impact that aircraft noise can have on colonies of penguins and seals on Antarctica and on sub-Antarctic islands (for example, Hughes et al., 2008), and consequently this issue was also raised by stakeholders in relation to the 2015 drilling campaign. There have been few scientific studies that have examined such effects, however, evidence from these studies has suggested behavioural and physiological changes in penguins and seals resulting from low flying aircraft (discussed in Hughes et al., 2008).

Low flying aircraft invoke particularly strong responses in penguins, which can lead to trampling of adults, chicks and eggs, and the loss of exposed eggs and chicks to predators. There have been several studies to investigate the short-term behavioural response of penguins to overflying helicopters on South Georgia (Hughes et al., 2008; Lee and Black, 2013). In both studies, the behaviour of penguins changed significantly at a range of over flight heights (230 – 1,768 m) but the lower the flight the greater the observed changes in behaviour. It is usually the non-incubating / non-brooding birds that react most and will often leave the colony. Mortality of chicks or loss of eggs as a result of helicopter disturbance was not recorded in either study. To date, no studies have measured the physiological stress on penguins that is associated with this type of disturbance.

This section investigates the potential for disturbance caused by low flying helicopters on penguins and other wildlife, as well as the local community.

10.5.2 Sources of Helicopter Noise during the Rhea-1 drilling campaign

Ambient Aircraft Noise in the Falkland Islands

There are a number of helicopters based at MPC that are used for Search and Rescue (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 KEMH, landing on the school's football pitch.

Additionally, there are a number of military fixed-wing aircraft (from Typhoon jets to C130 Hercules) that regularly practice low-level flying around the Islands. In recognition of the threat posed by low-flying aircraft to wildlife, and also the risk of bird strikes and damage to aircraft, the Ministry of Defence (MoD) has developed a flight avoidance map to protect areas of sensitive wildlife in the Falklands from disturbance (MoD, 2014).

Helicopter Noise Generated during the Rhea-1 campaign

Three Sikorsky S92 helicopters will be used to transport crew members to and from the drilling rig. Helicopter operations will be mostly run from Stanley but some flights may also use Mount Pleasant Airfield. The site used in previous drilling campaigns at Cape Dolphin will not be used during the 2015 drilling campaign.

It is anticipated that helicopter flights would occur on a daily basis, with at least one flight per day, as a worst-case. Additionally, every two weeks, half the rig crew will change and it is anticipated that this will require 4-8 flights to and from the rig. In total it is estimated that 40 helicopter support flights and 5 helicopter test flights will be required during the Rhea-1 drilling campaign.

10.5.3 Environmental Receptors Onshore

In the Falklands, the most vulnerable receptors are breeding and moulting penguins; a number of species will be present on land throughout the year.

The unusual breeding strategy of king penguins means that birds breeding at the Volunteer Point colony will be present year-round, as it takes over a year to raise a chick. This colony supports virtually the entire Falklands breeding population.

Although they do not breed year-round, Gentoo penguins return to shore to rest throughout the winter months and 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).

Rockhopper and Magellanic penguins depart from the Islands shortly after moulting and do not return until the spring (September). When breeding, Magellanic penguins are dispersed around much of the coastline but there are no population estimates. Rockhopper penguins are relatively uncommon in the north of East Falkland, which supports approximately 2.3% of the Islands' population.

It is also possible that helicopter noise could impact on livestock in the Islands. Following the austral winter, local farmers are concerned about the condition of their livestock and the likelihood of a poor lambing season (mid Sep - end Oct). The farmers are equally concerned about the shearing season that runs from Nov - Feb. The danger is one of mass panic by a corralled flock, which has been startled by aircraft noise (FILFH, 2014).

The Rhea-1 well is scheduled to be drilling during August 2015 and will most likely be completed prior to the start of the penguin breeding periods and prior to the sensitive lambing seasons onshore.

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 NNRs, Ramsar sites or IBAs. Additionally, Eddystone Rock is used by South American fur seals, these animals favour the seclusion of isolated offshore rocks/small islands to avoid human disturbance (Campagna, 2008). Figure 51 highlights the distribution of sensitive environmental receptors and community settlements in the north of East Falkland. Direct flight lines between the two main heliports and drilling locations are indicated by arrows.

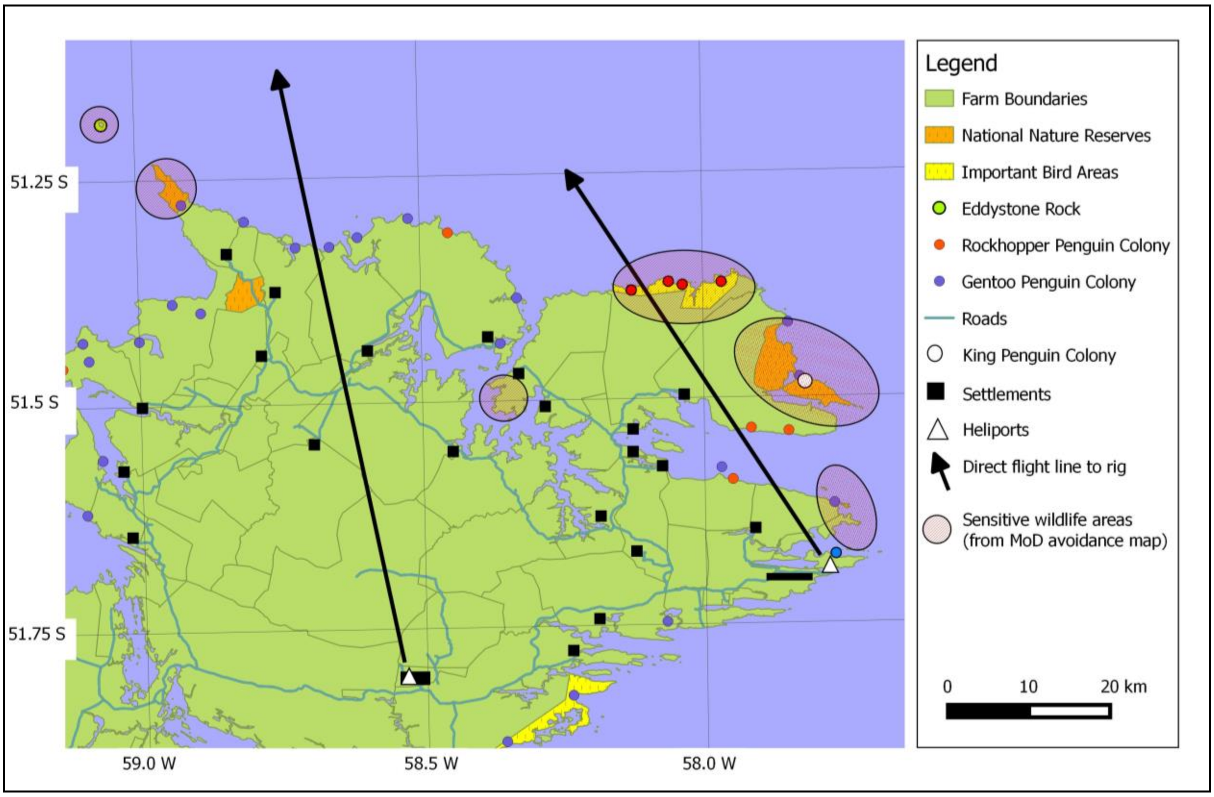


Figure 51: The distribution of sensitive wildlife receptors and settlements in the north of East Falkland.

Helicopters flying directly between Stanley and the drilling rig will pass nearly 10 km to the west of the king penguin colony at Volunteer Point. However, they will pass directly over the Seal Bay IBA, on the north coast of East Falkland. This area is designated an IBA due to the populations of breeding rockhopper, gentoo and Magellanic penguins and sooty shearwaters (see Section 5.4.6). These species will be absent from breeding sites during August but return in September. The flights could also pass over a number of farms.

Disturbance to the Residents of Stanley and Other Settlements

The heliport in Stanley is approximately 3.5 km from the nearest housing. The north of East Falkland is dotted with small settlements and farms (Figure 51).

10.5.4 Characterising and Quantifying the Impact of Helicopter Noise on Wildlife and Human Settlements Onshore

Helicopter transfers of crew are an essential component of the campaign and will happen on a daily basis, they are planned events. Every two weeks, there will be up to five flights, to and from the rig, to change crew.

There are several sources of helicopter noise, which can be broadly split into three types; main rotor, tail rotor and engine noise. The Sikorsky S92 is fitted with tapered rotor blades that are swept back and downwards to increase lift but this also reduces noise.

These aircraft are widely used in the oil and gas industry but there is little data available regarding the sound level generated in flight. One study, looking at the impact on human health, reported sound levels of 110-115 dB as passengers boarded an idling aircraft (Klovning, 2012). It can be assumed that the same helicopter in flight would be considerably louder (assumed to be approximately 125 dB here). The noise experienced on the ground will be directly related to the distance between the helicopter and the listener. It is possible to calculate the sound level at various distances from the source (Table 57) by applying the following equation:

Noise difference = $20 \times \log_{10} (r_2/r_1)$: where r_1 and r_2 are distances in metres.

In the above equation, r_1 is a reference point with known sound levels (r_1 m from the source); r_2 is the location under investigation (r_2 m from the source).

Table 57: Sound Level from Helicopter Activity Experienced at Ground Level (BMT, 2005)

	Maximum sound level at distance from helicopter (dB)		
Activity	**1 m**	**600 m**	**3,500 m**
Idling	115	58	44
Hovering	125	68	54

In terms of human disturbance, for comparison Table 58 gives representative values of the sound experienced in everyday situations. Wildlife is likely to be far more sensitive and react not only to the sound of a helicopter but also to the visual disturbance (A. Black pers. obs.).

Table 58: Typical Sound Levels in Relation to a Hovering Helicopter at 600m Distance

Sound Level (dB)	Typical Everyday Activities Characteristic of Each Sound Level	Sound Level Relative to Idling Helicopter at 600m Distance
80	Diesel truck at 40 mph at 50 ft	Twice the 70 dB reference
70	Vacuum cleaner	1, 70 dB reference
60	Conversation in a busy restaurant	$^1/_2$, as loud as 80 dB
50	Conversation at home	$^1/_4$, as loud as 80 dB
40	Urban ambient (library)	$^1/_8$, as loud as 80 dB

Environmental factors, especially wind, will also influence the propagation of sound and far more sophisticated models are required to accurately predict the noise level experienced by a receptor 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 wind conditions.

10.5.5 Impact Assessment summary

A summary of the impact assessment is shown in Table 59, page 271.

10.5.5.1 Severity and Receptor Sensitivity

Disturbance to Wildlife

The sensitive wildlife receptors that are most vulnerable to helicopter noise are mostly coastal in distribution. The impact of a single helicopter over-flight is likely to be short-term and rapidly reversible. However, the combined impact of numerous (daily) disturbances could have serious implications for the survival of moulting birds or chicks. The species of greatest concern is king penguin as these birds breed year-round and virtually the entire Falklands population is in one location, Volunteer Point. Under normal circumstances, the helicopters should have no need to overfly this area, which is designated as a NNR and should be avoided. Gentoo penguins return to shore throughout the winter. Nearly a quarter of the Falklands population breed in the north of East Falkland. Outside the breeding and moulting periods, these birds are less vulnerable to disturbance but over-flights should be avoided to minimise the impact of human activities on these species. Magellanic and rockhopper penguins will be on land between September and April but are at-sea between May and August. Due to the potential for chronic effects in small areas over the course of the campaign (currently August / September), the severity of helicopter over-flights has been assessed as '**Moderate**'.

There are areas that are designated as NNRs close to the direct flight paths between the rig and Stanley or MPC; Kidney and Cochon Islands, Volunteer Point and Cow Bay, Cape Dolphin and Moss Side (see Section 5.4.7). Additionally, the north coast of East Falkland, known as Seal Bay, and Bertha's Beach, near MPC, are designated IBAs for their colonies of penguins. The national importance of these areas means that the sensitivity of the receptors is assessed as '**High**'.

Disturbance to Human Settlements

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. There should be no need for helicopters to overfly Stanley during normal operations, although this may happen in the case of a medivac situation.

The distribution of settlements in the north camp is well known. The impact of helicopter noise will be localised and short-term resulting in a barely detectable impact on the local population. The severity of the impact on Falklands' residents is **'Minor'**.

The use of aircraft to transport passengers is an everyday occurrence in the Falklands so there is a degree of tolerance. Direct flight lines between the heliports and the drilling rig locations do not pass directly over settlements. The sensitivity of the local population to helicopter disturbance is assessed as '**Low**'.

Disturbance to livestock

Generally, 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, if animals were gathered in a confined space the impact would be more severe. Following the precautionary approach, the severity of helicopter disturbance on livestock is assessed as '**Moderate**', due to the small area that will be affected and short-term nature of the impact. Where animals are gathered, there is the potential to impact a high proportion of any one farms livestock, therefore, the sensitivity of receptors has been assessed as '**Moderate**'.

10.5.5.2 Significance

The overall significance of helicopter noise on wildlife and livestock onshore has been assessed as '**Moderate**' and therefore mitigation measures to reduce the significance will be developed and implemented.

The significance of helicopter noise on Falklands' residents is '**Low**'. This is largely due to the tolerance of people to aircraft and the fact that people subjected to mild noise disturbance do not come to any physical harm. Nonetheless, every effort will be made to ensure that helicopters do not fly unnecessarily close to settlements.

10.5.5.3 Degree of Confidence

The project activities are clearly defined in terms of the start and end points of flights, the frequency of flights and the locations of vulnerable receptors. The precise flight paths are yet to be determined but avoiding sensitive areas should be easily achievable. The long-term consequences of the impact to wildlife are not fully understood but means of completely negating the impact can easily be implemented. Confidence in the assessment is '**Certain**'.

10.5.5.4 Cumulative impact

Military helicopters generally fly under wildlife avoidance guidelines and in line with the Falkland Islands Low Flying Handbook (FILFH, 2014), which should negate any wildlife and livestock disturbance. However, MoD aircraft operate under the proviso that they follow the rules unless operationally necessary. In the past this has resulted in a degree of wildlife disturbance (Reid and Huin 2005). Under normal operating conditions helicopter activity during the drilling campaign will follow planned routes and have no need to land anywhere other than Stanley airport or MPC. Therefore, the drilling campaign should not result in any additional impact on wildlife or livestock disturbance.

10.5.6 Mitigation Measures

The simplest and most effective way to mitigate the effects of noise from helicopter over-flights is to route helicopters away from colonies of penguins, other seabirds, seals, farms and human settlements. Following the example set by the MoD and on other islands; such as South Georgia, risk reduction methods (flight avoidance maps) are available, which generally have a history of successful use and acceptance. The development of a project specific flight plan should be sufficient to mitigate against the impact of helicopter noise on wildlife and people in the Falklands and allay the concerns expressed by stakeholders during consultations. NEFL will use the flight avoidance map as the basis for flight planning, follow the Falkland Islands Low Flying Handbook Guidance, and brief helicopter pilots in flight avoidance protocols. The areas of greatest concern on the direct route between Stanley and the well sites are Volunteer Point and the IBA at Seal Bay. Where it is not possible to avoid areas of high wildlife sensitivity, minimum flight heights will be specified (>900 m, >3,000 ft). In addition to the restricted areas identified on the MoD map, the following recommendations follow those of the Government of South Georgia and the South Sandwich Islands:

- When following the coastline, maintain a vertical separation distance of 600 m (2,000 ft) and a horizontal separation of ¼ nautical mile (c.500 m) from the coastline where possible;
- Cross coasts at right angles and above an altitude of 600 m (2,000 ft) where possible;
- Never hover or make repeated passes over wildlife concentrations or fly lower than necessary; and,
- Avoid unnecessary over flight of livestock or known livestock grazing areas.

10.5.6.1 Residual Impact

With a flight plan in place that avoids areas containing sensitive wildlife the severity of the impact will be reduced to '**Minor**'. Avoidance of the high densities of receptors will also reduce the sensitivity of receptors to Low. With mitigation, the significance of disturbance caused by helicopter noise on wildlife and livestock will be reduced to '**Low**'.

10.6 Introduction of Terrestrial Invasive Species with Cargo Imports

10.6.1 Introduction

Many species have been introduced to the terrestrial environment of the Falklands, some intentionally and some unintentionally. In recent years, there has been a concerted effort by FIG to reduce the risk of visitors to the Islands unintentionally introducing more non-native species and biosecurity procedures have been improved.

There are numerous examples in the Islands where invasive species have had socio-economic impacts and almost certainly impact on the biodiversity of the Islands. For example, 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, and the long-term in-direct impact from the use of chemical pesticide treatments on native species and loss of fruit and vegetable crops. 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. Currently, a proposal to conduct biological control, with a parasitic fly, has been given consent. It has been assessed that this method has the potential to control earwigs without impacts on other environmental receptors (CABI, 2013).

The following section assesses the risk of introducing non-native species with cargo associated with the 2015 drilling campaign.

10.6.2 Sources of Non-native Species Introduction during the 2015 Drilling Campaign

Any cargo arriving from outside the Islands during the 2015 Exploratory Campaign poses a risk of unintentionally introducing non-native species. In this regard, the highest risks are invertebrates, seeds and soil (containing micro-organisms) that can adhere to the outside of containers or be hidden within cargo. Ecologically, the terrestrial habitat of the Falklands is comparable with that of the UK. Species that may be transported from the UK are very likely to survive and potentially become established in the Falklands (*c.f.* European earwig).

Coaster vessels arrived in Stanley, from the UK, every 10-14 days during the early stages of the campaign. Each vessel carried a range of cargo to facilitate all aspects of the 2015 drilling campaign. At the time of writing (April 2015), all of the cargo required for the campaign has been delivered to the Falkland Islands. There have been cases of non-native species arriving on cargo associated with the 2015 and previous campaigns. Fortunately these incidents were reported to the FIG Biosecurity Officer and treatment was applied, to remove the possibility of these species spreading and becoming established. As part of the planning consent, a TDF biosecurity plan (BSP, NEFL, 2015c) was in place and has developed over the life-time of the facility. Currently, the Biosecurity Officer is informed in advance of cargo arriving and inspections carried out prior to it being offloaded. Guidance is given regarding the preparation of cargo before leaving the UK (all wood is treated; equipment is steam washed and containers fumigated). The TDF is also equipped with monitoring devices and equipment to clean any cargo that does not meet the specified standards.

Importing Fruit and Vegetables

During the previous round of exploratory drilling in 2011, fresh fruit and vegetables were imported into the Falkland Islands on the campaign charter flight. While this was welcomed by local residents, 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 MPC via the charter flight. This is not the preferred method for importing materials to the Islands but may be used if urgent drilling supplies are required.

10.6.3 Environmental Receptors Affected by the Introduction of Non-native Species

The greatest environmental impact associated with the introduction of non-native species would be on the biodiversity of the Falklands. When non-native species thrive to the point of becoming invasive, they tend to outcompete or depredate native species. The precise receptor species would depend on the species introduced.

10.6.4 Characterising and Quantifying the Impact of Non-native Species

A cargo laden coaster arrived in the Falklands every 10-14 days over a period of 5-6 months, during late 2014 and early 2015. A detailed inventory of cargo is not available but has included drill pipe and bulk chemicals and all other equipment associated with exploration well drilling.

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 are harbouring some non-native species, whether these are able to survive, breed to become invasive depends on the species concerned and whether they find a niche to exploit in the Falklands. Therefore, the impact of any introduction should be assessed on a case-by-case basis.

10.6.5 Impact Assessment Summary

A summary of the impact assessment is shown in Table 59, page 271.

10.6.5.1 Severity and Sensitivity of Receptor

If invasive species were introduced during the drilling campaign 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 and therefore the sensitivity of the receptors has been assessed as '**Moderate**'. If found, potentially invasive species, particularly plants, 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 non-native species become established (invasive), the long-term implications for the Islands could be severe and difficult to reverse. In the terrestrial environment the possibility of detecting potential invasive species and eradication, thereby reversing the effect, is feasible but may be costly, in time and money, on this basis the severity has been assessed as '**Major**'. Therefore, the impact is assessed as '**Moderate**'.

10.6.5.2 Likelihood

Coaster vessels will be arriving in Stanley throughout the drilling campaign 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 industry elsewhere in the world. Non-native species (with the potential to become invasive) have arrived in the Falklands in cargo associated with the 2015 drilling campaign and therefore the likelihood of invasive species becoming established as a result of the drilling campaign has been assessed as '**Possible**'.

10.6.5.3 Significance

The movement of large quantities of cargo has discernible environmental and social risks in terms of the potential to introduce non-native species. There are means of reducing the risk, which are becoming widely used and accepted. Overall the significance of the risk of introducing non-native terrestrial species has been assessed as '**Moderate**'.

10.6.5.4 Degree of Confidence

The nature of the impact of currently established invasive species on the terrestrial environment of the Falklands is understood. It is known that the 2015 drilling campaign has already 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. Therefore there is a degree of uncertainty regarding the sensitivity of environment receptors. Confidence in the assessment is therefore assessed as '**Probable**'.

10.6.5.5 Cumulative Impacts

Any cargo coming into the Falklands has the potential to transport non-native species into the Islands. The 2015 drilling campaign will add considerably to the existing risk of introducing invasive species to the Falkland Islands.

10.6.6 Mitigation measures

The best means of reducing the likelihood of introducing non-native species is to ensure that all materials are clean when packed or loaded in the port of origin, particularly items of fresh fruit and vegetables.

- All NEFL personnel should be briefed on the significance of non-native species and instructed to capture/kill any invertebrates that are found while unloading/unpacking cargo.
- Cargo should be clean when packed and sealed in appropriate packaging.
- Falkland Islands Biosecurity Guidelines will be adhered to for any freight imported via the charter flight.
- On arrival in the Falkland Islands, cargo will be inspected for biosecurity breaches. Any breaches should be reported to the FIG Biosecurity Officer.

NEFL have produced a TDF biosecurity plan (BSP), which specifies how cargo should be prepared for shipment; requires notification of cargo arrival; provisions for cargo inspection on the vessel and specifies monitoring requirements.

FIG Biosecurity guidelines

Any person, vehicle or cargo travelling to the Falklands has the potential to introduce non-native species. The Government's guidance to visitors states:

The Falkland Islands are extremely fortunate in that they are free from most of the serious animal and plant pests and diseases that affect many other parts of the world.

The Government and people of the Falkland Islands would like this favourable situation to continue into the future. Your assistance is requested in ensuring that unwanted diseases and pests of either plants or animals are not inadvertently introduced into the Islands by the illegal importation of any biological material. The list is endless but includes the following:

- *Animals (Alive or dead).*
- *Unprocessed plant material to include everything in the nature of a plant and the flowers. To include fruits, vegetables, plants, shrubs, tubers, bulbs, nuts, seeds, leaves, cuttings, sprigs, bark and cut flowers.*
- *Uncooked foods of animal origin. To include meats of any kind such as Beef, Lamb, Pork, & Venison; Poultry such as Chicken &Turkey; Meat & Poultry products such as bacon, hams, sausages, burgers, pates, salamis & chorizos; Dairy foods such as milk, butter, cheese, yoghurts & milk puddings; Eggs, including eggshells.*
- *Any other unprocessed items of animal origin such as wood, feathers, hides, leather, wool, bone or any other biological product.*
- *Soil or any articles containing soil.*
- *Compost particularly if untreated.*
- *Any veterinary products or medicines.*
- *Any animal foodstuffs such as Oats/Barley/Hay/Straw/Animal Concentrate.*
- *Packaging that has contained any of the above products.*

10.6.6.1 Residual Impact

An increase in awareness regarding the risks associated with the import of non-native species, added vigilance when packing and unloading cargo and fumigation/trapping, where appropriate, should remove potential invasive species at source or enable the detection/capture of non-native species before they escape into the environment. The capacity for rapid on-site cleaning will reduce the severity to '**Minor**' and increased vigilance will reduce the likelihood to '**Rare**', resulting in '**Moderate**' post mitigation significance. Monitoring of incoming cargo will help to evaluate the effectiveness of the biosecurity protocols and indicate if revision is needed.

10.7 Disturbance to Wildlife and Local Residents from Shore Based Light and Noise Sources

10.7.1 Introduction

The impact of the operation of the TDF and the laydown yards has already been covered in a separate EIA (see NEFL/RPS, 2013). For completeness, the impacts associated with shore based light and noise are summarised here.

As with lights at-sea, lights onshore can attract and disorientate wildlife, particularly nocturnal seabirds. Where endangered species of petrel nest near urban areas this has proved to be a major problem (Reed et al., 1985; Le Corre et al., 2002). Birds are vulnerable throughout the breeding season but fledgling birds are particularly vulnerable.

Light pollution and excessive noise can become a nuisance to local residents resulting in a reduced quality of life.

In the following section, the impact of artificial light and noise from inshore and onshore activities are assessed.

10.7.2 Sources of Onshore Light and Noise

Ambient Sources of Light

The area of the shore base is already an industrialised area, approximately 1.5 km to the east of Stanley. Additionally, vessels anchored in Stanley Harbour and Port William can at times add considerably to terrestrial sources of ambient light.

Ambient Sources of Noise

Although situated in an industrialised area, there is no heavy industry in the vicinity of the shore base. FIPASS is the most industrialised area in Stanley, which sits between the TDF/shore base and the town. It is rare that vessels work cargo at FIPASS outside core working hours (8am to 8pm); however, there is no perception that these activities cause undue noise.

At times, vessels anchor in the Harbour adjacent to Stanley. Noise from these vessels, particularly if they have large generators, can be heard by local residents on calm nights.

Sources of Inshore and Onshore Light during the Rhea-1 Drilling Campaign

It is anticipated that at times the TDF, shore base and laydown yards will be floodlit to enable safe working of cargo. Activity on the TDF and laydown yards could occur 24 hours a day, seven days a week, therefore, there could be a visual impact during night time hours. Night time lighting on the TDF may be visible from long distances and has the potential to cause a nuisance to residents.

Presently, there is a considerable background level of artificial light in Stanley. The town of Stanley is currently illuminated by street lights and industrialised areas (such as FIPASS) are equipped with floodlights similar to those on the TDF.

Sources of Inshore and Onshore Noise during the 2015 Drilling Campaign

The TDF and shore base could operate 24 hours a day seven days a week. The most significant noise generating sources and activities during operations are considered to be:

- Vessel arrival / departure during drilling programme OSV/PSVs, typically 5,000 to 10,000 brake horsepower; and
- Vessel loading / unloading using a 250-tonne crane, a 30-tonne crane; and a 15-tonne forklift.

10.7.3 Environmental Receptors Impacted by Inshore on Onshore Light and Noise

The environmental receptors to light and noise can be broadly classified as; the residents of Stanley (including Stanley Airport) and local wildlife.

Residents of Stanley and Stanley Airport

The receptors that are most likely to be affected by the light and noise emitted by the TDF and shore base during the drilling campaign are the residents of Stanley and Stanley Airport. The location of the TDF and shore base is within the existing industrial area of Stanley, to the east of FIPASS, and is more than a kilometre away from the nearest residential receptor.

An additional issue raised by stakeholders is the potential for east-facing lighting from the TDF and the use of bright lighting on vessels at the dock to affect night-time flying operations at Stanley Airport. It is anticipated that supply vessels will moor facing into the prevailing wind (westerly) and therefore the main deck lighting will face east. These lights have the potential to affect the night vision of pilots approaching the main runway at Stanley Airport. Night flying at Stanley is not a regular occurrence and is mainly limited to occasional medical emergencies and training flights in the winter months. However, the potential for lighting from the TDF to affect night-time flights remains.

Local Wildlife

The species most vulnerable to artificial light are small petrels and shearwaters (see Section 5.4.6). The closest breeding colonies of nocturnal petrels to Stanley are found near Hadassa Bay, on Top and Bottom Islands in Port William and Kidney Island near Mengeary Point. These are approximately two, five and eight and a half kilometres away respectively from the TDF and laydown yards and are not in direct line of sight. Breeding birds are present on these Islands during the summer months (September to May), fledging dates range from early April to early May (Woods and Woods, 1988). Wrecked birds (incidences of numerous dead seabirds), presumed to be juveniles, are occasionally found in Stanley after autumn storms. Outside the breeding season these birds remain at-sea.

10.7.4 Characterising and Quantifying the Impact of Inshore Sources of Light and Noise

Light

The preliminary lighting design for the TDF consists of 400 Watt high pressure sodium (HPS) lamps, located 3 m above the deck, tilted at 60 degrees and facing in-board. On the causeway, HPS flood-lamp will be placed every 18 m. This is similar to street lighting as it is only required for traffic travelling to and from the barge and therefore does not require intense lighting. Light towers fitted with 1,000 Watt flood-lamps will also be installed on both the bow and the stern of the barge facing in-board. In addition, it is planned to have 400 Watt flood-lamps installed in the boom of the crane to further aid visibility during lifting operations.

The majority of lights (other than on the causeway) will be directed away from Stanley towards the loading face of the barge during operation. The nature of lighting intensity will be similar to that already emitted by FIPASS. Since the start of the 2015 Drilling Campaign, a local resident has raised concern about light disturbance from one of the OSV/PSVs moored alongside the TDF, however, this was quickly rectified (N. Baxter pers. comm.).

The shore base laydown yards are equipped with floodlights. These lights are generally directed inland and downwards, away from residential areas and the sea.

Noise

The EIA for the construction and operation of the TDF included a noise modelling study to assess the potential for noise generation and the potential impacts. Details of the modelling can be found in the TDF EIA (NEFL/RPS, 2013).

The supply vessels, which will be moored alongside the TDF or at anchor in the harbour, are equipped with very powerful engines. Engine noise from similar vessels currently using the harbour can be heard by Stanley residents on a calm night.

Forklift trucks at the TDF and the shore base will require safety reversing signals (a repetitive beeping sound), which may be audible outside the nearest houses in Stanley (Ross Road East and Rowlands Rise) during calm (i.e. quiet) weather.

Noise levels received by outside receptors at the eastern end of Stanley are predicted to be less than 15 and 25 dB $L_{Aeq,5\text{-}min}$ during night-time unloading at the TDF with average (westerly) and worst–case (easterly) wind respectively. Following consultation with local residents, some concerns were raised regarding the level of noise disturbance during the construction phase of the TDF, activity on FIPASS is also audible. Whether this is at a level that causes undue disturbance is uncertain and is likely to depend on the time of day that noise is heard. Since the start of the 2015 Drilling Campaign, there have been no complaints from local residents regarding undue noise disturbance from operations at the TDF (N. Baxter pers. comm.).

10.7.5 Impact Assessment Summary

A summary of the impact assessment is shown in Table 59, page 271.

10.7.5.1 Severity and Sensitivity of Receptors

Light and Stanley Residents

Light spillage towards Stanley will be minimised, given the orientation of the lights and attenuation with distance. In addition, the lighting is unlikely to add significantly to the light emitted by FIPASS and will be of a similar nature to that already employed there. The impact will be localised and short-term and therefore the severity is assessed as '**Minor**'. The sensitivity of Stanley residents is assessed as '**Low**' as they are already subjected to artificial light from FIPASS and from within the town.

The main deck lights of vessels alongside the TDF will face east, towards Stanley airport. Although they point downwards this has the potential to temporarily interfere with the night vision of pilots and the severity is assessed as '**Moderate**'. The potential for disruption of night flights from Stanley Airport is clearly of concern to stakeholders. Therefore, without mitigation the sensitivity of Stanley Airport is assessed as '**Moderate**'.

Light and Wildlife

The TDF and shore base will add to the existing sources of artificial light in the Stanley area and there is some potential for the additional lights to attract small petrels and shearwaters, which could collide with the TDF structure as a result. Currently, there is little evidence that the existing lights in Stanley have resulted in any displacement or collision impacts for petrels or shearwaters. The impact resulting from the drilling campaign will be localised and short-term and in the context of current ambient light levels will have negligible impact on the species concerned, therefore the severity of the impact has been assessed as **'Minor**'.

The nearest breeding colonies of such species are not in direct line of sight of the TDF and birds will migrate away from the Falklands during most of the drilling campaign. The sensitivity of receptors (sooty shearwaters) has been assessed as '**Low**'.

Noise and Stanley Residents

Significant adverse effects to the population of Stanley as a whole are unlikely due to the separation distance between the site of the TDF, the shore base and most homes. However, there are indications that noise can be heard by the residents closest to the TDF (approximately 1 km from the TDF). The results of the noise modelling assessment undertaken for the TDF indicate that the magnitude of operational noise would be below any thresholds at which noise is considered to cause an impact (NEFL/RPS, 2013). The modelling assessment also indicated that, during concurrent daytime operations at the TDF and FIPASS, cumulative noise will be dominated by existing operations at FIPASS and consequently the daytime noise environment will be unchanged due to the operation of the proposed TDF. Noise was raised as an issue during public consultations prior to the start of the 2015 Drilling Campaign but there have been no complaints since the drilling operations began.

The magnitude of noise impact during loading and unloading at the TDF and shore base during a calm and dry night for which there is a light easterly wind (worst-case scenario) is considered to be barely detectable and unlikely to cause any potential impact to local residents (NEFL/RPS, 2013). The predominant wind direction is westerly so these conditions occur for a minority of the time. In view of comments during the consultation it is likely that there will be some localised disturbance to residents in the east end of Stanley. The severity of the impact is assessed as '**Minor**' and the sensitivity of receptors is '**Low**'.

Noise and Wildlife

The noise generated during the operational phase of the TDF and the shore base is believed to be lower than during the construction phase of the TDF. Modelling suggests that the level of noise will be similar to that already generated by FIPASS and is not thought to be sufficient to impact on local wildlife (NEFL/RPS, 2013). The severity of the impact is assessed as '**Minor**' and the sensitivity of receptors is '**Low**'.

10.7.5.2 Significance

Light and Stanley Residents

The significance of the impact of light on the residents of Stanley has been assessed as **'Low'** and no further measures are proposed.

Light and FIGAS pilots

The orientation of deck lighting from vessels alongside the TDF (facing east) has raised concerns over night flying from Stanley Airport. The significance of the impact is assessed as **'Moderate'** and mitigation measures will be implemented to reduce the significance.

Light and Wildlife

The significance of artificial light from the TDF and shore base on inshore wildlife has been assessed as **'Low'**, lights will be directed inboard to minimise the impact but no further mitigation measures are proposed.

Noise and Stanley Residents and Wildlife

The significance of noise on the residents of Stanley and local wildlife has been assessed as '**Low**' as it will not exceed levels generated by existing activities in the area.

10.7.5.3 Degree of Confidence

This assessment relies largely on the EIA, and associated modelling, that was presented prior to the construction of the TDF (NEFL/RPS, 2013). The TDF and shore base adds to existing sources of light and noise in the industrialised area to the east of Stanley and therefore the nature of the impact is well understood. However, a degree of monitoring is required to ensure that artificial lights do not interfere with FIGAS flights or local wildlife. Therefore the confidence in the assessment is '**Probable**'.

10.7.5.4 Cumulative Impacts

The drilling campaign operations at the TDF will add slightly to the noise generated in what is already an industrialise zone. Modelling indicates that the addition of noise generated at the TDF and shore base will be unnoticeable to the residents of Stanley. However, local residents have raised concerns regarding noise generated since operations commenced on the TDF at the start of the 2015 joint drilling campaign.

10.7.6 Mitigation Measures

Although the significance of artificial light during the operational phase of the TDF is Moderate, several measures will be used to reduce the impact of the drilling campaign on the residents of Stanley.

Light

All lamp units, save those required for safety and navigation aids, will be pointed in-board towards the causeway and barge, to reduce potential light pollution to local residents in Stanley;

- The TDF and shore base permanent lighting will be designed and implemented in accordance with the Health and Safety in Ports (SIP009) Guidance on Lighting. This is a document jointly prepared by Port Skills and Safety with assistance from the UK Health & Safety Executive (HSE). This will ensure that the artificial lighting used does not generate light spill or reflection that could be a possible nuisance to local residents or attract wildlife; and
- NEFL will continue consultation with FIGAS to ensure that the lighting design minimises any potential issues related to the operations of flights in and out of Stanley Airport;

Noise

The significance of noise has been assessed as Low; however, the following measures will further reduce the impact on Stanley residents and wildlife.

- Vessel movements will be reduced where possible through optimised planning, making efficient use of vessel loads;
- All vessel engines shall be switched off whilst not in use and not left to idle, where possible; and
- Loading or unloading operations at night shall not normally occur and if necessary will be minimised where practicable.

10.7.6.1 Residual Impact

The correct orientation of lighting should allow for safe working practices and reduce the amount of light escaping into the surrounding environment. This should minimise the number of potential wildlife receptors (seabirds) that are disorientated and therefore reduce the sensitivity of these receptors to '**Low**'. Liaison with FIGAS to coordinate their requirements for night flying with cargo movements (and therefore the requirement for floodlighting) will help to minimise the sensitivity of this receptor to '**Low**', thus reducing the overall significance to '**Low**'.

10.8 Demands for Accommodation in Stanley

Throughout the drilling campaign, it is anticipated that approximately 85 additional personnel (representing NEFL, Premier Oil, third parties and stand-by crew) will be based in Stanley. The majority of personnel with be based offshore but will pass through Stanley during crew changes. During previous exploration campaigns, personnel have been accommodated in local hotels, guesthouses or rental property. However, there is a limit to the number of available beds and properties in Stanley and therefore a different strategy to accommodate personnel during the 2015 campaign is needed.

Having explored a number of potential options, a temporary accommodation block for the exclusive use of the 2015 Drilling Campaign has been constructed on a brown field site to the south of Stanley (near Stanley Services). It is intended that this facility will satisfy the bulk of the Rhea-1 well campaign's accommodation needs, and will also be able to cope with the eventuality of delayed flights, for instance due to bad weather, when 'emergency' accommodation may be required. The accommodation block places some additional demands on the power and water supplies in Stanley, although these are on a domestic scale. As a back-up to local power supplies, the unit is equipped with generators.

It is likely that some individuals involved in the campaign will be accommodated in local hotels and guesthouses, providing a boost to business. However, it is anticipated that the majority of workers will be housed in the purpose built temporary accommodation unit. Nonetheless, there is a shortage of accommodation in Stanley, which can cause problems for visitors to the Islands.

Permanent Stanley based personnel

It is anticipated that the number of additional permanently shore based NEFL personnel working in Stanley during the course of the 2015 exploratory campaign will be low (five individuals). Although this is a small number of people they will put extra pressure on the local housing market. Although the recent development of the Sapper's Hill site and extension to Murray Heights have helped to reduce the demands for rented accommodation, rented accommodation in Stanley is in short supply.

Crew change

The majority of personnel will be working offshore. The rig, *Eirik Raude* can take a maximum of 120 workers, with half the rig personnel exchanged every two weeks. Workers may well require accommodation for a night as they arrive in or depart from Stanley.

Table 59: Summary of the assessment of inshore and onshore impacts associated with the 2015 drilling campaign

Activity	Aspect	Potential Impact	Type of Activity	Likelihood	Sensitivity	Severity	Significance		Certainty	Mitigation / Prevention / Control
							Pre-mitigation	Post-mitigation		
Support/supply vessels	Physical presence in Stanley Harbour	Interference with other sea users	Planned	N/A	Moderate	Minor	Moderate	Low	Certain	TDF Manager to liaise with Harbour Master
Support/supply vessels	Collision with marine mammals	Injury to marine mammals	Unplanned	Remote	High	Major	Moderate	Low	Probable	Awareness and increased vigilance in inshore waters
Support/supply vessels	Marine biosecurity	Introduction of invasive species	Unplanned	Remote	High	Major	Moderate		Probable	Follow IMO guidelines on ballast water exchange and bio-foulling management. Hull inspections, monitoring in Stanley Harbour
Heli-ops	Noise disturbance to wildlife	Disturbance to seabirds onshore	Planned	N/A	High	Moderate	Moderate	Low	Certain	Identify flight avoidance areas
Heli-ops	Noise disturbance Falklands population	Disturbance	Planned	N/A	Low	Minor	Low		Certain	Identify flight avoidance areas
Heli-ops	Noise disturbance livestock	Disturbance	Planned	N/A	Moderate	Moderate	Moderate	Low	Certain	Identify flight avoidance areas

** See Section 6.0 for definitions of sensitivity, severity, likelihood and significance.*

Table 59 continued: A summary of the assessment of inshore and onshore impacts associated with the 2015 drilling campaign

Activity	Aspect	Potential Impact	Type of Activity	Likelihood	Sensitivity	Severity	Significance		Certainty	Mitigation / Prevention / Control
							Pre-mitigation	Post-mitigation		
Shore base, marine and air freight	Terrestrial biosecurity	Introduction of invasive species	Unplanned	Possible	Moderate	Major	Moderate		Probable	Educational awareness, ensuring that cargo is clean and checking cargo on arrival in the Falklands. Report any breaches in biosecurity to the FIG Biosecurity Officer
Shore base/TDF	Light	Disturbance to Stanley Residents	Planned	N/A	Low	Minor	Low		Probable	Orientate light away from Stanley
Shore base/TDF	Light	Disturbance to FIGAS pilots	Planned	N/A	Moderate	Moderate	Moderate	Low	Probable	Liaise with FIGAS
Shore base/TDF	Light	Disturbance to local wildlife	Planned	N/A	Low	Minor	Low		Probable	Orientate lights in board
Shore base/TDF	Noise	Disturbance to local residents and wildlife	Planned	N/A	Low	Minor	Low		Probable	None Required

** See Section 6.0 for definitions of sensitivity, severity, likelihood and significance.*

11.0 Waste Management

11.1 Introduction

All industrial waste falls under the category of 'controlled waste' and thus has to be accounted for and recovered or disposed of in a safe and environmentally responsible way. The discharge of waste to sea is prohibited with the exception of certain discharges, which are permitted under international law and 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, waste disposal options in the Falkland Islands are limited.

The accepted approach to waste management involves the application of prioritised management practises, referred to as the Waste Hierarchy (Figure 52).

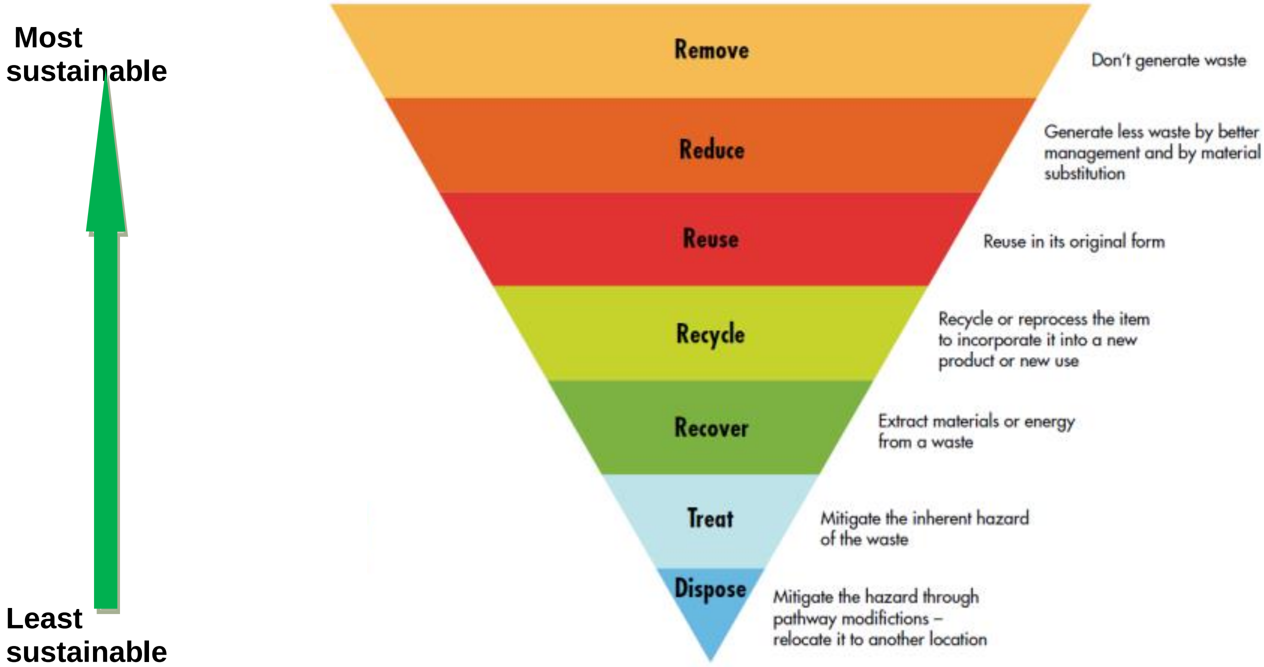


Figure 52: Waste Hierarchy

A range of hazardous and non-hazardous waste will be produced during the Rhea-1 well operation. Given the limited waste management facilities in the Falklands, NEFL has developed a waste management plan (WMPA; NEFL, 2015d) specific to exploratory drilling operations in the Falkland Islands to ensure that all waste is processed, stored, transported and disposed of responsibly. Discharges of waste water will be managed in line with the NEFL Offshore Discharge Management Programme (ODPO; NEFL, 2015e).

This chapter describes the types and estimated quantities of waste that are likely to be generated during the Rhea-1 well drilling operation, potential impacts and risks to the environment of that waste and the intended disposal routes. The content and implementation of the WMPA and key mitigation controls are also described.

The discharge of ballast water is covered in Chapter 10.0.

The discharge of Water Based Mud during drilling operations is covered in Chapter 12.0.

International Legislation Regarding Waste Management

Currently there is no waste-specific legislation enacted in the Falkland Islands. Therefore, NEFL has developed its WMPA to comply with Noble Energy policies and standards as well as international and UK law (Scottish law as the final waste destination).

There are numerous international and national laws and regulations that govern and control disposal of waste generated in the marine environment. Key legislation implemented via the WMPA includes:

International Conventions:

- International Convention for the Prevention of Pollution from Ships (MARPOL) 1973/78 which provides regulation on the different types of potential pollution and specifies whether discharge to sea is permitted, discharge distances from land and the manner in which they may be disposed of. MARPOL regulations specifically relevant to the management of waste are:
  - Annex I – Regulations for the Prevention of Pollution by Oil
  - Annex IV – Regulations for the Prevention of Pollution by Sewage from Ships
  - Annex V – Regulations for the Prevention of Pollution by Garbage from Ships.
- 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.

Key UK Legislation:

- 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.
- Environmental Protection Act 1990 which introduced the 'Duty of Care' principle. Anyone who imports, produces, carries, keeps, treats or disposes of waste is subject to a duty of care whereby they must take all reasonable and applicable measures to:
  - Ensure that waste is stored and transported appropriately and securely so it does not escape;
  - Check that waste transferred to people or businesses for disposal are authorised to do so; and
  - Complete Waste Transfer Notes (WTNs).
- 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:

- 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

11.2 Sources and Types of Waste Generated during the Rhea-1 Drilling Operation

Virtually every aspect of drilling the Rhea-1 well will generate controlled waste materials, including: the NEFL in-country office, drilling, construction, installation, logging, utilities, and well abandonment.

Controlled waste streams generated during well operations can be broadly categorised as:

- Galley and domestic waste (e.g. food, waste water)
- Non-hazardous waste (e.g. paper, packaging, scrap metal)
- Hazardous waste (e.g. empty chemical drums, oily rags, waste oil, oily water (drainage and bilge water) etc.)

One of the guiding principles of waste management is the identification and categorization of waste products to enable segregation of waste of different types thus ensuring efficient, safe and environmentally responsible disposal. From the perspective of environmental impact and risk, the key distinction to make is that between non-hazardous and hazardous waste.

11.2.1 Definitions of Waste Types

Non-Hazardous Waste: will typically include domestic waste e.g. paper, plastics, cans, food waste, scrap metal and wood and domestic waste water such as water used in bathrooms, kitchens and laundry (grey water) and sewage (black water) that are not cross-contaminated with hazardous waste and can therefore be removed and recovered e.g. via reuse or recycling or disposed of onshore.

Hazardous Waste: shares the properties of a hazardous material (e.g. ignitability, corrosivity, reactivity, or toxicity) and includes oily waste including waste oil, used oil filters, oily rags etc., Waste Electrical and Electronic Equipment (WEEE), empty oil/chemical containers, asbestos, batteries, chemicals, paints, radioactive material and medical wastes all of which may pose a potential risk to human health or the environment if not properly managed.

11.2.2 Waste Disposal in the Marine Environment

Few waste streams generated during the Rhea-1 drilling campaign will be eligible for discharge at sea. In compliance with the relevant legislation, those that are eligible include:

- Domestic waste water e.g. grey water and black water;
- Food waste;
- Seawater used in fire pumps;
- Deck drainage water e.g. precipitation run-off;
- Bilge water from supporting vessels;
- Ballast water from ships (see Chapter 10.0); and
- Water-based mud and drill cuttings (see Chapter 12.0).

Discharges to sea will be carried out in accordance with the NEFL ODPO.

Grey Water, Black Water and Food

Domestic waste including black water, grey water and food waste is generated and discharged in the course of normal rig and vessel operations. These discharges are regulated internationally through MARPOL Annex IV and Annex V which are transposed into UK legislation via The Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008.

In compliance with MARPOL Annex IV, black water will be treated prior to disposal at sea and may be discharged in waters greater than 12 nautical miles from the nearest land. Food waste will be macerated to ensure a maximum solid particle size of less than 25 mm prior to discharge as required under MARPOL, to aid its dispersal and decomposition in the water column.

Firewater

The firewater system on the rig relies on seawater mixed with foam. The system is tested every week with seawater alone to ensure that it is working. The foam system is tested on an annual basis and testing is not planned to occur during the Rhea-1 well operation. Discharge of foam to sea is only permitted during the annual foam tests, or under *force majeure* in the event of a real incident.

Deck Drainage and Bilge Water

Deck drainage water may contain emulsified oil and grease, diesel, hydraulic oil, lube oil, and a full range of marine fuel oils. Drainage water is passed through a separator to remove any oil that is picked up from the deck.

Both deck drainage water on the rig and bilge water from supporting vessels operate under MARPOL 73/78 Annex I. Under Annex I, the discharge to sea of drainage or bilge water is prohibited unless the oil content of the discharge, without dilution, is less than or equal to 15 parts per million (ppm). All oil discharges will be recorded in an Oil Record Book in line with MARPOL Annex I.

11.2.3 Waste Generation and Handling in the Falkland Islands

The majority of waste streams generated by the drilling rig and its supporting vessels will initially be shipped back to the TDF in Stanley. These waste streams will include:

- General waste (packaging, scrap metal); and
- Hazardous waste (empty chemical drums, oily rags etc.).

Received waste will be stored, along with waste generated in the NEFL shore base, on a short-term basis at the supply base in a suitably controlled environment prior to being shipped back to the UK for disposal. The WMPA will ensure that waste is collected, handled, stored and transported in a manner that reduces the impact of waste, reduces the risk of escape to the environment and minimises the risks to human health.

In accordance with the WMPA, NEFL will ensure that:

- No solid wastes arising from the drilling program will be landfilled in the Falkland Islands;
- Non-hazardous combustible waste (i.e. paper, cardboard, wood etc.) will be segregated and sent to a local incinerator in the Falkland Islands in line with FIG approval;
    - The waste ash arising from this incineration will be landfilled in the Falkland Islands at an existing landfill facility (e.g. Eliza Cove).
- No hazardous waste is disposed of in the Falkland Islands*;
- Hazardous waste is exported to an approved disposal facility in the UK in accordance with the Basel Convention; and

*The only potential exception is that some, or all, of the waste oil accumulated (e.g. cooking oil, oil from drainage/bilge water separators) may be provided to a local business, Stanley Growers, for their oil burning heaters, thus providing a benefit. Re-use of waste oil in this way is listed as a project specific environmental objective (Chapter 14). Waste oil that is not provided to the Stanley Growers will be shipped to the UK as hazardous waste in line with the WMPA.

Detail on the above FIG approved waste destinations will be provided in the project specific Waste Register (Section 11.6).

11.3 Potential Receptors

11.3.1 Potential Receptors in the Marine Environment

The main potential marine environmental receptors, which may be significantly impacted by the production of waste and the discharge of grey, black and bilge water, are seabirds and water quality.

11.3.2 Potential Receptors on the Falkland Islands

The main potential environmental receptors on the Falkland Islands, which may be significantly impacted if waste is not handled and stored correctly, are soil, local wildlife and human health.

11.4 Characterizing and Quantifying the Impact of Waste Generated during the Drilling Operation

11.4.1 Impacts and Risks to the Environment

Discharge to Sea of Grey Water, Black Water and Food

As with any vessel at-sea, the rig and associated vessels are likely to attract a mixed flock of seabirds, including albatross and petrel species listed under ACAP (see Chapter 5). These species rely on scavenging for much of their food and are attracted to anthropogenic activity, such as vessels, which often generates sources of food.

With regard to seawater quality, the discharge of grey water, black water and galley food waste may lead to minor localised impact, due to eutrophication (nutrient enrichment). The release of contaminants may lead to deterioration in seawater quality and localised increase in Biological Oxygen Demand (BOD) around the discharge point.

Solid waste (sewage and food) will be macerated before being discharged, to achieve no floating solids and no discolouration of surrounding water in compliance with MARPOL 73/78 Annex IV, the NEFL ODPO and rig/vessel procedures. The discharge point is 12.5 m below the surface of the water. Both the discharge point and maceration should ensure that waste is dispersed and diluted rapidly by the natural water movement around the rig thus minimizing the impact of eutrophication. Additionally, the activity of bacteria and other marine organisms will rapidly break down organic waste.

The volume of waste water produced depends on whether a conventional or vacuum system is used. Vacuum systems make more efficient use of water and thus decrease the volumes discharged. The *Eirik Raude* rig and the ERRV both operate a vacuum system for both black and grey water. The two supply vessels operate a conventional system for grey water and a vacuum system for black water.

Vacuum systems generate 0.185 m^3/man/day of grey water and 0.025 m^3/man/day of black water (0.21m^3/man/day combined) (Huhta *et al*., 2007). To account for the less efficient water use associated with conventional systems, it is estimated that the conventional systems on the OSV/PSV's will generate 0.2 m^3/man/day of grey water. Using these data it is possible to estimate the total volume of 1333.8m^3 waste water will be produced by the rig and vessels during the 38 day Rhea-1 well operation (Table 60).

Table 60: Estimated Grey and Black Water Production volumes during Rhea-1 Drilling Operation

Source	System	Water m3 /day/ person		Number of men	Number of days	Grey water (m^3)	Black water (m^3)
		Grey water	Black water				
Rig *Eirik Raude*	Vacuum	0.185[1]	0.025[1]	120	38	843.6	114
ERRV	Vacuum	0.185[1]	0.025[1]	15	38	105.45	14.25
2 Supply vessels	Conventional	0.2		30	38	228	
	Vacuum		0.025[1]				28.5
Total	**n/a**	**n/a**		**165**	**114**	**1177.05**	**156.75**
Total						**1333.8**	

[1]Huhta *et al*., 2007.

Discharge to Sea of Deck Drainage and Bilge Water

Deck drain water and bilge water will pass through an oil separator before being discharged, at a maximum oil concentration of 15 ppm in compliance with MARPOL Annex I, the NEFL ODPO and rig/vessel procedures. Separated oil will be collected and stored in drums / transit tanks. Waste oil will be shipped back to the Stanley supply base for storage prior to transportation to the UK and/or provision to Stanley Growers for use in oil burning heaters. The amount of water passing through the drains and bilge pumps will depend on the amount of precipitation received and the cleaning activities on the rig. At present, it is therefore not possible to estimate the quantity of water (and thus oil) that will be discharged.

While seabirds may potentially be affected by surface oil sheens, at a concentration of 15 ppm, oil does not create a sheen on the water surface and hence birds do not become oiled (Wiese, 2002). Whether oil at this concentration still has the potential to damage other marine organisms is not known. Nonetheless, wave action will help to dilute and disperse any oil entering the sea.

Management of all Other Waste Products

By nature, the generation of waste products will always have the potential to impact upon the environment. The impact is greater if the Waste Hierarchy is not adhered to such that the production of waste is not minimised e.g. no segregation of waste to maximise recovery over disposal to landfill (either as waste ash in the Falkland's or to UK landfill sites). During the Rhea-1 drilling operation, the waste hierarchy will be utilised to reduce the volumes of waste where possible and to maximise the potential for waste recovery. The majority of waste products will be shipped back to the UK either for recovery or disposal. Waste will be shipped in returning coaster vessels that may otherwise be empty and will therefore not result in any additional shipping or emissions. Once in the UK, compliance with UK legislation will ensure appropriate recovery and/or disposal of the waste.

Additionally, 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. Loss of containment of solid or liquid hazardous or non-hazardous waste through poor handling and storage could have the potential to impact upon the environment. Liquid waste could leach into the ground and loss of solid and/or liquid wastes could attract and affect local wildlife e.g. by ingestion of materials, tangling etc.

Implementation of the NEFL WMPA will ensure that waste is minimised, handled, stored and transported appropriately at all stages and in accordance with legislation and best practice. The mitigation controls inherent in the WMPA (Section 11.6.3) will minimise the impacts associated with the production of waste and will minimise the likelihood of incident thus reducing the risk of loss of containment.

Data on the quantity and type of wastes generated during previous exploratory drilling campaigns in the Falklands was obtained from waste reporting paperwork. It is anticipated that the quantities of waste produced during the Rhea-1 well drilling operation will be of a similar magnitude to previous rounds of exploratory drilling. It is therefore possible to estimate the quantities of each type of waste that will be produced and to plan for responsible waste management and ensure that the supply base has sufficient storage capacity.

The estimated quantities provided are based upon the waste volumes generated during the Falklands Oil and Gas Ltd. (FOGL) exploratory drilling campaign carried out in 2012. The 2012 FOGL drilling campaign comprised two wells and lasted a duration of four months. Estimates of waste products that were not generated during the FOGL campaign (such that no FOGL data exist) are based upon data from the Rockhopper (RH) 2011 drilling campaign. The Rockhopper campaign comprised nine wells drilled over 12 months.

Estimated quantities of waste likely to be generated during the Rhea-1 well operation are made as follows:

- Operational waste (e.g. chemical sacks) estimates are based upon the average quantity of waste produced per *well*.
- Non-operational waste (e.g. fluorescent light bulbs, cooking oil) estimates are based upon the average quantity of waste generated per *month*.

Table 61 identifies the waste types and estimated quantities.

Table 61: Estimated Total Waste Generated during the Rhea-1 well Operation (one well)

Waste	Data Source	Estimate based on:	Quantity (kg)
Hazardous Waste			
Aerosol Cans, Empty	FOGL 2012	No. of wells	200
Batteries	RH 2011	Duration of operation	2
Chemical Sacks, Empty	FOGL 2012	No. of wells	1,800
Fluorescent Light Tubes	FOGL 2012	Duration of operation	25
Grease / Oil Tins	RH 2011	No. of wells	61
Oil Filters	FOGL 2012	No. of wells	150
Oily Rags	FOGL 2012	Duration of operation	2,300
Paint Cont. Rags & Brushes	RH 2011	Duration of operation	17
Paint Scales / Chippings	RH 2011	Duration of operation	40
Paint Tins, Empty	RH 2011	Duration of operation	88
Thinner	RH 2011	Duration of operation	8
Waste Oil	FOGL 2012	Duration of operation	20,400
Other (mostly oily water)	RH 2011	No. of wells	189
Hazardous Waste Total			**25,280**
Non-hazardous Waste			
Cardboard	FOGL 2012	Duration of operation	713
Electronic Equipment, Waste	RH 2011	Duration of operation	64
Glass	FOGL 2012	Duration of operation	288
General Waste	FOGL 2012	Duration of operation	5,400
Plastic Cans / Containers, Empty	RH 2011	No. of wells	75
Plastic Drum, 210 L, Empty	FOGL 2012	No. of wells	588
Plastic Waste	FOGL 2012	Duration of operation	500
Rubber Waste	RH 2011	No. of wells	183
Scrap steel	FOGL 2012	No. of wells	27,350
Steel Cans / Tins	RH 2011	Duration of operation	8
Steel Drum, 210 L, Empty	FOGL 2012	No. of wells	793
Wood Pallets	FOGL 2012	No. of wells	3,820
Wood Waste	FOGL 2012	No. of wells	8,170
Other - unsegregated non-hazardous waste	RH 2011	No. of wells	803
Non-hazardous Waste Total			**48,753**

11.4.2 Impacts and Risks to Human Health and Wellbeing

If any waste is to be disposed of in the Islands it will be incinerated with waste ash added to an approved landfill site. NEFL has committed not to add any waste directly to the landfilled waste at Eliza Cove or Mary Hill Quarry.

Waste that is not handled, labelled and/or stored correctly could lead to loss of containment of either hazardous or non-hazardous liquid or solid material. Loss of containment of liquids stored at the supply base could lead to leaching of the substance to ground, which may affect human health. While loss of containment of solids could be targeted by scavengers and/or create unsightly litter both of which may impact upon communities with regard to human health and wellbeing.

Loss of containment leading to the above potential impacts would be an unplanned event and as such it is not possible to quantify the impact. However, mitigation controls (Section 11.6.3) will be utilised to minimise the likelihood of an incident, thus reducing the risk of loss of containment to ALARP.

11.5 Impact Assessment Summary

A summary of the impact assessment is shown in Table 63, page 286.

11.5.1 Severity and Receptor Sensitivity

Scheduled Discharges into the Marine Environment

The discharge to sea of grey water, black water and food waste may cause slight eutrophication of the surrounding waters; however, wave action will rapidly disperse and dilute effluent and the action of micro-organisms will breakdown additional nutrients. The impact on the marine environment will thus be negligible and the severity of the impact has been assessed as '**Slight**'.

The offshore habitat of the Falklands in the vicinity of the Rhea-1 well is undesignated and ubiquitous in nature and the influence of eutrophication from the rig is comparatively very small. For grey water, black water and food waste, the sensitivity of receptors has been assessed as '**Very Low**'.

In accordance with MARPOL and the NEFL ODPO, storm water drains and bilges will be fitted with oil separators and the discharge will be monitored to ensure a maximum oil content of 15 ppm. At this concentration, these events would have a localised, short-term and reversible effect on the environment. The severity of oil or chemical contaminated water passing via the oil separator has been assessed as '**Minor'**. Given that, the discharge of oil in water at 15 ppm does not form a sheen on the surface and birds do not become oiled (Wiese, 2002) and given that wave action will rapidly dilute any oil remaining in the drain water, the sensitivity of the environmental receptors to this level of oil contamination is assessed as '**Low**'.

Disposal of Waste on the Falkland Islands

Small quantities of combustible non-hazardous waste may be disposed of in the Falklands via incineration with all associated waste ash disposed of to an approved landfill site e.g. Eliza Cove. Where approved by FIG, waste oils may be provided to a local business, Stanley Growers, for use in oil burning heaters rather than being shipped to the UK. In line with NEFL's WMPA, no direct disposal of wastes to Eliza Cove or Mary Hill Quarry landfill sites will occur. Such use of landfill sites will have negligible environmental impact and the severity is assessed as '**Slight**'. As NEFL will not be contributing to landfill at Eliza Cove or Mary Hill Quarry, the waste management practices that may occur on the Islands are expected to have a limited effect on the environment and the sensitivity of receptors in the terrestrial environment has been assessed as '**Very Low**'.

Transport and Storage of Hazardous Waste Onshore prior to onward Treatment or Disposal

Given that waste will be shipped on otherwise empty coaster vessels making a return journey, the shipment of waste to the UK is unlikely to result in additional impact with regard to shipping volume and emissions.

Additionally, with appropriate waste handling and storage protocols in place, the likelihood of the accidental release of hazardous waste into the Falkland's environment is assessed as '**Remote**'. The mitigation controls incorporated into the WMPA (Section 11.6.3) will enable a rapid on site clean-up resulting in a barely detectable impact on the environment or human health. In the event of an accidental release, the severity is assessed as '**Minor**'.

11.5.2 Significance

The discharge to sea of waste water and food will be carried out in compliance with MARPOL regulations to minimise the impact on the marine environment. Management of all other waste streams will conform to MARPOL and the NEFL WMPA, which should result in no, or negligible, environmental impact. Compliance with regulation will also reduce the risk of accidental loss of waste products. Compliance with the NEFL ODPO and WMPA will ensure the implementation of Good International Industry Practice (GIIP) impact/risk mitigation measures. The ODPO/WMPA will be rigorously followed such that the environmental impact/risk is negligible. The significance of environmental impact/risk associated with waste disposal is assessed as '**Low**'.

11.5.3 Degree of Confidence

The NEFL exploration drilling WMPA advises upon best practice in the oil and gas industry. The magnitude, extent, reversibility, duration and frequency of the impact of waste generation and management is well understood from previous projects. As is the risk of incident the confidence in the assessment is assessed as '**Certain**'.

11.5.4 Cumulative Impact

All vessels discharge grey and black water and food waste at-sea in line with MARPOL regulations. The volumes discharged are related to the number of persons at sea at any given time. It is estimated that, averaged over August and September, there will be a total of 139 fishing vessels operating within Falklands waters throughout the duration of the Rhea-1 well drilling operation (FIG 2014). While the number of crew on each fishing vessel varies, with an assumption of 40 men per vessel, the total number of men at sea on fishing vessels during the Rhea-1 well drilling operation is estimated at approximately 5,560 men. During the Rhea-1 well drilling operation, the combined disposal of grey and black water and food waste from the rig, the ERRV and the OSV/PSV's will add to that produced by existing users of the marine environment. However, the addition of 120 men on the rig and 45 on the support vessels represents a small increase (<3 %) in the total number of people at sea in these waters. Additional waste production therefore amounts to <3 % of waste generated by fishing vessels for the duration of one month. With the volumes estimated and the short-lived nature of the increase, these waste streams are not regarded as an environmental threat.

The additional loss of oil in drain and bilge water from the rig, the ERRV and OSV/PSV's at a maximum concentration of 15 ppm is not believed to pose any additional risk to seabirds. The impact on other marine organisms is unknown but is likely to represent a small risk to marine organisms.

There is the potential for certain waste streams generated during the operation to be disposed of on the Falklands which will add to waste already generated by the community. However, this will not include disposal of un-combusted waste to Eliza Cove or Mary Hill Quarry landfill sites, and as such is not expected to add to the cumulative impact of the current waste disposal practices in use.

11.5.5 Indirect Effects

Seabirds are known to congregate around offshore installations. In the North Sea, Tasker *et al*. (1986) reported seabird densities seven times higher within 500 m of an oil rig than in the surrounding waters. In the northwest Atlantic, seabird concentrations were 19-38 times higher around rigs than in adjacent waters (reported in Wiese *et al*., 2001). Munro (2011) also recorded birds in close attendance to rigs during previous exploration campaigns in the NFB. The exact reason for this is unclear. However, it is likely that birds view offshore installations as feeding opportunities, whether feeding on discharged waste (food and/or sewage) or on aggregated prey species, which may be attracted by discharges. The structure itself will be visible from many miles and may attract seabirds out of curiosity.

In the southwest Atlantic, many bird species, e.g. albatross, giant petrels, Cape petrel and Antarctic fulmar are large diurnal scavengers. All albatross species and seven species of petrel are covered by the Agreement for the Conservation of Albatrosses and Petrels (ACAP) and are the focus of international concern (see Section 5.4.6 for a description of these species abundance and distribution). Some of these species may exploit feeding opportunities associated with the rig, which may increase the risk of collision with the structure and/or the risk of contamination from any minor oil spills.

11.6 NEFL Waste Management

NEFL will follow the 'Duty of Care' principle, which is essentially a self-regulating system based on good practice. To ensure the appropriate management of waste, NEFL will implement its exploratory drilling WMPA.

11.6.1 Offshore Discharge Management Programme

The NEFL ODPO (NEFL 2015e, document number: 062-14-EHSR-ODP-PO-T3) provides guidance to ensure that all discharges to sea of grey and black water, drainage and bilge waters are carried out in accordance with the International Maritime Organization (IMO) International Convention for the Prevention of Pollution from Ships, 1973 as modified by MARPOL Annex IV.

Specifically the ODPO details:

- Key roles and responsibilities of NEFL personnel and contractors with regard to the management of discharges to sea;
- The regulatory and GMS guidelines upon which the ODPO is based;
- Detail on the relevant:
  - Sampling requirements;
  - Monitoring requirements;
  - Proper operation and maintenance; and
  - Record keeping and reporting; and
- Use of the Discharge Monitoring Form

11.6.2 Waste Management Plan

The NEFL WMPA (NEFL 2015d, document number: 013-15-EHSR-WMP-PA-T4) provides guidance on efficient working practices for the safe handling, storage, transportation and disposal of waste generated during exploration drilling on the Falkland Islands continental shelf.

Specifically the WMPA details:

- Key roles and responsibilities of NEFL personnel and contractors with regard to waste management;
- The regulatory and GMS guidelines upon which the WMPA is based;
- The Waste Hierarchy used to minimise the amount of waste generated;
- Definition of waste types; and
- Guidance on all aspects of waste management in the Falklands.

Implementation of the Waste Management Plan

Implementation of the NEFL WMPA is assured by:

- Definition of roles and responsibilities within the WMPA;
- Provision of training to NEFL personnel and contractors as specified in the WMPA;
- Use of waste management tools provided in the WMPA:
  - Project specific Waste Register (Table 62) which is subject to update following monthly review of the Register and Waste Disposal Log;
  - Waste Disposal Log template;
  - Hazardous Waste Tank Inspection Checklist;
  - Hazardous Waste Storage Area Weekly Inspection Checklist; and
  - Corrective Action List.
- Monitoring and reporting as defined in the WMPA; and
- Internal auditing of the waste management process (Chapter 14.0)

Waste Mitigation and Operational Controls

The following measures, as outlined in the WMPA, will be taken to prevent the potential impacts of waste and reduce the likelihood, and thus the risk, of waste products escaping into the environment:

- Implementation of the waste hierarchy at all times ensuring minimization of waste, the appropriate categorisation and segregation of waste;
- Use of the Waste Register;
- Offshore Storage:
  - All waste skips will be suitable for offshore use with some form of containment (e.g., lids, nets) to prevent waste material blowing overboard and subsequent pollution to sea;
  - Laydown areas with suitable storage space will be allocated on the rig and OSV/PSV's for waste bins and containers that provide sufficient working space to allow unobstructed movement for personnel and equipment;
  - Recyclable hazardous wastes will be stored separately from non-recyclable wastes and will be appropriately labelled;
  - All hazardous waste materials will be stored in hazardous waste skips, drums or tote tanks, with secondary containment for transport to shore;
  - Ignitable or reactive wastes shall be stored at a specified distance from heat sources and living quarters with appropriate warning signage;
  - All waste streams that are non-compatible will be segregated and stored appropriately in designated locations;
  - Waste drums and containers will be regularly checked for leakage or corrosion and shall be of such design that water will not collect on tops and resting surfaces; and
  - If used, contaminated spill kit materials will be stored in hazardous waste bags or disposed of to the designated hazardous waste skip and transported to shore for disposal.
- Onshore Storage:
  - Wastes stored at the supply base will be segregated into designated skips and waste containers in a dedicated waste management area, which is clearly identified and assigned for waste storage;
  - All waste skips will be fit for purpose, with some form of containment, (e.g., lids, nets) to prevent waste material escaping, and will be appropriately labelled;
  - All hazardous waste materials will be stored in hazardous waste skips, drums or tote tanks (for liquid wastes), with appropriate secondary containment (bunding);
  - Liquid chemical and liquid hydrocarbon waste storage areas will be bunded, with bund volume being 110% of the largest tank or 25% of the total capacity, whichever is greater.
  - Spill kits of appropriate size will be provided in areas, such as the waste drum store, where there is a potential risk of a spill.
- Inspection
  - Visual inspections at the supply base will be carried out at least weekly and each time waste is transferred from the drilling rig and OSV/PSV's. Waste storage area and hazardous waste tank inspection checklists are provided within the WMPA.

Waste Monitoring

Monitoring of waste and compliance with the WMPA will be monitored via:

- Use of the Waste Disposal Log;
- Weekly inspection of storage facilities in line with the WMPA inspection checklists and use of the NEFL Corrective Action list where non-conformances cannot be immediately remedied;
- Internal NEFL waste reporting e.g. monthly provision of the Waste Disposal Logs, reporting of non-conformances or spills;

  - Waste reports will be made available to the appropriate regulatory bodies as required;
- The requirement to audit/assess waste contractors (Chapter 14.0).

Table 62: Excerpt of the standard Waste Register within the NEFL WMPA illustrating potential waste streams and disposal routes*

Waste Stream	Offshore Storage	Transport offshore to onshore	Onshore storage	Transport from onshore FI to final disposal	Final Disposal
Waste Generated Offshore					
Chemicals - used WBM and cements	To sea with cuttings/ downhole	N/A	N/A	N/A	Seabed/ downhole
Containers (contaminated)	Hazardous waste skip	OSV/PSV	Supply base	Coaster	All hazardous waste returned to UK waste company for disposal
Waste oil (e.g. cooking oils, oils from drainage separators)	Sealed containers	OSV/PSV	Supply base	Coaster/Road transport	All hazardous waste returned to UK waste company for disposal and/or provided to the community for use in oil burning heater. TBC
Cuttings (water-based mud)	to Seabed	N/A	N/A	N/A	Seabed
Medical waste	Containers for incineration	OSV/PSV	Supply base	Road transport	FI incinerator (ash to Eliza Cove)
Mercury-containing waste (incl. fluorescent tubes)	Hazardous waste skip	OSV/PSV	Supply base	Coaster	All hazardous waste returned to UK waste company for disposal
NORM contaminated waste	Secure containers	OSV/PSV	Supply base	Coaster	All hazardous waste returned to UK waste company for disposal
Oily sludge/ sand/ soil	Sealed containers	OSV/PSV	Supply base	Coaster	All hazardous waste returned to UK waste company for disposal
Oily rags	Hazardous waste skip	OSV/PSV	Supply base	Coaster	All hazardous waste returned to UK waste company for disposal
Wood and pallets	Waste skip	OSV/PSV	Supply base	Road transport	FI incinerator (ash to Eliza Cove)
Plastic and rubber	Waste skip	OSV/PSV	Supply base	Coaster	Returned to UK to waste company
Waste Generated Onshore					
General waste from onshore base	N/A	N/A	Supply base	Road transport / Coaster	All hazardous waste returned to UK waste company for disposal, non-hazardous waste TBC
Sewage and grey water from onshore	N/A	N/A	N/A	Local sewage system	Local sewage disposal (Rookery Bay)

* NOTE: This waste register will be tailored to the Rhea-1 project and all disposal routes will be approved with FIG. The Register is subject to change depending on actual waste generated and will be subject to monthly review.

11.7 Future Waste Management Solutions

Waste management in the Falklands currently relies on an unregulated landfill, which is unsustainable. The development of the oil industry in the Islands is likely to result in the improvement and/or development of waste management infrastructure in the Islands. This will not only be of benefit to the oil and gas industry but will also greatly improve waste management and recycling in the Islands generally. During this exploration stage of oil and gas development in the Falklands, exporting waste to the UK for disposal is a more economically viable option but the potential for developing waste management strategies in the Falklands for future campaigns and developments is under review.

11.7.1 Residual Impacts/Risks

The impacts and risks associated with waste management are considered to be of low significance prior to mitigation measures. It is however best practice to minimise environmental impacts where possible. With the WMPA in place to ensure compliance and to guard against accidental release of waste into the environment, any residual impact will be of '**Low**' significance.

Table 63: Summary of the impact assessment for waste generated during the 2015 Campaign

Activity	Aspect	Potential Impact	Type of Activity	Likelihood	Sensitivity	Severity	Significance		Certainty	Mitigation / Prevention / Control
							Pre-mitigation	Post-mitigation		
Drilling operations	Grey water	Eutrophication	Planned	N/A	Very Low	Slight	Low		Certain	Discharged at-sea
Drilling operations	Black water	Eutrophication	Planned	N/A	Very Low	Slight	Low		Certain	Macerated and discharged at-sea, Rig/vessel MARPOL compliance audits
Drilling operations	Food waste	Eutrophication	Planned	N/A	Very Low	Slight	Low		Certain	Macerated and discharged at-sea, Rig/vessel MARPOL compliance audits
Drilling operations	Storm drain run-off and bilge water	Minor oil and chemical spills	Planned	N/A	Low	Minor	Low		Certain	Good housekeeping, Oil separator Rig/vessel MARPOL compliance audits
Drilling operations	All non-hazardous waste	Emissions from transportation	Planned	N/A	N/A	Minor	Low		Certain	Application of the WMPA and project specific Waste Register, Majority of waste returned to UK for management
Drilling operations	All hazardous waste	Emissions from transportation	Planned	N/A	N/A	Minor	Low		Certain	Application of the WMPA and project specific Waste Register, Majority of waste returned to UK for management
Drilling operations	Indirect effects	Attraction of ACAP species	Unplanned	Remote	Very High	Minor	Low		Certain	Follow best practice to limit the risk of accidental spills

** See Section 6.0 for definitions of sensitivity, severity, likelihood and significance.*

12.0 Discharge of Drilling Mud and Cuttings

12.1 Introduction

Drilling muds, also known as drilling fluids, are an essential component of any drilling operation. The mud or fluid consists of a liquid phase to which various chemical and solids have been added to modify the operational properties of the drilling system. The primary function of the drilling mud is to suspend the drill cuttings and return them to the surface, however, muds are designed to fulfil a number of additional functions such as; cool and lubricate the drill bit; increase the density (weight) of the mud to balance formation pressure and prevent any uncontrolled releases (i.e. blow-outs) from the well; plug leaks in the wellbore wall to prevent loss of drilling mud to the formation.

Drilling mud is pumped from the platform down the wellbore hole through the drill string, where it exits through nozzles in the drill bit. As the drill bit grinds rock into drill cuttings, the cuttings become trapped within the mudflow and are carried to the surface through the annular space between the drill string and the walls of the borehole. As the initial, top-hole, wellbore sections are drilled the mud and cuttings are discharged directly onto the seabed. Once the top-hole sections have reached a set depth a steel pipe, known as a casing, is lowered into the wellbore and cemented in place to prevent the wall from caving into the wellbore. A blow-out preventer (BOP) is secured to the top of the casing, and then a riser pipe to the drilling rig is secured to the BOP which allows mud and cuttings to be returned to the rig where they are separated so the drilling mud can be re-used in the wellbore.

A number of different types of drilling muds have been developed over the history of oil and gas exploration, including water based mud (WBM), diesel based mud, oil based mud (OBM), synthetic oil based mud (SOBM) and low-toxicity oil based mud (LTOBM). Diesel and oil based muds were introduced to overcome instability issues associated with WBM, however, the discharge of oil based muds was subsequently banned due to the environmental impact of hydrocarbon discharge.

Drilling activities for the NEFL Rhea-1 well will use seawater for the top-hole sections and WBM for the lower section, both of which will contain a number of additives to control the downhole conditions. WBM is an aqueous suspension of clay or other viscosifiers such as bentonite, using either freshwater or seawater as the carrier fluid. By its nature WBM has a lower toxicity and environmental impact than diesel or oil based muds, however, some of the fluid additives may pose other impacts to local marine life, such as damage to the gills of filter feeding organisms.

This chapter draws on modelling studies to assess the expected environmental impact arising from the discharge of drilling mud and cuttings during the Rhea-1 exploration drilling campaign. All discharges will be carried out in line with NEFL's Offshore Discharge Programme (ODPO).

12.2 Sources of Discharge Associated with Drilling Exploration Wells

Drilling the Rhea-1 well will result in the discharge of drilling muds and rock cuttings in the proximity of the Rhea-1 well location. The exploration well design comprises four main sections (42″, 26″, 17.5″ and 12.25″) (Table 64).

The 42″ and 26″ top-hole sections of the well will be drilled with seawater with bentonite sweeps, and bentonite displacement mud, with all mud and cuttings being discharged directly to the seabed. The 17.5″ and 12.25″ sections of the well will be drilled with a WBM, with mud and cuttings being returned to the rig and separated so that the mud can be reused. The cuttings will be discharged near the sea surface, and mud will also be discharged once drilling activities have been completed or when the mud can no longer be reused. Oil based mud will not be used during the drilling campaign.

Table 64: Rhea-1 Exploration Well Design

Well Section (inches)	Section Length (m)	Drilling Mud Type	Release Depth and Location
42 (1,067 mm)	77	Seawater with bentonite sweeps, and bentonite displacement mud	Seabed (460m)
26 (660.4 mm)	395		Seabed (460m)
17.5 (445 mm)	850	Water Based Mud (WBM)	Near Surface (23m)
12.25 (311 mm)	870	Water Based Mud (WBM)	Near Surface (23m)

12.3 Potential Environmental Receptors

There are a wide range of environmental receptors to the discharge of drill cuttings and mud during the exploration campaign. These include:

- Seabed sediment – discharge direct to the seabed and settlement of particles through the water column will impact sediment chemistry and particle size over the affected area.
- Water quality – suspension of mud and cuttings in the water column as well as discharge to surface waters will impact water chemistry and turbidity.
- Phytoplankton and Zooplankton – organisms with limited mobility will be impacted by changes in local water quality.
- Benthic organisms – discharge of drill cuttings and mud affects benthic organisms through direct burial, habitat change and sediment suspension at the seabed.
- Fish – mobile species such as fish may be affected if drilling coincides with certain life history stages such as spawning periods and juvenile stages when they inhabit particular spawning or nursery grounds, or if it coincides with productive feeding season and feeding grounds.

Chapter 5.0 describes the range of species recorded within the vicinity of the northern licence blocks and the sensitivity of different aspects of their lifecycle. A site specific ROV survey will be conducted and analysed prior to commencing drilling operations to check for the presence of sensitive habitats and species.

12.4 Characterising and Quantifying the Impact

The drilling discharges were modelled using the 'DREAM' (Dose-related Risk and Effect Assessment Model) published by the Foundation for Scientific and Industrial Research (SINTEF) (v6.5.1), which incorporates the 'ParTrack' sub-model used for modelling the dispersion and settlement of solids.

The modelling studies were specifically designed to estimate:

- Drill cuttings and mud depositional thickness on the seabed;
- Environmental risk to the seabed resulting from burial thickness, particle size change, toxicity and pore water oxygen depletion;
- Environmental risk in the water column resulting from toxicity and particle stresses; and,
- Recovery of the sediments over time.

The methods and outputs of the modelling studies have been summarised in this chapter, and the full details are available in the following report:

- Genesis, 2015a. Drill Cuttings Modelling, Rhea-1 Exploration Well. Document Number: J73727A-Y-TN-24000/B1. Prepared for Argos Ltd/Noble Energy.

12.4.1 Exploration Drilling Model Input Parameters

The well top-hole, 42″ and 26″, sections will be drilled with seawater and bentonite sweeps which contain barite, bentonite as well as caustic soda, soda ash and lime. The latter three components are categorised as PLONOR, which means that they have been assessed to 'pose little or no risk' to the environment, consequently they were not included as a mud component in the cuttings discharge model. Both barite and bentonite are known to be toxic to marine life and contribute to the environmental risk from drilling discharges and consequently their physical and toxicological characteristics were modelled in the release from these two sections (Table 65).

The discharge from the 17.5″ section comprises WBM, which also contains barite as well as several chemicals, five of which are PLONOR and were therefore not specified as mud components in the model. Two of the WBM chemical additives are non-PLONOR, PERFORMATROL HPWBM and GEM GP, and consequently they are included in the model input parameters (Table 65).

The discharge from the 12.25″ is also drilled using PERFORMATROL HPWBM but has a slightly different formulation. It features an additional non-PLONOR chemical Driscal-D Polymer which is included in the model input parameters (Table 65).

Table 65: Drilling Mud Components and Estimated Discharge Quantities per Well

Well Section (Inches)	Quantity of Drilling Mud Discharged (tonnes)	Quantity of Drill Cuttings Discharged (tonnes)	Barite (tonnes)	Bentonite (tonnes)	Chemicals (tonnes)
42	229	182	0	26	0
26	342	357	0	39	0
17.5	482	348	26	0	Performatrol: 19 Gem GP: 14
12.25	415	175	102	0	Performatrol: 17 Gem GP: 12 Driscal D: 3

Details of the specific drilling mud type have not yet been finalised, consequently characteristics of 'MI-high' (a type of barite used in WBM) were used as a conservative estimate of heavy metal content within UK-market sourced drilling mud barite (Neff, 2005). Background concentrations of heavy metals recorded in sediments close to previously drilled Sea Lion exploration wells in the NFB (Section 5.3) (these survey data are taken as a nearby reference for the Rhea-1 well as site specific survey data has not been collected at the time of writing the EIS) are compared with MI-high concentrations in Table 66.

Table 66: Metals in Typical Barite Water Based Drilling Mud Compared to Background Sea Lion Values in Sediment

Heavy Metal	Barite WBM (µg/g)	NFB (Sea Lion) Background Concentrations (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

The concentration of chromium in barite mud is lower than the average concentrations recorded in Sea Lion sediments and consequently would not pose any additional risk and are therefore not included in the model parameters (Table 66).

Concentrations of cadmium, copper, mercury, lead and zinc in the barite mud were found to exceed those recorded from Sea Lion area sediments (Table 66). However, these metals are present in barite primarily as insoluble mineralised sulphide salts with limited environmental mobility and low toxicity (Neff, 2005) and consequently these components are not considered to pose a specific risk to the environment and they were not included in the modelling (Genesis, 2015a).

Current data used in the model utilises data collected from a single acoustic doppler current profiler (ADCP) deployed 22 km southeast of the Rhea-1 well (49° 12.909' S, 59° 7.395' W). The ADCP took measurements across 46 depths between 6 m and 453 m (Fugro, 2012). The 46 measurements were made every 10 minutes between 7th November 2011 and 16th November 2012 and therefore represent approximately one year of measured data. From the surface to approximately 200 m the predominant currents are towards the west and northwest. From 200 m to the seafloor, the predominant currents are towards the southwest and west. The current speed decreases with depth from approximately 0.2 m/s in the surface waters to 0.1 m/s near the seafloor (Genesis, 2015a).

12.4.2 DREAM/ParTrack model (SINTEF)

The DREAM/ParTrack model calculates the dispersion and deposition of drilling muds and cuttings on the seabed and the dispersion of chemicals and particles in the water column (Genesis, 2015a). The model calculates the time required for concentrations of contaminants in water column or sediment to return to previous levels once the discharges have ceased. Within the water column, the solids settle out relatively quickly, but recovery of the sediment on the seabed takes substantially longer.

The rates of ecosystem recovery are variable depending on the particular location, and the model predicts the subsequent physio-chemical composition over time by taking into account processes such as mixing, re-suspension and dilution due to currents, and sediment re-colonisation rates leading to bioturbation and biodegradation of the sediments. Additionally, expected recovery times from burial and grain size change, and changes in chemical toxicity over time (generally around 5-10 years after cessation of the drilling programme) are included in the forecast of the reduction in environmental risk to the sediments over time. Figure 53 illustrates the processes computed by the model.

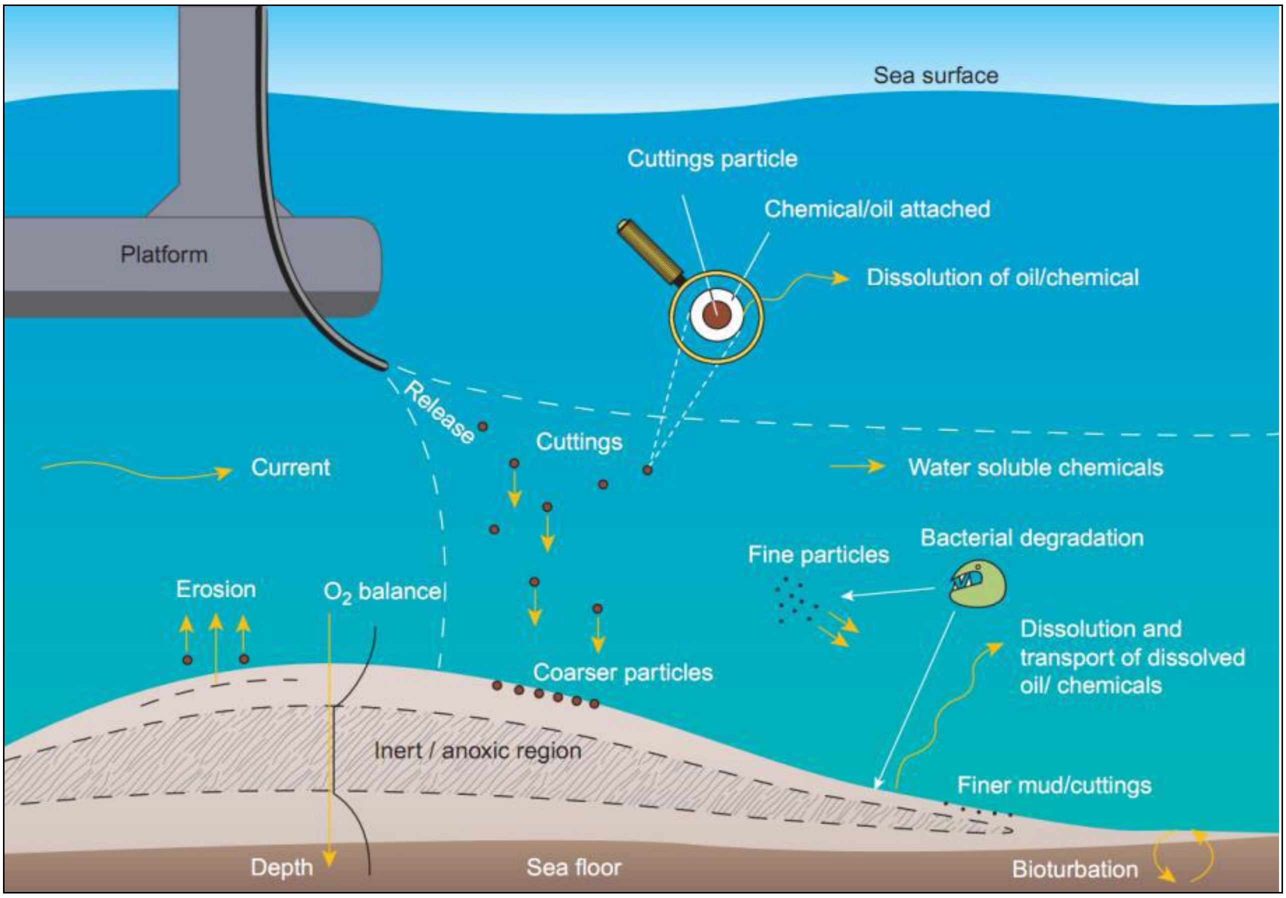


Figure 53: Processes involved in DREAM/ParTrack model (Genesis, 2015a)

12.4.3 Calculation of environmental risk

The model output also calculates an estimate of risk to the environment using a metric known as the Environmental Impact Factor (EIF), which is based on the PEC:PNEC ratios used to estimate environmental risks for chemicals in different marine environmental compartments. The PEC (Predicted Environmental Concentration) is an estimate of the concentration of a chemical to which the biota would be exposed during and after the discharge of the chemical. The PNEC (Predicted No Effect Concentration) is the concentration of the chemical in the environment below which it is unlikely that adverse effects on the biota inhabiting a particular environmental compartment would occur. The ratio of the PEC to the PNEC indicates the likelihood of the occurrence of adverse effects from drilling discharge chemicals in the water column and sediments.

The EIF for drill cuttings is based on the following identified stressors relating to drill cuttings and the PNEC values for each of the stressors, which were determined from scientific literature:

- Water Column: Toxicity of chemicals and oil, physical effects of suspended matter;
- Sediments: Toxicity of chemicals and oil, burial of organisms, change in sediment structure, oxygen depletion.

The model calculates an individual PEC:PNEC ratio for each of the stressors and applies a species sensitivity distribution to each stressor, which allows the model to combine and compare the contribution of different stressors to the overall risk, known as the potentially affected fraction (PAF) of species. The level of 5% PAF (corresponding to a PEC/PNEC ratio of 1) is a generally accepted risk level representing the concentration below which unacceptable effects on organisms will most likely not occur (EC, 2003). As such the value of EIF is taken as the spatial extent over which the multi-stressor PAF exceeds 5%. An EIF of 1 in sediment occurs when an area of 100 m x 100 m is predicted to exceed a 5% risk. This is referred to as “risk > 5%” throughout the remainder of this Section.

Model predictions were recently validated through field measurements at the Trolla Field in 265 m water depth in the Norwegian Sea, where reasonably good correspondence was obtained between measured and simulated deposition of the cuttings on the sea floor (Rye, 2010; Jødestøl & Furuholt, 2010). The observed deposition thickness was lower than was predicted by the ParTrack model, which suggests that the modelling results are conservative (Genesis, 2015a).

12.4.4 DREAM/ParTrack Model Uncertainties

There are a number of uncertainties associated with this modelling technique (Genesis, 2015a). The main uncertainties identified in the model are:

Release volumes and geometry

The release 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.

Discharge characterisation

The properties of the mud components are well understood and produced to industry standard specifications. The size distribution of the cuttings particles themselves is based on an average of data from a drilling programme in the Norwegian Sea. Some 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. It is unlikely that new data would alter the overall conclusions, however.

Mud Volumes

Mud volumes were calculated by NEFL based on the open hole volume, the cased hole volume, the riser volume and the mud pit volume (assumed to be 1,000 bbl). The mud density was then used to convert the calculated volume to mass of mud in tonnes.

The actual mud volumes used in practice may differ and a smaller pit volume may be used. Assuming 1,000 bbl is discharged from the mud pit after each section is drilled is a worst-case assumption.

The assumed mud volumes are therefore conservative.

Mud Formulation

The mud program for Rhea-1 had not been decided at the time of writing therefore mud formulations used for drilling the Humpback-1 exploration well was adopted. The mud components (barite, bentonite and chemicals) will be the same as those assumed for each section but the proportions in the final Rhea-1 mud program may differ somewhat. However, Genesis have assumed conservative (large) volumes of mud, and thus for each mud component, this has ensured conservative risk predictions.

Background Sediment Grain Size

An environmental seabed survey has not been carried out in the vicinity of the Rhea-1 well. The nearest survey was carried for the Sea Lion development 20 km away. It has been assumed that the mean grain size of the background sediment is the same as that identified in the Sea Lion survey, namely 27 µm. Sediments in the Sea Lion survey were found to be poorly to very poorly sorted, comprising on average 70.5% of fines, 27.9% of sand and 1.6% of gravel across the survey area. The background mean grain size therefore represents relatively fine sediments.

Given most of the deposited particles are larger than this, assuming such a fine grain size gives a conservative (worst-case) prediction of particle stress on the seabed. A coarser background sediment would give rise to a lower degree of particle stress.

The assumed background grain size therefore gives conservative risk predictions.

Metocean data

The metocean dataset covers 12 months of direct observations covering the full depth of the water column. This provides a full annual cycle and a wide range of weather conditions, although a statistical analysis of all potential outcomes throughout this period has not been undertaken. Instead, discharges have been timed approximately to coincide with the most likely scheduling of the well.

The modelling results are relatively conclusive in showing a tendency for deposition and water column dispersion to the west of the site. It should be noted, however, that the currents do move in all directions at different times. While it is most likely that effects are concentrated to the west of the location, they could occur at other points depending on the precise conditions at time of discharge, which are short in duration. Overall distances of effect and deposition rates would, however, be similar.

Environmental sensitivities

Grain size change is an important parameter and it should be noted that the thresholds for this parameter within the risk assessment are 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. There may be regional differences in prevailing fauna that would give different thresholds for the Rhea-1 location. The basis of the thresholds is felt, nevertheless, to represent the best available data and covers a wide range of normal benthic fauna.

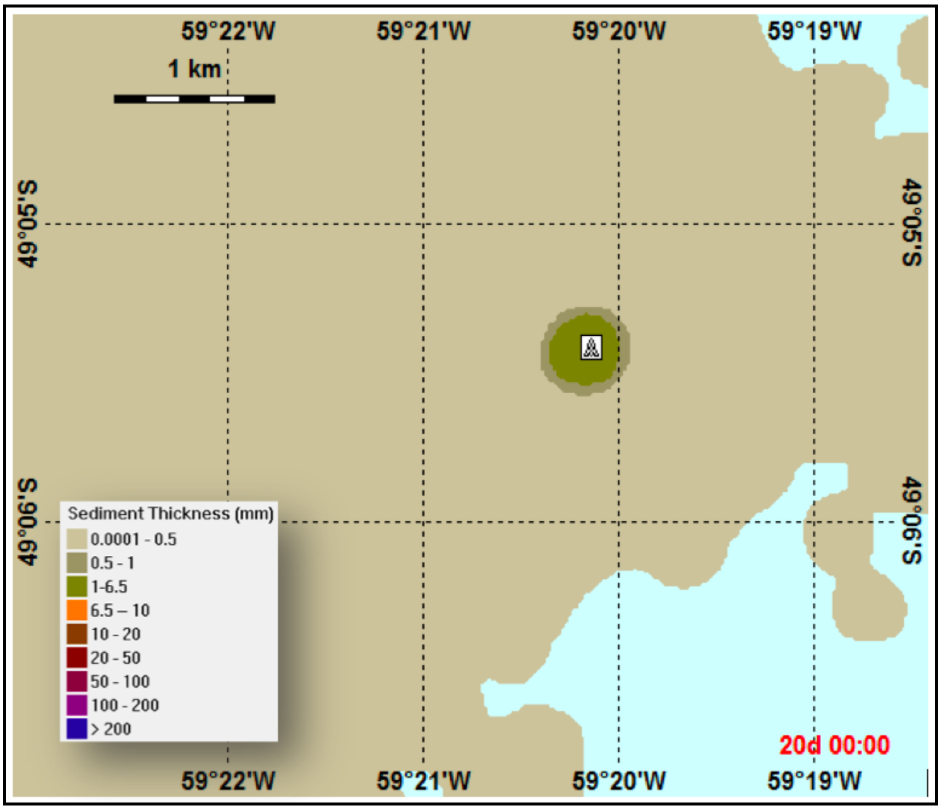
12.4.5 Modelling Results: Prediction of Impacts to Sediments and the Water Column

Sediment Impacts

Discharges of drill cuttings and mud directly to the seabed from the top-hole sections (42″ and 26″) result in deposition of the majority of relatively dense cutting material immediately around the well location with peaks in sedimentation thickness of 330 mm.

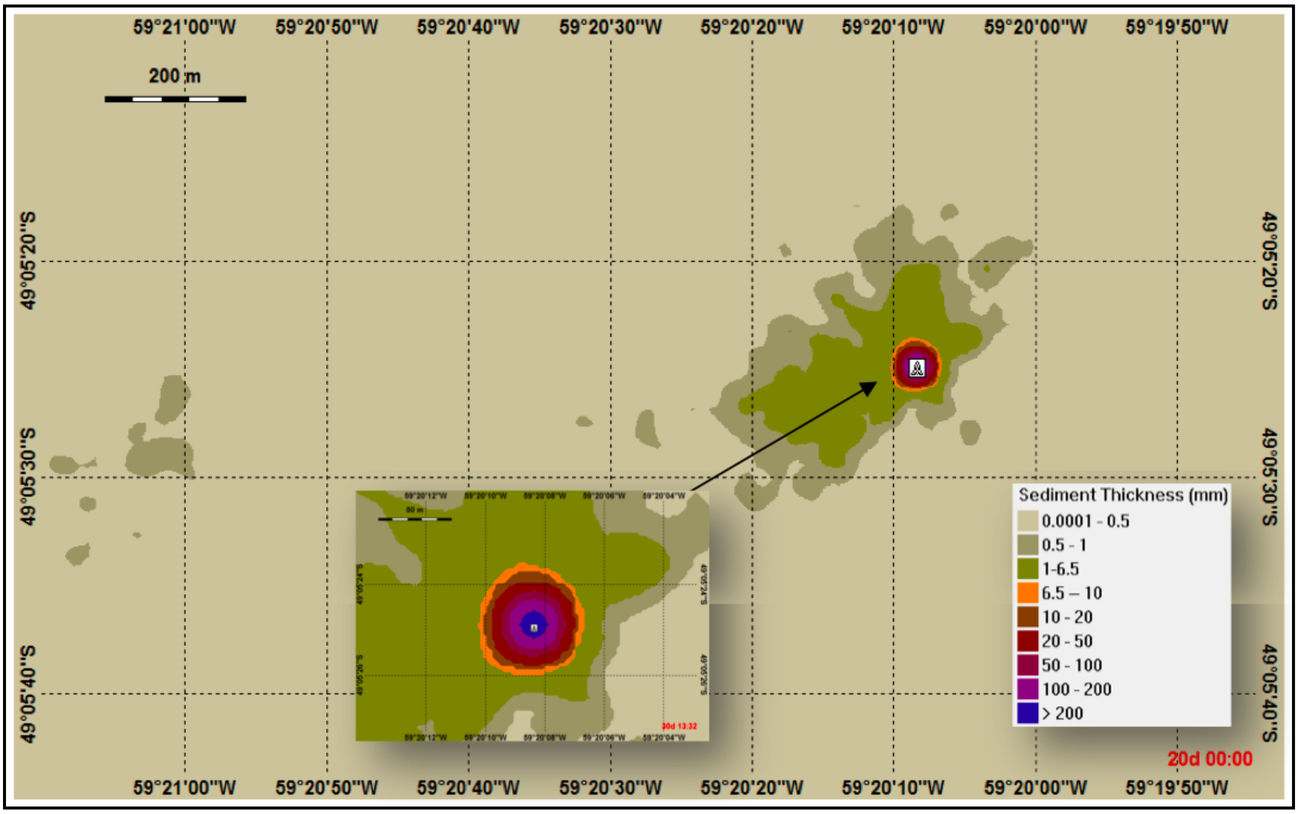
Sediment thickness rapidly diminishes to below 6.5 mm within the first 45 m distance from the well. Kjeilen-Eilertsen (2004) reported that, in general, a thickness of 6.5 mm represented the threshold at which 5% of the most sensitive species would be affected by smothering, in the absence of other risk stressors. This threshold has been adopted in the modelling approach and hence this assessment. The area of seabed around the Rhea-1 well where cuttings deposition >6.5 mm corresponds to approximately 6.3 km^2.

Whilst the predominant current flows in a westerly direction, current direction is variable and may change over a period of several hours. A close up view of the area of thickest deposition around the Rhea-1 well (modelled with a higher resolution grid) (Figure 54) indicates that the resulting deposition pattern reflects the variability in current direction. A small area of thickness greater than 0.5 mm extends up to 330 m around the well, and a much larger area of deposition with thickness less than 0.5 mm extends in a mainly westerly direction.



* Low resolution 20 km x 14 km grid with a cell size of 100 m (i.e. calculations averaged over 100 m).

Figure 54: Immediately Post Drilling – Overview of Drill Cuttings and Mud Depositional Thickness around the Rhea-1 Well from the Discharge of all Well Sections.



** High resolution 2.4 km x 2.6 km grid with a cell size of 10 m (i.e. calculations averaged over 10 m)*

Figure 55: Immediately Post Drilling - Drill Cuttings and Mud Depositional Thickness around the Rhea-1 Well Post Drilling resulting from Discharge of the all Well Sections

Discharges of drill cuttings and mud modify the natural sediment particle size distribution across the area where they are deposited. The average particle size in background sediments from the wider NFB exploration area was measured to be 27 µm in the environmental baseline surveys (Section 5.3). Modelling results predict that particle size following drilling operations would range from a peak of 4,000 µm 350 m east of the well location (from discharge of the 42″ and 26″ sections direct to the seabed).

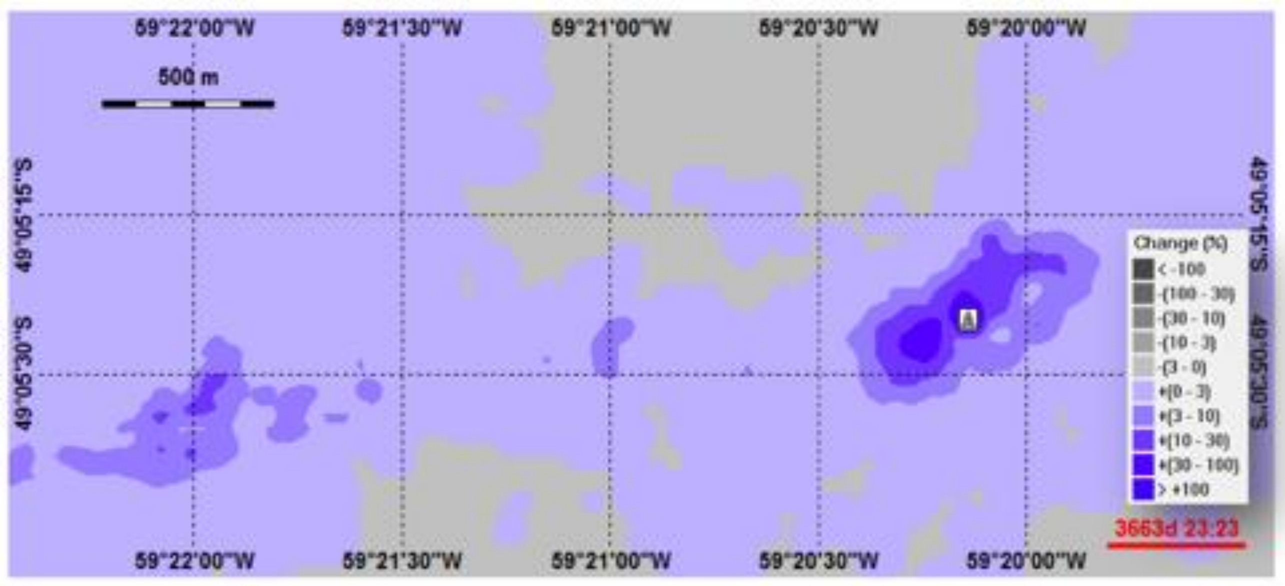


Figure 56: Close up contour plot of median particle size for the Rhea-1 well.

The majority of the cuttings from all well bore sections are deposited near to the discharge point, particularly during slack currents. Particles above 3,000 µm (3 mm) in diameter, corresponding to rock cuttings, are deposited around the well itself and also at 2-3 km to the west. In periods of strong currents at certain states of the tide, the cuttings from the surface discharge of the 17.5″ and 12.25″ sections are carried west for a period before this current wanes resulting in a secondary area of deposition from particles in surface waters. The cuttings travel this distance given the combination of water depth in this area and current strength. This is illustrated further in Figure 58, which represents an instantaneous pattern of particle motion influenced by the particular current conditions at the time.

It should be noted that although the plots show the size of the particles deposited, they are complementary to the mass deposited; the vast majority of the mass of cuttings is deposited within 100 m of the discharge point, and only a very small fraction is deposited at distances of several kilometres. The deposited grain size is important, however, as it can be a relatively significant stressor compared with burial thickness. The background grain size if assumed to be 27 µm, which is relatively fine. Given that the majority of deposited particles are larger than this, assuming such a fine grain size gives a conservative prediction of particle stress.

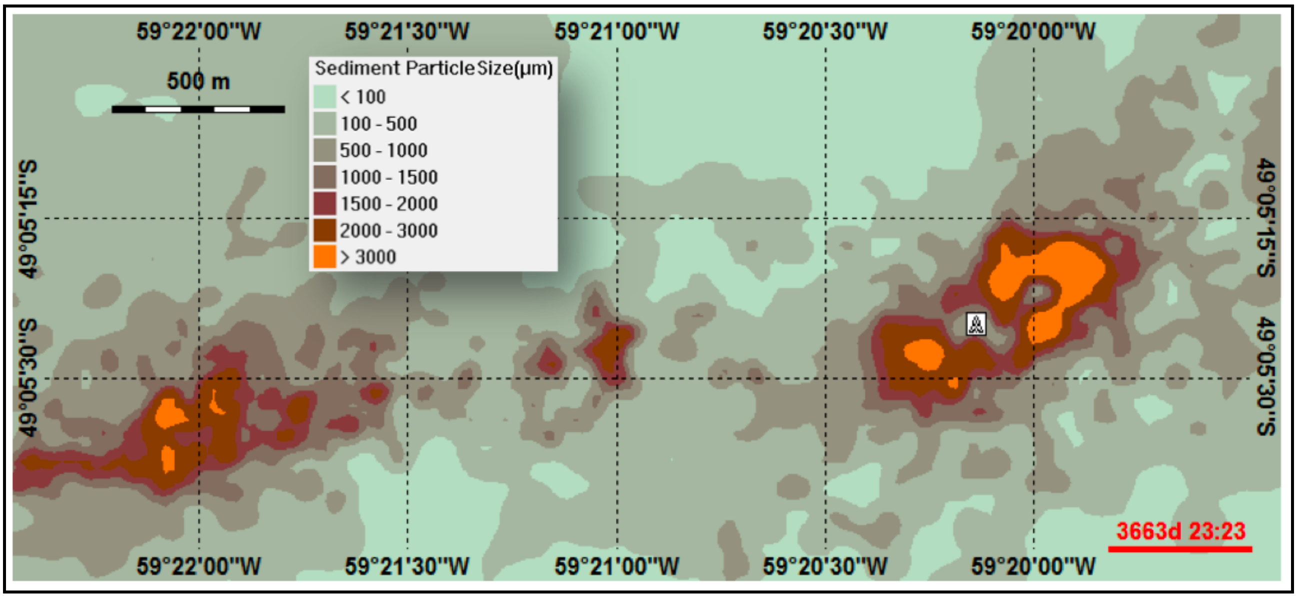


Figure 57: Post-Drilling - Median Particle Size Distribution resulting from Discharge of Mud and Cuttings from the all Well Sections of the Rhea-1 Well

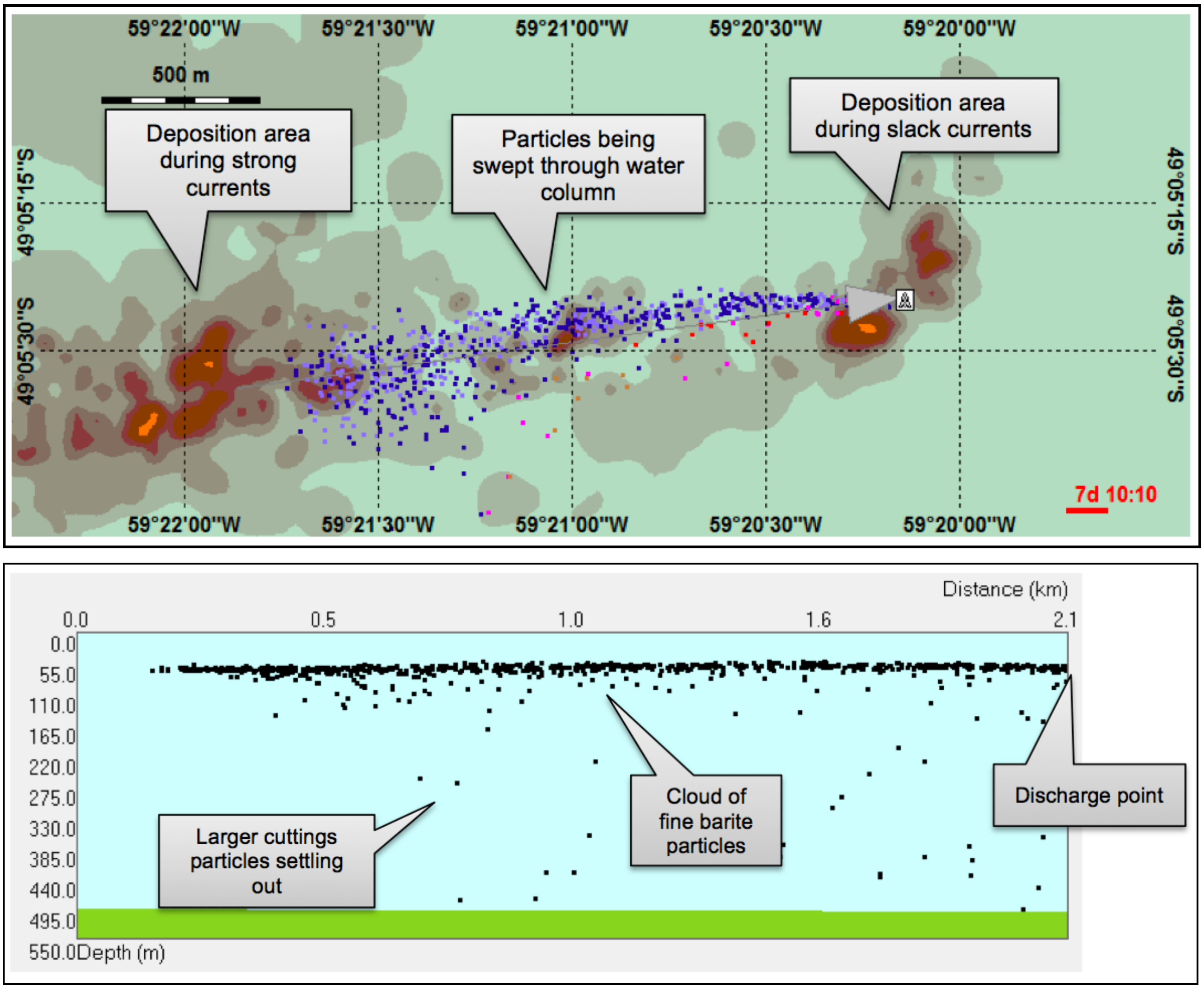


Figure 58: During Discharge – Instantaneous Snapshot of the Dispersion Pattern of Cuttings Particles from the 17.5" Section being carried with the Currents

Total environmental risk to the seabed sediment was calculated from the Environmental Impact Factor (EIF), which describes the area within which the predicted environmental concentration (PEC) exceeds the predicted no effect concentration (PNEC), i.e. there is a risk to at least 5% of the most sensitive species ("risk > 5%"). The EIF is based on a combination of factors such as, grain size change, burial thickness and pore-water oxygen depletion.

Modelling results indicate that a maximum EIF of 18.5 would be generated in the seabed sediments, which corresponds to an area of seabed at >5% risk of approximately 0.185 km^2. Analysis of the EIF indicated that the primary contributing factor, accounting for ~98% of the risk, was the change in grain size resulting from deposition of cuttings particles; whilst the sediment deposition thickness leading to smothering is a minor contributing factor ~2% risk (Genesis, 2015a).

Figure 59 indicates that there are two areas in which the risk exceeds 5 %, i.e. there is a risk to at least 5 % of the most sensitive species: immediately around the well, extending to 360 m, and 2 - 2.5 km to the west. The area of risk around the well corresponds to the tophole discharges from the seabed along with deposited particles from the surface discharges during slack currents. The second area displaced to the west coincides with particles deposited from the surface discharges during periods of strong currents.

The risk is predicted to fall below 5 % approximately four years after drilling ends.

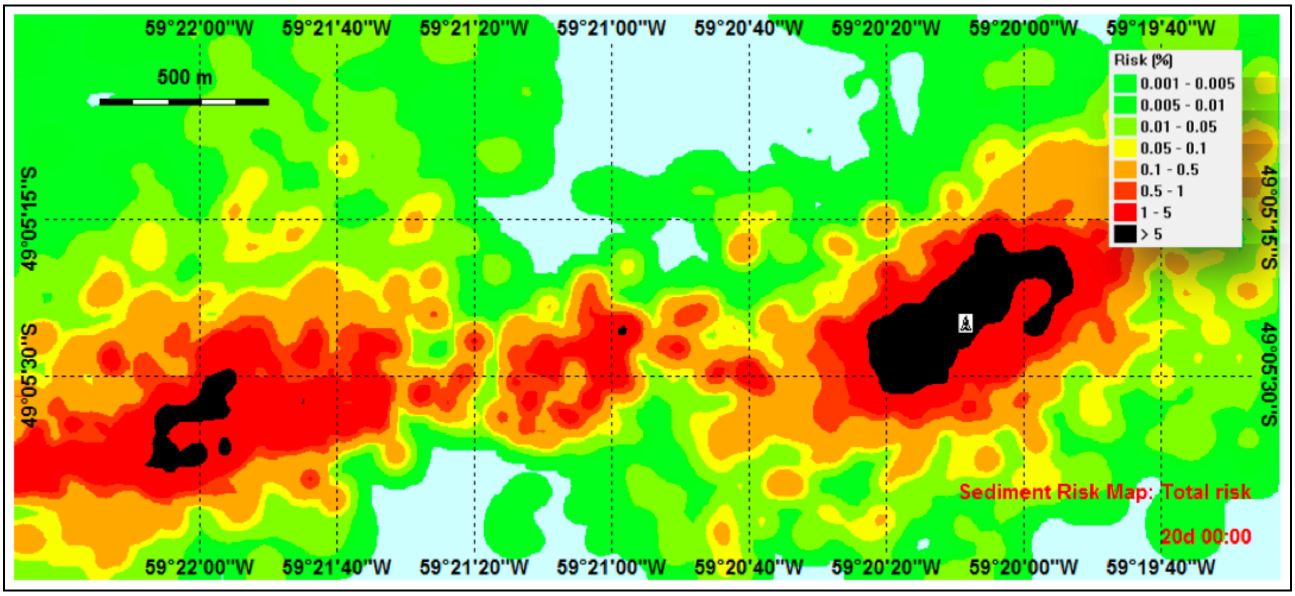


Figure 59: End of Drilling Operations - Total Environmental Risk (EIF) to the Sediment from the discharge of all Well Sections from the Rhea-1 Well

Water Column Impacts

Water depths in the region of the Rhea-1 well location are approximately 470 m. Currents in the area were found to vary with depth, with predominant currents from the surface to approximately 200 m depth flowing towards west and northwest; whilst from 200 m to the seabed predominant currents flow towards the southwest and west (Genesis, 2015a).

Drill cuttings and mud from the upper sections (42″ and 26″) will be discharged directly to the seabed, whilst mud and cuttings from the lower sections (17.5″ and 12.25″) will be discharged near the surface, hence modelling results indicate very different zones of impact for surface and seabed discharges.

Discharge at the Seabed

A snapshot of the instantaneous risk to the water column resulting from the discharge of seawater and bentonite sweeps at the seabed from the longer 26″ top-hole section of the Rhea-1 well is shown in Figure 60. The discharge only contains seawater, cuttings and bentonite (no added chemicals).

The plume is dispersed away from the drilling location along the direction of prevailing currents changing direction over time. The contour plot indicates that water affected at greater than 5% risk (black contour) from the cuttings discharge extends at least 1.0 km to the west of the well and remains in the lower 100 m of the water column. A risk of >5% can occur up to 4 km from the well in a northly direction. Modelling results indicate that the environmental risk falls below 5% within 11 hours on completion of the discharge.

A maximum water column EIF of 648, corresponding to a volume of 0.0648 km^3 of water where the risk is >5%, is predicted from the discharge from the 26″ top-hole section.

Analysis of the EIF indicate that the primary contributor to the risk were suspended bentonite particles, accounting for 100% of the cumulative risk.

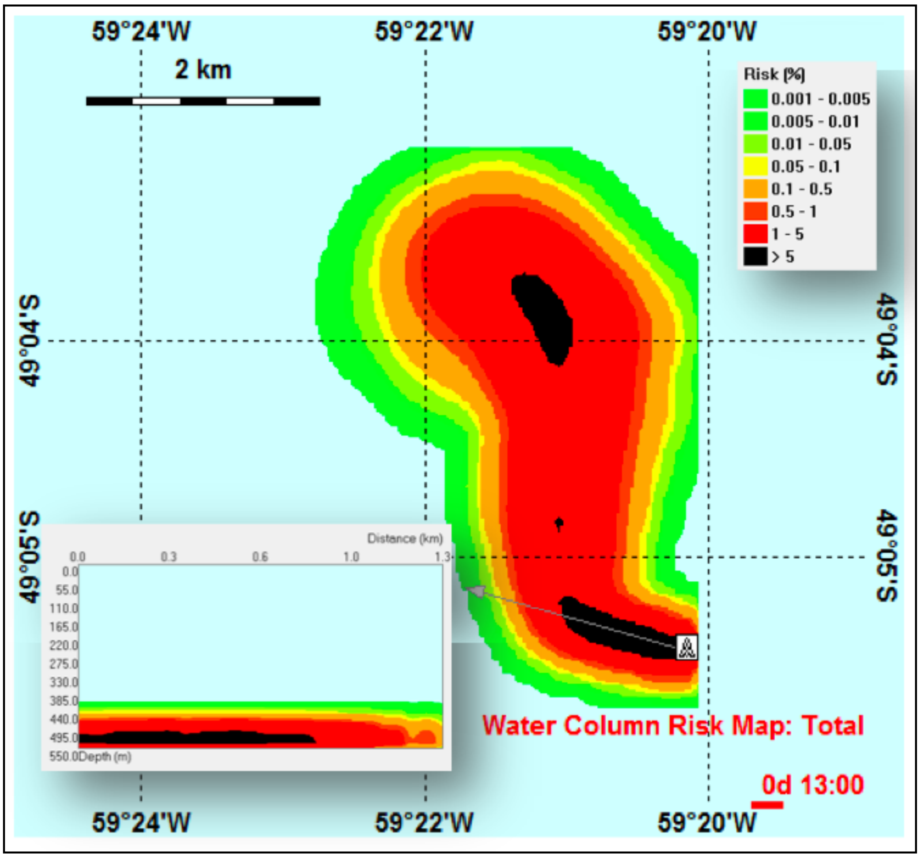


Figure 60: During Discharge – Instantaneous Environmental Risk (EIF) to the Water Column from the Discharge of the 26″ Section at the Seabed

Discharge at the Surface

A snapshot of the instantaneous risk to the water column resulting from the near-surface discharge of WBM from the 17.5″ section of Rhea-1 well is shown in Figure 61. The discharge only contains WBM, cuttings, barite and the shale stabilising chemicals PERFORMATROL and GEM GP.

The plume is dispersed away from the drilling location along the direction of prevailing currents, changing over time. The contour plot indicates water affected at greater than 5 % risk (black contour) from the cuttings discharge, which extends approximately 1 km from the well and remains in the upper 100 m of the water column. Modelling results indicate that the environmental risk falls below 5% within 12 hours on completion of the discharge.

A maximum instantaneous water column EIF of 708, corresponding to a volume of 0.0708 km^3 of water where the risk is >5%, is predicted from the discharge of WBM from the 12.25″ section. This volume reflects the maximum volume of water experiencing an EIF >5% at any one point in time and does not reflect the total volume of water at risk over the duration of the discharge.

Analysis of the EIF indicates that suspended barite particles are the primary contributors to the risk, accounting for 98% of the cumulative risk. The stresses incorporated into the model include the physical effect of the barite particles on zooplankton and filter feeders, primarily due to the sharpness of the particles. This creates a high localised but low temporal risk as the cloud disperses. The discharge of the drilling chemical PERFORMATROL contributes 2% of the remaining risk.

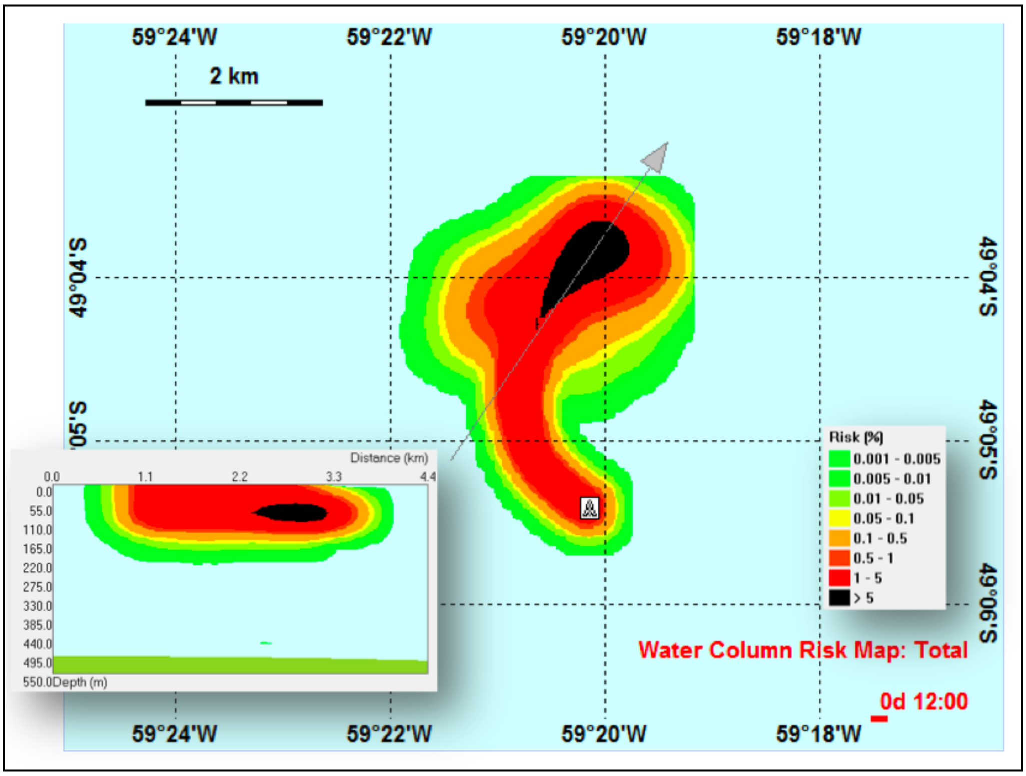


Figure 61: During Discharge – Instantaneous Environmental Risk (EIF) to the Water Column from the Discharge of the 17.5″ Section near the Sea Surface

Overall time development of water column risk

Figure 62 illustrates the development of environmental risk over time during the course of drilling all sections of the Rhea-1 well. The water column EIF represents the volume of water above a risk of 5% with one EIF equal to 100,000 m^3 (0.0001 km^3) volume of water. The maximum risk to the water column is caused by the release of bentonite particles during the discharge of top-hole cuttings near the seabed. Discharges from the 12.25″ section at the sea surface pose the next most significant risk, which is dominated by the presence of barite in the drilling mud. The fluctuations in risk are largely caused by variations in metocean conditions, which influence the plume size before it is deposited on the seabed or disperses to an insignificant concentration.

The environmental risk to the water column is expected to fall below 5% approximately 15 days after the Rhea-1 drilling programme commences.

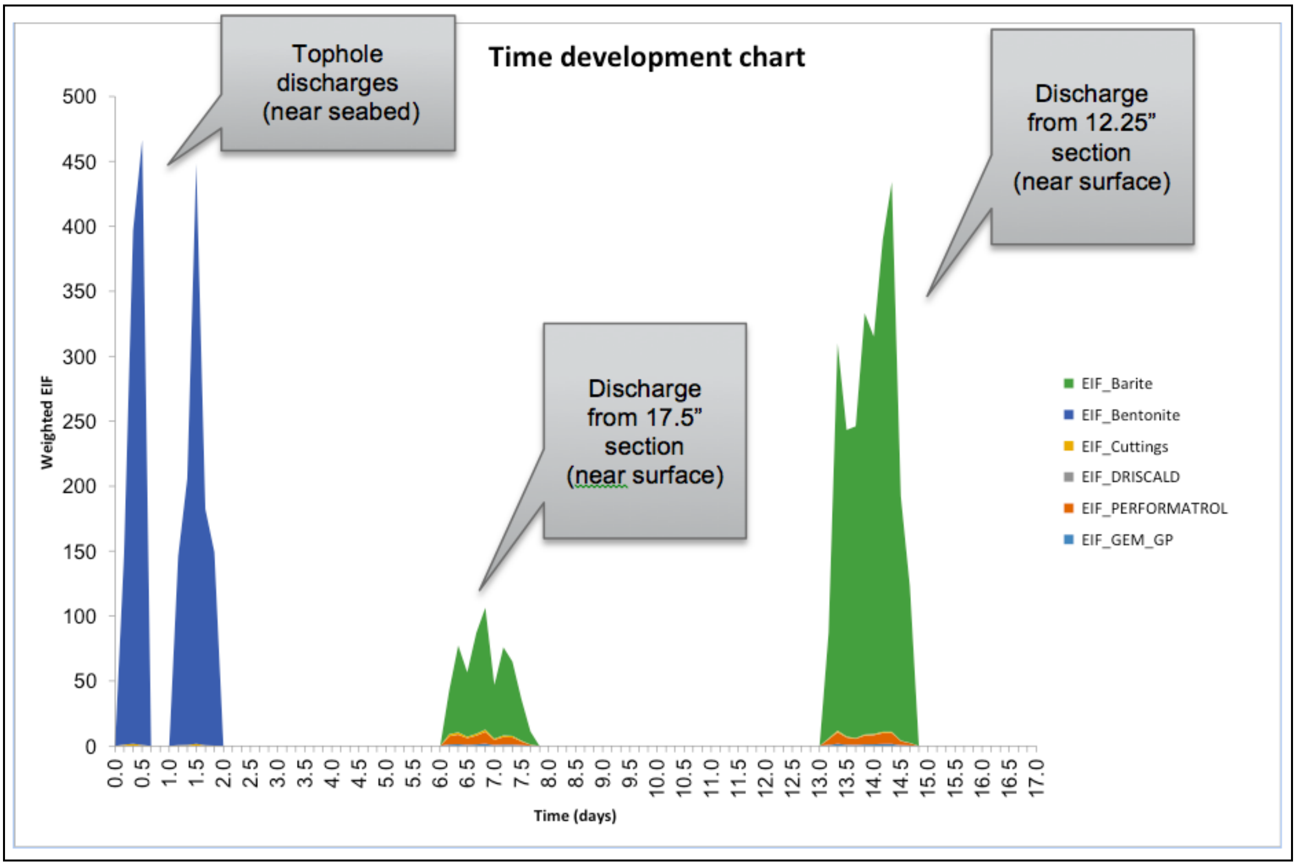


Figure 62: Instantaneous Environmental Risk (EIF) to the Water Column Throughout Time During the Discharge of Mud and Cuttings of all Well Sections from the Rhea-1 Well

12.5 Impact Assessment Summary

12.5.1 Severity and Receptor Sensitivity

Seabed Sediment

Sediment quality will primarily be affected by the discharge of drill cuttings direct to the seabed from the two top-hole sections (42″ and 26″), which will result in an increase in average sediment grain size in the close vicinity of the well. These sections will also be circulated with bentonite sweeps, which contains barite, bentonite, caustic soda, soda ash and lime; however, these components are virtually toxicologically inert (Neff, 2005) and will therefore have little impact on the sediment quality aside for their contribution to the sediment particle size modification.

Modelling indicates that coarser drill cuttings (4,000 µm) will be deposited within 350 m of the well location, and that a median particle size nearly three orders of magnitude greater than typical background sediments, will extend to a distance of 2-3 km along the prevailing current to the west. This will result in a highly modified sediment structure along the direction of prevailing current from the well location. It is expected that these changes to local sediment grain size will persist for at least 10 years (Genesis, 2015a).

Concentrations of a number of heavy metal components within the drilling mud will exceed the natural background sediment concentrations within the exploration area, including cadmium, copper, mercury, lead and zinc. However, these metals are present in barite primarily as insoluble mineralised sulphide salts which will therefore have limited environmental mobility and a low toxicity (Neff, 2005).

The severity of the impact to sediment quality is assessed as '**Moderate**' having an effect over a relatively small area, from a short-term release that will have a temporary but reversible impact on the habitat.

The sensitivity of the receptor is assessed as '**Very Low**' as the habitat is undesignated and has no geographical importance owing to it being widespread in nature. The nature of the habitat in the vicinity of the Rhea-1 well location will be surveyed by ROV prior to commencing drilling activities. If sensitive habitats are encountered FIG will be informed and the location of the surface hole will be moved to another location. Any changes of well tophole location will be accompanied by a pre-drill ROV survey.

Water Quality

The discharge of drill cuttings is expected to result in a local reduction in water quality both in surface waters and in the lower part of the water column, due to an increase in turbidity. Modelling results indicate that a plume of affected seawater would extend over 4 km down-current from the Rhea-1 well location. Turbidity in the water column is not expected to extend more than a 100 m above the seabed whilst drilling the top-hole sections (42″ and 26″) and within approximately 100 m of the sea surface whilst drilling the bottom hole section (17.5″ and 12.25″) (Genesis, 2015a).

Drilling operations for the Rhea-1 well are scheduled to occur during August and September 2015, taking approximately 38 days to drill and abandon the well. On completion of drilling operations the oceanic currents would rapidly dilute the suspended particles and drill cuttings would re-settle onto the seabed, with water quality largely recovering within approximately 11 hours (Genesis, 2015a).

It is therefore concluded that there would be a '**Minor**' impact to the water quality based on a relatively small volume of water being affected, short duration of the operations and the short recovery period (Table 67).

The sensitivity of the receptor is assessed as '**Very Low**' as the area of affected water column is located in an area within the Falkland Islands continental shelf that is not very productive in the austral winter (Section 5.4), and is directly influenced by both Patagonian Shelf waters and superficial sub-Antarctic waters which spread over wide areas of the continental shelf.

Phytoplankton and Zooplankton

Increased turbidity leading to reduced light penetration in surface waters can affect primary production, and could lead to a shorter or shifted phytoplankton bloom period or shifts in species composition. Experiments assessing the impact of WBM concentrations on survivorship of the marine diatom *Thalassiosira pseudonana*, did not show any significant changes in algae biomass or physiological condition that could be attributed to WBM following exposure to 50 mg/l for a period of 10 days (Cranford et al., 1998).

High concentrations of suspended particulates may cause responses in zooplankton, such as physical interaction with the gills, gastrointestinal tract and feeding behaviour, as opposed to chemical toxicity (Smit et al., 2006).

The increase in water column turbidity resulting from suspended fine particulates is expected to be localised to within a distance of approximately 5 km to the west of the well location, continuously affecting a volume of approximately 0.0708 km^3 in the upper water column. The drilling operations and hence cuttings discharge are scheduled to take 38 days and the upper water column is predicted to recover within 12 hours of drilling completion.

The severity of the impact to plankton is therefore considered to be '**Minor**' as there will be a short-term release at the well location, the environmental risk is predicted to be localised and the impact will be minor in nature.

Both phytoplankton and zooplankton have a '**Low**' sensitivity as they are widely distributed throughout the water column and over the Falklands Continental Shelf and do not represent any rare or vulnerable species (Section 5.4).

Benthic Fauna

Discharge of drill cuttings at the seabed and from the surface will physically disturb benthic fauna in the area around the discharge location and will bury sedentary benthic fauna in the immediate discharge area. In the short-term, this would lead to the mortality of some benthic organisms in the area of the cuttings discharge and create a collective area of disturbed habitat of approximately 6 km^2 in the vicinity of the Rhea-1 well location. Modelling indicates that the modification of sediment grain size drives the environmental risk factor, with sediment thickness accounting for a much smaller proportion of risk. It is feasible that changes in sediment particle size characteristics could affect the suitability of the seabed for re-colonisation, by species normally characteristic of the area, for a number of years; whilst sediment deposition may have a lethal short-term effect from burial these sediments will have a negligible toxicity in the long-term.

Modelling outputs indicate that the environmental risk will fall below 5% within four years after the end of drilling activities (Genesis, 2015a). 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).

Predictions of rapid recolonisation are supported by results from environmental surveys conducted in the exploration area during 2012. These studies compared baseline surveys where no drilling had previously taken place, with post-drilling surveys around areas of historical drilling activity (Section 5.3, Gardline, 2013a and b). These surveys indicated that there was no evidence of anthropogenic 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 5.4, Gardline, 2013a). Additionally, environmental surveys conducted in the NFB during the FOSA drilling campaign in 1998 included a pre- and post-drilling survey around the '*Little Blue A*' well (Section 5.3) (also drilled with WBM). Survey results indicated no change in the composition of dominant species and similar levels of abundance and species diversity in both pre- and post-drilling surveys. Therefore, drilling activities did not appear to appreciably disturb the benthic community in the area.

Benthic filter feeding organisms, such as bivalve molluscs, are known to experience toxic effects of suspended particulate matter causing clogging in the gills (Cranford et al., 1998). Laboratory studies have shown that elevated concentrations of bentonite and barite, the two major constituents of WBMs, can affect the growth of suspension feeding organisms (Cranford & Gordon, 1992; Cranford et al., 1999; Barlow & Kingston, 2001), with some species more sensitive than others. However, particles such as barite settle out rapidly from the WBM and the cuttings plume resulting in declining concentrations of barite in the water column, and even in the benthic boundary layer where most bivalves feed, therefore it is probable that barite has limited toxic effect to these organisms (Neff, 2010).

The severity of the impact to the benthic fauna is considered to be '**Moderate**' affecting a relatively small area; the impact will be temporary with environmental risk to benthic fauna falling below 5% within four years after completion of drilling.

There remains some uncertainty in relation to the environmental sensitivity of the benthic environment due to the lack of site-specific benthic survey data. Considering that area wide surveys conducted within 20 km of the Rhea-1 well location did not record any unique or protected species, and that ROV surveys will be conducted prior to commencing drilling activities (the well location will be moved if sensitive species are identified) it is likely that the sensitivity of the receptor will be low. However, taking a precautionary approach due to the lack of site-specific data, the sensitivity of the receptor is considered to be '**Moderate**',

Fish and Shellfish

Fish are highly mobile organisms and are likely to avoid the areas of re-suspended sediments and turbulence during the drilling operations; consequently, larvae and eggs of fish are more sensitive to an increased concentration of suspended sediment than adult life stages. Experiments assessing the impact of turbidity on survivorship on 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 day post-hatch) at the highest WBM concentrations tested (100 mg/l); whilst 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., 1998). Other studies suggest that concentrations of suspended particulate matter of approximately 200 mg/l may damage the gills of fish; whilst higher concentrations are may inhibit feeding activity (Kinne, 1971 – referenced in Smit et al., 2006).

The proposed well location is situated within the Falkland Islands Northern Slope habitat zone (Section 5.4.4), which has been identified as an important feeding area for a number of fish species, whose abundance varies with season. The drilling operations are scheduled to occur in August and September 2015, and would therefore coincide with recorded high abundances of the following fish species in the Northern Slope: loligo squid, common hake, kingclip and yellownose skate; and lower abundances of hoki, Patagonian toothfish, southern hake, greater hooked squid, Patagonian rock cod and spur dog. Many of these species, with the exception of the Patagonian toothfish, primarily inhabit the shallower areas of the NS habitat than the area where the exploration drilling will take place. Additionally, most species have relatively wide distributions being present in several habitat areas within each season, which suggests that no species is solely reliant on the NS area as a feeding ground. However, during the austral winter yellownose skate predominantly inhabit the NS over other habitat areas.

Whilst Falkland Islands waters support diverse and productive feeding grounds, the majority of higher trophic fish species migrate outside of Falkland Islands waters to spawn elsewhere. Of the few commercial finfish species that remain in Falkland Islands waters to spawn, to our knowledge none spawn within the Northern Slope habitat zone (Section 5.4.4). However, some non-commercial species are likely to spawn in this area including the psychrolutids *Psychrolutes marmoratus* and *Cottunculus granulosus*, small morid cods like *Notophycis marginata* (P Brickle pers obs.). Other species in the area include mytophids and bathylargids with the former in significant quantities (P Brickle per obs). The former species were observed in a high proportion of the down camera surveys during the Sea Lion Field survey in 2013 (Gardline, 2013). It is also likely that a number of skate species will breed in this area but are not concentrated over specific spawning grounds (e.g. Arkhipkin et al., 2008; Arkhipkin et al., 2012); egg cases from a number of species have been encountered in this area (P Brickle per obs.).

During the Rhea-1 drilling programme discharges of drilling mud and cuttings will be made both to the surface waters and to the seabed, resulting in high levels of suspended particulate matter concentrated within the upper and lower 100 m of the water column, settlement of particles will also occur throughout the water column. Of the fish species that migrate to the Northern Slope habitat to feed during the winter months, five are pelagic feeders primarily consuming zooplankton, small fish and squid, and the remaining species are near bottom predators feeding primarily on Patagonian rock cod and other small fish.

The Northern Slope habitat covers an area of 50,686 km^2, with an average depth of greater than 400 m. Modelling indicates that a maximum instantaneous volume of water of 0.0708 km^3, would be at >5% environmental risk at any one time during the drilling operations. 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.

The severity of the impact to fish species in the exploration area is expected to be ‘**Minor**’ in nature owing to the absence of spawning commercial fish species on the Northern Slope which are the most sensitive life stage; the relatively localised area of effect; short-term impact and reversibility of the effect (less than 15 days per well including recovery of the water column to <5% risk).

Of the fish species known to be present in the exploration area, the yellownose skate and grey-tailed skate have been assessed as Vulnerable and Endangered respectively on the IUCN Red List. These species are primarily found on the northwest outer shelf habitat area during the austral winter period, where they are most abundant between 100 and 300 m water depths, they also known to occur on the southern slope habitat area during this period (Section 5.4.4).

As adult fish are highly mobile species, capable of migrating outside of Falkland Islands water to spawn and are likely to avoid areas of high turbidity, and once drilling commences any individuals within the area are likely to move into adjacent areas of the Slope that are unaffected by the discharge. Overall the sensitivity of the receptor is considered to be '**Low**', due to the very small proportion of key species that would be affected. Additionally, the species of skate assessed as Vulnerable or Endangered on the IUCN Red List are most commonly found in habitats located in much shallower water depths than the Rhea-1 well, and therefore if present are likely to be in low numbers in the Northern Slope. As highly mobile species skate have the ability to move to another area of habitat if disturbed by drill cuttings discharge, will be of short duration.

12.5.2 Significance

Seabed Sediment

The severity of the impact to seabed sediments was assessed as '**Moderate**' and the sensitivity of the receptor was assessed as '**Very Low**', hence the overall significance is considered to be '**Low**' and of an acceptable level of risk.

Water Quality

The severity of the impact to water quality was assessed as '**Minor**' and the sensitivity of the receptor was assessed as '**Very Low**', hence the overall significance is considered to be '**Low**' and of an acceptable level of risk.

Phytoplankton and Zooplankton

The severity of the impact to phytoplankton and zooplankton was assessed as '**Minor**' and the sensitivity of the receptor was assessed as '**Very Low**', hence the overall significance is considered to be '**Low**' and of an acceptable level of risk.

Benthic Fauna

The severity of the impact to benthic fauna was assessed as '**Moderate**' and the sensitivity of the receptor was assessed as '**Moderate**', hence the overall significance is considered to be '**Moderate**' to reflect the uncertainty in relation to the sensitivity of the benthic environment.

Fish and Shellfish

The severity of the impact to fish species was assessed as '**Minor**' and the sensitivity of the receptor was assessed as '**Low**', hence the overall significance is considered to be '**Low**' and of an acceptable level of risk.

12.5.3 Degree of Confidence

The duration of the drilling campaign is known and the quantities of drilling mud and cuttings have been estimated on a conservative basis. Modelling uncertainties have been identified and their potential to materially alter the outcome of the modelling has been considered. The environmental receptors are well known from the extensive fisheries research in the area and wider NFB area benthic survey data. However, site-specific benthic survey data is not available at the time of writing the EIS, and although an ROV survey will be conducted prior to the drilling operations there remains a data gap with regards to the impact assessment. The nature of the impact from water based drilling discharges is relatively well known from several decades of research and also from model validation studies conducted by SINTEF. NEFL will deploy sediment trap devices at 50m, 100m, and 200m up-stream and down-stream of the well location during the period of drilling operations. When recovered the traps will provide data on the settling of cutting material over the area surrounding the well site and will be used to further validate the SINTEF model.

The level of confidence in the impact predictions (in terms of the nature of the impact and its level of significance) for drilling discharges is considered to be '**Probable**' as the activity is clearly defined, the nature of the impacts are well understood, but the sensitivity of the benthic receptors at the Rhea-1 well site are unknown. It is acknowledged that improvements in the modelling design could also increase accuracy of quantification of the impact.

12.5.4 Cumulative Impact

The Rhea-1 well will be drilled as part of the larger 2015 exploration drilling campaign being jointly conducted by NEFL and Premier Oil. During this period there will be no other oil and gas activities occurring in the NFB. As the Premier Oil exploration drilling operations are also located in the NFB they should be considered for cumulative and in-combination impacts. The closest of the Premier Oil wells is located approximately 22 km from the Rhea-1 well location. Drilling mud and cuttings discharge modelling indicates that the environmental risk to the seabed will be limited to within approximately five kilometres of the Rhea-1 well location. This would create a very small cumulative impact within the NFB but is unlikely to result in any in-combination impacts due to the limited area of effect, distance from the Premier Oil wells and the sequential nature of the joint drilling campaign.

The interactions with other pressures acting on the environment must also be considered for their potential in-combination effects. The Falkland Islands support rich fishing areas within the Falkland Islands Conservation and Management Zones (FICZ/FOCZ), which are sustainably managed by the Directorate of Natural Resources, Fisheries Department. Any significant detrimental interactions or cumulative effects could impact the current running of the fishery within the area. Analysis of fisheries statistics data between 2009 and 2014 indicated that fishing activity within the exploration area was consistently very low during this period, with catch for all species accounting for <1% of total catch within the FICZ/FOCZ in all cases (Section 5.6.1.1). The fishing effort within the exploration area is by jig and trawl vessels targeting primarily Argentine shortfin squid, skates or finfish. Fisheries Department data indicate that both jig and trawl vessels spent only 21 days in the exploration area between 2009 and 2014, (Section 5.6.3). Impacts resulting from drilling discharges are expected to have an environmental impact within <5 km from well location, and as the exploration area is of very low importance to the Falkland Islands fishing industry any in-combination or cumulative effects are considered to be negligible.

12.6 Mitigation measures

The impact significance is considered to be low for most environmental receptors and moderate for benthic communities, good practice measures will be followed during drilling operations to ensure that the risk to the environment is maintained as low as possible and a pre-drill survey will be conducted to further inform the sensitivity of the benthic environment:

- Drilling fluids will be re-circulated with cuttings being separated from the muds and the mud being re-used to minimise discharges as far as possible.
- The majority of WBM chemicals planned for use are considered to Pose Little or No Risk, known as PLONOR chemicals. Where non-PLONOR chemicals are required for operational or safety reasons, their use and discharge will be strictly monitored and minimised as far as possible.
- ROV surveys of the proposed drilling location for the Rhea-1 well will be conducted prior to commencing drilling activities. The survey will be analysed in real-time by RPS who have taxonomists experienced in Falkland Islands fauna. Should any sensitive habitats or species be identified, DMR will be notified and agreement to move the well location will be sought. Should a new well location be necessary, an ROV survey would also be conducted at that location prior to drilling.

12.6.1 Residual Risk

While the majority of impacts associated with drilling discharges are considered to be of low significance prior to mitigation measures, the impacts to the benthic communities were of moderate significance. It is best practice to minimise any impacts to the marine environment where possible and on this basis standard industry mitigation measures, and NEFL's ODPO, will be employed during the campaign, with particular mitigation to survey the benthic community prior to commencing drilling options and move the tophole location if required. This mitigation is considered to reduce the pre-mitigation impact of '**Moderate**' significance for benthic communities to a '**Low**' significance residual impact.

Table 67: Summary of the impact assessment for discharge of WBM and drill cuttings during the Rhea-1 drilling operations

Activity	Aspect	Potential Impact	Type of Activity	Likelihood	Sensitivity	Severity	Significance		Certainty	Mitigation / Prevention / Control
							Pre-mitigation	Post-mitigation		
Drilling operations	Discharge of seawater and bentonite sweeps, WBM and drill cuttings	Deposition of drill cuttings modifying sediment particle size	Planned	N/A	Very Low	Moderate	Low	Low	Certain	Drilling fluids will be re-circulated with cuttings being separated from the muds and the mud being re-used to minimise discharges as far as possible. The majority of WBM chemicals planned for use are considered to Pose Little or No Risk, known as PLONOR chemicals. Where non-PLONOR chemicals are required for operational or safety reasons, their use and discharge will be strictly monitored and minimised as far as possible. ROV surveys of the proposed drilling location for the Rhea-1 well will be conducted prior to commencing drilling activities. The survey will be analysed in real-time by RPS who have taxonomists experienced in Falkland Islands fauna. Should any sensitive habitats or species be identified, DMR will be notified and agreement to move the well location will be sought. Should a new well location be necessary, an ROV survey would also be conducted at that location prior to drilling. All discharges will be carried out in line with NEFL's Offshore Discharge Program
		Suspension of particles leading to increased turbidity			Low	Minor	Low	Low	Certain	
		Reduction the ambient light, barite particles may affect zooplankton			Very Low	Minor	Low	Low	Certain	
		Burial of benthic fauna and modification of habitat			Moderate	Moderate	Moderate	Low	Probable	
		Suspended barite particle may affect gill structures			Low	Minor	Low	Low	Certain	

** See Section 6.0 for definitions of sensitivity, severity, likelihood and significance.*

13.0 Accidental Events Leading to Oil or Chemical Spills

13.1 Introduction

Along with the potential environmental impacts from planned exploration activities, impacts may arise from unplanned/accidental events. Chemical spills, fuel spills and oil spills are unplanned events that would result in potential impacts, the significance of which will depend on the conditions of the event; for example, the properties of the oil/chemical spilt and the size of spills. These accidental events would have varying impacts on the offshore and onshore environments, and on the socio-economics of the Falkland Islands.

The following accidental events were identified during the Environmental Risk Identification (ENVID) process:

- Emergency situation leading to an uncontrolled release or blow-out;
- Accidental loss of containment during operations leading to small diesel or chemical spills;
- Major rig incident resulting in loss of rig;
- Major vessel incident resulting in a collision with rig or another vessel; and,
- Loss of containment of drilling mud from riser due to rig failing to maintain station.

The most significant spills that could occur are associated with an uncontrolled release or blow-out during drilling or loss of containment of diesel fuel inventory from the drilling rig.

The sources of smaller spills can include; bunkering of diesel and drilling muds from Offshore Supply Vessels / Platform Supply Vessels (OSV/PSV's) to the drilling rig and loss of containment of drilling mud due to the rig failing to maintain station.

In this chapter, the environmental risk of these events occurring during the 2015 Rhea-1 exploration operations is assessed.

13.2 Emergency Situation Leading to an Uncontrolled Release or Blow-out

13.2.1 Sources of Major Oil Loss of Containment into the Environment, Uncontrolled Releases or Blow-outs

There are two main control measures that prevent the uncontrolled release of hydrocarbons during drilling; primary and secondary:

- Primary well control is achieved by maintaining 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 – this is done using drilling mud. If the formation pressure exceeds the wellbore pressure reservoir fluids will flow into the wellbore,
- A blow-out-preventer (BOP) is installed onto the wellhead at the seabed once the top-hole section has been drilled, to function as a secondary control measure. In the event that the primary control fails and the formation pressure exceeds the wellbore pressure, the BOP will be activated from the rig to positively close the wellbore.

In the unlikely event that both primary and secondary well controls fail, an uncontrolled release or blow-out can occur.

13.2.2 Potential Environmental Receptors

The impacts of oil spills on marine organisms are well documented. Moore and Dwyer (1974); Burger (1993) and Kingston (2002) provide comprehensive reviews of the impact on marine life.

Oil does not affect all components of marine ecosystems equally; some are more vulnerable to physical impacts, others to chemical toxicity and some are relatively resilient to both. The key effects of oil include the following:

Plankton

Plankton plays a key role in marine food web dynamics, biogeochemical cycling and fisheries recruitment. However, despite the importance in the marine environment our knowledge of the interactions between plankton and anthropogenic pollutants is not well known. Although low concentrations of hydrocarbons (<0.05 mg/l) may stimulate phytoplankton growth, higher concentrations are likely to inhibit growth or kill phytoplankton.

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). Any changes in the distribution and abundance of plankton communities could result in secondary effects. Plankton form the base of the food chain and therefore sub-lethal contamination of plankton could result in significant toxic effects in higher predators.

There are three main types of interactions between zooplankton and pollutants.

- pollutants can have direct toxic effects on zooplankton, including lethal or sub-lethal effects (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 et al., 2002).
- zooplankton may play an important role in the bioaccumulation of pollutants up food webs. Therefore, understanding the interactions between pollutants and zooplankton is crucial for our understanding of the fate of pollution in the pelagic zone and their impact on marine environments.

The oceanography and topography of the southern Patagonian Shelf, with the strong Falkland Current deriving from the ACC moving northwards both west and east of the Falkland Islands, creates an area of very high zooplankton productivity immediately to the north of the Islands (Tarling et al., 1995; Agnew, 2002). The distribution and abundance of plankton in Falkland Islands waters varies on a seasonal basis.

Benthic Communities

Invertebrates vary greatly in their sensitivity to oil. Corals are among the most sensitive, whereas some barnacles and limpets may withstand a degree of oiling. Shellfish may accumulate oil residues with attendant secondary effects, particularly relating to health (OSPAR, 2009b).

To date, benthic surveys in the northern Licence Blocks (PL001, PL032 and Pl033) have indicated that the seabed in the exploratory area is fairly uniform, in terms of habitat classification. The results of the latest surveys, in the vicinity of the Isobel Deep well, indicate that there are some localised differences in the habitats and species encountered in the NFB. These differences are largely due to erratic rocks, which provide habitat for corals. Although a desk-top study has used seismic data to characterise the habitat types found in the area of the Rhea-1 well site (RPS, 2015), benthic sampling has not been carried out at the Rhea-1 well site. Prior to the start of drilling, visual surveys and sampling will be carried out with the aid of an ROV, which should detect whether the area surrounding the Rhea-1 well site contains any rare or vulnerable habitat types.

Fish and Fisheries

Fish eggs and larvae are more susceptible to toxic effects of oil than are adults, due to the ability of adult fish to avoid contaminated water. However, adult fish may accumulate hydrocarbons in their tissues that may affect their health and also taint their flesh (OSPAR, 2009b). Toxic components in crude oil include Polycyclic Aromatic Hydrocarbons (PAHs), phenols, naphthalene, phenanthrene and pyrenes. PAHs can also be mutagenic and carcinogenic.

Although there is little fishing effort in the immediate vicinity of the well site, the Rhea-1 well is located on the Northern Slope, which supports a number of commercial species. The most abundant fisheries resources here include southern blue whiting (summer); hoki (spring, summer and autumn); Patagonian toothfish (summer and autumn); Loligo squid (winter); common hake (autumn and winter); kingclip (winter); Patagonian rock cod (summer); Argentine shortfin squid (summer and autumn); and skate (see Section 5.4.4 for more detail). Perhaps of greatest significant is the Argentine shortfin squid, which migrates into deeper water (in May and June) to access the Falkland Islands current to aid their northerly spawning migrations, a significant proportion of the South Patagonian Stock passes through the North Slope. However, the movement of these animals through the NFB falls outwith the timeframe of the Rhea-1 exploration well drilling schedule.

The most significant fishing ground in the vicinity of the exploration area is in the deeper waters to the north and northeast. These areas are targeted by longliners fishing for Patagonian toothfish (Section 5.4.4 and Section 5.6.1).

The area is also used by species of little or no commercial value, 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 this is potentially a new fishery for the Falkland Islands (Payá, 2009)

Seabirds

The affinity between oil and plumage makes seabirds particularly vulnerable to accidental oil spills. Worldwide, millions of seabirds have been killed by oil pollution (e.g. Goldsworthy et al., 2000; García Borboroglu et al., 2006 and 2010; Wolfaardt et al., 2009) and seabirds tend to be the most conspicuous group affected during oil spill events. Oil pollution can impact birds directly through contamination, or indirectly through consumption of contaminated prey (Committee on Oil in the Sea, 2003).

Most birds have a poorly developed sense of smell; however, procellariiforms (albatrosses and petrels) are unusual in having a well-developed sense of smell. The enhanced sense of smell in these scavenging species enables them to find food and it is likely that these birds would be able to detect oil from a considerable distance. It is unclear whether this makes these birds more vulnerable due to attraction to surface oil or whether it enables them to avoid noxious smelling slicks.

Although oil ingested during plumage cleaning may be lethal, the most common cause of death is due to the loss of feather condition, which leads to hypothermia. Plumage is essential to flight, heat insulation and waterproofing, and even small effects on any of these functions can result in mortality.

Seabird species differ in their susceptibility to contamination from oil pollution due to differences in foraging ecology, geographical distribution, breeding phenology (timing) and life history traits (White et al., 2001). Although a wide variety of seabirds may be affected, the greatest impact is generally on those species that spend a large amount of time at the sea surface, such as diving species. For this reason, 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). The potential for treating contaminated birds is also species specific, robust species that can be housed in groups (such as penguins) have been successfully treated following oil spills elsewhere in the world (Wolfaardt et al., 2009). It may not be possible to treat and rehabilitate many of the procellariiform species that occur around the Falklands (NEFL, 2015).

Oil can also indirectly influence the survival or reproductive success of seabirds by affecting the distribution, abundance or availability of prey, but this is much more difficult to assess.

The seasonal vulnerability of seabirds within Falkland Islands waters is presented in White et al. (2001) and Figure 29 to Figure 34 (Section 5.4.6). The most sensitive months for seabirds around the Rhea-1 exploration well site are February, March, May, August, September and October when vulnerability to surface oil pollution was considered to be ‘high’ in the surrounding area.

Vulnerability was generally ‘moderate’ for the remainder of the year, and ‘moderate’ to ‘low’ during December, when relatively few seabird species were present in low densities.

The area around the Rhea-1 well site 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.

The timing of the Rhea-1 exploration operation (August/September) coincides with the period when seabird vulnerability to oil pollution is highest in the vicinity of the well.

Marine Mammals

Like seabirds, pinnipeds (seals) may be directly impacted through contact with hydrocarbon pollution, or indirectly through impacts to lower trophic level prey that may change foraging patterns or lead to bioaccumulation of contaminants.

The pelage (fur) of pinnipeds can be fouled by coming into contact with oil at sea or when crossing an oil contaminated shore. It is generally accepted that phocid (true seals) are less sensitive to the effects of direct hydrocarbon fouling than otariids (eared seals - fur seals and sea lions) and seabirds. Whilst for phocids the pelage can be coated/fouled with oil it is the sub-dermal fat layer that provides most insulation. Only in the fur seals and sea lions that rely on the insulation provided by the animal's coat, is oiling likely to result in hypothermia (Atlantic OCS, 1988). The location and severity of an oil spill will obviously influence the level of impact and contamination of coastal breeding sites, near-shore transit routes and restricted foraging areas. Besides hypothermia, there are a number of other potential impacts. 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 it might be assumed that prolonged exposure could result in permanent damage (Atlantic OCS, 1988; Salaza, 2003). Severe fouling of 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 and this may be exacerbated if the animal is already stressed from the secondary effects of spill and disturbance (Atlantic OCS, 1988; Jenssen, 1996).

Cetaceans (whales, dolphins and porpoise) are believed to be less vulnerable to oil pollution than pinnipeds or seabirds. Cetaceans generally spend a longer period submerged, than seabirds and pinnipeds, rather than on the surface of the water where contaminants are likely to occur. However, they do need to surface to breathe and rest and it is here that they can be fouled or inhale volatile components of hydrocarbons. 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. Polyaromatic Hydrocarbons tend not to be accumulated in marine mammals but certain metallic trace elements present in oil can be transferred and bioaccumulate.

A description of the spatial and temporal distribution of marine mammals in the NFB can be found in Section 5.4.5.

Potential Coastal Impacts

Premier Oil has recently conducted an environmental sensitivity assessment of the North Falklands coastline to the potential impacts from an oil spill (Premier Oil, 2014c). This study is based on oil spill modelling to ascertain the potential distribution of oil in the unlikely event of a worst-case oil spill from the proposed Sea Lion Field Development and therefore the scale of the event is different to this exploration phase. The North Falklands Coastline Environmental Sensitivity study is also relevant to the Rhea-1 well exploration campaign as it highlights the most sensitive sites along the north Falklands coastline in the event that a shoreline oil spill response operation needs to be initiated, these sites have been summarised in Section 5.4.7.6).

Throughout the year, inshore and coastal waters are important feeding grounds for numerous species. Inshore waters support huge quantities of lobster krill and Loligo squid, which in turn are major food resources for higher predators. At certain times of the year, associated with breeding and moulting, animals return to land and therefore coastal waters contain high densities of vulnerable species. White et al. (2001) found inshore waters to be of very high vulnerability throughout the year.

Tourism

If an uncontrolled release or major loss of containment were to occur, the negative publicity could impact the Islands' tourism industry. Many visitors come to experience the pristine environment and wildlife; even if oil did not reach the shore the negative publicity would tarnish the image of the Islands.

13.2.3 Characterising and Quantifying the Impact of an Uncontrolled Release or Blow-out

As oil is released into the sea it undergoes a number of physical and chemical changes. These changes are dependent on the type and quantities of oil spilled and the weather conditions experienced over time by the spill (Figure 63).

Evaporation and dispersion are the main mechanisms that act to remove oil from the sea surface.

- Evaporation is the main mechanism by which the mass of oil is reduced immediately after a spill. 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. Evaporation is enhanced by warm air temperatures and moderate winds. The oil remaining in the slick will have a higher viscosity and specific gravity.
- 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. This process is dependent upon sea surface turbulence, which in turn is affected by wind speed.

Mathematical models can be used to predict the extent and duration of impacts resulting from a spill.

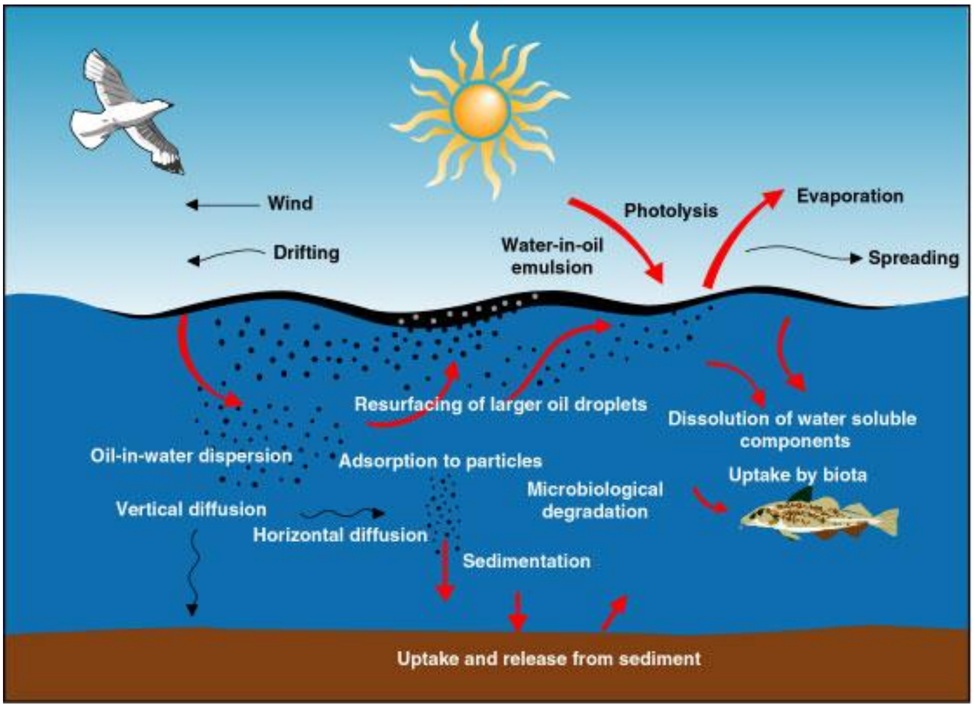


Figure 63: Behaviour and fate of oil in the marine environment (after Andreassen and Sørheim, 2013)

13.2.3.1 Oil Spill Modelling

The oil spill modelling was carried out by Genesis (2015b). The aim of the modelling was to recognize and understand:

- Where an oil slick is likely to travel;
- How an oil slick is likely to be dispersed over time (on the surface and in the water column);
- Where oil concentrations are likely to pose a risk in the water column;
- The likelihood and extent of oil arriving on the shoreline.

Modelling was conducted using the Oil Spill Contingency and Response (OSCAR) model developed by SINTEF (Stiftelsen for industriell og teknisk forskning – The Foundation for Scientific and Industrial Research) in Norway. OSCAR consists of a dispersion model based on wind and 3D current data and a component-specific fate model whereby the physical-chemical, toxicity and biodegradation properties of the components of a discharge are modelled.

A regional circulation model was used to generate the currents in the study area. The model was generated by Proudman Oceanographic Laboratory, who are now part of the National Oceanography Centre (NOC) in Southampton. NOC incorporated data from the Patagonian Shelf Model developed by Glorioso and Flather (1997) into POLPRED. The model includes the Falkland Current as a steady state flow, and does not include the effects of wind. Given the presence of hydrocarbons in different depth layers in different scenarios and the need to accommodate wind forcing of the surface layers, the data was subsequently depth-layered by Oceanwise using a depth-dependent algorithm to take advantage of the 3D nature of OSCAR. Over recent years, the Falklands based oil industry has taken steps to improve on the existing oceanographic data sets on which predicted oil spill modelling has been based. A new coupled inshore tidal and oceanographic circulation model is under development and is due to be fully completed later this year (2015). This has been undertaken by a collaboration between BMT Argoss, BMT WBM and the UK Met Office. A Specification Report is available on request (SeaLion Hydrodynamic Modelling, Model Specification, Ref: A14043, Sept 2014). The Fisheries Department and other stakeholders have reviewed the model set up and are collaborating with the oil industry by providing historic data for model ground truthing. Through the GAP project NEFL is committed to continuing to improve the model when new oceanographic data becomes available from third parties and to also seek cost effective solutions to gather further data themselves for model validation.

Spill scenarios were stochastically (non-deterministically) analysed with time series weather and current data, demonstrating how the behaviour of the hydrocarbons change in variable metocean conditions. Stochastic outputs examined shoreline, surface and water column statistics. Deterministic model runs were undertaken to predict the behaviour and fate of the plume over time in terms of surface accumulation, water column concentrations and oil reaching the shore.

In addition, deterministic analysis was undertaken of each scenario using a specific set of metocean conditions to give further detail on the behaviour of the release. Typically, the choice of deterministic run is based on worst-case conditions for wax beaching.

The methods and outputs of the modelling studies have been summarised in this chapter, and the full details are available in the following report:

- Genesis, 2015b. Oil Spill Modelling for Rhea-1 Exploration Well. Document Number: J73727A-Y-TN-24001/B1. Prepared for Argos Ltd/Noble Energy.

13.2.3.2 Model Thresholds

The OSCAR model uses a Lagrangian (particle tracking) approach, which enables tracking of the movement and location of individual particles in a 3D environment. Here, each particle represents a body of oil that is either dispersed in droplets, dissolved, or in the form of a surface layer. Each particle represents a bulk mass that is a fraction of the overall release, but which behaves according to the properties of the individual droplets or dissolved components or surface layer that it represents. During the simulation, these particles tend to lose mass to evaporation, decay or deposition and the model will terminate particles or cease recording them when the oil property represented falls below a certain value. Normally these are values of concentration or surface thickness that are chosen to reflect a level of insignificance.

Uncontrolled Release or Blow-out

For the uncontrolled release/blow-out scenarios a threshold level of 25 ppb has been chosen as a water column concentration threshold, which is below established levels of impact. For surface thickness, a value is often chosen that represents a significant thickness for response purposes (e.g. 1- 10 microns) or a thinner value that represents visibility of liquid oil and/or potential impacts on bird plumage, e.g. 0.04 - 0.2 microns, although it is noted that there is no consensus on thicknesses of surface oil that correspond to impacts.

The oil type associated with the Rhea-1 prospect is currently unknown and will be characterised as part of the exploration drilling activities. To account for this uncertainty two different types of crude oil have been assessed in the EIS. The first is based on the properties of the hydrocarbon characterised in nearby Sea Lion field, which is a heavy waxy crude, and the second is a lighter more volatile crude based on the characteristics of Ekofisk crude from the North Sea which is a typical light crude. For Sea Lion crude, the overwhelming properties of the wax components mean that a surface thickness parameter is not meaningful, and a scale has been devised to reflect the density of wax droplets, or 'waxlets', on the sea surface.

The scale of waxlet density chosen to represent results is 1, 5, 50, 200 and 1,000 grams per square metre. These are not intended to imply significance in terms of impacts, but to convey factual information regarding the model predictions and allow a means of visualising the results. In general, the model predicts that sub-millimetre sized particles will result once a modest amount of dispersion and wave action has taken place, and it is therefore unlikely that waxlet densities at the lower end of the scale provided would be visible.

13.2.3.3 Modelling Uncertainties

Release Volumes

Uncontrolled releases/blow-outs are rare events that are often controlled within a matter of days using subsea intervention techniques or by the well 'bridging' over and restricting flow. Records from real events indicate that 90% of blow-outs are controlled within 15 days.

Oil Characterisation

As described above, the oil type associated with the Rhea-1 prospect is unknown and consequently two different types of oil have been considered in the modelling. The characteristics of the Sea Lion and Ekofisk oil types that have been used in the modelling fulfil opposite ends of the spectrum one with a waxy nature and one with a volatile nature (Table 68).

Table 68: Oil Types and Characteristics Modelled (Genesis, 2015b)

Property	**Value adopted for OSCAR modelling**	
Oil type	Sea Lion	Ekofisk Blend 2000
Specific gravity	0.883	0.851
Viscosity	500,000 cP	93 cP
Pour Point	+ 39 °C	0 °C
Asphaltene content	0.05 % wt.	0.07 % wt.
Wax content	23 % wt.	4.93 % wt.

Behaviour of a Waxy Crude in the Model

The OSCAR model is primarily written 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. The Ekofisk analogue provides a counterpoint to this uncertainty.

Metocean Data

The metocean dataset used in the oil spill modelling covers three years of depth-averaged data from an established regional current model. This provides a wide range of weather conditions within several annual cycles of weather. This is considered to be the best dataset available for the area and, given the large spatial coverage; it is believed that this data is sufficient for drawing conclusions on the fate of oil in this area (Genesis, 2015b). It is acknowledged that there are limitations in this model. Little oceanographic data have been collected in a systematic way for this area with the exception of two monthly transects conducted from 18 m to 1,000 m directly east of Stanley and also southeast from lively Island (off the east coast of East Falkland). FIFD data clearly show the presence of eddies and mesoscale features across the Falkland Current (see Glorioso, 2002). Arkhipkin et al., (2010) also show mesoscale features and eddies to the south of Cape Meredith, West Falkland. The challenge is to gain the data to identify and understand traits such as; eddies and mesoscale features caused by upwellings and bottom topography across the Falkland Islands and especially in the areas that are being either explored or developed. The GAP analyses programme has an element that specifically deals with oceanography in relation to oil spill modelling and identifying features that are important to productivity and foraging predators. The strategy, in its infancy, will potentially utilise a number of different methodologies including drifter buoys, gliders and CTD surveys. The data available for the area of the northern Licence Blocks is currently limited. The data set used here is the only one that covers an area large enough in this case.

Single point, depth resolved currents were used to model the mud spill, assuming the same currents across the model domain. In reality there will be some variation across the domain.

13.2.3.4 The OSCAR Model - Release parameters

Table 69 lists the physical input parameters provided by NEFL for each of the model scenarios. Blow-outs were modelled as a non-declining release over 15 days within a model period of 120 days. Blow-outs are very unlikely, and according to industry blow-out records, 90% of blow-outs are arrested within 15 days where shear ram BOPs are used and two-barrier principles followed, as here. Stochastic sensitivity runs have been undertaken on releases of 23 days and 72.5 days to reflect the range of times it would take to cap a well blow-out.

The model parameters predict a lot of water and gas being released with the oil, so it is almost 1:10 diluted even as it leaves the well and the gas gives it a lot more initial dilution, which results in high dispersion.

Ekofisk is Norway's 'Forties' field and is very well tested and understood and represents a medium crude, so if there is an incident, NEFL will be able to decide which sort of oil is the closest to their discovery and use the appropriate results, and gives some range to the environmental impacts. It represents 'normal' oil weathering processes unlike the very unusual Sea Lion wax.

Spill scenarios were stochastically analysed (probabilistic analysis) with time series weather and current data, demonstrating how the behaviour of the hydrocarbons change in variable metocean conditions. Stochastic outputs examined shoreline, surface and water column statistics. Deterministic model runs were undertaken to predict the behaviour and fate of the plume over time in terms of surface accumulation, water column concentrations and oil reaching the shore. Multiple scenarios (stochastic) with varying start times can be compiled to calculate the probability of some event e.g. oil reaching shore, or, single (deterministic) oil spill scenarios can be completed for a specified meteorological period (which can be forecast as well as historical data).

Table 69: Parameters modelled in the well blow-out and diesel spill scenarios

Scenario	Fluids released	Release volume or rate	Release depth (m)	Release temp. (°C)	Release diameter	Release duration
Well blow-out – Sea Lion crude	Sea Lion crude, formation water, gas	Max oil rate – 1,163 bpd Water rate – 6,772 bpd GOR – 430 scf/bbl	Initially at surface and then at seabed	60.6	N/A for surface, 314 mm at seabed,	2 days at surface, 13 days at seabed
Well blow-out – Ekofisk crude	Ekofisk crude, formation water, gas	Max oil rate – 1,163 bpd Water rate – 6,772 bpd GOR – 430 scf/bbl	Initially at surface and then at seabed	60.6	N/A for surface, 314 mm at seabed	2 days at surface, 13 days at seabed
Diesel inventory loss	Diesel	4,631 m^3 released over 24 hours	Surface	7 (ambient)	N/A	24 hours
Diesel transfer spill	Diesel	30 tonnes released over 1 hour	Surface	7 (ambient)	N/A	1 hour

The wax content of the Sea Lion crude is higher than any oil present in the OSCAR oil weathering database and, therefore, a user-defined oil type was been created (Genesis, 2015b). A similar approach has been used in other modelling studies with waxy crudes; for example, the Shah Deniz Phase 2 Project in the Caspian Sea (BP, 2013), where modified database properties were used to best reflect the hydrocarbon properties using the advice of an oil specialist. Details of the key Sea Lion crude oil properties and Sea Lion Pseudo-assay generated by OSCAR to model biodegradation and toxicity are detailed in Genesis (2015).

13.2.3.5 Model Results – Sea Lion Crude

Overall Behaviour of the Sea Lion Crude from an Uncontrolled Release or Blow-out over

The behaviour predictions over time for Sea Lion crude over the model simulation duration of 120 days and a well blow-out of 15 days is illustrated in Figure 64.

The variation in surface oil over time is due to the combination of differing weather conditions, whereby the crude is dispersed into the water column during periods of rough weather. This relationship can be seen in the corresponding increase in dispersed oil when surface oil decreases. In calm weather, the buoyant wax resumes position on the surface. The wax biodegrades at a relatively steady rate throughout the uncontrolled release period (15 days in this model, the time taken to control 90% of all blow-outs), and declines over the 60 days following the end of the uncontrolled release.

Wax that reaches the shoreline is referred to as ‘stranded’, and this forms an extremely small proportion of the total oil released. A larger fraction is predicted to deposit in coastal sediments as the wax in the water column approaches the shoreline.

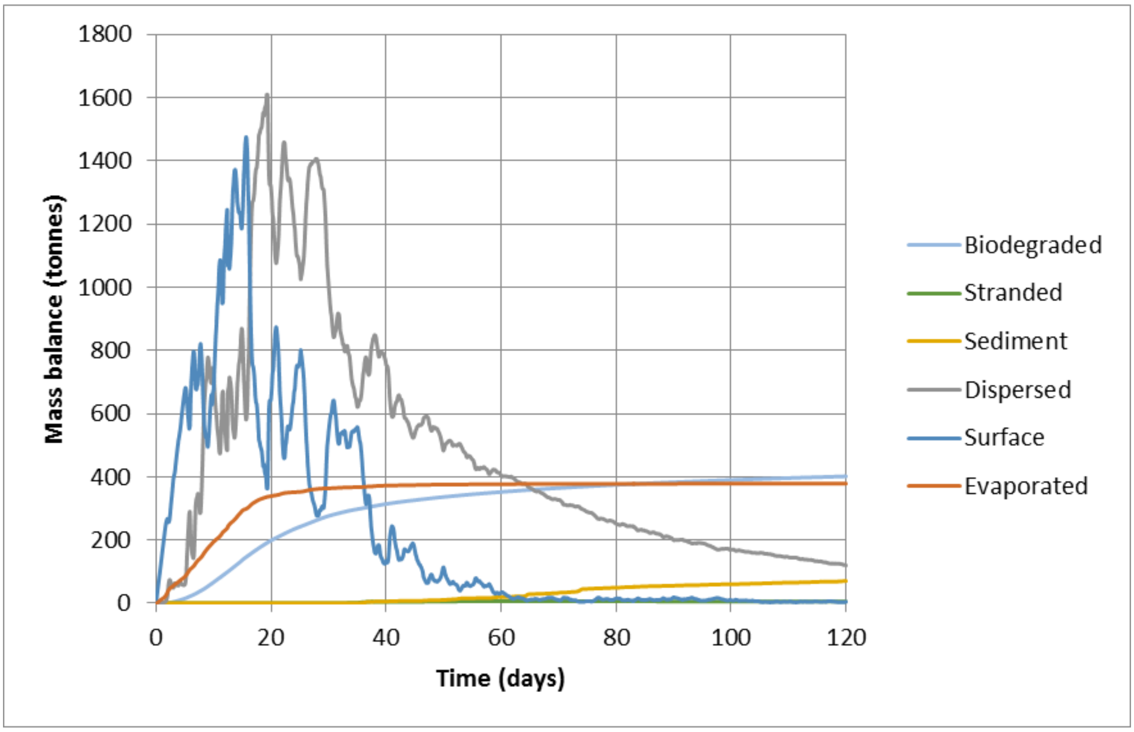


Figure 64: Behaviour of oil over time during the modelled blow-out

Surface Statistics

Figure 65 shows the probability of wax, above the threshold of 1 g/m^2, appearing on the sea surface at any time over the model duration (120 days) based on 50 different sets of metocean conditions within the overall available window (a stochastic analysis). As this is such a low density crude, and the waxlets are persistent and will travel far over such a long period, there is a high probability of some appearance of surface waxlets, which may reach the north Falklands coastline. This output does not reflect the size of the surface manifestation of wax at any one time, which is much smaller. The main direction that the wax travels in is northwards in line with underlying current circulation.

Figure 66 and Figure 67 show the corresponding minimum arrival times and maximum exposure times, respectively, for the Sea Lion crude blow-out scenario. After a well blow-out, the Sea Lion crude can potentially travel up to 30 km within 1 day, and there is the possibility that it can travel up to 160 km within 30 days. However, this only occurs with very small probability and the crude will be in a highly dispersed state. After the well blow-out, it takes approximately 9.5 hours for the crude to enter the FICZ. There is a likelihood that the crude can cross the FOCZ boundary line after 25 days. It should again be noted that the oil will be in a highly dispersed state at this point and would unlikely be visible.

The maximum times that any surface location is exposed to oil is demonstrated in Figure 67. This shows that the sea surface in the immediate vicinity of the release point can be exposed to oil for up to seven days. At locations further away from the well blow-out, the surface exposure times are far shorter (typically less than a day) as the Sea Lion crude gets dispersed by the waves and currents.

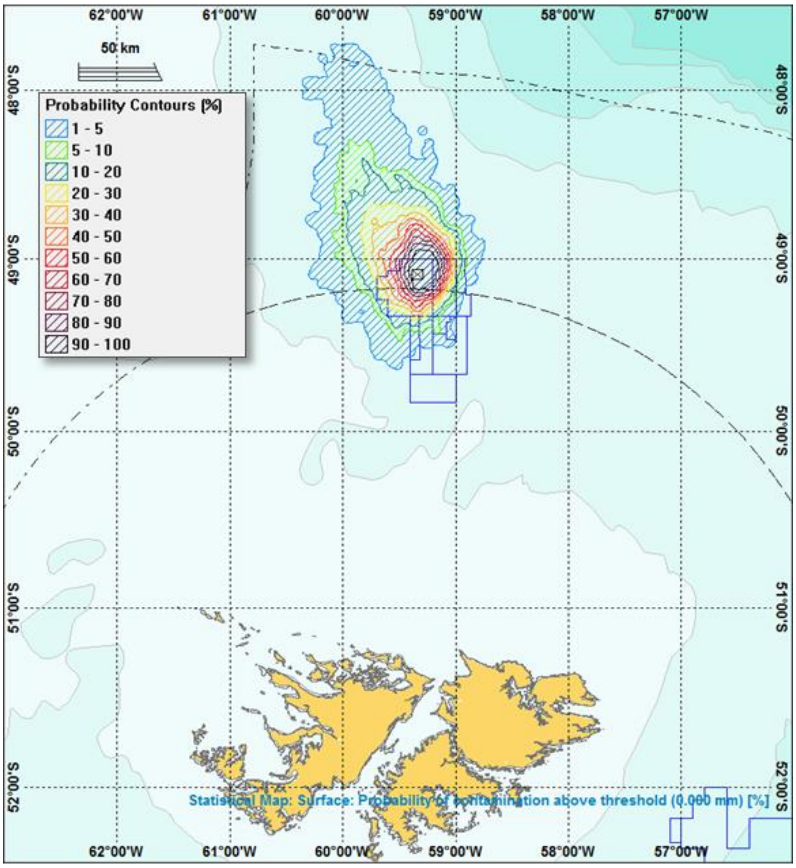


Figure 65: Probability of wax on the sea surface after Sea Lion crude well blow-out (stochastic)

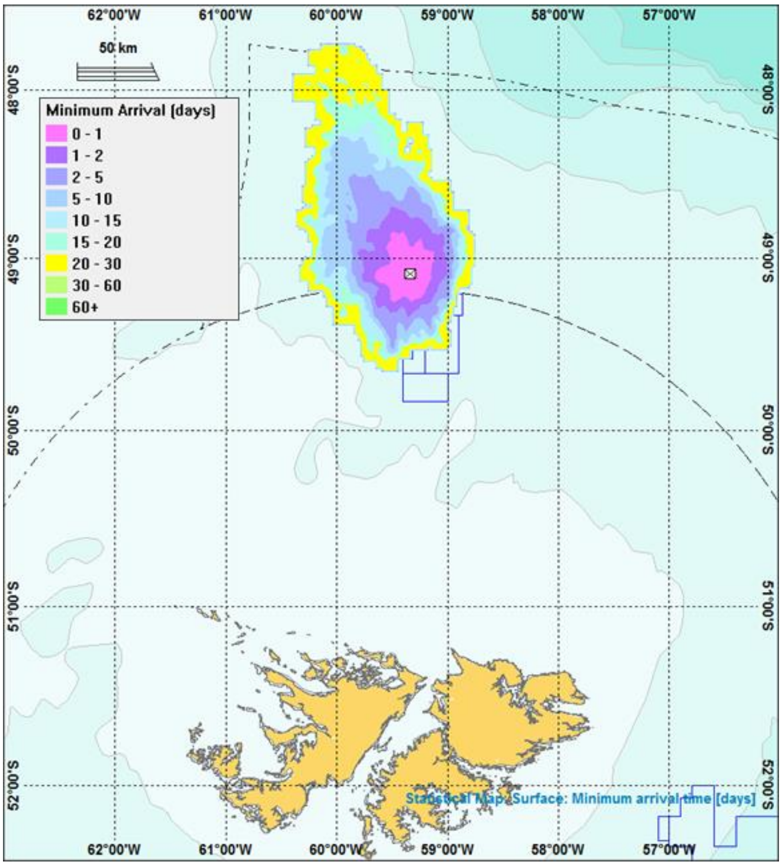


Figure 66: Minimum surface arrival times after Sea Lion crude well blow-out (stochastic)

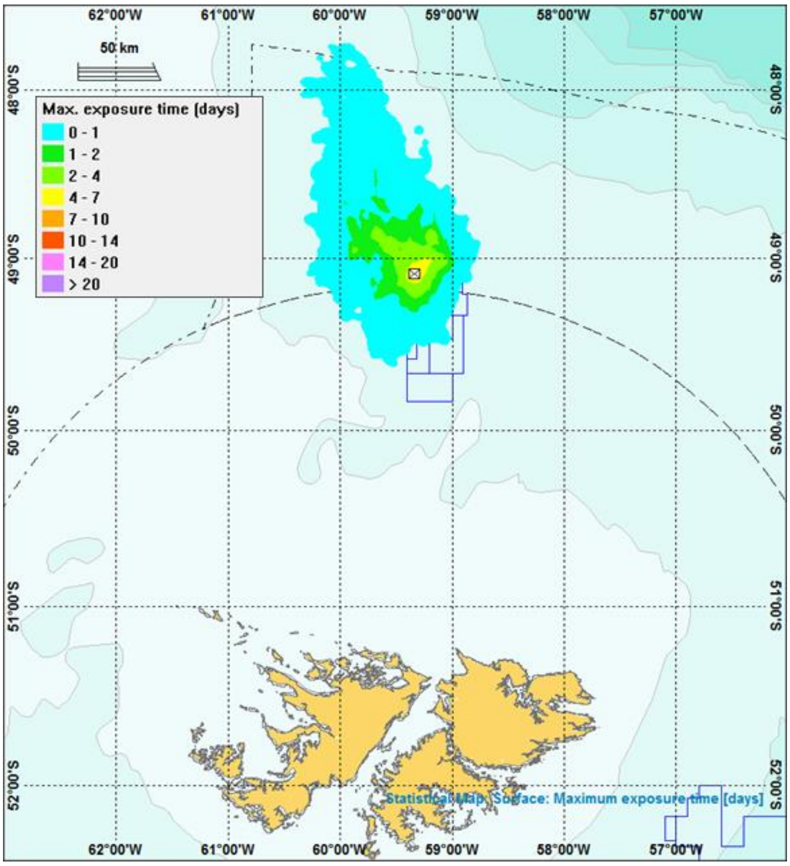


Figure 67: Maximum time sea surface may be exposed to wax after Sea Lion crude well blow-out (stochastic)

The figures above were obtained from the stochastic simulation runs and demonstrate a combined output from all 50 runs. A single (deterministic) run of the Sea Lion crude well blow-out scenario was also conducted to identify the density of surface wax and is shown in Figure 68. This deterministic run was selected based on the stochastic run that resulted in the worst-case mass on-shore. The main graphic of Figure 68 shows the maximum surface density of the wax that occurred at any time over the 120 days modelling duration for this deterministic run. It should be noted that this figure does not represent a single surface slick at a particular instance in time, which is much smaller. The snapshot inset to the main figure shows a typical surface wax density four days after the start of the blow-out.

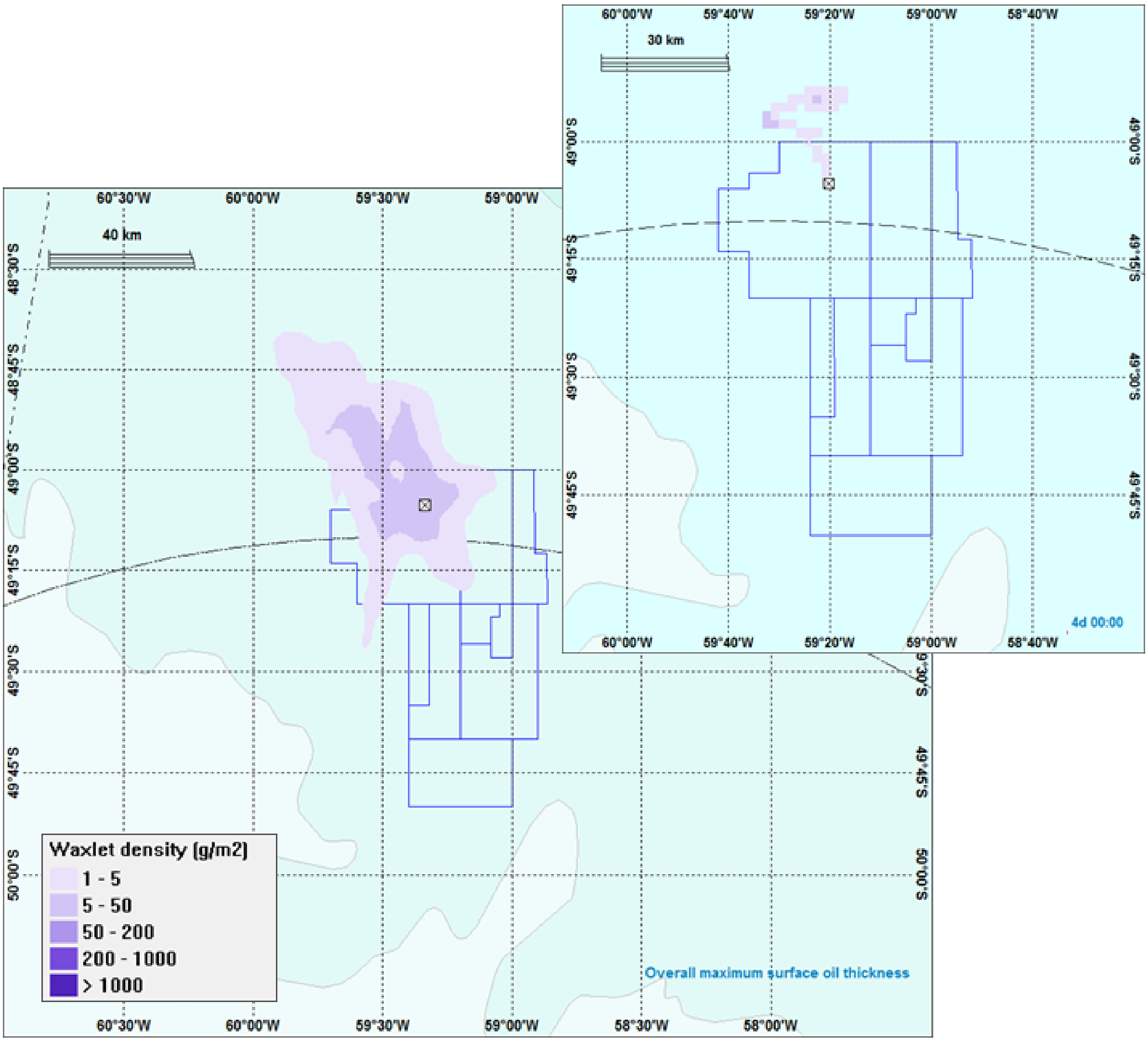
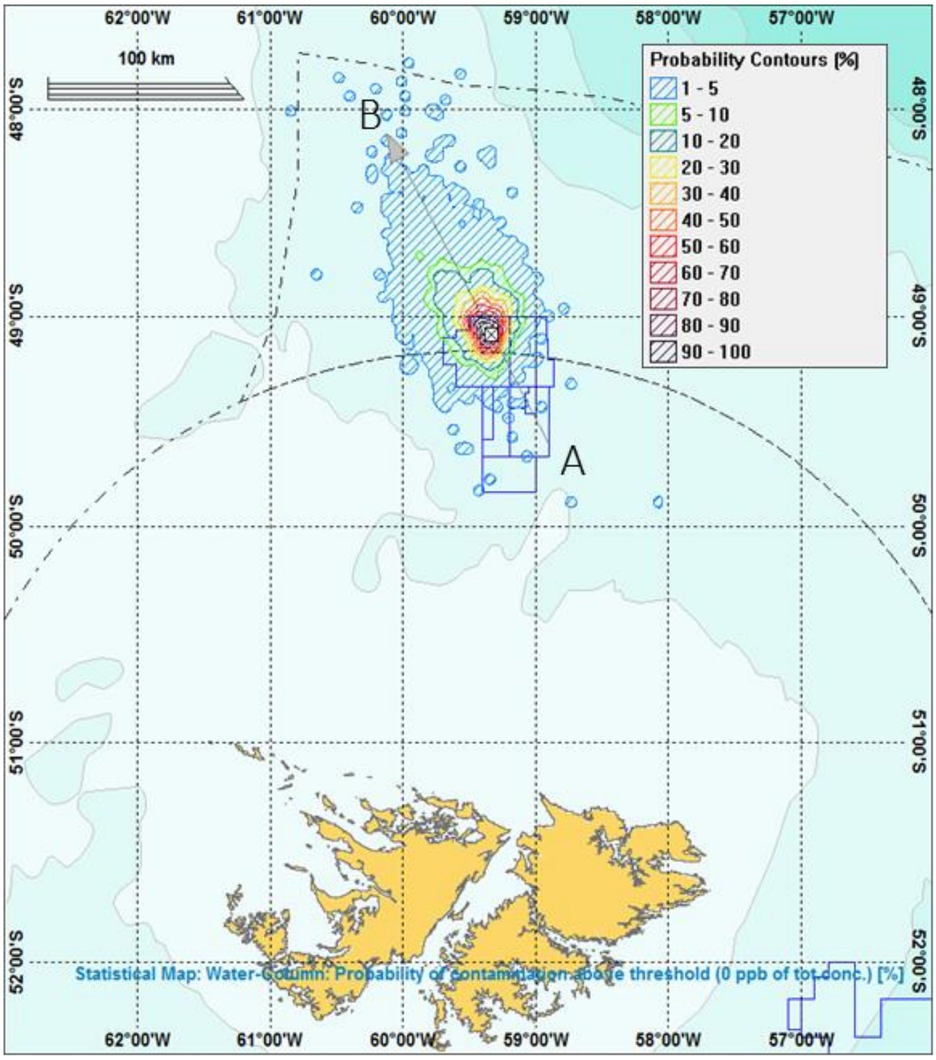


Figure 68: Maximum surface waxlet density for the Sea Lion crude well blow-out scenario (deterministic)

Water column statistics

The probability of the Sea Lion crude accumulating in the water column above the threshold of 25 ppb is demonstrated in Figure 69. The probability of oil being above the threshold of 25 ppb is highest in the immediate surroundings of the well blow-out discharge location. However, outwith 50 km from the discharge point, the probability of oil concentration being above 25 ppb is less than 5 %. There is a very small probability (less than 5 %) that the Sea Lion crude could travel up to 150 km in the water column.

The maximum length of time that any location in the water column is exposed to oil is demonstrated in Figure 70. The immediate surroundings of the discharge location can be exposed to oil (above a concentration of 25 ppb) for up to three days. At locations further away from the well blow-out discharge point, the water column is exposed to oil above a concentration of 25 ppb for less than a day. The cross-sectional plot in Figure 70 demonstrates that the oil from the subsea discharge location rises to the surface very quickly.



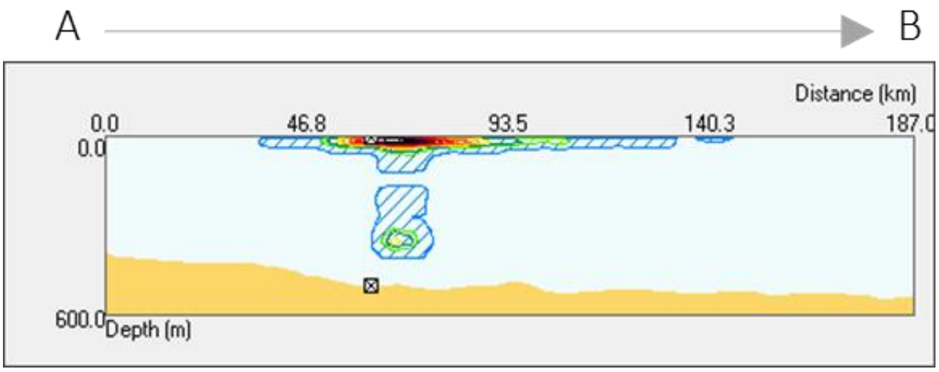


Figure 69: Probability of wax in the water column after Sea Lion crude well blowout (deterministic)

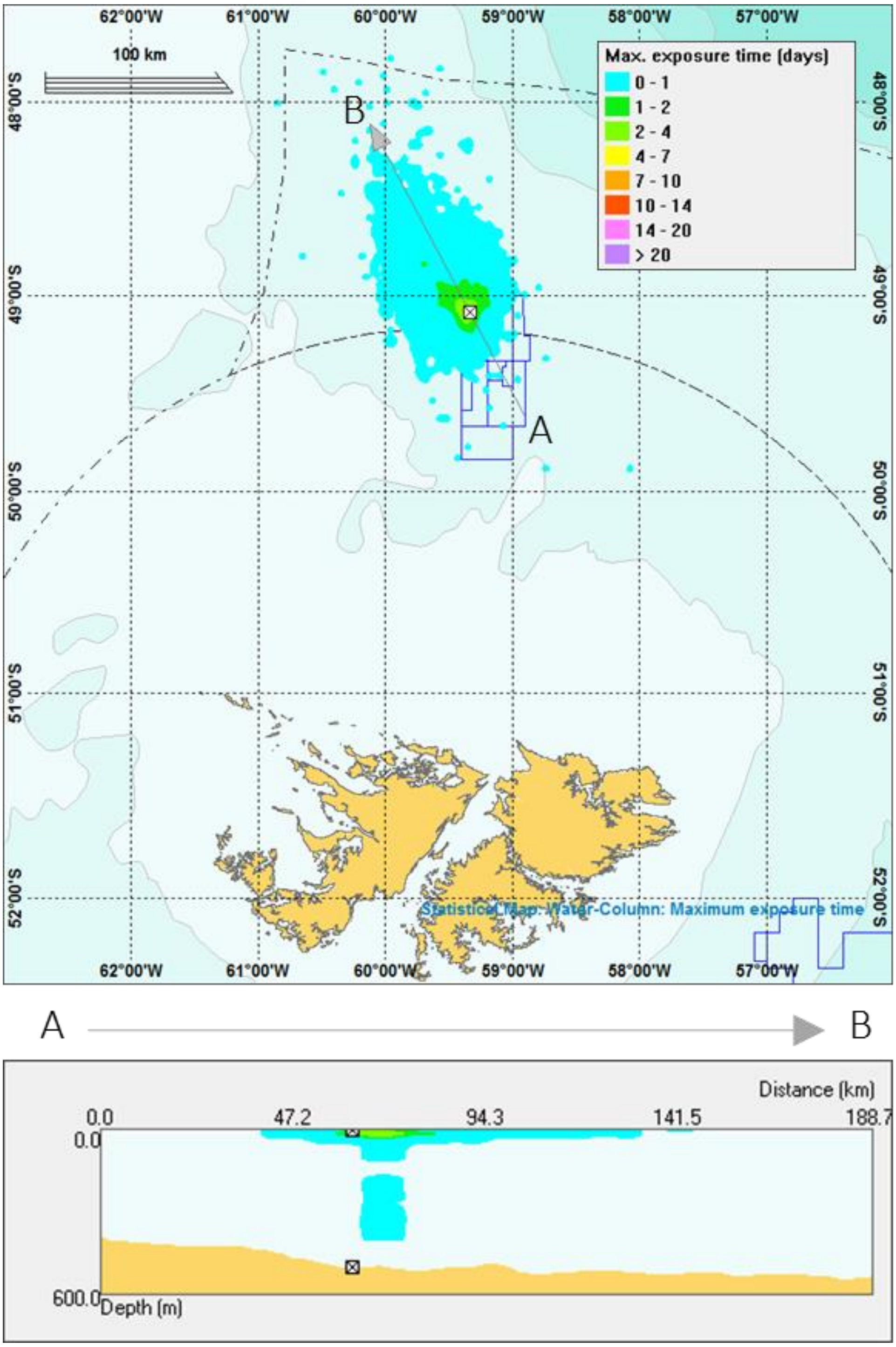


Figure 70: Maximum duration the water column may be exposed to wax after Sea Lion crude well blow-out (deterministic)

Figure 71 shows the typical total water column concentration for the Sea Lion crude well blow-out scenario obtained from a single deterministic run. It is observed that the water column concentration never exceeds 50 ppb. It was observed during this deterministic simulation that the maximum total oil concentration dropped below 25 ppb after approximately 31 days.

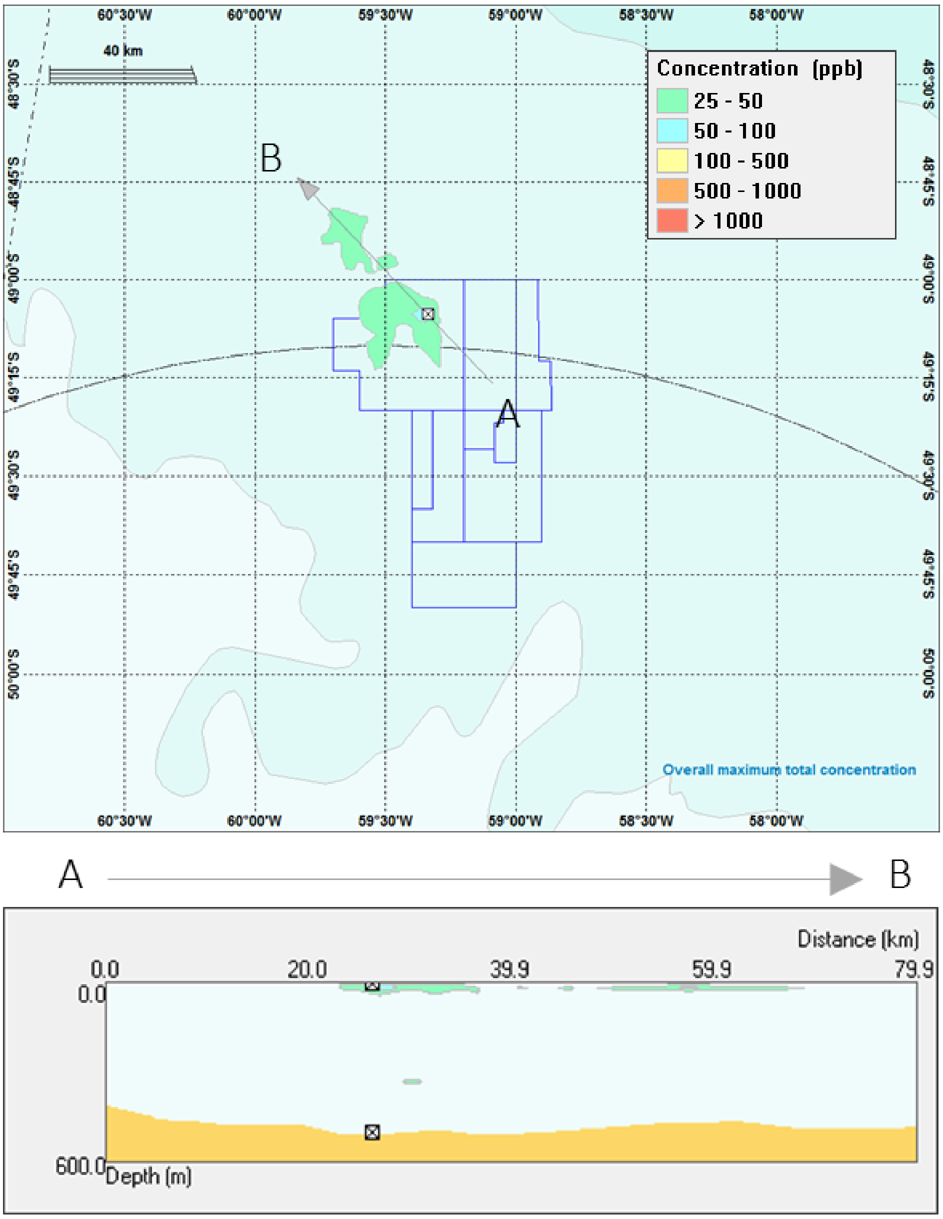


Figure 71: Maximum total water column concentration for the Sea Lion well blow-out scenario (deterministic)

Shoreline Statistics

The probability of waxlets reaching the shore is shown in Figure 72, which highlights that the probability of the Sea Lion crude reaching the Falklands coastline after the well blow-out is extremely small (less than 5 %). Figure 73 shows the corresponding minimum arrival times of oil on shore, and demonstrates that the oil is not expected to arrive on the Falklands coastline until at least 30 days after the start of the discharge. In fact, the minimum time taken for any oil to arrive on-shore was approximately 33 days. The worst-case and average mass arriving on-shore for the Sea Lion crude well blow-out scenario are shown in Figure 74. Here the worst-case curve shows the maximum mass of oil that arrived onshore for *any* of the 50 stochastic simulations, whilst the average curve shows the mass of oil that arrived on-shore averaged across all 50 of the stochastic simulations. In the worst-case the maximum mass of oil that arrived on-shore was approximately 6.5 tonnes, which occurred 60 days after the start of the well blow-out. The average curve in Figure 74 demonstrates that the mass of oil arriving on-shore after the well blow-out can typically be expected to be a lot smaller than this (0.15 tonnes). Any wax reaching the shoreline would be highly dispersed and may not be detectable above background levels.

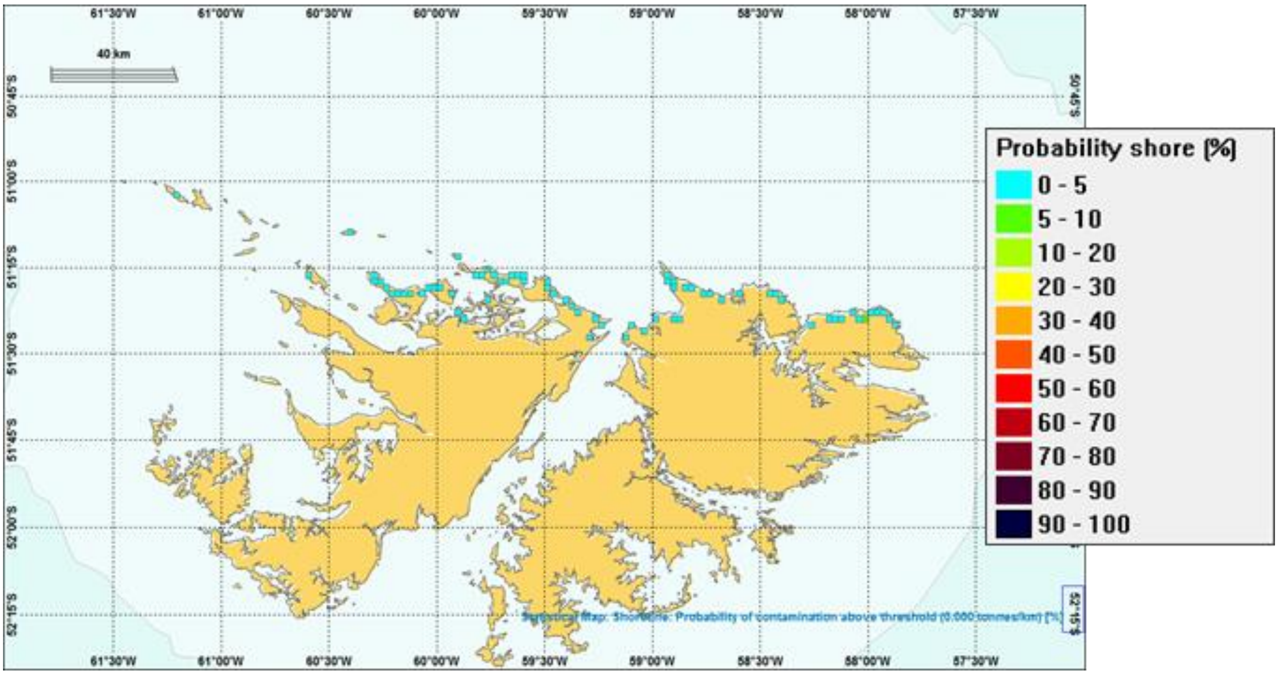


Figure 72: Probability of wax reaching the shoreline after Sea Lion crude well blow-out (stochastic)

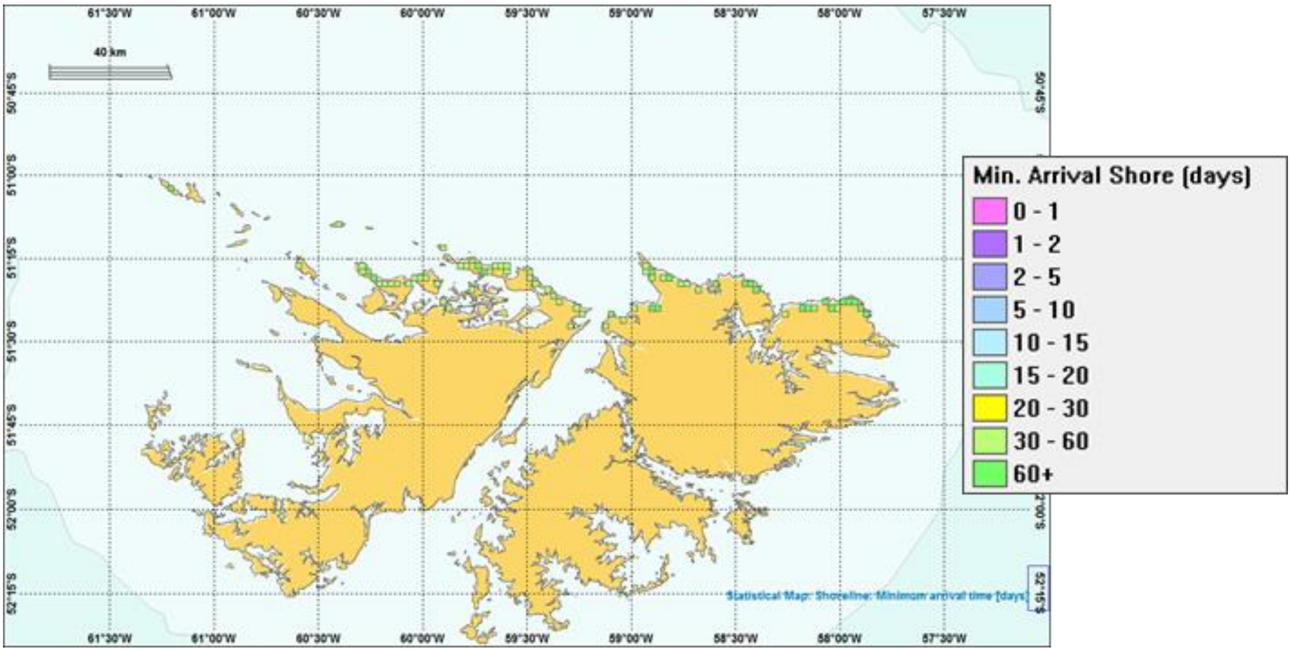


Figure 73: Minimum times for oil to arrive onshore after Sea Lion crude well blow-out (stochastic)

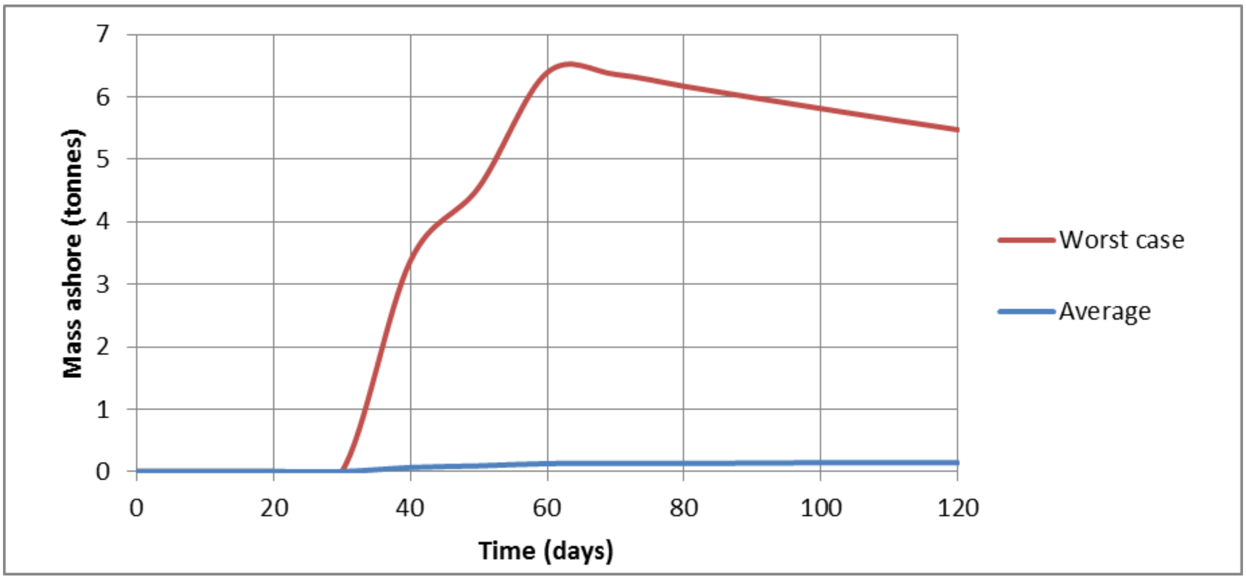


Figure 74: Mass arriving onshore after Sea Lion crude well blow-out (stochastic)

Model Predictions After the Oil has been at Sea for a Long Time

It is normal to run scenarios for the entire duration of an uncontrolled release/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. In this case, there is modest shoreline beaching and some dispersed wax remains at sea at the end of the uncontrolled release. There are reasons to view the longer-term surface predictions as conservative, as the particles at sea will tend to combine with suspended solids and sink. It is also not certain that the model physics for very weathered waxlets is representative. The representation of the waxlets as a density, which appears to evenly cover grid cells of 1 km square in the uncontrolled release model run, is a reasonable way to envisage the wax during the early stages of a release but may lose relevance when the waxlets are extremely small and widely dispersed. It is possible to employ a higher threshold to 'screen out' smaller concentrations of wax, but this has not been done in the interest of transparency (Genesis, 2015b).

Overall, the interpretation of results at long timescales should be conducted with caution and experience. In general, the model results may exaggerate the apparent impact of dispersed waxlets and so are conservative (Genesis, 2015b).

Discussion of Sea Lion Crude Blow-out

The behaviour of Sea Lion crude at sea is atypical of a crude oil given the extremely high wax content, which is higher than any analogue in the SINTEF database. Crudes with high wax content, such as that experienced in the Montara incident in 2009, tend to behave in a specific way whereby the crude rapidly congeals on release as it cools to ambient temperature and below its pour point. The crude transforms into semi-solid pellets with the properties of wax (waxlets). The amount of energy experienced during the release determines the initial size of the waxlets, with small waxlets likely to be formed during a blow-out. Subsequent waxlet size is determined by prevailing shear forces from waves and turbulence. Ultimately, waxlets will attach to suspended solids and sink, or be biodegraded in the water column. 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.

Based on a Sea Lion crude release, waxlets are expected to be above 1 g/m^2 within 100 km of the release for up to 1 day at any particular location. Within 10 km of the release, persistence will be between 1 and 10 days. From experience, small waxlets are extremely difficult to see visually and in the presence of moderate sea states, surface accumulation of wax is likely to be visually dispersed very quickly (A. Lewis, 2013, *pers. comm.*). Soluble components, which pose a risk to water column ecology, will be released slowly as permeation through the wax is very slow and dissolution relies on new faces being exposed during shearing. Such shearing is more likely during rough weather when dispersion is high, which further limits the water column impact.

The stable nature of the waxlets minimises their impact on seabirds, as they are unlikely to stick to feathers and consequently they are unlikely to be ingested by birds.

13.2.3.6 Model Results - Ekofisk Crude Well Blow-out Scenario

Overall Behaviour of the Ekofisk Crude from an Uncontrolled Release or Blow-out

The predicted typical behaviour of the Ekofisk crude oil over the complete modelling period of 120 days after the initial well blow-out is shown in Figure 75. In comparison to the Sea Lion crude (*c.f.* Figure 64), which is a very persistent oil, the Ekofisk crude disperses more rapidly, due to it being a lighter crude. The oil biodegrades at an increasing rate during the blow-out, as the quantity of oil spilt increases, the rate of biodegredation declines steadily following the end of the blow-out (after 15 days). Compared to the Sea Lion crude oil, a larger proportion of the Ekofisk crude oil would evaporate since it is a lighter more volatile oil type. It can be seen that none of the Ekofisk oil reaches the Falklands coastline (i.e. becomes 'stranded'), and very little mass gets absorbed by sediment.

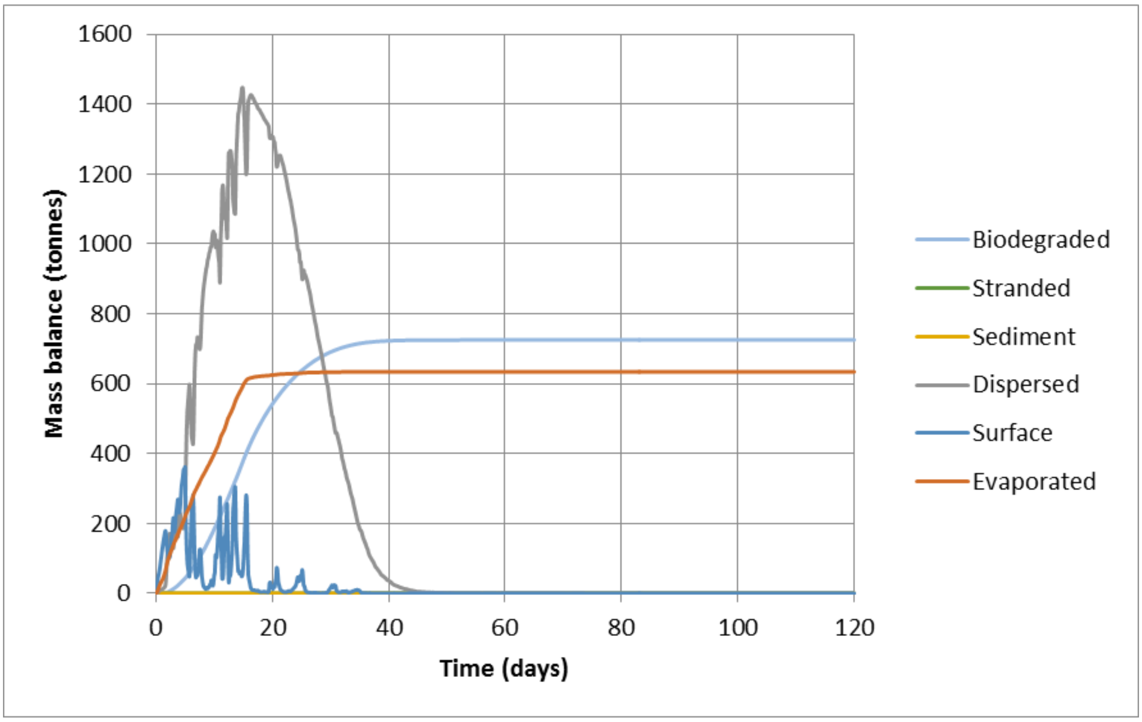


Figure 75: Predicted typical behaviour of oil over time after Ekofisk crude oil well blow-out

Surface Statistics

The probability of oil above the threshold of 0.3 µm appearing on the sea surface at any time over the model duration of 120 days is shown in Figure 76. This statistical plot was obtained based on 50 different sets of metocean conditions within the overall available window (i.e. a stochastic analysis). Since the Ekofisk crude is a light crude there is a high probability of oil appearing on the surface at some point after the discharge. As demonstrated in Figure 76, the probability of oil on the surface near the discharge location is greater than 90 %. There is the possibility of oil appearing up to approximately 175 km away from the discharge location, although it should be noted that this only occurs with a probability of less than 5 %.

Figure 77 shows the minimum time taken for surface oil to reach any location on the modelling grid. This figure shows that the Ekofisk oil can travel up to approximately 40 km within a day, and can potentially travel up to 175 km within 30 days (although oil appearing on the sea surface at such a distance from the discharge location is unlikely). After the well blow-out, it takes approximately four hours for the Ekofisk oil to cross the FICZ boundary. There is the potential that the crude can cross the FOCZ boundary line (into International waters) after approximately 23 days, although it should be noted that this occurs with a very small probability.

The maximum surface exposure times for the Ekofisk well blow-out scenario are demonstrated in Figure 78. Areas immediately surrounding the well blow-out discharge point can be exposed to oil for up to seven days. As the oil gets dispersed further from the discharge location the length of time that any surface area is exposed to oil drops.

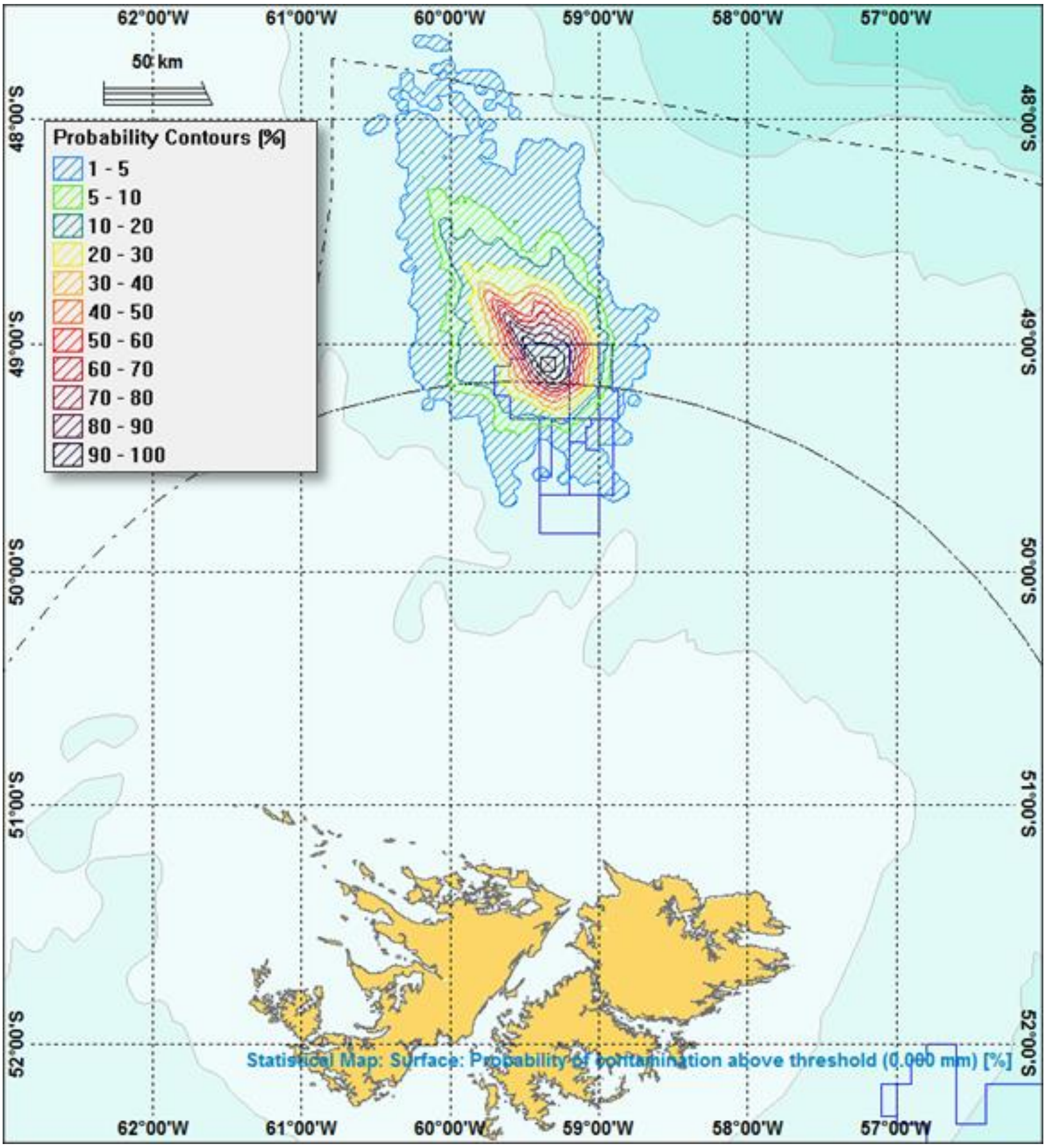


Figure 76: Probability of oil on the sea surface after Ekofisk crude well blow-out (stochastic)

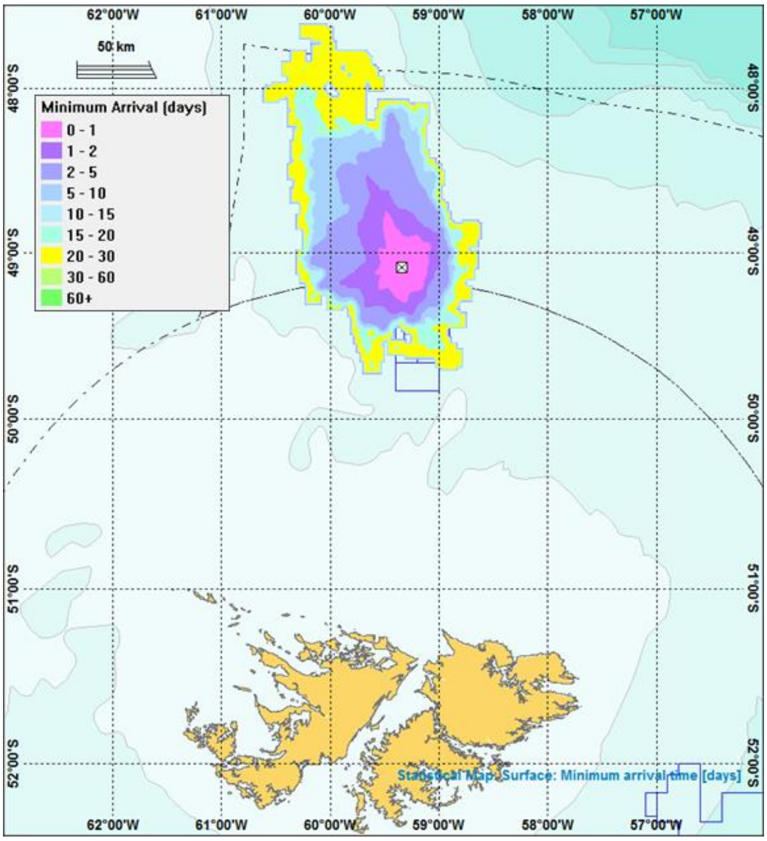


Figure 77: Minimum surface arrival times after Ekofisk crude well blow-out (stochastic)

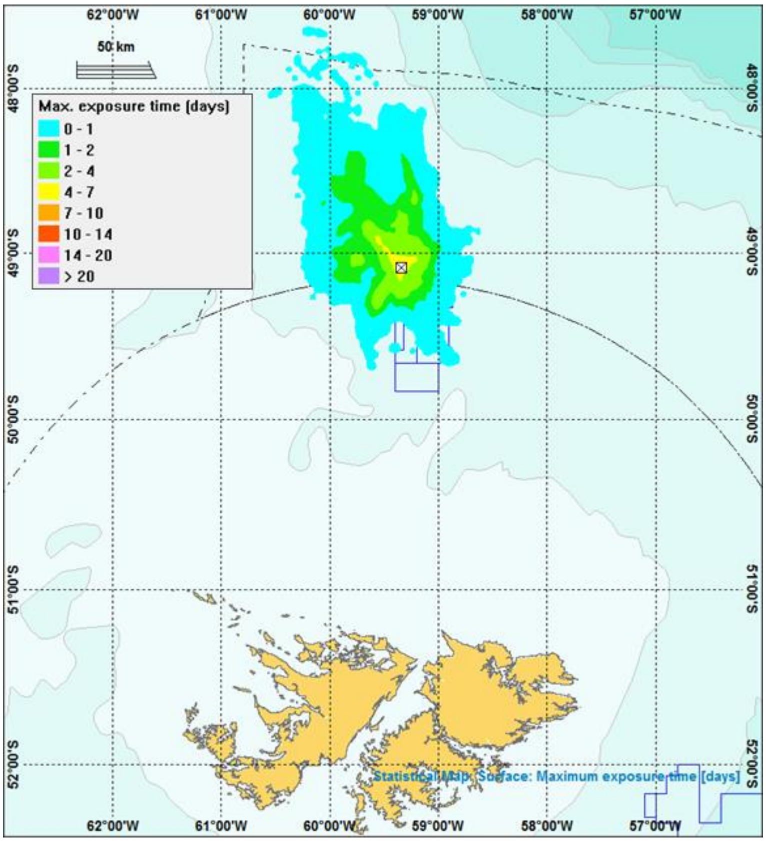


Figure 78: Maximum time sea surface may be exposed to oil after Ekofisk crude well blow-out (stochastic)

A deterministic run of the Ekofisk crude well blow-out scenario was conducted in order to predict the surface oil thickness. The main graphic in Figure 79 shows the maximum surface thickness that occurred at any time over the 120 days modelling duration for this deterministic run. It should be noted that this figure does not represent a single surface slick at a particular instance in time, which is much smaller. As an example of the oil slick at a single instance in time, the snapshot inset to the main figure shows the surface oil thickness four days after the beginning of the discharge.

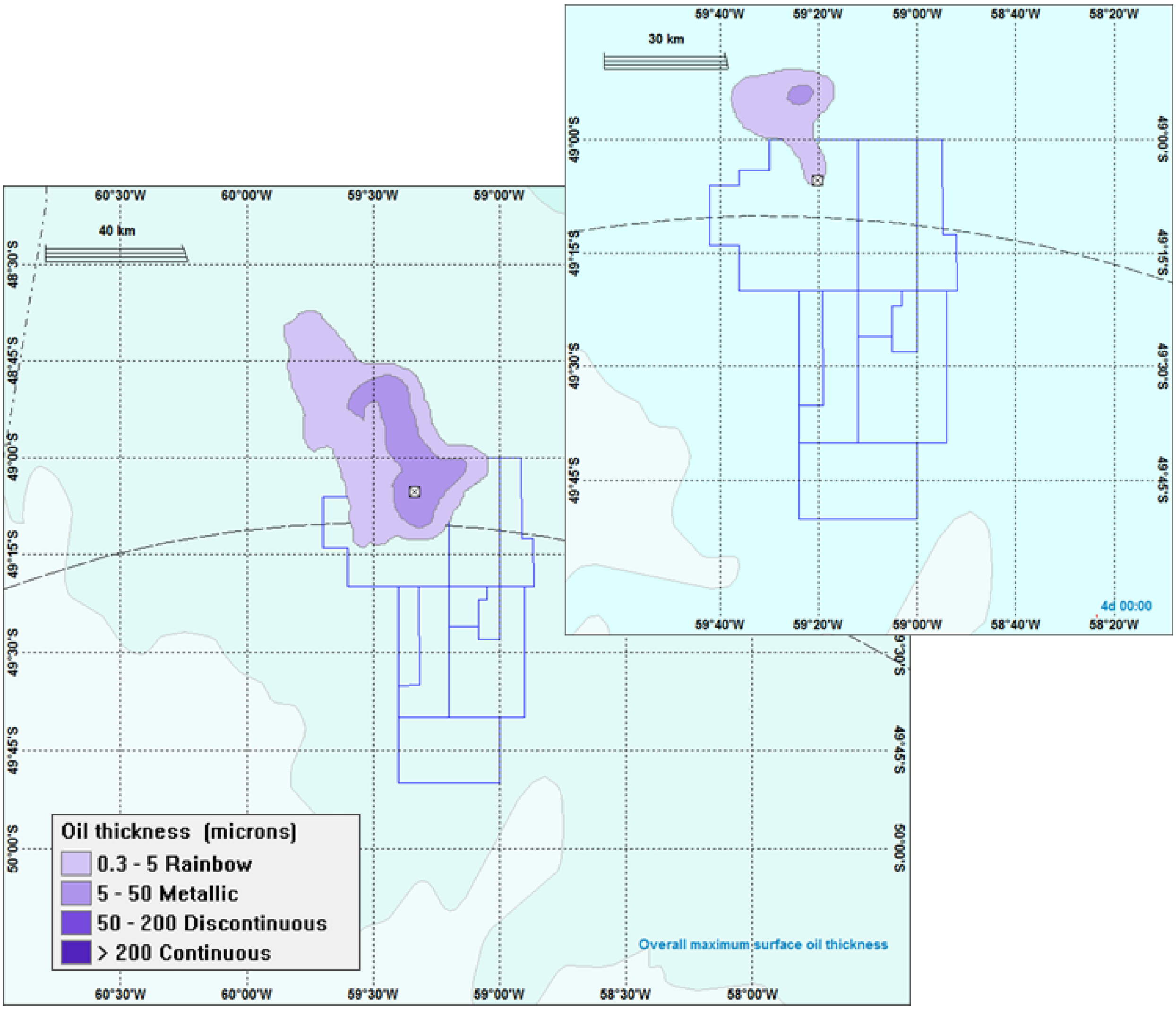


Figure 79: Maximum surface oil thickness for the Ekofisk crude well blow-out scenario (deterministic)

Water column statistics

Figure 80 displays the probability of Ekofisk oil above the threshold of 25 ppb being present through the water column. It is observed that the oil mainly travels through the water column in a northwesterly direction from the discharge point. The maximum length of time that any location in the water column is exposed to oil is demonstrated in Figure 81. It is shown that there is a small area of the water column, which extends approximately 30 km from the discharge location, that may be exposed to oil for up to 14 days. The cross-sectional plot in Figure 81 demonstrates that the oil from the subsea discharge location rises to the surface very quickly.

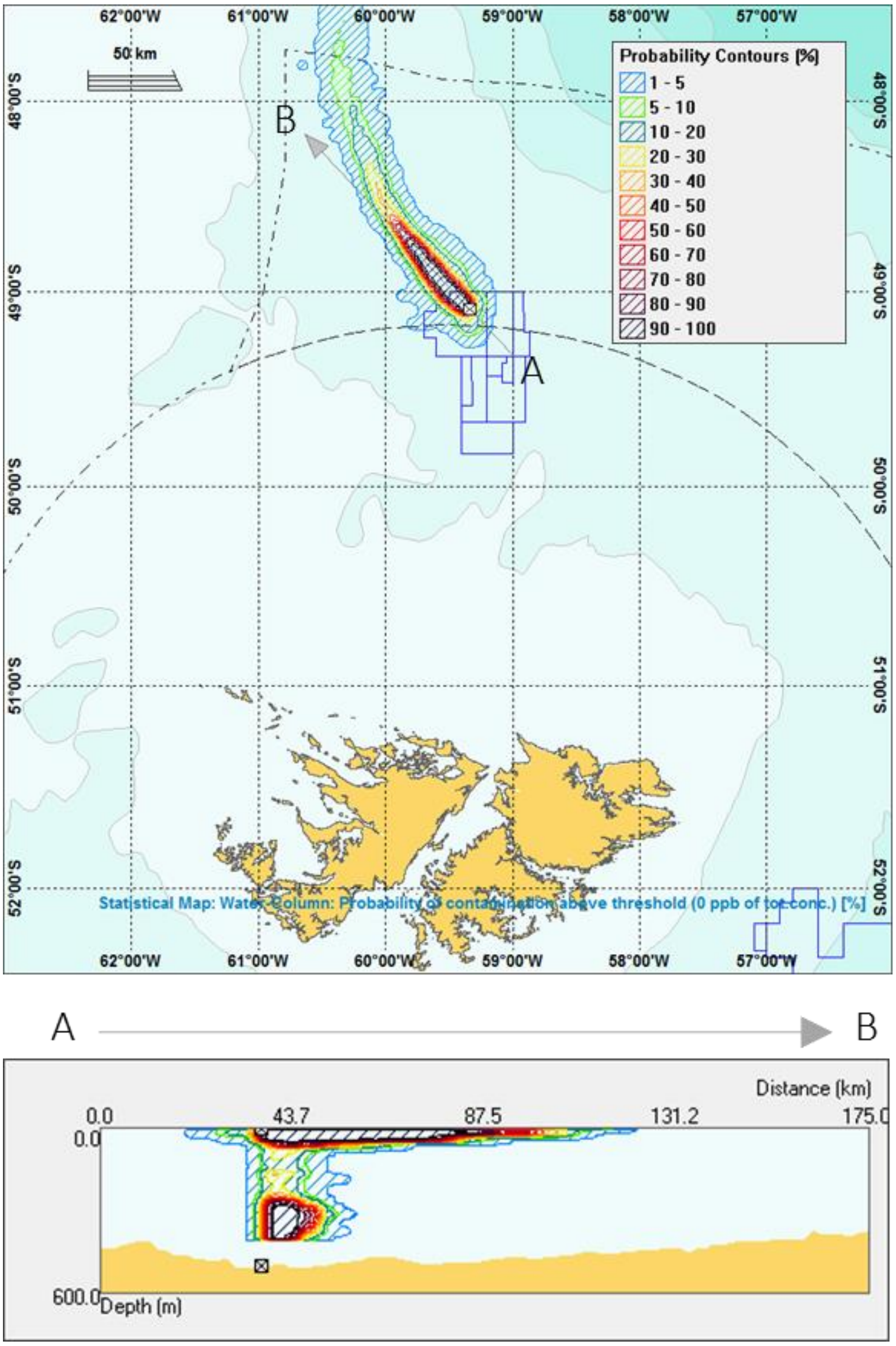


Figure 80: Probability of oil in the water column after Ekofisk crude well blow-out (deterministic)

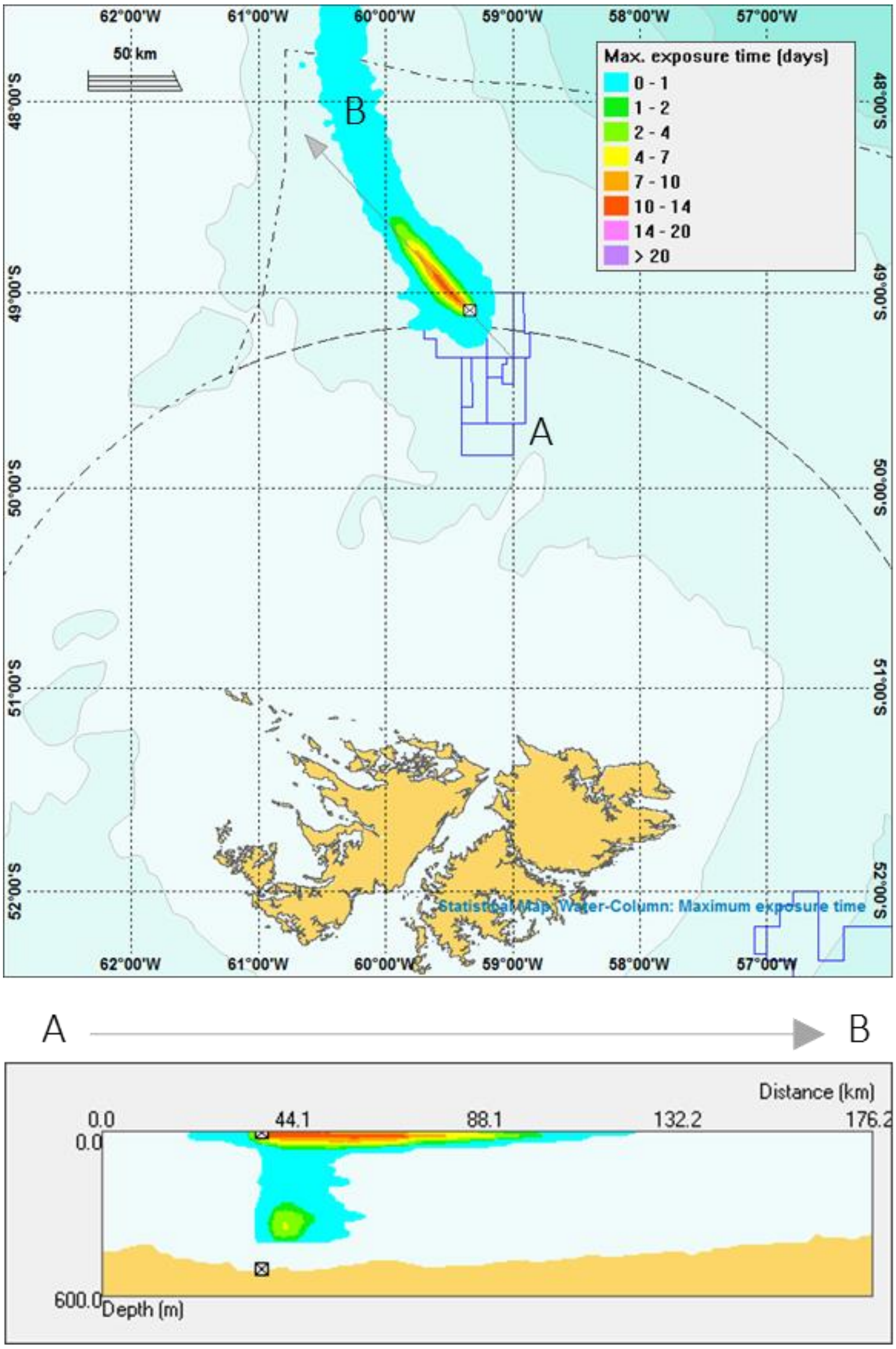


Figure 81: Maximum time water column may be exposed to oil after Ekofisk crude well blow-out (deterministic)

The predicted typical total water column concentrations above the threshold of 25 ppb for the Ekofisk crude were obtained by conducting a single deterministic run of the scenario. Figure 82 shows the typical total water column concentration, which shows that water column concentrations of 200 ppb can occur in the near vicinity of the discharge. The furthest distance from the discharge location where concentrations above the 25 ppb threshold were observed was approximately 75 km. It was observed that the maximum total oil concentration threshold of 25 ppb was not exceeded in the 26 days following the start of the discharge.

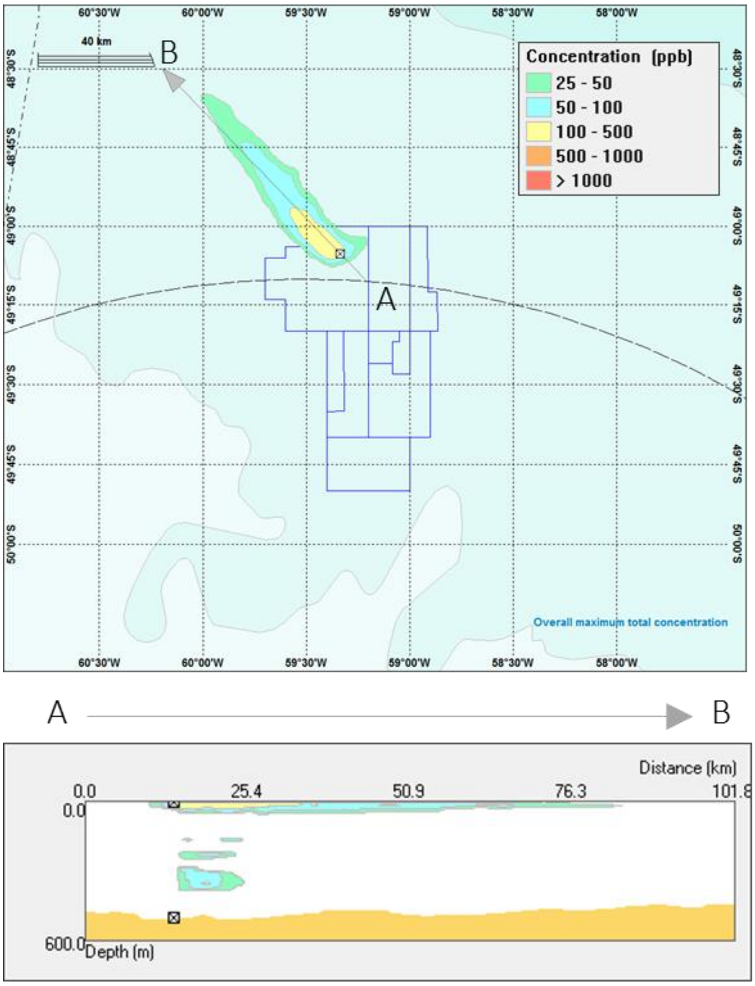


Figure 82: Maximum total water column concentration for the Ekofisk well blow-out scenario (deterministic)

Shoreline Statistics

It was observed during all simulations of the Ekofisk well blow-out scenario that no oil reached the Falklands coastline.

Discussion of Eskfisk Blow-out

Risks from surface sheens are higher with an Ekofisk-type oil blowout. Persistence is, however, lower and more oil evaporates, disperses and biodegrades over time. A significant oil sheen is predicted within 150 km of the release for up to 1 day at any particular location. Within 50 km of the release, persistence will be between 1 and 15 days. No oil is predicted to reach the shore of the Falkland Islands from a well blowout with oil characteristics of the Ekofisk oil.

Water column concentrations could be potentially toxic in the area above the blow-out and in the upper 50 m of the water column underneath the surface oil and dispersed oil droplets. For the Sea Lion crude, toxic risks are predicted to last for less than one day beyond 25 km from the release point, and within 25 km could last for as long as the release duration. For the Ekofisk crude, which is more soluble, water concentrations near the seabed are higher and the area near the surface potentially at risk is also larger, extending to around 60 km in the direction of the slick for as long as the release duration. After the end of the release, water column concentrations can take one month to drop below the threshold level.

Sensitivity to Release Duration

A well blowout for 15 days represents the duration within which 90% of blow-outs are arrested where North Sea Standards apply (Scandpower, 2011), i.e. using a blowout preventer with shear rams and a two-barrier philosophy as in this drilling programme. Should a blow-out exceed this duration, NEFL has calculated that it would take between 23 days and 72.5 days to install a capping device to seal the well at the surface, while a relief well was drilled to 'kill' the well permanently using cement plugs in the wellbore underground. Stochastic sensitivity runs have been undertaken on releases of 23 days and 72.5 days respectively, this analysis is ongoing but key outputs from these model runs are shown in Table 70.

Table 70: Key outputs from release duration sensitivity model runs

Crude Type	Duration of release (days)	Mass oil released (tonnes)	Max mass on shore (tonnes)	Average mass on shore (tonnes)	Worst scenario approx % on shore	Time to oil first reaching shore (days)
Sea Lion crude	15	2449	6.5	0.15	0.3%	33-108
	23	3755	31.8	0.84	0.8%	33-109
	72.5	11838	520.7	44.6	4.4%	29-118
Ekofisk crude	15	2360	0	0	0.0%	-
	23	3619	0	0	0.0%	-
	72.5	11409	1.3	0.05	0.0%	36-60

This shows that releases using Sea Lion crude result in less than 1% of oil reaching shore in the vast majority of blow-out durations that might be expected, and it will reach shore having been weathered at sea for approximately a month. After this length of time, it will be highly dispersed and in very small waxlets that are unlikely to be detectable from background levels of oil. In the case of a 72.5 day release, the fraction that could appear on shore is at most 4.4%, and on average 0.4%, again taking around a month or more to reach the north Falklands shoreline.

The reason for the significant increase in oil reaching shore with the 72.5 day case is that the scenarios with greatest travel southwards occur at the end of the period April to September throughout which the releases are scheduled to start in the stochastic analysis. The 72.5 day scenarios starting in September continue through October and early November, and it is the oil released in October and November that has the greatest chance of reaching shore, and this does not occur in the 15 or 23-day cases.

Using the Ekofisk crude analogue, no oil reaches shore for 15 or 23 day releases, and only a maximum of 0.05% of oil reaches shore in the worst outcome for a 72.5 day release. Although Ekofisk oil would be more visible and more harmful to most fauna than a very waxy crude, such volumes are relatively small and would be extremely dispersed, taking over 5 weeks to reach shore.

In both cases, the areas at sea that are put at risk increase with the overall size of the release. The maximum size of surface wax is predicted to be 772 km^2 for the 15 day case which rises to 1,967 km^2 in the 72.5 day case. For the Ekofisk oil, the maximum size of surface sheen is predicted to be 419 km^2 which rises to 5,020 km^2 in the 72.5 day case. In context, the surface oil travels through an area of approximately 160,000 km^2 over the course of the 120 day simulations, so occupies a maximum of up to 3% of this area, and average surface coverage at any point during the release is around one quarter of this figure.

13.2.4 Risk Assessment Summary

13.2.4.1 Severity and Receptor Sensitivity

The behaviour of Sea Lion crude at sea is atypical of a crude oil given the extremely high wax content, which is higher than any analogue in the SINTEF database. Crudes with high wax content tend to behave in a specific way whereby the crude rapidly congeals on release as it cools to ambient temperature, below its pour point. The crude transforms into semi-solid pellets with the properties of wax (waxlets). The amount of energy experienced during the release determines the initial size of the waxlets, with small waxlets likely to be formed during an uncontrolled release. Subsequent waxlet size is determined by prevailing shear forces from waves and turbulence. Eventually, waxlets will attach to suspended solids and sink, or be biodegraded in the water column.

The oil has very high wax content and will form waxy droplets at ambient temperatures also the low potential asphaltene content indicates that the oil will not form a stable oil in water emulsion. A significant surface slick is not predicted from a release of a Sea Lion type crude oil under the scenario modelled, instead a raft of wax droplets is predicted to form and migrate from the area predominantly near the water surface. Waxlets will not coalesce and will become more and more dispersed with distance, and are only likely to be visible near the release where there is a close aggregation of particles.

The modelling conducted in this study predicts that toxic water column impacts for Sea Lion crude are not above a widely accepted level of concern, due to the waxy nature of the oil, except directly above an uncontrolled release or directly beneath a surface accumulation, and that this occurs for short periods.

A lighter more volatile crude was modelled based on the characteristics of Ekofisk crude, which is considered a typical light crude oil. These results are intended to provide a comparison of different oil types, given the uncertainty of the crude from each well at this stage.

The severity of impact to each environmental receptor will be different and dependent on the environmental conditions, and subsequent the dispersion of oil, experienced in the weeks following any spill.

Plankton

An area of high zooplankton abundance occurs in the vicinity of the well sites, with abundances peaking in January and February, (Agnew, 2002). There are complex seasonal patterns of plankton production, and higher predator abundance, in the NFB that are not fully understood; however, the timing of any incident that results in a major spill will clearly have implications for the overall impact on the marine environment.

Although oil spills may have lethal effects on individual plankton, the effects on whole plankton communities generally appear to be short-term, through a combination of high reproductive rates and immigration from outside the affected area. Any effects will be greater during the summer when the area surrounding the exploration area support high densities of zooplankton. At other times, the area is less significant for zooplankton but is still very productive. Contamination of marine prey including plankton and small fish species may then lead to aromatic hydrocarbons accumulating in the food chain. The sensitivity of plankton is assessed as '**Low**'.

The severity of an uncontrolled release/blow-out of both a waxy crude or a lighter volatile crude to plankton has been assessed as **'Moderate'**.

Benthic Communities

Surveys of the northern Licence Blocks (PL032 and PL004) conducted in March 2012 revealed little variation in sediment across the seabed with the absence of any extensive seabed features. Typically the survey area was dominated by easily disturbed, very fine silt, with some occasional patches of more cohesive sediment. The results of a desk-top analysis of seismic data from the area of the Rhea-1 well site shows similar bathymetry and sediment types (RPS, 2015). The epifaunal communities were relatively uniform across the surveyed area. There were no species or habitats equivalent to those of conservation significance under the UK's Offshore Marine Conservation Regulations 2010 (which implements the EC Habitats Directive 92/43/EEC) observed within the surveyed area.

Results of benthic surveys in the wider NFB area indicate fairly uniform epifauna and to date have found no evidence of habitats potentially considered as Annex I (European Habitats Directive). The presence of scleractinian (hard) corals in the form of an occasional cup coral over the softer sediments suggests a presence of some CITES Appendix II listed species, although these are not currently Red listed (IUCN). There were no records of geogenic or biological reefs or coral gardens, although isolated examples of octocorals are likely to be found on the larger individual drop stones (erratics), which can be found in localised areas across the NFB. Pre-drilling ROV surveys will identify whether vulnerable habitat types or species are present in the vicinity of the Rhea-1 well site. However, the impact of a blow-out would fall outwith these surveys and therefore a precautionary approach has been taken and the sensitivity of the receptors has been assessed as '**Moderate**', which assumes that the benthos could be of national importance. Model predictions indicate that little Sea Lion crude, in the form of wax, enters the sediment in the first 60 days following the start of an uncontrolled release. At this stage, waxlets will be dispersed over a wide area and the impact will be moderate. After 60 days, the amount of wax deposited in sediments increases. Wax is resistant to mechanical and biological breakdown and may persist for some time. The amount of wax in the sediment was approximately 3% of the total released at the end model period, 120 days after the uncontrolled release. The results of modelling show very little oil in the sediments and nothing above a threshold of 10 mg/kg which Patin (2004) asserts is a no-effect concentration for crude oil in sediments. However, it is not clear what the impact of waxlets will be on benthic organisms, following a precautionary approach it is assumed that they have the potential to block gills and filter feeding apparatus.

The lighter Ekofisk crude is predicted to rapidly biodegrade and evaporate within the first 50 days during which time no oil is deposited in the sediments. The impacts of the Ekofisk crude are likely to be similar to those of other light crudes. Surveys following the Macondo incident found that the most severe relative reduction of faunal abundance and diversity extended to 3 km from the wellhead covering an area about 24 km^2. Moderate impacts were observed up to 17 km towards the southwest and 8.5 km towards the northeast of the wellhead, covering an area 148 km^2 (Montagna et al., 2013). Benthic effects were correlated to total petroleum hydrocarbon, polycyclic aromatic hydrocarbons and barium concentrations, and distance to the wellhead. Healthy coral communities were observed at all sites >20 km from the Macondo well, including seven sites previously visited in September 2009, where the corals and communities appeared unchanged (White et al., 2012). The impact of the Macondo blow-out on benthic organisms was therefore over a relatively small area despite the scale of the incident. The oil type and scale of the Macondo incident are not directly comparable with the uncontrolled release scenarios modelled here. However, given that on the model predicts a small proportion (<3% of Sea Lion crude and none of the Ekofisk crude) of oil will end up in the sediment, spread over a considerable area (the majority of wax or oil is likely to be on the surface and or dispersed within the water column for the first *circa* 50 days post uncontrolled release) the sediments would to be subject to low concentrations of wax or oil (Genesis, 2015b). Given the nature of the unique wax, the effect on benthic filter and deposit feeders are unknown. The severity of an uncontrolled release on the benthos has been assessed as **'Major'** due to the unknown long-term consequences for benthic fauna.

Seabirds

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 (on seabirds) than a larger spill in an area with few seabirds.

A release of waxy Sea Lion crude, resulting in droplets of solidified oil would pose a reduced risk of contamination of the plumage of seabirds, as compared to emulsified crude oils. The stable nature of the waxlets minimises their impact on seabirds, as they are unlikely to stick to feathers and consequently they are unlikely to be ingested by birds. Significant risks to the marine environment are restricted to the immediate vicinity of the uncontrolled release. Away from the immediate release site, seabirds are not considered significantly at risk due to the semi-solid nature of the wax.

Modelling results for the less waxy crude (Ekofisk) indicate that the oil would travel in a northerly direction, reaching the outer boundary of the FOCZ 20-30 days after the blow-out, therefore spreading faster than the Sea Lion crude. The effects of oil on birds includes both immediate chronic impacts which can kill birds or 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). The oil can become incorporated into the feathers, which can cause loss of insulation and waterproofing. If birds were to become heavily oiled their survival rate would be lowered.

The Rhea-1 drilling programme will only be in operation for a limited period at a time (August/September 2015), however, this is a period when seabird assemblages in the area are regarded to have 'high' vulnerability to oil spills (Section 5.4.6). Of the ten most abundant species recorded from surveys in the drilling area several sensitive species observed included two that are listed as Near Threatened in the IUCN Red List (black-browed albatross, sooty shearwaters), three that are listed as Vulnerable (white-chinned petrel, Southern royal albatross and wandering albatross) and one that is listed as Endangered (Northern royal albatross). During the proposed drilling period (August/September) seabird vulnerability to oil spills, as classified by JNCC, indicates a moderate to high vulnerability due to the presence of high densities of black-browed albatross and white-chinned petrel in surrounding waters. These species are most likely to be impacted by the release of hydrocarbons into the marine environment. Due to the presence of relatively high densities of birds, including Endangered species, the sensitivity of seabirds to the effects of a blow-out are assessed as '**Very High**'.

The severity of an uncontrolled release, of both oil types, on seabirds has been assessed as **'Major**' due the spatial extent of the slick (potentially covering important foraging areas) and the potential for chronic impacts on reproductive biology in long-lived, late reproducing species.

Marine Mammals

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, there have been suggestions that 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). While not causing significant immediate impact or mortality the longer-term effects of such sub-lethal exposure are difficult to determine and are thus not fully understood.

Insulation is considered less of an issue for marine mammals such as true seals that do not rely on fur for insulation and cetaceans as their skin forms a nearly impenetrable barrier to hydrocarbons. However, where oil is in contact with the skin there is the potential for it to cause irritation to the eyes or burns to mucous membranes. Ingestion of oil by marine mammals can damage the digestive system or affect the functioning of livers and kidneys. If inhaled, hydrocarbons can impact the respiration.

Cetacean behaviour, diet and habitat use will determine the level of contact with an oil spill (Wursig, 1988). Species that forage in mid-water or deep waters will be at less risk than species that feed at the surface. Species like right whales and rorquals that surface skim and lunge feed respectively are more sensitive. This may also be true for some dolphins that 'chase' prey to the surface. However, away from the immediate release site, marine mammals are not considered significantly at risk due to the semi-solid nature of the wax.

Sperm whale (IUCN Vulnerable) and fin whale (IUCN Endangered) were recorded throughout the year in the NFB (Section 5.4.5). The sensitivity of marine mammals is assessed as '**High**' due to the potential presence of these Endangered species.

The severity of an uncontrolled release on marine mammals has been assessed as **'Moderate'** in the case of Sea Lion crude, because the waxy nature of the oil will mean a lower exposure to volatile and toxic components of the crude. The severity of an uncontrolled release of the lighter Ekofisk crude to marine mammals has been assessed as **'Moderate'** as the area of predicted surface coverage is relatively small. The majority of the oil disperses, biodegrades and evaporates, therefore, it does not persist on the sea surface and is predicted to be of little significance after 20 days at sea.

Fish and Fisheries

Typically fish are not considered highly sensitive to impacts of oil spills. Adult individuals are mobile and are able to detect areas of heavy contamination and poor water quality. In the open ocean, fish have the ability to move away from polluted areas. Adverse impact of oil spills on fish is 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. Fish in early life stages are known to be more vulnerable to oil compared to adults. Critical to understanding the potential impact of oil spills on fisheries in the Falkland Islands is knowledge of the timing and distribution of spawning grounds and, egg and larval transport through oceanographic features. The understanding and knowledge of spawning grounds is poor. Spawning sites for southern blue whiting and red cod have been identified (Arkhipkin et al., 2010) south of Cape Meredith and toothfish spawning sites have been identified on the southern and eastern parts of the Burdwood Bank (Laptikhovsky et al., 2006). However, these are significant distances from the northern Licence Blocks and it is extremely unlikely that they will be impacted. Similarly, loligo spawning grounds are known to occur near shore and in great intensity on the eastern fringes of the Falkland Islands (Arkhipkin et al., 2000) and are also unlikely to be impacted.

With regards to fisheries a significant proportion of the south Patagonian stock of Argentine shortfin squid passes near this area on their northerly spawning migration in May/June. This resource is a significant component in regional fisheries and the wider ecosystem; however, this species is not present at the proposed Rhea-1 well site in August/September. Given the importance of this fishery to the Falklands' economy a precautionary approach should be taken, we do not know how this species or fishery may be impacted in the longer-term by a large oil spill incident such as a blow-out. Other commercial species are present in the wider area (see Section 5.4.4), but the fishing effort in the direct vicinity of the Rhea-1 well site is low. However, oil released into the marine environment would spread and is likely to overlap with the distribution of major finfish grounds on the edge of the continental shelf. This would likely result in closure of these grounds and subsequent economic impact for the fishing industry.

The other major fishery in the area is the longline fishery for Patagonian toothfish. This fishery operates in the deeper waters to the north and east of the Rhea-1 well site. The results of modelling indicate that waxlets and lighter crude are likely to spread over part of the area fished and there is potential for these areas to be closed in the short-term. If there was a major spill, monitoring would need to be undertaken to assess whether there was any contamination of the fish caught within the area of influence of the spill. The sensitivity of fish and fisheries related receptors to a blow-out is assessed as '**Moderate**'.

The severity of an uncontrolled release on fish and fisheries has been assessed as **'Major'** because the slick will overlap with major finfish and toothfish fishing grounds. An uncontrolled release will result in the closure of the fishing grounds due to potential tainting and contamination, which will have a knock-on economic impact.

Coastal

With regard to coastal impacts, the likelihood and quantities of Sea Lion crude reaching the shore from an uncontrolled release/blow-out are low. The resultant solid waxlets are predicted to be non-adhesive and non-cohesive, and in this state will present a relatively low risk of direct impacts to avifauna. East Falkland has a higher probability of waxlets beaching on the coast than islands to the west, with the most northerly headlands of East Falkland showing the highest overall probabilities. This area (Seal Bay) is designated an IBA (see Section 5.4.7.3). The likelihood of waxlets reaching shore declines to the west across West Falkland, reaching a minimum on the western Jason Islands chain. Likewise to the east and south of McBride's Head, towards Volunteer Point and Cape Pembroke, the likelihood of waxlets beaching declines. Although the likelihood of wax reaching the shore is very low and the quantities involved are very small, barely detectable in the modelled scenario, the areas that are potentially at risk are of national importance, therefore, the sensitivity of the coastal environment is assessed as '**Moderate**'.

The results of modelling of the dispersion of lighter Ekofisk crude predicts that none of the oil will reach the Falklands coastline.

The severity of an uncontrolled release on coastal environments has been assessed as **'Moderate'** as there is still some uncertainly over the longer-term chronic impacts on this environment.

Tourism

The marketing of tourism provides the image and window into the Falklands for international perceptions. 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. In general, the model predicts that sub-millimetre sized particles will result once a modest amount of dispersion and wave action has taken place, and it is therefore unlikely that waxlet densities at the lower end of the scale provided would be visible. Given the distance offshore and the relatively long travel times it is unlikely that tourists would see any evidence of oil pollution. The sensitivity of tourism is assessed as '**Moderate**' as there is moderate capacity to absorb change in the aftermath of a major incident.

The severity of an uncontrolled release on Tourism has been assessed as **'Major'** due to the long lasting negative impacts of perceived environmental degradation.

Overall Severity of the Impact

The NFB is utilised by numerous different receptors at various times of the year. There is some seasonal variability in the potential severity of the impact of an uncontrolled release on these receptors, with the impact in the winter months likely to be lower than during the summer months. However, there are many unknowns concerning the impact on environmental receptors and in the model. Under the severity criteria defined in Chapter 6, the impact of the scenario modelled here is assessed as '**Major**'. Taking the receptor with highest sensitivity (seabirds '**Very High**'), the worst-case severity of the impact from an unmitigated blow-out is assessed as '**Very High**'. An uncontrolled spill would result in serious multi-year impact on the ecosystem of the NFB, although this impact would be reversible. A full NEFL response (Tier 3) would be required to contain and recover oil offshore and potentially on-shore.

13.2.4.2 Likelihood

Although known in the oil and gas industry, uncontrolled releases/blow-outs and major losses of containment are rare events. Strict regulations governing working practices and lessons learnt from previous incidents help to minimise the likelihood of accidental events. Following the Deepwater Horizon incident in the Gulf of Mexico, the Oil Spill Prevention and Response Advisory Group (OSPRAG) was established to review all UKCS regulations and pollution response arrangements and assess the adequacy of financial provisions for that response. This has resulted in significant amendments to the legislation oil spill prevention and response.

One of the key Government requirements for drilling applications is the preparation and approval of an Oil Pollution Response Plan (OPRP). NEFL have already prepared an OPRP are currently developing a specific OPRP for the Rhea-1 exploration campaign, which will be submitted to FIG as a separate document. Strict regulations are followed to minimise the risk to the environment and human health. The well design will be peer reviewed by NEFL's well examiner and the Health and Safety Executive to ensure that the risk of an uncontrolled release is minimised. Design features, such as mud weight and a BOP that includes an auto shear, reduce the risk of uncontrolled releases. The drilling mud will help to maintain primary well control and the BOP will seal the well in the event of a major incident. Uncontrolled releases are highly unlikely, nevertheless, they do happen occasionally within the oil and gas industry.

For an uncontrolled release to result in serious environmental damage a number of factors would have to occur;

- An uncontrolled release would have to occur;
- The BOP would have to fail;
- A significant quantity of oil would have to be discharged (if the well is under low pressure this might not occur);
- The oil spill would have to spread sufficiently to contact sensitive receptors.

The scenarios chosen in this assessment to look at worst-case conditions and the maximum spill possible for the Rhea-1 well in accordance with DECC guidelines. The likelihood of an uncontrolled release occurring has been assessed as '**Remote**', it has happened in the industry but on extremely rare occasions.

13.2.4.3 Significance

The overall significance of an uncontrolled release is assessed as '**Moderate**'. There is a discernible risk to the environment; however, a number of measures to manage the risk are built into standard operating procedures (such as, the use of a BOP). Nonetheless, an OPRP for the Rhea-1 well is in preparation prior to the start of drilling to outline the response capability for hydrocarbon spills.

13.2.4.4 Degree of Confidence

There are many unknowns and assumptions surrounding the modelling of oil spills, in terms of both the properties of the oil (unknown at this stage, with both a waxy and light volatile crude assessed) and environmental conditions (currents, wind and wave action). Wherever possible, worst-case scenarios have been assumed to ensure that the impact is not under-estimated. However, due to the uncertainties surrounding major accidental events the confidence in the significance of the risk presented in this assessment is '**Probable**'.

13.2.4.5 Cumulative Impacts

The Rhea-1 well location is in an area that is not usually occupied by other vessels and therefore the risks of added cumulative impact are minimal.

13.2.5 Mitigation Measures

Oil Spill Response

The remoteness, poor transport infrastructure and abundant wildlife in the Falklands pose unique challenges when responding to a major incident. NEFL have prepared a project specific OSRP (NEFL, 2014) and are currently preparing a Rhea-1 well specific OSRP. If a spill occurred, tiered responses would be initiated, proportional to the spill. Key aspects of the response would be;

- ***Well intervention*** – these are means of stopping the flow of oil from the wellhead and could include the drilling of a relief well or the use of a subsea capping device;
- ***Surveillance*** - it is vital to track the progress of any spill with the aid of aerial surveys and tracking buoys;
- ***Dispersants*** - it is unlikely that dispersants would be effective on oil with a high wax content, like Sea Lion crude, and they are unlikely to be used, although they will be available in field in case lighter more volatile hydrocarbons are encountered;
- ***Containment and recovery*** – under suitable weather conditions, booms and skimming devices can be used to recover oil at-sea. The supply vessels will be appropriately equipped to undertake this;

- ***Shoreline clean-up*** – an assessment of the sensitivity has been undertaken to prioritise sites in the event oil approaches the coastline (Premier Oil, 2014);
- ***Wildlife rescue and rehabilitation*** – specific response equipment to support wildlife rescue and rehabilitation will be available for the campaign ana a dedicated Wildlife Response Plan (WRP; NEFL, 2015f) has been produced.

13.2.5.1 Residual Impact

With the measures outlined above in place, it is not possible to reduce the likelihood of an uncontrolled release/blow-out any further; however, an oil spill response will reduce the severity of the impact on the marine environment. In the unlikely event that a spill does occur, a plan is in place to cap the well and contain and recover oil from the sea. The success of these measures will be dependent on environmental factors such as the weather, which is unpredictable. The significance of an uncontrolled release may be reduced to '**Low**' for some receptors but the overall significance is likely to remain '**Moderate**'.

13.3 Accidental Loss of Containment During Operations Leading to Diesel or Chemical Spills

13.3.1 Introduction

All rig and vessel operations are powered by diesel engines. Diesel is a light, volatile mixture of hydrocarbons and is toxic to marine life. Large quantities of fuel will be transferred to supply vessels at FIPASS and delivered to the rig. During each transfer, there is the potential for small leaks and spills.

13.3.2 Sources of Diesel Spills

Loss of Containment During Fuel or Chemical Transfers

All diesel fuel will be sourced in Stanley, transported to the rig and transferred aboard. At each stage of this process there is the potential for leaks and spills to occur.

Major Loss of Containment Leading to the Loss of the Entire Rig Inventory of Diesel

It is difficult to envisage a situation where the entire rig inventory of diesel fuel would be lost; however, there are some large moving objects at-sea that pose a risk to the rig. The most credible risk would be collision with a vessel, although the potential for icebergs to collide with the rig should also be considered.

13.3.3 Potential Environmental Receptors of Diesel Spills

Diesel fuel is rapidly dispersed but its volatile nature makes it more toxic than heavier crude oils. The impact will occur over a relatively small area close to the spill site and within the surface layers of the sea. Potential receptors are:

- Plankton
- Fish and Squid
- Seabirds
- Marine Mammals

For further discussion regarding the vulnerability of these groups to hydrocarbon pollution, see Section 13.2.2.

13.3.4 Characterising and Quantifying the Impact of Offshore Diesel Spills

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.

13.3.4.1 Modelling Diesel Spills

Two scenarios that were considered to be representative of the potential risks for loss of diesel containment during the exploration campaign were modelled using the OSCAR, which was also used to describe the behaviour of oil following an uncontrolled release (see Section 13.2.3 for details) (Genesis, 2015b). The scenarios included loss of containment while bunkering diesel fuel to the rig; and a total loss of rig diesel fuel inventory while at the Rhea-1well location.

Diesel Spill Thresholds

For the diesel spill scenarios the following thresholds have been referred to in the results:

- A minimum surface sheen of 0.3 µm (rainbow sheen under the Bonn Agreement Oil Appearance Code of oil thicknesses (Bonn Agreement, 2009);
- Total water column concentrations (dissolved hydrocarbons plus droplets) greater than 25 ppb, below which oil is not expected to have acute toxic effects (50 ppb is the lowest PNEC for acute toxicity of the oil components in the OSCAR database and is also mid-range of the concentrations of crude oil found to give sub-lethal effects (Patin, 2004));

The input parameters for the two offshore scenarios are shown in Table 71.

Table 71: Input parameters for the offshore diesel spill model

Scenario	Release Location	Release depth	Quantity released	Assumed release duration	Simulation duration	Release Temp
1 - Diesel transfer spill	Rhea-1	Sea surface	30 tonnes	1 hour	30 days	Ambient 7°C
2 - Diesel inventory loss	Rhea-1	Sea surface	4,631 m^3 (4,088 tonnes)	1 hour	30 days	Ambient 7°C

13.3.4.2 Scenario 1: Diesel Transfer Spill

The first scenario models the loss of containment during operations to bunker diesel from a supply vessel to the rig.

The diesel transfer spill scenario shows similar behaviour (Figure 83) with diesel evaporating rapidly. As the release point is on the surface, evaporation begins very quickly while some of the diesel becomes dispersed in the water column.

For both scenarios, all of the diesel would evaporate or biodegrade after 30 days with none remaining in the water column.

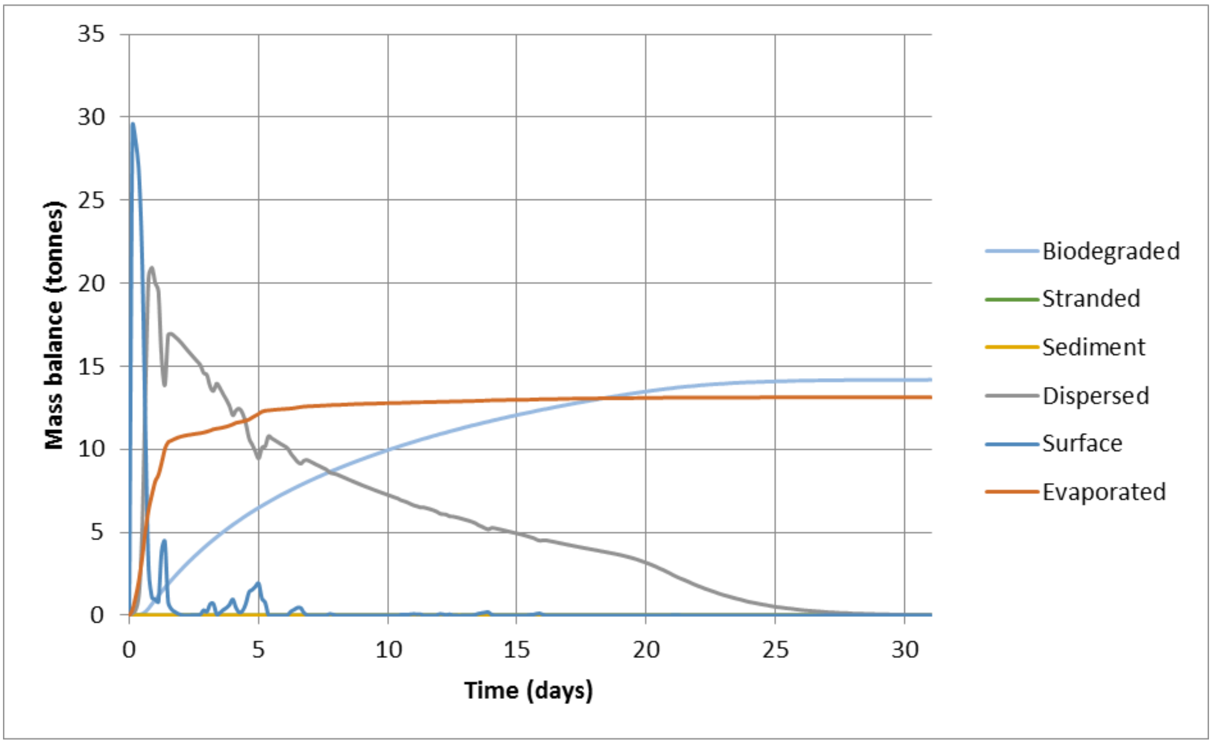


Figure 83: Typical behaviour of diesel over time for diesel transfer spill scenario

Surface statistics

Figure 84 shows the probability of diesel on the surface following the transfer spill scenario. There is 2 % probability of the diesel reaching the FICZ and zero probability of it reaching the northern boundary of the FOCZ.

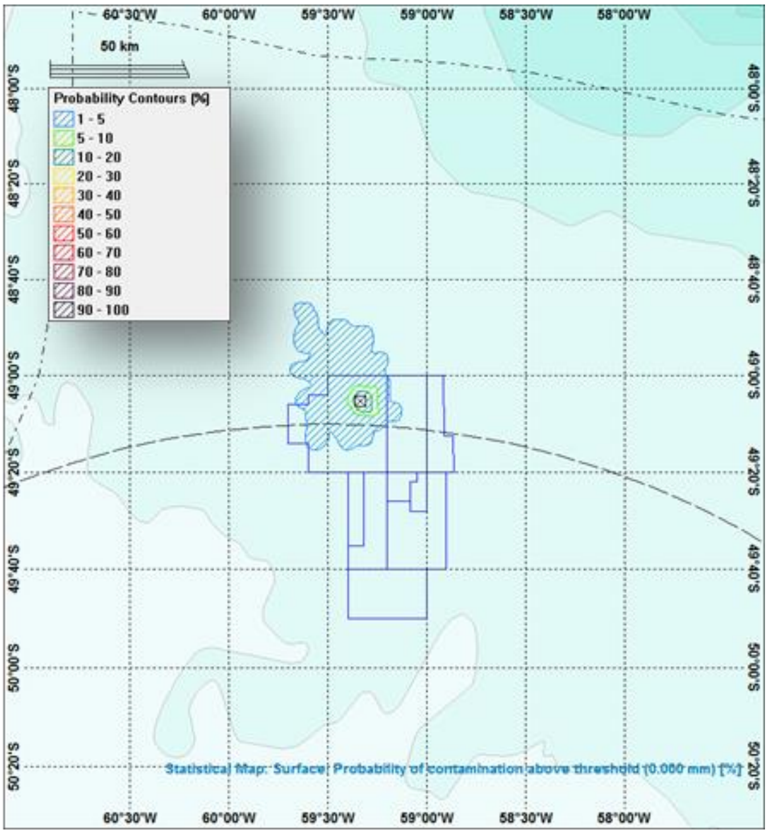


Figure 84: Probability of diesel on the sea surface after diesel transfer spill (stochastic)

Figure 85 shows the minimum arrival time of the diesel on the surface following a transfer spill. Diesel reaches the FICZ within 14 hours but evaporates well before reaching the FOCZ northern boundary.

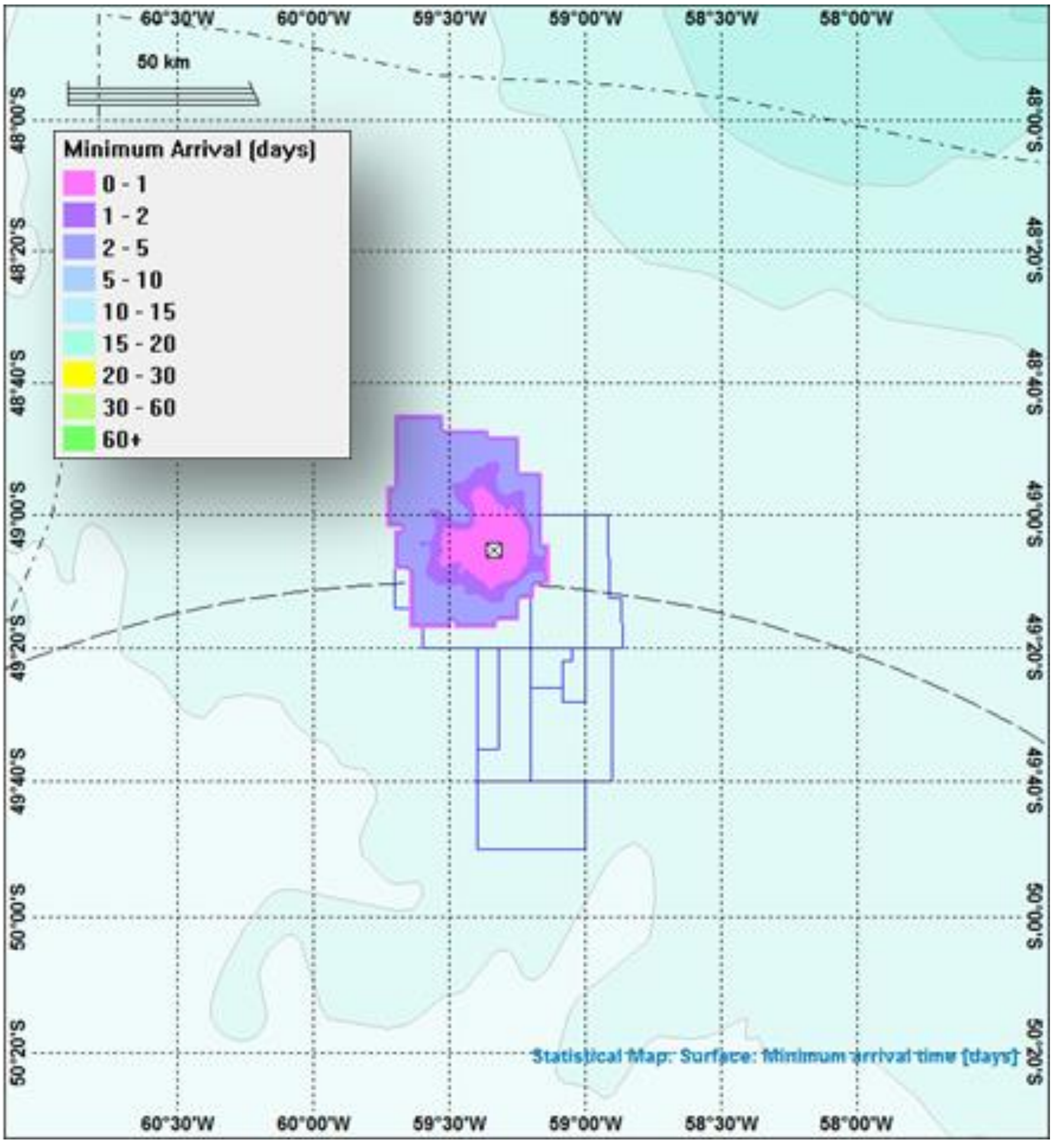


Figure 85: Minimum surface arrival times after diesel transfer spill (stochastic)

Due to the relatively small amount of diesel released during a transfer spill (30 tonnes), diesel only persists on the surface for up to 8 hours (Figure 86).

The transfer spill results in rainbow sheen extending 10.5 km south just entering the FICZ (Figure 87. Diesel concentrations above 25 ppb persist for at most 12 hours following a transfer spill (Figure 88), staying within the FOCZ.

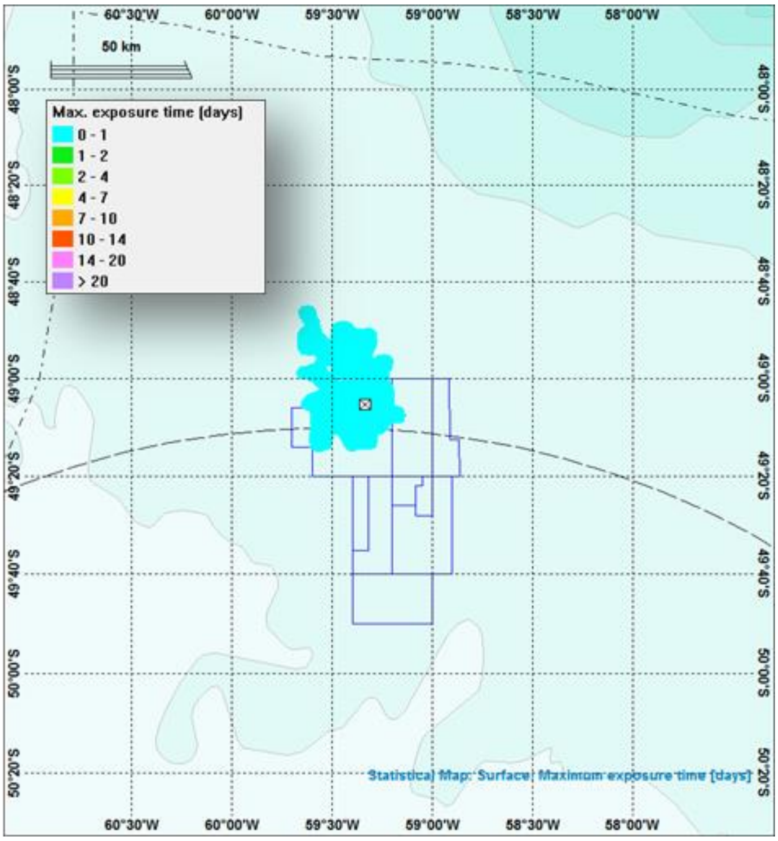


Figure 86: Maximum time sea surface may be exposed to diesel after diesel transfer spill (stochastic)

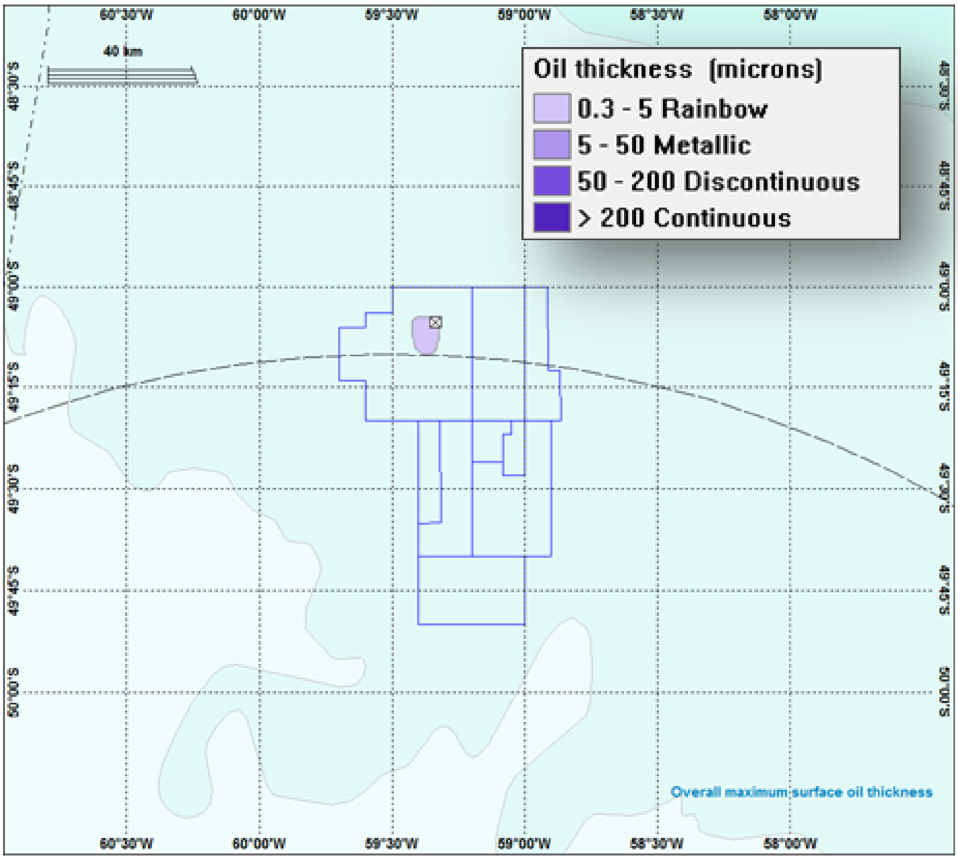


Figure 87: Maximum surface thickness for the diesel transfer spill scenario (deterministic)

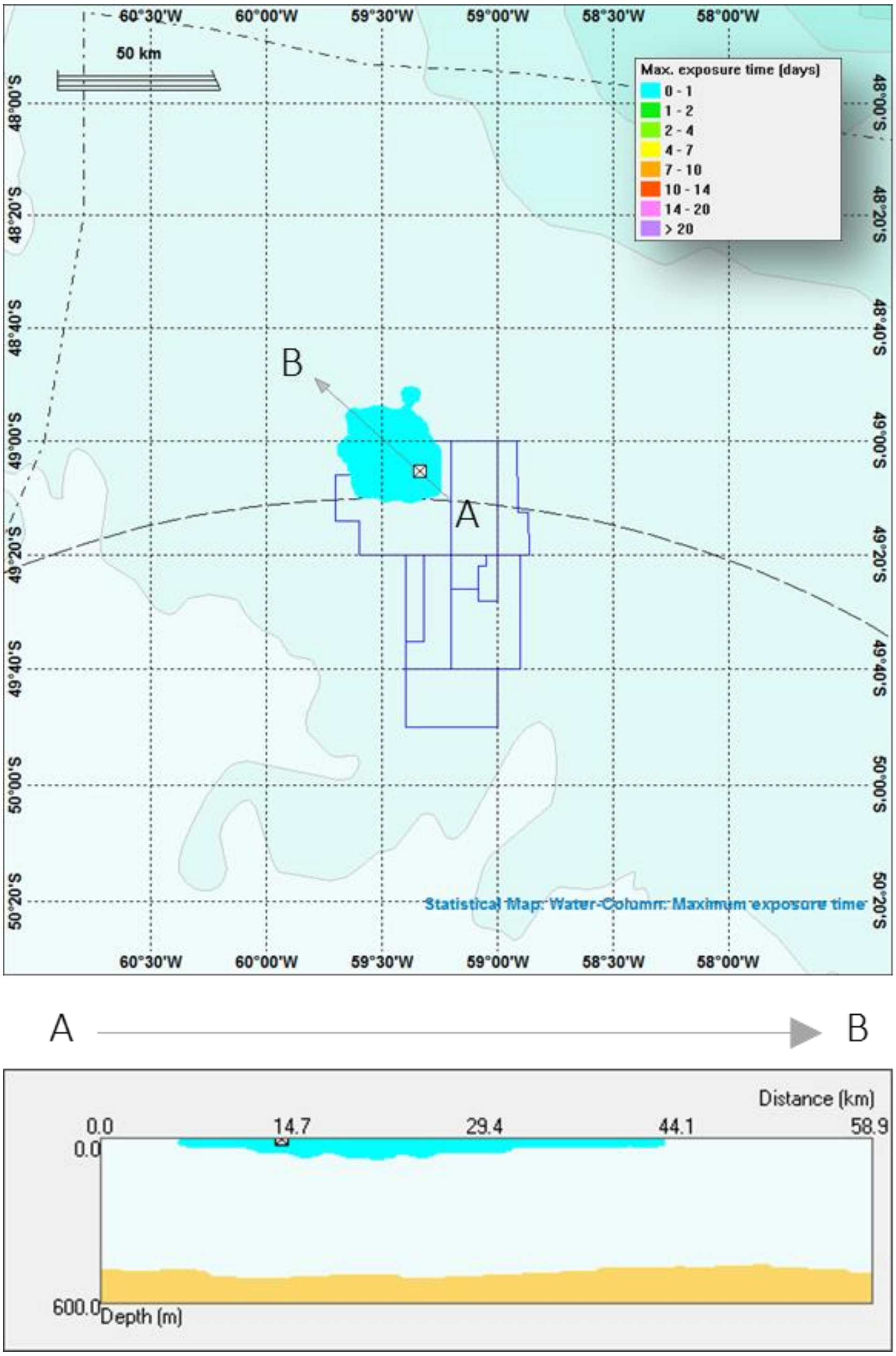


Figure 88: Maximum time water column may be exposed to diesel after diesel transfer spill (stochastic)

The deterministic run predicts the variation of water column concentrations over time. The transfer spill leads to much lower peak concentrations (at most 29 ppb) within a much smaller area, as shown in Figure 89.

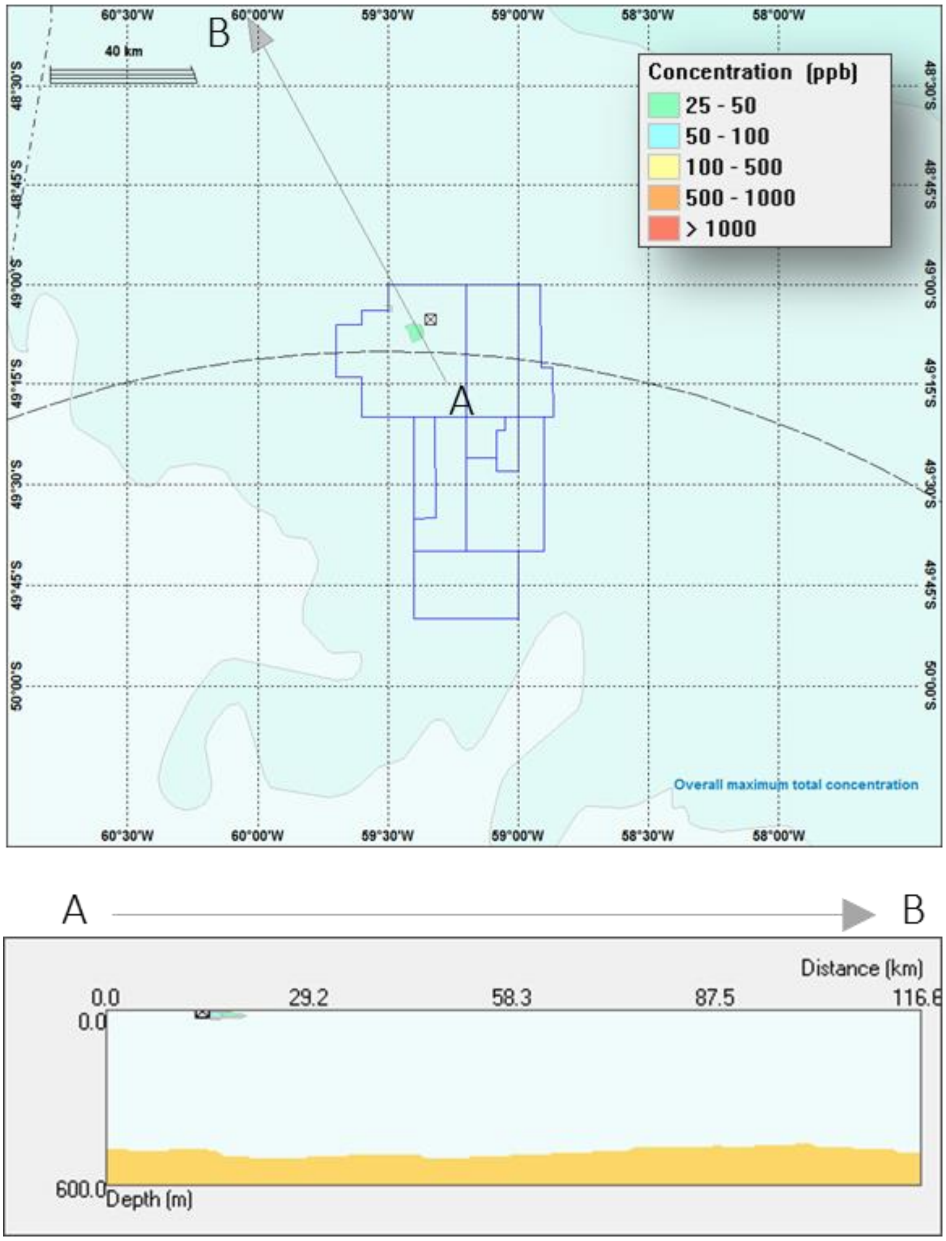


Figure 89: Maximum total water column concentration for the diesel transfer spill scenario (deterministic)

Shoreline Statistics

None of the diesel spill scenarios resulted in any diesel arriving on the Falklands coastline.

13.3.4.3 Scenario 2: Diesel Inventory Loss of Drilling Rig

The second scenario modelled investigated the likely dispersion pattern of diesel following the catastrophic loss of the *Eirik Raude's* entire diesel inventory (>4,000 tonnes).

The total loss of diesel from the rig would most likely occur if the rig suffered a catastrophic impact from a large vessel such as an oil tanker or an iceberg.

Figure 90 shows the behaviour prediction from the model of the diesel inventory loss scenario. As the release point is on the surface, evaporation begins very quickly while some of the diesel becomes dispersed in the water column. The diesel is only on the surface for approximately five days, after 30 days the diesel has evaporated with none remaining in the water column.

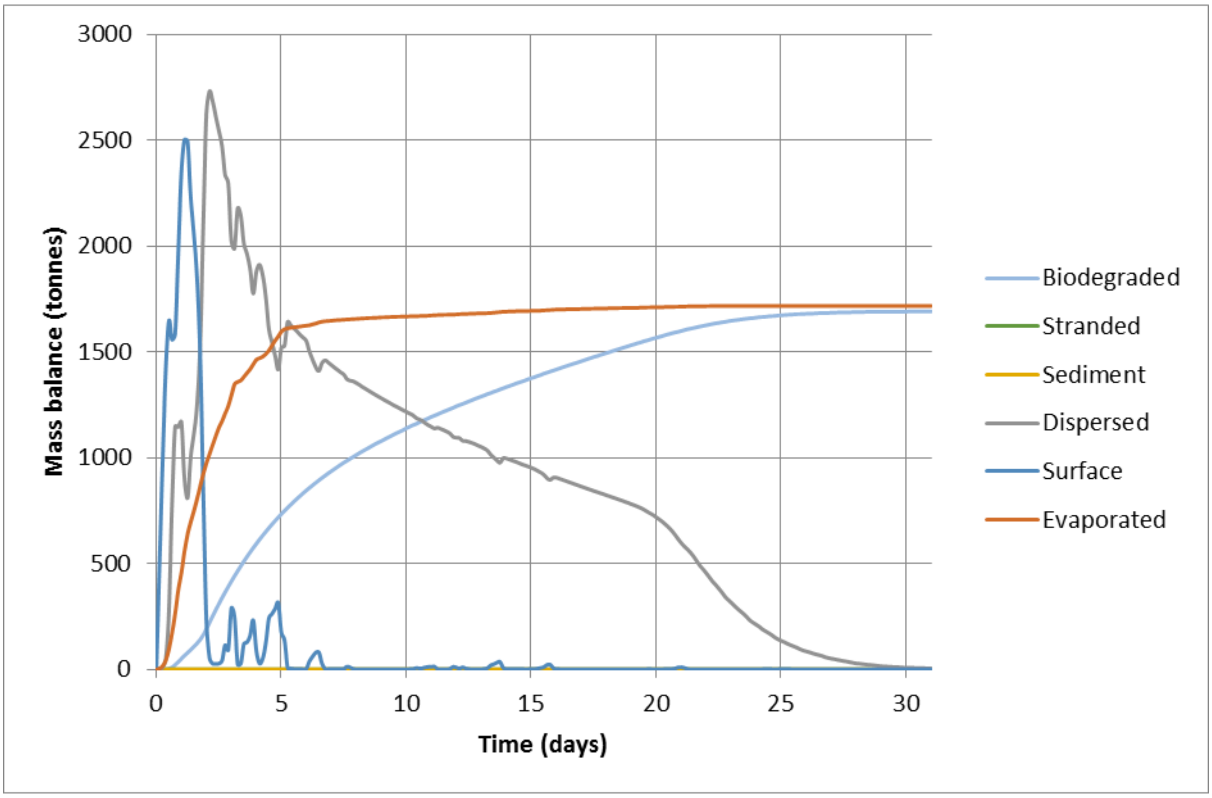


Figure 90: Typical behaviour of diesel over time for diesel inventory loss scenario

Figure 91 shows the probability of surface diesel above the threshold thickness of 0.3 µm following an inventory loss. There is 41 % probability of the diesel reaching the FICZ and 4 % probability of it reaching the northern boundary of the FOCZ.

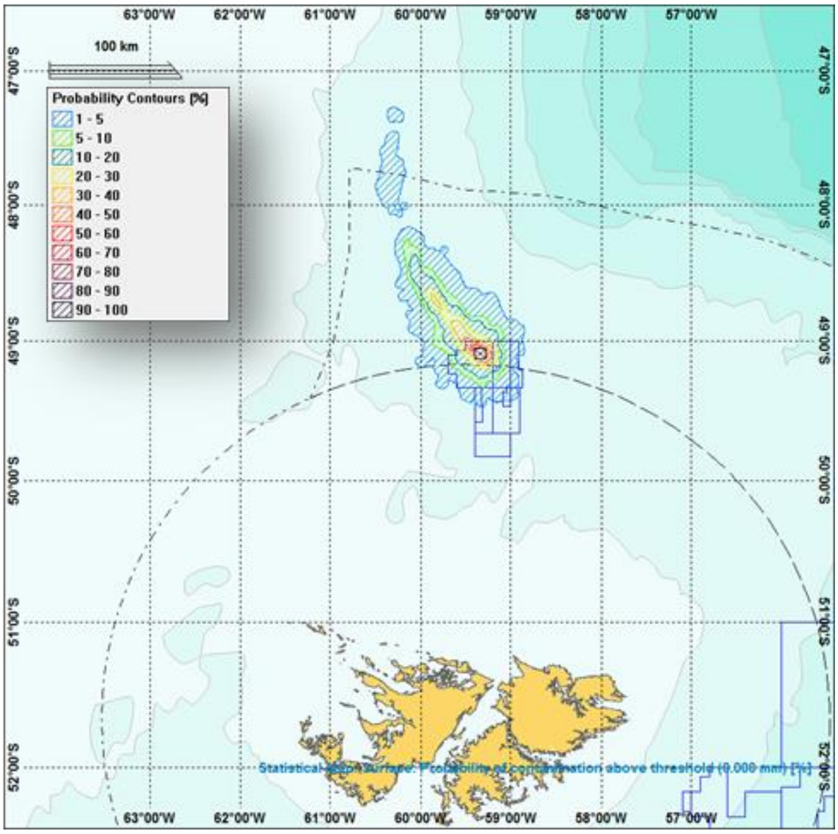


Figure 91: Probability of diesel on the sea surface after diesel inventory loss (stochastic)

Figure 92 shows the minimum arrival time of the diesel on the surface following an inventory loss. The diesel reaches the FICZ within 8.5 hours and the FOCZ northern boundary in 11 days.

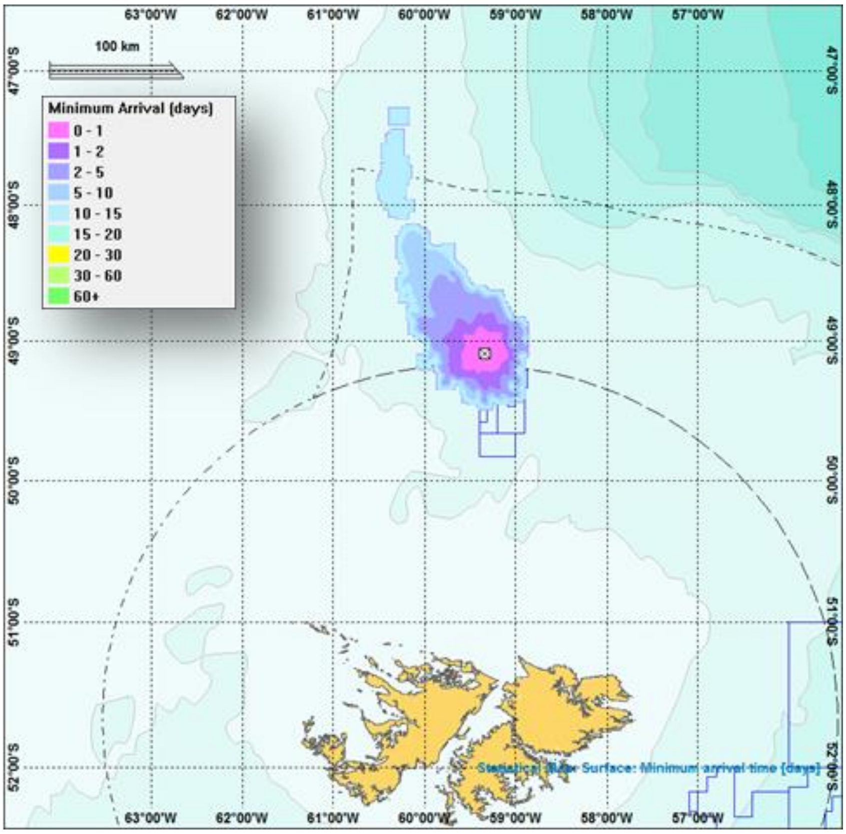


Figure 92: Minimum surface arrival times after diesel inventory loss (stochastic)

The maximum duration the diesel stays on the surface following an inventory loss is 31 hours (Figure 93).

The maximum surface thickness following an inventory loss is shown in Figure 94. The thickness of the diesel does not exceed 97 µm, classified as a discontinuous sheen under the Bonn Agreement Oil Appearance Code. A rainbow surface sheen extends up to 53 km northwest of the release point, while a metallic sheen extends into the FICZ by approximately 5 km.

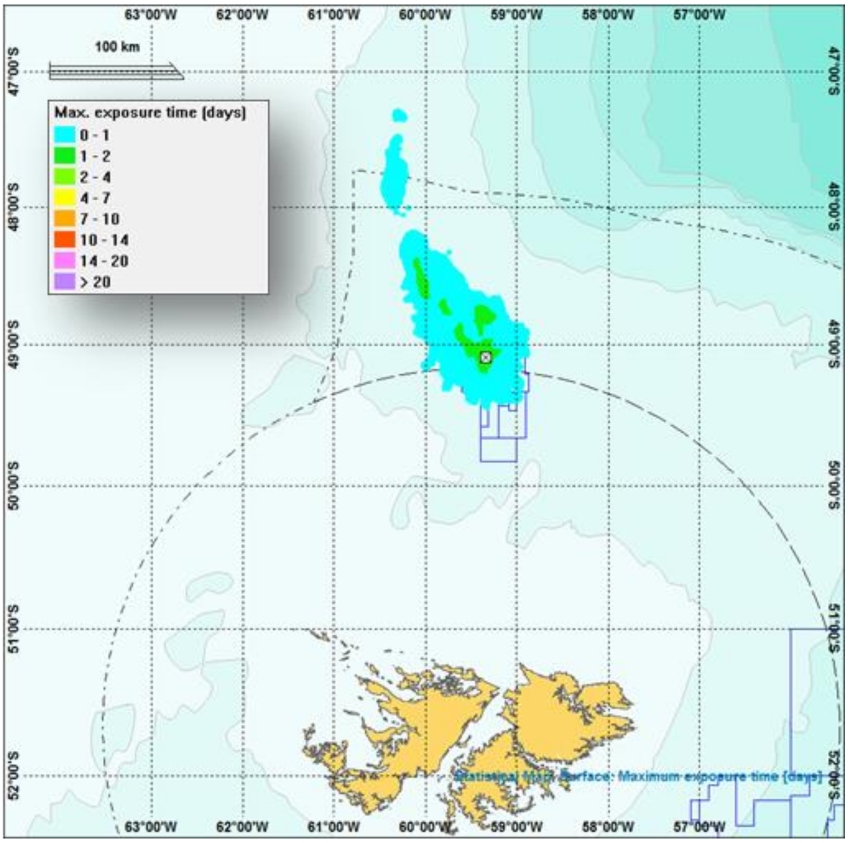


Figure 93: Maximum time sea surface may be exposed to diesel after diesel inventory loss (stochastic)

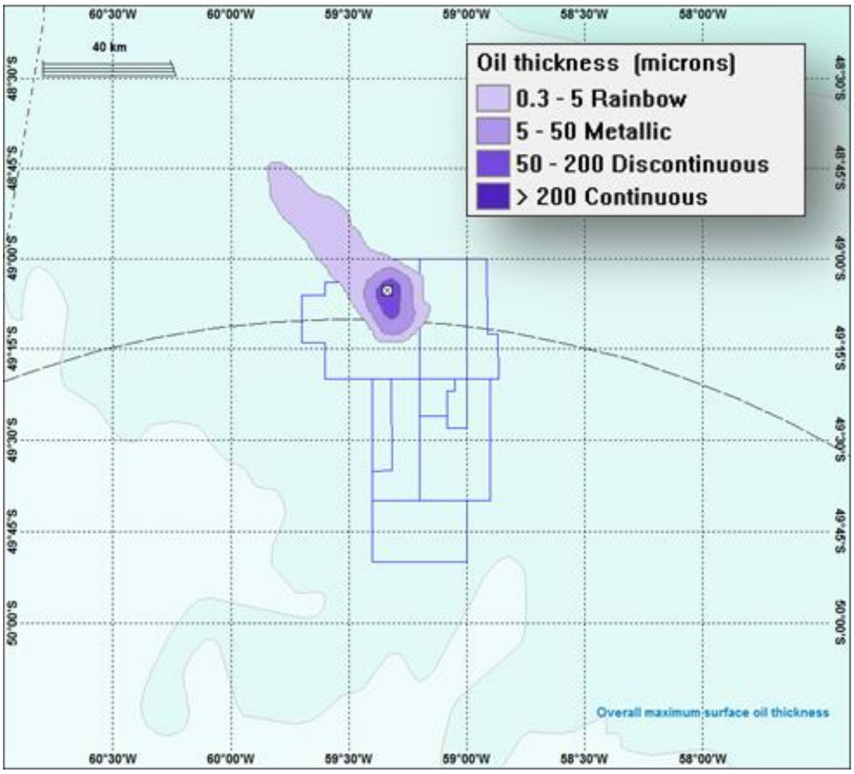


Figure 94: Maximum surface thickness for the diesel inventory loss scenario (stochastic)

Water column statistics

Figure 95 shows the probability of diesel concentrations in the water column above 25 ppb following an inventory loss. There is up to 92 % probability of concentrations above 25 ppb, indicating that it is likely that some acute toxic effects may occur. The probability of concentrations above 25 pbb at the boundary of the FICZ is at most 38 %. Meanwhile, at the northern boundary of the FOCZ, there is at most 26 % probability of concentrations exceeding 25 ppb. Concentrations above 25 ppb are confined to within the upper 100 m of the water column.

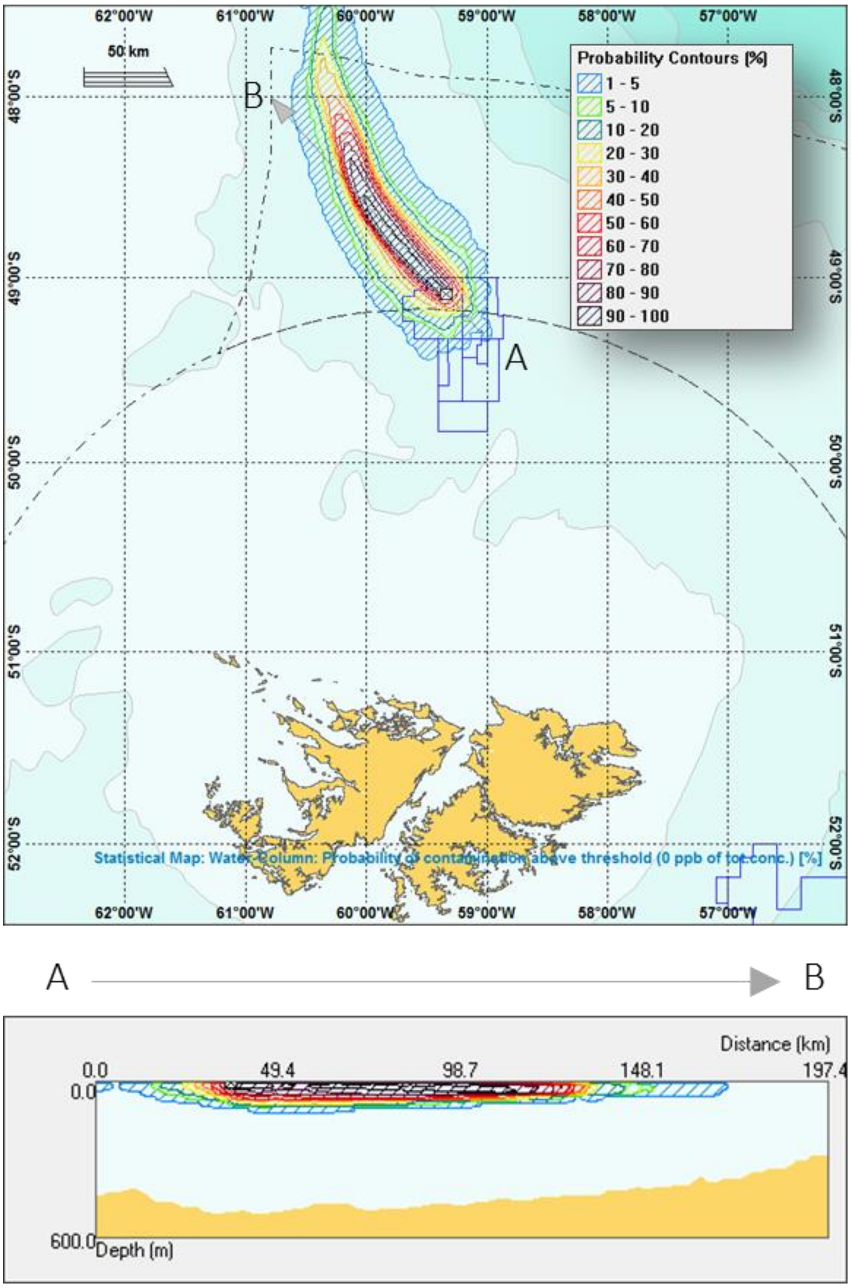


Figure 95: Probability of diesel in the water column after rig diesel inventory loss (stochastic)

Diesel is predicted to exceed 25 ppb for up to five days following an inventory loss (Figure 96). Acute toxic effects may therefore occur within a 30 m^2 area within the FOCZ for 4-5 days. Beyond the northern boundary of the FOCZ, concentrations above 25 ppb only persist for up to 31 hours. Within the FICZ, concentrations exceed 25 ppb for three days at most.

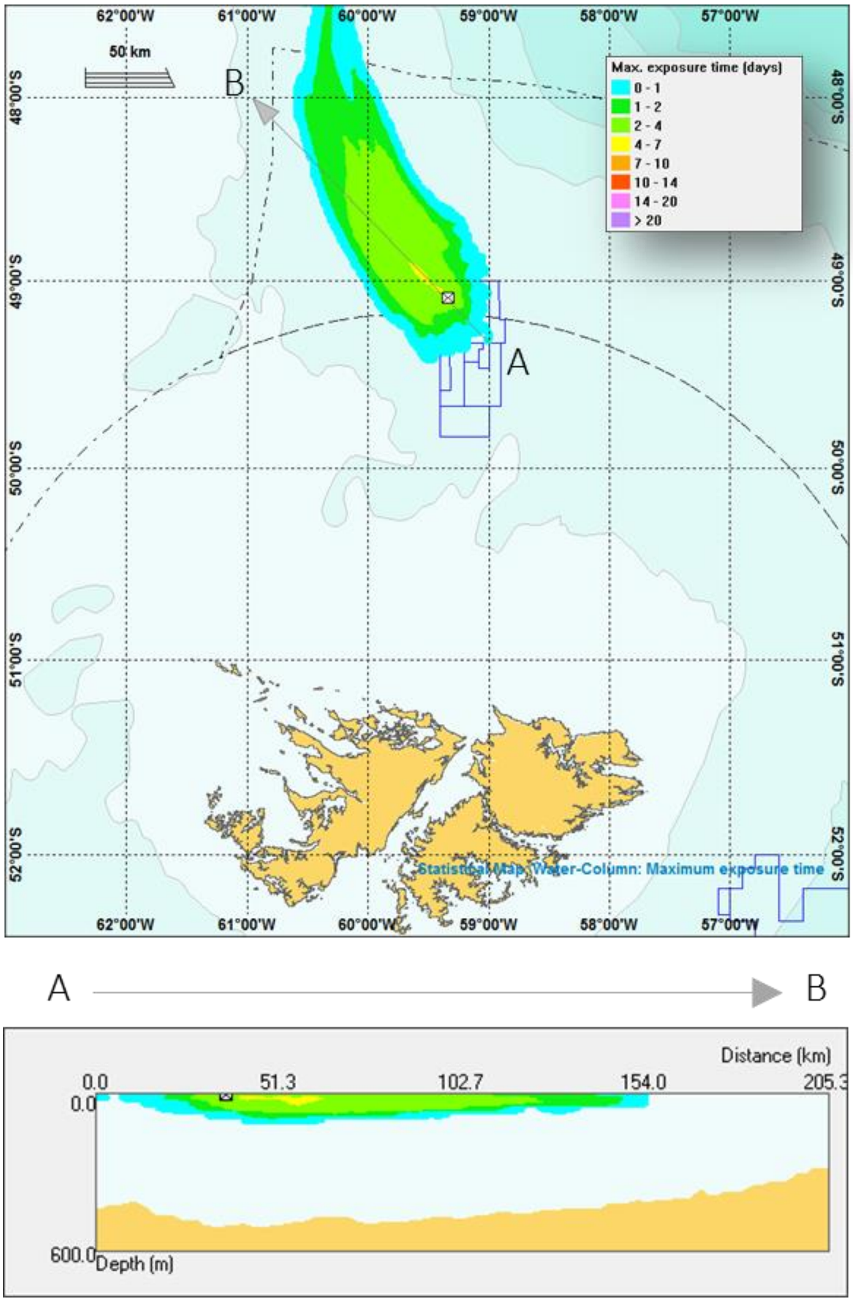


Figure 96: Maximum time water column may be exposed to diesel after diesel inventory loss (stochastic)

The deterministic run predicts the variation of water column concentrations over time. Figure 97 shows the instantaneous maximum concentration in the water column over the entire model duration of 31 days following an inventory loss. Concentrations peak at 1,100 ppb within the FOCZ. As the plume crosses into the FICZ, concentrations reach 540 ppb. At these high concentrations, acute toxic effects are likely. The plume disperses quickly, as discussed above, and concentrations fall to levels where no toxic effects occur within five days.

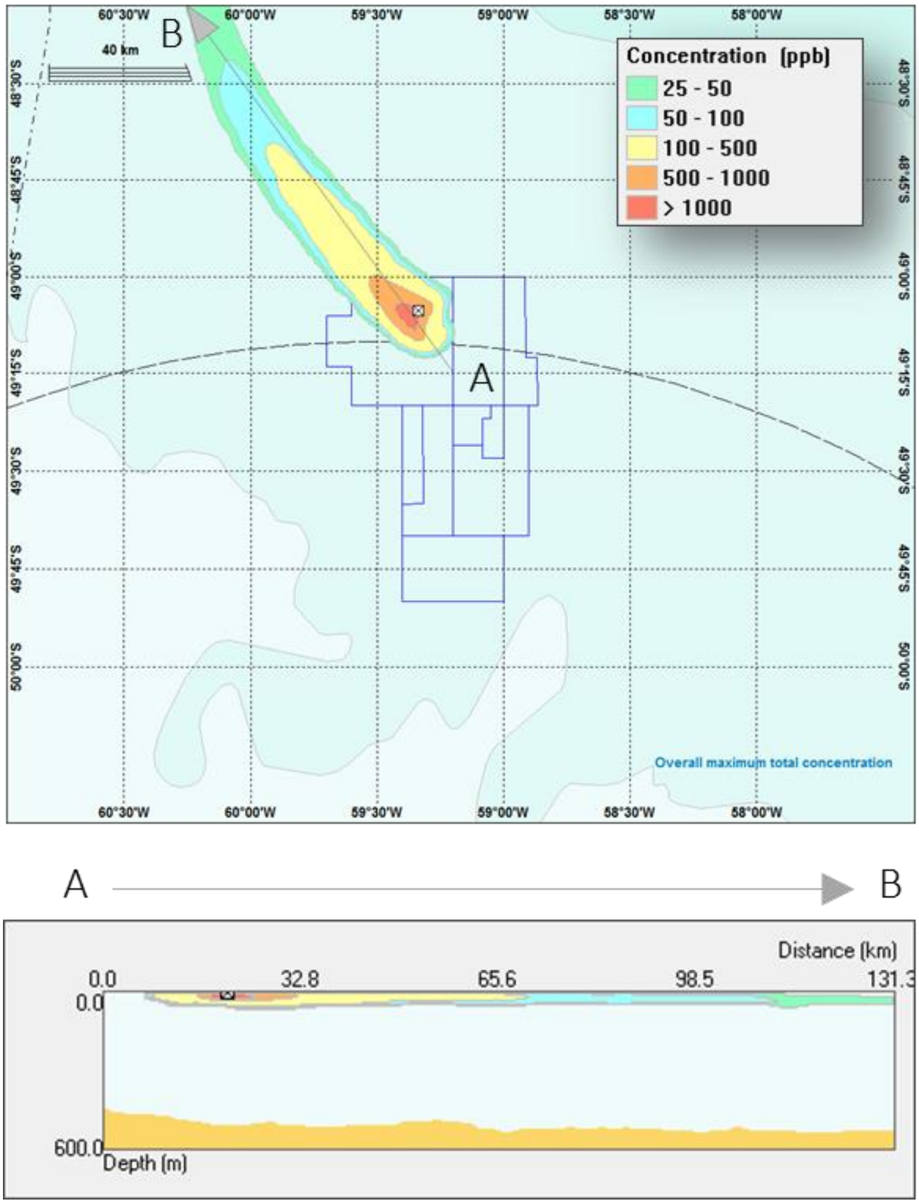


Figure 97: Maximum total water column concentration for the rig diesel inventory loss scenario (deterministic)

Shoreline statistics

None of the diesel spill scenarios resulted in any diesel arriving on the Falklands coastline.

13.3.5 Impact Assessment Summary

13.3.5.1 Severity and Sensitivity of Receptors

Diesel fuels contain volatile aromatic compounds, those of concern include; alkylbenzenes, toluene, naphthalenes, and PAH, which are potentially acutely toxic to marine life in the water column. Potential impacts on vertebrates include; changes in the liver and harmful effects on the kidneys, heart, lungs, and nervous system. Increased rates of cancer, immunological, reproductive, fetotoxic, genotoxic effects (Irwin, 1997). PAHs are relatively long-lived in the environment and bioaccumulate in the fatty tissues of animals, resulting in vital organ malfunction (particularly liver and kidney).

Both diesel spill scenarios indicated that the spill would only remain on the sea surface for a short period of time before the diesel was dispersed in the water column. The area of potential impact, to both the surface and the water column, were only found to be significant close to the release point. Although short-lived, diesel is far more volatile than Sea Lion crude and will release toxic substances, such as PAHs into the water column. These chemicals are toxic to marine life and will have a localised impact. The larger the spill the greater is the area over which it will spread and the longer it takes to degrade to an insignificant concentration. The size of the spill does not necessarily relate directly to the scale of the impact, the impact is determined by how many receptors are exposed to the pollutant. Spatial and temporal variations in the distribution of receptors may influence the scale of the impact as much as the size of the spill, although smaller spills will disperse more rapidly. However, it is likely that the presence of the rig will act as a focal point for marine animals and therefore the greatest impact is likely to be close to the rig.

Plankton

In both scenarios, the diesel remains on or close to the surface of the water throughout the course of the model. Planktonic organisms will be contaminated over a small area for a short period of time. Any impact will affect a small proportion of the local populations and therefore the sensitivity of plankton is assessed as '**Low**'. It is thought that, a combination of high reproductive rates and immigration from outside the affected area would see a quick recovery in the affected communities. Any effects will be greater during a period of plankton blooms or during fish spawning periods. The severity of the impact of diesel spills on plankton is assessed as '**Minor**'.

Fish and Fisheries

Fish and squid could be killed 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. In the offshore environment, diesel spills will be dispersed very quickly and so fish may be more vulnerable to non-lethal effects and accumulation of toxins that can taint the flesh of fish. Any impact will affect a small proportion of the local fish and squid populations and therefore the sensitivity of these species is assessed as '**Low**'. The impact of the spills modelled here is very localised and short-term in nature and the severity of the impact is assessed as '**Minor**'.

Seabirds

Procellariiformes (albatrosses, petrels and shearwaters) have an acute sense of smell and rely on olfactory detection of volatile oils to locate prey over great distances (Warham, 1990 and 1996). Diesel fuel and other volatile petroleum products are likely to be detected by seabirds from great distances and could be confused as a food source. However, the impact of oil spills on albatrosses and petrels appears slight compared with other seabirds, such as penguins. It has been suggested that the highly developed sense of smell in these species helps them to avoid contamination with surface oil (Brooke, 2004). Conversely, observations at-sea indicate that shearwaters do not avoid these areas (Vander Werf et al., 2005). The conservation status of albatrosses and some petrels means that even a small impact could be significant for the population.

Diesel rapidly spreads to form a sheen on the surface of the water. Scenario 1 of a transfer spill of 30 tonnes, indicates that the diesel will only be on the surface for a matter of hours and therefore the impact is short-lived and localised. Although there are gaps in the data, a general picture of seabird and marine mammal distribution within the NFB has been acquired through a combination of satellite tracking, visual and acoustic surveys. During the intended drilling period, the seabird vulnerability to oil spills in waters to the west and northwest of the drill site are relatively high compared with other months of the year (see Section 5.4.6.6). Additionally, the presence of the rig is likely to attract birds (see Munro, 2011) and it is these animals that are at greatest risk of suffering from the chronic impact of small scale leaks and spills and loss of containment events. Amongst others, species such as royal, wandering and black-browed albatrosses, giant and white-chinned petrels are among the most numerous that associate with vessels at-sea. Several of these are classified as Endangered under IUCN guidelines (see Section 5.4.6.5 and are all covered by ACAP. The assemblage of the seabirds close to the rig means that seabird sensitivity is assessed as '**Very High**'. The impact of small diesel spills will be extremely localised and short-term and therefore the severity of a small transfer diesel spill (30 tonnes) on seabirds is assessed to be '**Moderate**'.

Scenario 2, a far larger diesel spill, indicates that diesel will be on the surface for longer and will spread over a larger area. The potential impact increases in proportion to the size of the spill. The sensitivity of seabird receptors remains '**Very High**'. Nonetheless, the area covered by the spill is still relatively small (on the scale of the NFB) and the slick will be short-lived. The severity of a large loss of diesel fuel is assessed as '**Moderate**'.

Marine Mammals

Acoustic survey data of the exploration area indicates that marine mammals do not heavily use the area in the vicinity of the Rhea-1 well location during the seasons when the proposed drilling operation is scheduled to take place. Marine mammals, particularly fur seals, that come into contact with a diesel spill may suffer adverse consequences, although any spill would impact a 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, and would therefore be most likely to be affected for a short period immediately following a spill before the diesel is dispersed from surface waters. Due to seasonal fluctuations in abundance, there is a very small chance that Endangered species of marine mammal (fin and sei whales) could be present in the vicinity of the rig and therefore the sensitivity of marine mammals to spilt deisel during the Rhea-1 exploration period is assessed as '**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 a small chronic short-term release of diesel (Scenario 1) on marine mammals has been assessed as '**Minor**'.

Like seabirds, the potential impact is related, to some extent, to the size of the spill. Nonetheless, large diesel spills are short-lived and localised and the likelihood of marine mammals being exposed and suffering serious adverse effects is low. The severity of a large diesel spill (Scenario 2) on marine mammals is assessed as '**Minor**'.

Coastal Impact

In both scenarios, the diesel rapidly evaporates, biodegrades or is dispersed in the water column, none of the diesel is transported to the coast.

Overall Assessment of Impact

For both diesel spill scenarios, the receptors most heavily impacted are seabirds, which display '**Very High**' sensitivity any impact would have '**Moderate**' severity. Therefore, the overall impact on seabirds for diesel spills (both scenarios) is '**High**'.

Likelihood

Collisions with Shipping

Shipping movements in the NFB have been analysed to investigate the risk of vessels colliding with the rig (Anatec, 2015). They report that on average 289 vessels pass within 10 nautical miles of the Rhea-1 well location per year with 80% of these less than 5,000 DWT. Twenty of these vessels were tankers on passage between South Africa and Cape Horn. These are far larger vessels (>40,000 DWT) and therefore 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 $3.9x10^{-4}$ and the risk of a collision with a larger vessel (collision energy >200 MJ) was assessed as $9.1x10^{-5}$. Therefore, the likelihood of a vessel colliding with the rig, potentially leading to a loss of containment of the entire diesel inventory, is assessed as '**Remote**'. Measures such as, a 500 m exclusion zone, a guard ship (ERRV), AIS/radar surveillance and radio broadcasts to mariners (advising on the position of the rig and the exclusion zone) will further reduce the risk of collisions.

With all of the above measures in place as standard operating practice, the likelihood of small-scale diesel spills during fuel transfer has been assessed as '**Rare**'.

13.3.5.2 Significance

The significance of small-scale diesel spills has been assessed as '**Moderate**' for seabirds and '**Low**' for other environmental receptors. There is little more that can be done to mitigate the risk of these events occurring and therefore an oil response plan is required to reduce the severity of the impact on the marine environment.

13.3.5.3 Degree of Confidence

For any accidental event, there is a degree of uncertainty surrounding the environmental impact, due to assumptions made in the modelling.

The volatile nature of diesel fuel means that any spill will rapidly evaporate, disperse and biodegrade, the impact will be localised and short-lived. The impact will depend on the density of environmental receptors in the immediate vicinity of the rig, which is not possible to predict. The rig itself will influence the distribution of seabirds and may also influence the distribution of marine mammals and their prey. For these reasons, the confidence in the impact assessment of diesel spills on the marine environment is '**Probable**'.

13.3.5.4 Cumulative Impacts

The Rhea-1 well location is in an area that is not usually occupied by other vessels and therefore the risks of added cumulative impact are minimal.

13.3.6 Mitigation Measures

NEFL working procedures will provide the control and preventative measures that are designed to produce a zero discharge environment, these measures include;

- Operating equipment within specified safe limits;
- Conducting maintenance and inspection routines on time and diligently;
- Completing repairs within specified timescales;
- Reporting anything that is leaking or defective equipment;
- Investigating all 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.

Additionally, all hoses used to transfer diesel oil will be fitted with dry-break couplings, which will seal the end of the hose in the event of the hose becoming accidentally disconnected and limit the amount discharged. In the event that a spill occurs, support vessels will be equipped with oil spill response equipment to respond appropriately to all credible scenarios.

13.3.6.1 Residual Impacts

The measures outlined above are standard working practice over the UK continental shelf yet small oil spills (mostly less than one tonne) are still recorded (OSPAR, 2014). The vast majority of these spills are far smaller, and have lower severity, than the one modelled here. With safe working practices rigorously followed the likelihood of small spills occurring will be reduced. Under the direction of a well specific Oil Spill Response Plan (OSRP, NEFL, 2015g), a rapid response to any incidents will reduce the impact on the environment. Overall the significance of the residual impact of small spills is assessed as '**Low**'.

13.4 Emergency Situation Leading to Drilling Rig Loss of Station – Loss of WBM from Riser

13.4.1 Introduction

The use, purpose and properties of drilling muds are explained in Section 3.4.3. With more oil and gas fields being developed in the deep water and harsh environments, safe reliable positioning operations on floating offshore installations have become more important. This is particularly important for the dynamic positioning (DP) operation of a semi-submersible rig. The rig position is maintained by powerful thrusters on each corner of the rig, and has limited tolerance in any direction to remain ‘on station’. The degree of tolerance is dependent on water depth, in this case tolerance will be approximately three metres. In an event of loss of station, a DP drilling unit must shut in the well and disconnect the riser safely, before the connection is broken. Failure to disconnect may result in damaged riser, wellhead or BOP, and in worst-case an uncontrolled sub-sea release. Collisions with other vessels in the vicinity may also be applicable if in congested waters.

The risk of an uncontrolled release has already been assessed in Section 13.2, however, damage to the riser during drilling operations could result in a loss of the drilling mud and cuttings within the riser.

13.4.2 Reasons for failing to maintain station

Loss of station may be caused by a number of failures, the most common being related to failure of position references, operator error, thruster failure and DP computer failure (Figure 98). Figure 98 illustrates DP incidents and their causes between 1994 – 2003.

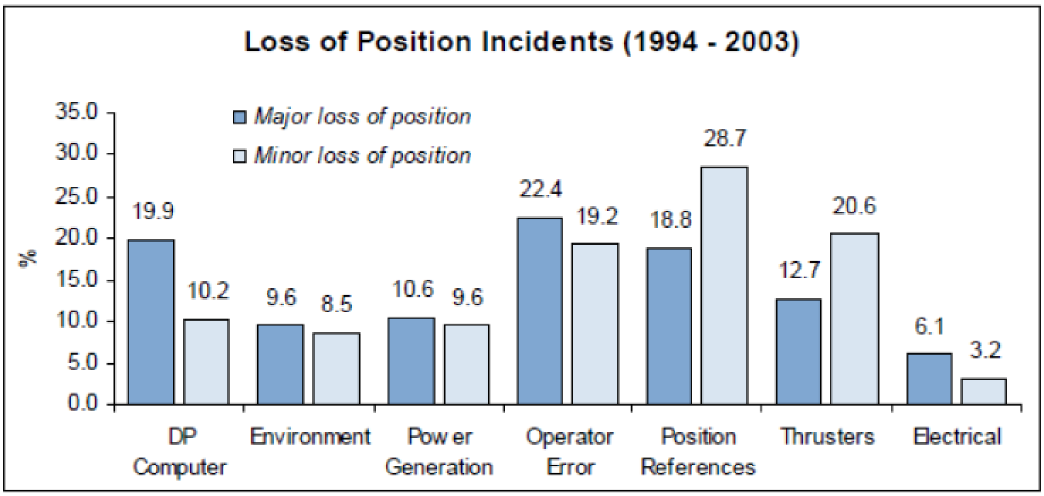


Figure 98: DP incidents and their causes (Tjallema, 2007).

This chapter discusses the consequences of loss of water based mud from the riser during the unlikely event of the drilling rig losing station (Genesis, 2015b).

13.4.3 Potential Environmental Receptors

Assuming that an uncontrolled release is avoided, the main environmental consequence of losing station is the loss of the riser and its contents of Water Based Mud (WBM).

There are a number of potential environmental receptors to the accidental loss of containment of WBM from a riser. These include:

- **Seabed sediment** – discharge direct to the seabed and settlement of particles through the water column will impact sediment chemistry and particle size over the affected area.
- **Water quality** – suspension of mud and cuttings in the water column as well as discharge to surface waters will impact water chemistry and turbidity.
- **Phytoplankton and Zooplankton** – organisms with limited mobility will be impacted by changes in local water quality.
- **Benthic organisms** – discharge of drill cuttings and mud affects benthic organisms through direct burial, habitat change and sediment suspension at the seabed.

- **Fish –** mobile species such as fish may be affected if drilling coincides with certain life history stages such as spawning periods and juvenile stages when they inhabit particular spawning or nursery grounds, or if it coincides with productive feeding season and feeding grounds.

13.4.4 Characterising and Quantifying the Impact of WBM

13.4.4.1 Physical Release Parameters

The potential volume of mud that could be lost from the riser was estimated to be 100 m^3, equivalent to the worst-case volume of mud that would be in the riser at any one time. It was assumed that the mud would be released through a rupture in the riser that at worst-case would be equal to the riser diameter (30″). A release duration of one minute was assumed for the total 100 m^3 mud, which is considerably denser than seawater and would therefore quickly drop out as soon as the riser ruptures. One minute was chosen as a conservative duration since the faster the release the less dispersion and hence more deposition in a confined area.

Environmental risk thresholds defined in the mud spill model

- Deposition thickness - Kjeilen-Eilertsen (2004) concluded that, in general, a deposited cuttings/mud thickness of 6.5 mm can be adopted as a threshold at which 5 % of the most sensitive species would be affected by smothering, which is deemed a tolerable risk level in EU Guidance (Commission Directive 93/67/EEC on risk assessment for new notified substances, the Commission Regulation (EC) No. 1488/94 on risk assessment for existing substances and the Directive 98/8/EC of the European Parliament and of the Council which covers the needs of the Biocidal Products Directive on chemical discharges) (Section 12.4).
- Where the predicted environmental concentration (PEC) is greater than the predicted no effect concentration (PNEC), a risk to at least 5% of the most sensitive species occurs. The sediment and water column risk predictions therefore use a threshold of 5% for the mud spill modelling (Section 12.4).

13.4.4.2 Conclusions Drawn from Drill Cuttings and Mud Spill Modelling

Mud spill modelling utilises the DREAM/ParTrack model. An overview of this model can be found in Chapter 12 of this EIS (Drilling mud and cuttings discharge; Section 12.0) and further details can be found in Genesis (2015a). The volume of mud discharged during normal drilling operations is far greater than the volume contained in the riser; however, if the rig lost station, the instantaneous release of mud from the riser may behave differently. The assessment below relies on the results of a WBM spill modelling from a well site in the NFB (Genesis, 2014). Although the impact in the immediate vicinity of the well site will vary from location to location the scale of the impact is valid for the Rhea-1 well site, which is subject to the same oceanographic conditions.

Sediment deposition

The distribution of mud was fairly uniform around the spill location, spreading away from the release location in a concentric pattern due to variable currents. This shows deposition on the sediment is minimal, reaching at most 0.005 mm southwest of the release point. The predicted thickness is much lower than 6.5 mm therefore smothering effects are not anticipated.

Grain size of deposited material

Smit et al., (2006) propose a median grain size change threshold of 52.7 μm before adverse effects occur. The model predictions for grain size change are below this threshold therefore no adverse effects are anticipated with median grain sizes ranging between 1 μm and 32 μm.

Risk to the sediment

Total risk to the sediment due to a combination of grain size change, burial thickness and pore-water oxygen depletion at cessation of drilling was modelled. The model predicted less than 0.005% risk to the sediment.

Risk to the water column

The mud and chemicals will be dispersed by the current resulting in risk to the water column. The plume quickly falls to the seabed within about five minutes and continues to disperse along in a westerly direction by the current. A greater than 5% risk to the water column extends at least 4 km from the spill location. The risk falls below 5% about 10 hours after the spill. It was predicted that a volume of at least 0.0146 km^3 where the risk exceeds 5% would be affected in the water column. The primary contributor to this risk is suspended barite particles, accounting for 83 % of the cumulative risk.

13.4.5 Risk Assessment Summary

13.4.5.1 Severity

Sediment Quality

Sediment quality impacts will be locally constrained. The distribution of mud and cuttings released was predicted to be fairly uniform around the spill location, spreading away from the well in a concentric pattern due to variable currents. This shows deposition on the sediment is minimal, reaching at most 0.005 mm southwest of the release point, well below the threshold of 6.5 mm thickness (Kjeilen-Eilertsen, 2004) at which 5 % of the most sensitive species would be affected by smothering. The total risk to the sediment due to a combination of grain size change, burial thickness and pore-water oxygen depletion at cessation of drilling was not predicted to exceed 0.005% risk to the sediments.

Concentrations of a number of heavy metal components within the drilling mud will exceed the natural background sediment concentrations within the vicinity of the Rhea-1 well location, including cadmium, copper, mercury, lead and zinc. However, these metals are present in barite primarily as insoluble mineralised sulphide salts which will therefore have limited environmental mobility and a low toxicity (Neff, 2005). The severity of the impact on the sediment is ‘**Minor**’.

Plankton

High concentrations of suspended particulates may cause localised responses in zooplankton over a small temporal window, such as physical interaction with the gills, gastrointestinal tract and feeding behaviour, as opposed to chemical toxicity (Smit et al., 2006). However, the sphere of influence would be so small that any plankton that came into contact with suspended particles would be of no geographic importance. Sensitivity of plankton is assessed as ‘**Low**’.

The severity of the impact to plankton is therefore considered to be **‘Minor**’ as it would be a short-term release (one minute) in the unlikely event of a drilling rig loss of station. The environmental risk is predicted to be localised and the impact will be minor in nature.

Benthic Fauna

The discharge of mud to the seabed from an accidental loss of containment from the riser due to the uncontrolled loss of station by the drilling rig will have limited effects on the seabed. The sediment quality impacts will be locally contained with a predicted thickness of less than 0.005 mm southwest of the release point. While benthic filter feeding organisms, such as bivalve molluscs, are known to experience toxic effects of suspended particulate matter causing clogging in the gills (Cranford et al., 1998), particles such as barite settle out rapidly from the WBM resulting in rapidly declining concentrations of barite in the water column. The effect in the benthic boundary layer where most bivalves feed would also be very short-lived, therefore it is probable that barite has limited toxic effect to these organisms (Neff, 2010). The sensitivity of benthic fauna is assessed as ‘**Low**’.

The severity of the impact to the benthic fauna is considered to be **‘Minor**’ affecting a relatively small area (due to relatively small volume of material released) over a small short duration, with rapid recovery of the communities in the area expected.

Fish and Fisheries

Larvae and eggs of fish are more sensitive to an increased concentration of suspended sediment than adult life stages. Adult fish are highly mobile organisms and are likely to avoid the areas of re-suspended sediments and turbulence during the drilling operations. Shellfish collectively, in general, tend to have lower mobility and can be sensitive to burial by sediments. The risk to the water column is predicted to be very localised in nature (0.0146 km^3) and the risk falls below 5% about 10 hours after the spill. The proposed Rhea-1 well location is situated within the Falkland Islands Northern Slope habitat zone (Section 5.4.4.1), which has been identified as an important feeding area for a number of fish species, whose abundance varies with season. However, the habitat is widespread in nature with a very small proportion would be influenced by a WBM spill, therefore, sensitivity is assessed as '**Low**'.

Given the localised and very short-term nature of this type of impact, with rapid recovery expected the overall severity to this receptor is considered to be **'Minor'.**

Overall Impact

With the most vulnerable receptor showing '**Low**' sensitivity to an impact of '**Minor**' severity the overall impact is assessed as '**Low**'.

13.4.5.2 Likelihood

The *Eirik Raude* is a DP3 semi-submersible drilling rig. There are strict procedures in place to minimise loss of station. The DP system of the rig typically uses a fixed point of the clump weight to maintain position by ensuring appropriate tension on the line. System redundancy is designed to ensure that DP related equipment is always available. However, there are multiple recorded cases in the oil and gas industry where semi-submersible rigs have lost station. The likelihood of the loss of containment from a riser as a result of loss of station is considered **'Remote'.**

13.4.5.3 Significance

The overall significance of a loss of containment from a riser due to drilling rig loss of station is '**Low**' as the environmental impacts are considered to be negligible.

13.4.5.4 Degree of Confidence

There are a number of uncertainties and assumptions that surround the events leading to loss of station and therefore loss of containment of the riser. Wherever possible, worst-case scenarios have been assumed to ensure that the impact is not under-estimated. However, due to the uncertainties surrounding major accidental events and the assumptions in the modelling approach the confidence in the significance of the risk presented in this assessment is '**Probable**'.

13.4.5.5 Cumulative Impact

During the drilling campaign there will be other sources of WBM in the NFB. However, it is possible that residue from previous campaigns is still present within the sediments. Although the impact of WBM is extremely localised, there may be a slight cumulative impact.

13.4.6 Mitigation Measures

There are a number of practices and procedures that will reduce the risk of loss of station and thus ultimately loss of containment of the riser;

- Redundancy is designed to ensure that DP related equipment are always available, which reduces the probability of the DP installations loss of position and the potential ensuing damage (see – DNV-RP-E306);
- DP trials on the rig will be undertaken when the rig reaches location and before operations commence;
- An exclusion zone of 500 m, ERRV vessel, radar, AIS and radio broadcasts to reduce the probability of vessel collision;

- Iceberg collision. The available evidence suggests that it is extremely unlikely that icebergs will be present in the NFB during the Rhea-1 exploration drilling period. Satellite and radar surveillance throughout the campaign will identify and track the progress of any icebergs, and other floating objects. This will give sufficient time to suspend the well and disconnect the rig in the event of an iceberg drifting towards the operation;
- Meteorological analyses to be prepared for extreme weather events;
- Continual monitoring of long-range and short-range weather forecasts, so that if storm conditions are predicted to exceed the safe weather conditions for the rig, a controlled containment and release from the wellhead could be performed if required.

Table 72: Summary of the impact assessment for accidental events during the Rhea-1 exploration campaign

Activity	Aspect	Potential Impact	Type of Activity	Likelihood	Sensitivity*	Severity	Significance		Certainty	Mitigation / Prevention / Control
							Pre-mitigation	Post-mitigation		
Emergency Situation Significant loss of containment or blow-out	Lethal and sub-lethal toxic effects	Plankton	Accidental	Remote	Low	Moderate	Moderate		Probable	Working practices will follow the industries best guidelines to prevent uncontrolled releases and other accidental events. An oil spill response plan will be enacted to; stop the uncontrolled release, contain and recover oil from the sea, surveillance will track the oil to inform the need for coastline clean-up, wildlife rescue and rehabilitation.
	Lethal and sub-lethal toxic effects	Benthic ecosystem		Remote	Mod	Major	Moderate		Probable	
	Oiling of feathers leading to hypothermia, ingestion of toxins	Seabirds		Remote	Very High	Major	Moderate		Probable	
	Oiling of fur leading to hypothermia, inhalation of toxins	Marine mammals		Remote	High	Moderate	Moderate		Probable	
	Lethal and sub-lethal toxic effects	Fish and fisheries		Remote	Mod	Major	Moderate		Probable	
	Impact on productive feeding and spawning grounds	Coastal		Remote	Mod	Moderate	Moderate		Probable	
	Negative publicity impacting tourist numbers	Tourism		Remote	Mod	Major	Moderate		Probable	

** See Section 6.0 for EIA methodology for unplanned events, and definitions of Likelihood, Sensitivity, Severity and Significance.*

Table 72 continued: Summary of the impact assessment for accidental events during the Rhea-1 exploration campaign

Activity	Aspect	Potential Impact	Type of Activity	Likelihood	Sensitivity	Severity	Significance		Certainty	Mitigation / Prevention / Control
							Pre-mitigation	Post-mitigation		
Emergency Situation Accidental loss of containment leading to loss of rig diesel inventory	Lethal and sub-lethal toxic effects	Plankton	Accidental	Remote	Low	Minor	Low		Probable	Working practices will follow the industries best guidelines to prevent uncontrolled releases and other accidental events. An oil spill response plan will be enacted to; stop the uncontrolled release, contain and recover oil from the sea.
	Oiling of feathers leading to hypothermia, ingestion of toxins	Seabirds			Very High	Moderate	Moderate		Probable	
	Oiling of fur leading to hypothermia, inhalation of toxins	Marine mammals			High	Minor	Moderate		Probable	
	Lethal and sub-lethal toxic effects	Fish and fisheries			Low	Minor	Low		Probable	
Accidental Event Leading to a minor diesel spill	Lethal and sub-lethal toxic effects	Plankton	Unplanned	Rare	Low	Minor	Moderate	Low	Probable	Working practices will follow the industries best guidelines to prevent accidental events. A Rhea-1 specific OSRP will be in place. Fuel hoses will be fitted with dry-break couplings to minimise the risk of small spills.
	Oiling of feathers leading to hypothermia, ingestion of toxins	Seabirds			Very High	Moderate	Moderate	Low	Probable	
	Oiling of fur leading to hypothermia, inhalation of toxins	Marine mammals			High	Minor	Moderate	Low	Probable	
	Lethal and sub-lethal toxic effects	Fish and fisheries			Low	Minor	Moderate	Low	Probable	

** See Section 6.0 for EIA methodology for unplanned events, and definitions of Likelihood, Sensitivity, Severity and Significance.*

Table 72 continued: Summary of the impact assessment for accidental events during the Rhea-1 exploration campaign

Activity	Aspect	Potential Impact	Type of Activity	Likelihood	Sensitivity	Severity	Significance		Certainty	Mitigation / Prevention / Control
							Pre-mitigation	Post-mitigation		
Emergency Situation Loss of containment of drilling mud from the riser	Increased turbidity	Water quality	Accidental	Remote	Very Low	Minor	Low		Probable	Redundancy is built into the dynamic positioning (DP) system to reduce the risk of loss of station, Ongoing testing and maintenance of the DP systems, a 500 m exclusion zone is maintained to reduce the risk of collisions with other vessels, environmental factors such as extreme wind and icebergs are constantly monitored .
	Clogging and damage to gills from Barite	Plankton			Low	Minor	Low		Probable	
	Clogging and damage to gills from Barite	Fish and fisheries			Low	Minor	Low		Probable	
	Change in mean grain size	Sediments			Low	Minor	Low		Probable	
	Clogging and damage to gills from Barite	Benthos			Low	Minor	Low		Probable	

** See Section 6.0 for EIA methodology for unplanned events, and definitions of Likelihood, Sensitivity, Severity and Significance.*

14.0 Project Specific Environmental Management and Conclusions

14.1 Introduction

Through a systematic evaluation of the proposed exploration drilling activities and their interactions with the environment, a variety of potential sources of impact were identified. The majority of activities were of limited extent and duration and the impacts were deemed minor.

Those activities, and associated impacts, that were identified as being of potentially greater concern were assessed further in the main impact/risk assessment chapters. A number of environmental management actions and operational controls were identified for consideration during final project planning and execution. NEFL will manage these actions/controls within the framework of its project specific Environmental Management Plan (EMP) and the Noble Energy GMS (Chapter 4.0). Specific management actions identified in the EIS (primarily in the context of impact/risk management and effects mitigation and monitoring) will thus be taken forward into detailed planning and through the project execution phase.

In addition to the EMP, other management plans will be implemented in compliance with FIG guidance and the Noble Energy ESHIA Guideline.

14.2 Project Specific Environmental Objectives and Targets

Environmental objectives and targets specific to the Rhea-1 well operation include:

- Zero unplanned releases of hydrocarbons to sea;
- Zero unplanned releases of chemicals to sea;
- Zero loss of containment of wastes offshore and onshore; and
- Re-use of waste oil within the local community e.g. for Stanley growers

Actions required to meet the above targets are incorporated into the project specific management plans and/or the project Commitments Register.

14.3 Project Specific Management Plans

Various project specific management plans may be required in compliance with the Noble Energy ESHIA Guideline, FIG guidance and to mitigate against impacts identified in the EIA as described in Chapter 4.0. Guidance and definition for management plans that may be required for a given project are provided in the Noble Energy ESHIA Guideline.

Management plans that are specifically relevant to environmental management during the Rhea-1 well operation, and which will be further developed in conjunction with the drilling rig contractor and other key contractors, include:

- Environmental Management Plan (EMP; NEFL, 2015a) – incorporates the monitoring and mitigation measures identified during the EIA process, any licence conditions issued by FIG post-consent and any actions related to the realisation of environmental objectives and targets. As with previous NEFL drilling operations off the Falkland Islands, the EMP will be developed as a separate document. Table 74 presents a summary of the environmental management mitigation and monitoring actions/controls identified during the EIA, and thus the framework for the project specific EMP.
- Waste Management Plan (WMPA; NEFL, 2015d) – ensures waste is minimised, handled, stored and transported correctly and that the risk of cross contamination and loss of containment is minimised with clear definition of roles and responsibilities. Details on the exploratory drilling WMPA (NEFL 2015d, Document number: 013-15-EHSR-WMP-PA-T4) are provided in Chapter 11.0.
- Offshore Discharge Program (ODPO; NEFL, 2015e) – provides a consistent set of discharge compliance requirements establishing effluent limitations, prohibitions, sampling

requirements, reporting requirements and any license/legislation based conditions on discharges. The NEFL Exploratory Drilling ODPO (NEFL 2015e, Document number: 062-14-EHSR-ODP-PO-T3) is a standalone Tier 4 document within the Noble Energy GMS and will be applied to the Rhea-1 well operation.

- Oil Spill Response Plan (OSRP; NEFL, 2015g) – 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). The OSRP defines the roles and responsibilities of all parties, provides an action plan, a description of the available oil spill response resources available, proposed response procedures and detail on 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 OSRP must incorporate all post-Macondo learning's on best practice. It must therefore include assessment of the worst-case oil spill scenario and a detailed analysis of the availability and mobilisation timetable for relief rigs and available well intervention devices. The Rhea-1 well will be added as an addendum to the existing NEFL OSRP (NEFL 2015g, Document number: 009-15-EHSR-OSR-PA-T3) which will be resubmitted to the FIG DNR for approval.
- Wildlife Response Plan (WRP; NEFL, 2015f) – detailing the oiled wildlife response strategy to be implemented in the event of an unplanned release of hydrocarbons. NEFL will work with OSRL/Sea Alarm and FIG to ensure the plan defines relevant details including initial response, management/coordination structure and appropriate local responder organisation/involvement. The NEFL Exploratory Drilling WRP (NEFL 2015f, Document number: 022-15-EHSR-WRP-PE-T4) is a standalone Tier 4 document within the GMS and will be applied to the Rhea-1 well operation.
- Bird Strike Management Plan (BSMP; NEFL, 2015b) – detailing measures to ensure the reduction of artificial light and the monitoring, recording and reporting of bird collisions. The NEFL Exploratory Drilling BSMP (NEFL, 2015b, Document number: 018-15-EHSR-BSp-PA-T4) is a standalone Tier 4 document within the GMS and will be applied to the Rhea-1 well operation.
- Biosecurity Management Plan (BMP; NEFL, 2015c) - provides a framework for the processes intended to reduce the likelihood of introducing non-native or harmful invasive species (invasive marine species and terrestrial species) to the ecosystem of the Falkland Islands. The NEFL Exploratory Drilling BMP (NEFL 2015c, Document number: 021-15-EHSR-BSP-PA-T4) is a standalone Tier 4 document within the GMS and will be applied to the Rhea-1 well operation. This plan is aligned with the project specific Temporary Dock Facility Biosecurity Plan.
- Harbour Management Plan (HMP; PMO/NEFL, 2014) – informed by a project specific navigational risk assessment, the HMP includes pre-notification protocols associated with the entry of vessels in Stanley Harbour, pre-defined passage routes within Stanley Harbour, procedures associated with vessel collision and emergency response.
- Emergency Management Plan (EMP, NEFL, 2015h) – required for each stage of the project lifecycle, the EMP will outline the procedures to be followed in the event of an emergency, will be commensurate with the potential risks and impacts identified in the EIA and will be sufficiently aligned with the OSRP.
- Stakeholder Engagement Plan (SEP) – required to identify stakeholder groups, focusing on affected communities, describe a clear strategy and timetable for sharing information and consulting with identified stakeholders throughout the life-cycle of the project. In line with NEFL's ESHIA Guideline, the SEP will include an external communications procedure, grievance mechanism and procedures for regular, on-going reporting to project-affected communities on project risks and impacts.
- Media Response Plan (MRP) – contains key media contacts, draft holding statements, and detail on primacy for response in the event of an incident providing detail on the process and procedures to be followed.

Figure 99 summarises the subject matter and operational phases that are relevant to each NEFL management plan during the Rhea-1 exploration drilling program.

In compliance with the Noble Energy ESHIA Guideline, key commitments in the above plans will be recorded in the project specific Commitments Register. All requisite activities will be transposed into the contractual obligations of contractors employed by NEFL to deliver the project.

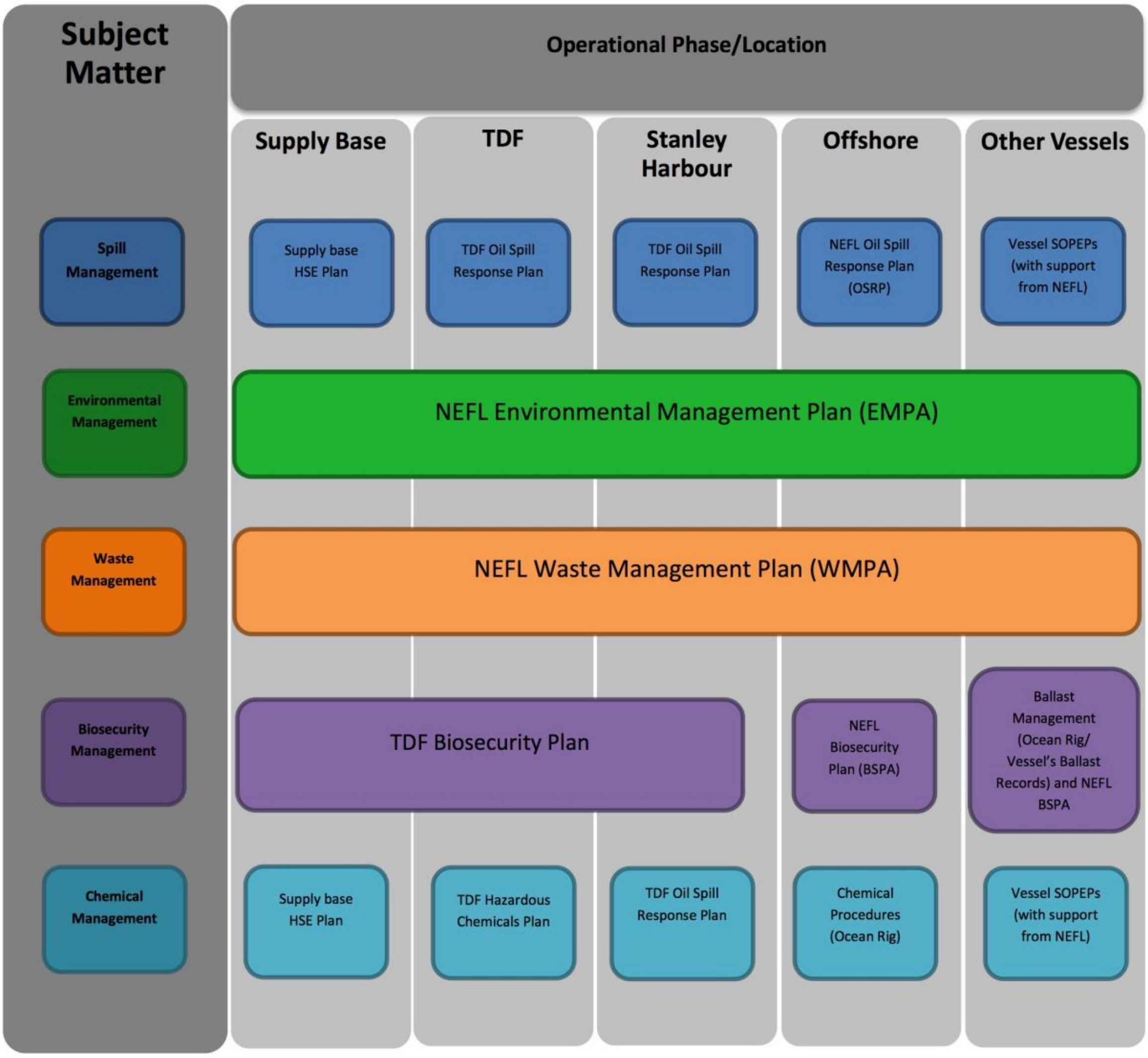


Figure 99: Operational EHS document map

14.4 Project Specific Audits

Audits are required before, during and after operations to ensure that the operation is being carried out in compliance with regulatory requirements, the Noble Energy GMS, the contractors EHS-MS and the commitments made within this EIS.

All relevant pre-hire, pre-mobilisation and contractor selection audits described in Chapter 4.0 were carried out prior to the rig mobilising from South Africa for the joint NEFL and Premier Oil exploration drilling campaign. Sufficient evidence was provided with regard to alignment of the management systems and compliance with regulatory requirements.

In line with the FIG EIA Guideline, the following compliance audits will be carried out specifically on the Rhea-1 well operation:

- Environmental compliance audits – conducted during and after the operation in order to ensure compliance with applicable regulatory requirements and management control measures identified in the EIA and recorded in project specific management plans e.g. the EMP and WMPA. Compliance audits aim to compare the impacts predicted in the EIA with those that actually occur.
- Contractor management audits – in addition to pre-selection audits, these are conducted during operations to ensure that contractors are in compliance with their own management systems and contractual obligations and that all agreed performance standards are being met.

In order to demonstrate that NEFL are complying with all key environmental legislation during the exploration campaign, the below legislative compliance table has been developed Table 73. This details the relevant key environmental legislation and how NEFL will ensure compliance.

Table 73: Legisalative compliance table for the Rhea-1 exploration well

Legislation / Policy / Guidance	Summary of Requirement	How the Requirement is met
Legislation		
Offshore Minerals Ordinance 1994 (including 1997 & 2011 Amendments).	To undertake an Environmental Impact Assessment (EIA) and present the results in an Environmental Impact Statement (EIS).	This EIS has been produced to comply with Schedule 4, which sets out the requirements of an EIS.
Offshore Petroleum (Licensing) Regulations 1995 and Offshore Petroleum (Licensing) Regulations 2000 (including amendments made in 2004 and 2009).	To obtain a licence for exploration drilling in Falkland Islands waters.	A licence has been obtained.
Petroleum Survey Licences (Model Clauses) Regulations 1992.	All surveys undertaken are subject to approval by FIG.	The relevant approvals required for all surveys conducted in connection with the exploratory drilling have been obtained.
Marine Environment (Protection) Ordinance 1995. Deposits in the Sea (Exemptions) Order 1995. Environmental Protection (Overseas Territories) (Amendment) Order 1997.	Strict liability for certain loss or damage in relation to polluting incidents is applied. Any deposits in the sea must be approved by FIG.	There will be no deposits of non-exempt materials taking place. Strict liability will be applied by FIG to NEFL for any pollution incidents. NEFL have a number of control measures in place to reduce the risk of pollution incidents as detailed in this EIS (Sections 11.6, 13.2.5, 13.3.6 and 13.4.6). A Rhea-1 specific OSRP has been prepared Doc. No. 009-15-EHSR-OSR-PA-T3.
Marine Mammals Protection Ordinance 1992.	The harming, taking or killing of any marine mammal or using explosives in such a manner that may cause harm to any marine mammal is prohibited.	Potential impacts to marine mammals from NEFL activities have been assessed throughout this EIS (Chapter 7, Section 10.3).

Legislation / Policy / Guidance	Summary of Requirement	How the Requirement is met
Conservation of Wildlife and Nature Ordinance 1999.	It is prohibited to kill, injure, capture, replace, or disturb any protected wild animal, bird or plant without a licence.	Potential impacts to local wildlife from NEFL activities have been assessed throughout this EIS (Chapters 7, 9 and 13. Sections 10.5, 10.7).
Policies and Strategies		
Falkland Islands Biodiversity Strategy (2008-18).	The Falkland Islands aim to conserve and enhance the natural diversity, ecological processes and heritage of the Falkland Islands, in harmony with sustainable economic development.	The environmental impact assessment has shown that, although there will be some environmental impacts during each phase of the project life cycle, adverse long-term environmental impacts from the exploration drilling programme have been assessed as **low**, and incremental cumulative impacts of the development will be minimal. Furthermore, due to the implementation of control and mitigation measures, the majority of residual impacts are considered to be **low**. Mitigation and control measures identified are summarised in Chapter 14. The Environment Management Plan Doc. No. 010-15-EHSR-EMP-PA-T4 details how the mitigation measures will be implemented and where appropriate, monitored.
Hydrocarbon Development Policy Statement (2013);	Exploitation of hydrocarbons is for the benefit of Falkland Islanders, retaining supervision and control over hydrocarbon activities. Activities must be efficiently managed whilst protecting the FI environment.	All activities are consented by FIG. This **EIS** and the Environmental Management Plan demonstrate the mitigation measures identified to protect the Falkland Islands environment, and are reviewed in detail by FIG prior to consent to drill being granted.
Petroleum Operations Notices (PONs)		
PON 1	Specifies the record and sample requirements for seismic surveys and wells.	The planned Rhea-1 rig based survey will follow the requirements of PON1.
PON 3	Provides guidance on the procedure to follow for notification prior to carrying out a geophysical survey.	NEFL have not conducted any geophysical surveys in PL001.
PON 4	Comprises the pro-forma and accompanying guidance notes to use for an application for consent to drill exploration, appraisal and development wells.	A PON4 submittal for the Rhea-1 well will be submitted.
PON 5	Comprises the pro-forma and accompanying guidance notes to use for an application to abandon or temporarily abandon a well.	A PON5 submittal for the Rhea-1 well will be submitted.

Legislation / Policy / Guidance	Summary of Requirement	How the Requirement is met
PON8	Specifies the reporting requirements in the event of an oil spill, guidance on the use of dispersants and provides contact numbers and reporting forms to use in the event of an oil pollution incident.	The requirements of PON 8 are fully integrated into the OSRP [Doc. No. 009-15-EHSR-OSR-PA-T3].
PON 10	Application for the use and/or discharge of Non-aqueous Drilling Fluids (NADFs) offshore of the Falkland Islands. Also specifies discharge quality requirements.	No NADFs are proposed for use.
FIG Guidance Note		
Falkland Islands Government Guidance Note 02/13: Approvals required for offshore operations in the Falkland Islands.	Rig Safety Case and Inspection	Safety Case for the *Eirik Raude* has been developed and approved NEFL has a Management System interface Document (MSID) in place
	Oil Spill Contingency Plan	An Oil Spill Response Plan (OSRP) has been developed and will be updated for Rhea-1 [Doc. No. 009-15-EHSR-OSR-PA-T3].
	Emergency Management Plan	An Emergency Management Plan (ERP) (Doc. No. 211-13-EHSR-EMP-PA-T3) has been developed and approved.
	Waste Management Plan	A Waste Management Plan (WMP) [013-15-EHSR-WMP-PA-T4] has been developed and approved.
	Media Strategy Plan	The Media Strategy has been developed and approved.
	Protection and Indemnity Insurance	A Financial Responsibility document will be produced and submitted for approval.

14.5 Overall Conclusion

The overall conclusion of the EIA is that with the implementation of the proposed mitigation controls and the management plans associated with the project, the proposed exploration operation will not result in any significant adverse effects on the environment or the community, which may be affected by potential project environmental impacts.

Table 74: Environmental Controls, Mitigation and Monitoring Measures Identified in the EIA Summarised in the Framework for the Project EMP

Action No	EIA Mitigation and Monitoring Reference	Recommended environmental mitigation measure/monitoring	Objectives of the measure and main concerns to address	Responsible Person / Organisation	Location / timing to implement measures	Achievement Criteria or Standards	Date Started and Complete
1	Section 3.0 Project Description	NEFL to notify the Fisheries Department (FIGFD) of rig moves and new rig locations.	To prevent interference with fishing vessels in the drilling area.	Drilling Superintendent.	Throughout the drilling operations, prior to each rig move.	Notification of FIGFD.	
2	Section 7.0 Underwater noise	Deployment of Marine Mammal Observer to implement JNCC guidelines for Vertical Seismic Profile (VSP) operations.	To prevent trauma to marine mammals, caused by the discharge of airguns.	VSP Co-ordinator (Ops Geologist NEFL).	During VSP operations, which occur for 12-15 hours.	Successful implementation of JNCC guidelines and provisions of MMO report to FIG.	
3	Section 7.0 Underwater noise	Use acoustic survey data to quantify the level of underwater noise produced during the drilling operations.	Verify the risk assessment in the current EIA.	Environmental Lead (NEFL).	Measurements taken during drilling operations.	This will better inform future EIAs.	
4	Section 8.0 Atmospheric Emissions	All vessels employed during drilling and installation activities will comply with MARPOL 73/78 Annex VI, which controls the levels of pollutants entering the atmosphere.	Reduction in Greenhouse Gas Emissions and Air Quality Pollutants.	Vessel masters.	Prior to vessel mobilisation.	All combustion equipment will be subject to regular monitoring and inspections and an effective maintenance regime will be in place, ensuring all combustion equipment runs as efficiently as possible.	

Table 74 continued: Environmental Controls, Mitigation and Monitoring Measures Identified in the EIA Summarised in the Framework for the Project EMP

Action No	EIA Mitigation and Monitoring Reference	Recommended environmental mitigation measure/monitoring	Objectives of the measure and main concerns to address	Responsible Person / Organisation	Location / timing to implement measures	Achievement Criteria or Standards	Date Started and Complete
5	Section 8.0 Atmospheric Emissions	The time spent drilling the well is the predominant factor in overall emissions and this is minimised through the careful planning of the well and by executing the well with a robust drilling platform, using state of the art combustion plant.	Reduce unnecessary emissions of greenhouse gases and local air quality pollutants.	Drilling Superintendent.	Throughout the drilling operations.	Adherence to planned drilling schedule and contractor management.	
6	Section 8.0 Atmospheric Emissions	MARPOL controls on the quality of diesel to limit the sulphur content of fuel to very low levels.	Control emissions of acid gas in the form of sulphur dioxide. Reduce impact of acid rain and local air quality issues.	Vessel Masters.	Throughout the drilling operations.	Vessels will be audited as part of selection and pre-mobilisation.	
7	Section 9.0 Offshore light	Minimise rig and ERRV light emission from accommodation with blackout blinds and general lighting arrangements on the rig. Development of Bird Strike Management Plan.	To prevent and monitor bird strikes.	NEFL Offshore HSE Advisor.	On the rig and vessels at all times.	Monitor and record number of bird strikes, where appropriate. Implementation of NEFL's Bird Strike Management Plan.	
8	Section 10.0 Physical presence of vessels in Stanley Harbour	Marine Superintendent to liaise with Harbour Master. Development of Harbour Management Plan.	Disruption to other users of Stanley Harbour.	Marine Superintendent.	Throughout the drilling operations.	Implementation of Harbour Management Plan.	

Table 74 continued: Environmental Controls, Mitigation and Monitoring Measures Identified in the EIA Summarised in the Framework for the Project EMP

Action No	EIA Mitigation and Monitoring Reference	Recommended environmental mitigation measure/monitoring	Objectives of the measure and main concerns to address	Responsible Person / Organisation	Location / timing to implement measures	Achievement Criteria or Standards	Date Started and Complete
9	Section 10.0 Collision with other vessels in Stanley Harbour	Awareness of other users of Stanley Harbour, Marine Superintendent to liaise with Harbour Master. Development of Harbour Management Plan.	Guard against the release of pollution.	Marine Superintendent.	Throughout the drilling operations.	Implementation of Harbour Management Plan and oil spill contingency plan for the TDF prior to project commencement.	
10	Section 10.0 Collision with marine mammals	NEFL to increase awareness of supply vessels. Increased vigilance in inshore waters.	Prevent injury to marine mammals.	Marine Superintendent.	Throughout the drilling operations.	Supply vessels to record any incidents to NEFL and FIG. Awareness for vessel crews during inductions	
11	Section 10.0 Marine biosecurity	Exchange ballast water off shore. Development of Biosecurity Plan.	Prevent the introduction of non-native species.	Vessel masters.	On passage and arrival in the FI EEZ.	Follow IMO best practice guidelines, record keeping. Implementation of Biosecurity Plan.	
12	Section 10.0 Marine biosecurity	Ensure that vessel biofouling treatments are maintained. Development of Biosecurity Plan.	Prevent the introduction of non-native species.	Vessel masters.	Prior to departure from home ports.	Follow IMO guidelines, record keeping. Implementation of Biosecurity Plan.	
13	Section 10.0 Marine biosecurity	Monitor TDF and Stanley Harbour for non-native species with settlement plates. Development of Biosecurity Plan.	Early detection of potential invasive species.	Environmental Lead NEFL.	Throughout the drilling operations.	Monthly inspection of settlement plates. Implementation of Biosecurity Plan.	
14	Section 10.0 Marine biosecurity	Comply with IMO Guidelines on Biofouling. Development of Biosecurity Plan.	Evaluate the effectiveness of antifouling and verify the assessed risk of introducing non-native species.	Environmental Lead NEFL.	Prior to arrival in FI waters and throughout the campaign.	Internal assurance that the biofouling is acceptable. Implementation of Biosecurity Plan.	

Table 74 continued: Environmental Controls, Mitigation and Monitoring Measures Identified in the EIA Summarised in the Framework for the Project EMP

Action No	EIA Mitigation and Monitoring Reference	Recommended environmental mitigation measure/monitoring	Objectives of the measure and main concerns to address	Responsible Person / Organisation	Location / timing to implement measures	Achievement Criteria or Standards	Date Started and Complete
15	Section 10.0 Helicopter noise disturbance to wildlife	Follow the MoD flight avoidance areas and Falklands Low Flying Avoidance Handbook (July 2014), and develop project specific flight plan.	Prevent disturbance to sensitive wildlife.	Helicopter Operator.	Throughout the drilling operations.	Project specific flight plan and maintenance of flight records to demonstrate adherence to the plan. Educational awareness for those planning flights and pilots.	
16	Section 10.0 Terrestrial biosecurity	Ensure cargo is packed clean, fumigate and use insect traps where appropriate.	Prevent the introduction of non-native species.	Logistics Co-ordinator, NEFL.	As cargo is packed in the UK.	Logistics supply base reputable company with experience in packaging equipment for transport to locations around the world. Adherence to FIG biosecurity guidelines	
17	Section 10.0 Terrestrial biosecurity	Inspections of arriving goods.	Prevent the introduction of non-native species.	NEFL Logistics Supervisor.	As cargo is unloaded in FI.	Adherence to FIG biosecurity guidelines. Report breaches to the FIG Biosecurity Officer.	
18	Section 11.0 Waste Management	Ensure compliance during discharge of grey, black and bilge water and food waste from rig/vessels. Development of Waste Management Plan.	Ensure no floating solids, no discolouration of surrounding water and minimisation of eutrophication.	Environmental Lead NEFL.	Throughout the drilling operations.	Compliance with MARPOL and UK legislation. Implementation of Waste Management Plan.	
19	Section 11.0 Waste Management	Minimisation of waste and appropriate handling, storing and transportation of waste. Development of Waste Management Plan.	Minimise waste production and prevent loss of containment onshore and offshore.	Environmental Lead NEFL.	Throughout the drilling operations.	Compliance with the Waste Minimisation Hierarchy. Implementation of Waste Management Plan. Environmental objective and target to give waste oil to the community for use in oil burners.	

Table 74 continued: Environmental Controls, Mitigation and Monitoring Measures Identified in the EIA Summarised in the Framework for the Project EMP

Action No	EIA Mitigation and Monitoring Reference	Recommended environmental mitigation measure/monitoring	Objectives of the measure and main concerns to address	Responsible Person / Organisation	Location / timing to implement measures	Achievement Criteria or Standards	Date Started and Complete
20	Section 12.0 Discharge of Drilling Mud and Cuttings	ROV surveys of the proposed drilling location for the Rhea-1 well will be conducted prior to commencing drilling activities. The survey will be analysed in real-time by RPS who have taxomonists experienced in Falkland Islands fauna.	Should any sensitive habitats or species be identified, DMR will be notified and agreement to move the well location will be sought.	Environmental Lead NEFL.	Prior to commencing drilling operations.	Characterisation of seabed fauna and habitats from ROV footage. Preparation of technical note summarising findings and identifying species from images. Survey to be conducted in sufficient detail to identify the presence or absence of sensitive habitats or species.	
21	Section 12.0 Discharge of Drilling Mud and Cuttings	Sediment traps will be deployed around the drilling location during operations.	To assess and validate the model sedimentation predictions.	Environmental Lead NEFL.	During drilling operations.	Successful deployment of sediment traps and subsequent data analysis to determine the scale of effects from drilling discharges and provide quality data to validate the dispersion model.	
22	Section 12.0 Discharge of Drilling Mud and Cuttings	Development of Discharge Management Plan.	Minimise discharges of drilling muds and prevent loss of containment offshore.	Environmental Lead NEFL.	During drilling operations.	All discharges will be carried out in line with NEFL's Offshore Discharge Programme (ODPO).	
23	Section 13.0 Accidental Events Uncontrolled release	Blow-out preventer incorporates auto-shear, Well design peer reviewed by well examiner and HSE, Develop an Oil Spill Response Plan (OSRP).	Employ safe working practices to avoid major spills and subsequent impact on the environment.	Drilling Superintendent.	Throughout the drilling operations.	OSRP Rhea-1 well operation addendum to be reviewed by FIG prior to the start of drilling.	

Table 74 continued: Environmental Controls, Mitigation and Monitoring Measures Identified in the EIA Summarised in the Framework for the Project EMP

Action No	EIA Mitigation and Monitoring Reference	Recommended environmental mitigation measure/monitoring	Objectives of the measure and main concerns to address	Responsible Person / Organisation	Location / timing to implement measures	Achievement Criteria or Standards	Date Started and Complete
24	Section 13.0 Accidental Events Accidental loss of containment, diesel spill	Dry break couplings will be used, containment ordered and zero discharge environment, procedures and processes in place to avoid spills.	Minimise the probability of a spill and the quantity of fuel that can be spilt.	Drilling Superintendent / Marine Superintendent.	Throughout the drilling operations.	Adherence to NEFL HSE working practices.	
25	Section 13.0 Accidental Events Loss of riser and drilling mud	DP3 rig, DP trials and verifications conducted prior to operations, auto shear if >10 m off station.	Ensure that the rig maintains station at all times to avoid the loss of the riser and enclosed mud.	Drilling Superintendent.	Throughout the drilling operations.	Internal assurance that the DP system is functioning.	
26	Section 13.0 Accidental Events Major incident leading to loss of rig	500 m exclusion zone patrolled by ERRV, local vessels aware of presence of rig via FLO and FishOps notices to mariners, rig hulls maintained regularly and inspected for integrity.	To ensure that other vessels maintain a safe distance.	Drilling Superintendent.	Throughout the drilling operations.	Regular and open communication with fishing community and notices regularly updated, Oceanrig maintenance regime audited regularly.	
27	Section 13.0 Accidental Events Collision with other vessel in Stanley Harbour	Harbour Management Plan Marine Superintendent to liaise with Harbour Master.	Reduce risk of vessel collisions within the harbour.	Marine Superintendent.	Prior to the arrival of supply vessels and throughout the drilling operations.	Implementation Harbour Management Plan.	

15.0 References

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.

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 Airbus A330-200 Fuel Consumption. https://www.airberlin.com/site/seatplan.php?seatTyp=A330_200_1 [Accessed Aug 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.

Almeda R, Wambaugh Z, Wang Z, Hyatt C, Liu Z, et al. 2013 Interactions between Zooplankton and Crude Oil: Toxic Effects and Bioaccumulation of Polycyclic Aromatic Hydrocarbons. PLoS ONE 8(6): e67212. doi:10.1371/journal.pone.0067212

Alonso-Alvarez C., Munilla I., Lopez-Alonso M. & Velando A., 2007. Sublethal toxicity of the Prestige oil spill on yellow-legged gulls. Environment International. 33, 773-781

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, 2015. 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.

Arata, J. & Xavier, J.C. 2003. The diet of black-browed albatrosses at the Diego Ramirez Islands, Chile. Polar Biology. 145, 593-610

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., 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. & 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., 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., D.A.J. Middleton, A.M. Sirota & R. Grzebielec 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.

Atlantic, O.C.S. 1988. Synthesis of effects of oil on marine mammals. J. R. Geraci, & D. J. S. Aubin (Eds.). Department of the Interior, Minerals Management Service, Atlantic OCS Region.

Au, W.W.L. and M.C. Hastings. 2010. Principles of marine bioacoustics. Springer.

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 to 76.

Barlow, J, & Gentry R. 2004. *Report of the NOAA Workshop on Anthropogenic Sound and Marine Mammals.* 26, National Oceanic and Atmospheric Administration, 2004.

Bastida, R., Roux, A. & Martinez, D.E. 1992. Benthic Communities on the Argentine Continental Shelf. Oceanologica Acta. 15, No. 6.

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., Wolfaardt, A.C., Crofts, S., Pistorius, P.A. & Ratcliffe, N. 2013b. Population status of Southern Rockhopper Penguins (*Eudyptes c. chrysocome*) breeding at the Falkland Islands. Polar Biology. DOI 10.1007/s00300-013-1324-6.

Baylis, A.M.M., Orben, R.A., Pistorius, P., Brickle, P., Staniland, I. and Ratcliffe, N. 2014. Winter foraging site fidelity of king penguins breeding at the Falkland Islands. Marine Biology, DOI 10.1007/s00227-014-2561-0

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.

Belkin, I.M., Cornillon, P.C. & Sherman, K. 2009. Fronts in large marine ecosystems. Progress in Oceanography. 81, 223–236.

Benthic Solutions. 2008. Burdwood Bank, South Falklands Basin. Regional Benthic Environmental Survey. Report for Borders and Southern.

Benthic Solutions. 2008. Regional Benthic Environmental Survey of the Southern North Falklands Basin. Report for Desire Petroleum Plc. Rockhopper Exploration Plc. Arcadia Petroleum Plc.

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.

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 2014a. Country profile: Falkland Islands (Malvinas). Available from: http://www.birdlife.org/datazone/country/falkland-islands-malvinas. Checked: 2014-01-10

BirdLife International 2014b. IUCN Red List for birds. Downloaded from http://www.birdlife.org on 07/07/2014.

Black, A. 2005. Light induced seabird mortality on vessels operating in the Southern Ocean: incidents and mitigation measures. Antarctic Science. 17, 67-68.

BMT, 2005. EIA study for heliport at Yung Shue Wan Lamma Island.

Boltovskoy, D., ed. 2000. South Atlantic zooplankton. Backhuys Publishers, Leiden, 1706 pp.

Bonn Agreement. (2009). Bonn Agreement Aerial Operations Handbook.

Borowitzka, M.A. 1972. Intertidal algal species diversity and the effect of pollution. Australian Journal of Marine Freshwater Research. 23, 73 – 84

BP. 2013. Shah Deniz Stage 2 Project Environmental and Socio-Economic Impact Assessment.

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. 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., Schuchert, P.C., Arkhipkin, A., Randhawa, H. & Reid, M.R. In Press. Otolith trace elemental analyses of South American austral hake, *Merluccius australis* (Hutton, 1872) indicates complex salinity structuring on their spawning grounds. PLoS One.

Britsurvey (*1998*). *Amerada Hess (Falkland Islands) Limited. FI 14/04-A Rockhopper-1 Site Survey Report*

Brooke, M. 2004. Bird families of the world: Albatrosses and petrels across the world. Oxford University Press

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

Bulat, J. and Long D. (2007), Recommended operating guidelines (ROG) for 3D seismic derived seabed imagery, MESH Action WP2.1. January 2007. Available at: http://www.emodnet-seabedhabitats.eu/PDF/GMHM3_3D_seismic_imagery_ROG.pdf

Burger, A. E. 1993. Estimating the mortality of seabirds following oil spills: effects of spill volume. Marine Pollution Bulletin. 26, 140-143.

Burkhardt, E. and C. Lanfredi. 2012. Fall feeding aggregations of fin whales off Elephant Island (Antarctica). Paper SC/64/SH9 presented to the IWC Scientific Committee (unpublished). 6pp.

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.

CABI, 2013. Biological control of the European earwig (*Forficula auricularia*) – a severe threat to horticulture and health & safety on the Falkland Islands. Report to Falkland Islands Government.

CABI, 2014. Invasive Species Compendium, Datasheet-*Carcinus meanus.* (downloaded 14/09/2014) http://www.cabi.org/isc/datasheetreport?dsid=90475

Campagna, C. (IUCN SSC Pinniped Specialist Group) 2008. *Arctocephalus australis*. In: The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on 16 September 2014.

Camphuysen C.J., J. Chardine, M. Frederiksen & M. Nunes. 2005. Review of the impacts of recent major oil spills on seabirds. In: Anonymous (ed.) Report of the Working Group on Seabird Ecology, Texel, 29 March – 1 April 2005. 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.

Catry, P., Campos, A., Segurado, P., Siva, 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.

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. & K. Pütz. 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.

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.

Committee on oil in the sea, 2003. *Committee on oil in the sea: inputs, fates and effects.* National Research Council *of the National Academies, T*he National Academies Press, Washington, D.C. ISBN:978-0-309-08438-3

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 to 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.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.

Cranford, P., K. Querbach, G. Maillet, K. Lee, J. Grant & C. Taggart. 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, 22pp. http://www.dfo-mpo.gc.ca/Library/334183parta.pdf [Accessed September 2014]

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., McInnes, S.J. & Prince, P.A. 1984. The status and conservation of seabirds at the Falkland Islands. In Croxall, J.P, Evans, P.G.H, and Schreiber, R.W. (Eds) Status and Conservation of the Worlds Seabirds. 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

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. http://www.climatechange2013.org/images/report/WG1AR5_Chapter01_FINAL.pdf [Accessed Sept 2014]

Cunningham, A.P., Howe, J.A. & Barker, P.F. 2002. Contourite sedimentation in the Falkland Trough, western South Atlantic Ocean. In Stow, D.A.V., Pudsey, C.J., Howe, J.A., Fauge`res, J.-C., and Viana, A.R., editors. Deep-water contourite systems: modern drifts and ancient series, seismic and sedimentary characteristics. Geological Society of London Memoir. 22, 337–352.

David, A. 2011. Underwater environmental impact assessments on marine mammals and fish by high power anthropogenic radiated sound. Proceedings of Acoustics 2011, Paper 27, 1-8.

Davidson, D., Lear, D. & Parr, J. 2003. Falkland Island Marine Biodiversity Archive. Darwin Initiative 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

DECC, 2014. 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 Sept 2014]

DNV guideline (2012): Dynamic Positioning Vessel Design Philosophy Guidelines, DNV-RP-E306, Høvik, Oslo, Norway.

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.

Durban, J.W. & R.L. Pitman. 2012. Antarctic killer whales make rapid, round-trip movements to subtropical waters: Evidence for physiological maintenance migrations? Biology Letters 8: 274–277.

Erbe, C. 2011 Underwater acoustics: Noise and the effects on Marine Mammals, a pocket Handbook 3rd edition, JASCO Applied Sciences

European Chemicals Bureau (ECB). 2003. Technical Guidance Document on Risk Assessment.

European Environment Agency (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 Sept 2014]

Exploration & Production Forum Oil Industry International. 1994. Methods for Estimating Atmosphere Emissions from E&P Operations. Report No. 2.59/197.

Falkland Islands Government (FIG) – Policy Unit. 2013. Falkland Islands Census 2012. Statistics and Data Tables.

Falkland Islands Government (FIG). 2014. Renewable Energy. http://www.falklands.gov.fk/our-home/renewable-energy/ [Accessed Sept 2014]

Falkland Islands Government. (FIG). 2014. Self-Sufficiency – The Economy. http://www.falklands.gov.fk/self-sufficiency/the-economy/ [Accessed January 2014].

Falkland Islands Government (FIG). 2013. Fisheries Department Fisheries Statistics, vol. 17. FIG Fisheries Department, 2003–2012.

Falkland Island Government (FIG) DMR. 2012. Field Developments Environmental Impact Statements Guidance Notes. Falkland Islands Government.

Falkland Island Government (FIG) DMR (Falkland Islands Government Department of Mineral Resources). 2013. Falkland Islands Designated Exploration Area. http://www.falklands-oil.com/ [Accessed 27 November 2013]

Falkland Island Government (FIG), 2013. Falkland Islands Government, Fisheries Department Fisheries Statistics, Volume 17, 2012: 72 pp Stanley, FIG Fisheries Department

Falkland Island Government (FIG), 2014. Falkland Islands Government, Fisheries Department Fisheries Statistics, Volume 18, 2013: 100pp Stanley, FIG Fisheries Department

FILFH, 2014. Falkland Islands Low Flying Handbook, July 2014

Falkland Islands Tourist Board (FITB). 2014. Cruise Fact Sheet. http://www.falklandislands.com/shopimages/imagelibrary/pdfs/Cruise%20factsheet.pdf. [Accessed, January, 2014]

FAO, 2014. Fishing Techniques. Industrial squid jigging. Technology Fact Sheets. In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 1 January 2001. [Cited 27 August 2014]. http://www.fao.org/fishery/fishtech/1114/en

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.

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, L02607.

FUGRO. 1999. North Falklands Metocean Survey Final Report - Volume 1 19-June-97 to 30-Sep-98. C10317/1762.

García-Borboroglu, P., Boersma, P.D., Reyes, L. & Skewgar, E. 2008. Petroleum Pollution and Penguins: Marine Conservation Tools to Reduce the Problem. In: Hofer, T.N. (ed.). Marine Pollution: New Research. Nova Science Publishers Inc., New York, USA, pp. 339-356.

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.

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.

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.

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, 2015a. Drill cuttings modelling for the Rhea-1 Exploration Well. Document number: J72925D-Y-TN-24000/B2. Prepared for Argos Ltd/Noble Energy.

Genesis, 2015b. Oil spill modelling for the Rhea-1 Exploration Well. Document number: J73727A-Y-TN-24001/B1. Prepared for Argos Ltd/Noble Energy.

Genesis, 2014c. 2015 Exploration Campaign Oil Spill Response Plan. Document number: FK-SL-PMO-EV-PLN-004. Prepared for Premier Oil.

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.

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.

Glasson, J. Therivel, R. & Chadwick, A. 2013. Introduction to Environmental Impact Assessment. Fourth Edition. Natural and Built Environment Series. Routledge.

Glorioso, P., D. & Flather R., A. 1997. The Patagonian Shelf Tides. Progress in Oceanography. 40, 263-283.

Glorioso, P. D. 2002. Modelling the South West Atlantic. Aquatic Conservation: Marine and Freshwater Ecosystems, 12, 27-37.

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.

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.

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.

Guerrero, R.A; Baldoni, A. & Benavides, H. 1999. Oceanographic Conditions at the Southern End of the Argentine Continental Slope. INIDEP Doc. Cient. 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.

Hastings, M.C. & Popper, A.N. 2005. Effects of sound on fish. Report to Jones and Stokes for California Department of Transportation, January 2005. 82pp.

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.

Hendley, N. 1937. The plankton diatoms of the Southern Seas. Discovery Reports Vol XVI, 151-364, Plates VI-XIII.

Hipsey, S.J., J. Delarue, B. Martin, R.D.J. Burns, E. Lumsden. 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.

Holmes et al, 2011 A summary of the biostratigraphic analysis and interpretation of Rockhopper wells drilled to date from the North Falkland Basin. Ichron Limited 2011

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.

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. 58 p.+ app. 13 p.

Huin, N. 2002 Foraging distribution of the black-browed albatross *Thalassarche melanophrys*, breeding in the Falkland Islands. Aquatic Conservation. 12, 89-99.

IEMA, 2008. 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.
http://iwc.int/private/downloads/80ff3jv9j7oko8gcggcw0ocg8/IFAW%20ship%20strike%20English%202013_web.pdf [Accessed September 2014]

Imber, M.J. 1975. Behaviour of petrels in relation to the moon and artificial lights. Notornis. 22, 302-306.

IMO, 2004. International Convention for the Control and Management of Ships' Ballast Water and Sediments (ISBN 92-801-0033-5).

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

Institute of Ecology and Environmental Management (IEEM). 2010. Guidelines for Ecological Impact Assessment in Britain and Ireland.

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.

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.

IWC Database , 2014. IWC global database on ship strikes http://data.iwcoffice.org/whalestrike [Accessed August 2014]

IWC/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.

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.

JNCC 2010, JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys. Joint Nature Conservation Committee, Peterborough

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).

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]

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.

Kyhn, L.A., J. Tougaard, F., Jensen, M.. Wahlberg, G.. Stone, A.. Yoshinaga, K.. Beedholm, & 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.

Laflamme, R.E. & Hites, R. A. 1978. The global distribution of polycyclic aromatic hydrocarbons in recent sediments. Geochim Cosmochim Acta. 42, 289-303.

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.
Mærsk, 2014. P-type anchor handling tug supply vessel. Downloaded from http://www.maersksupplyservice.com/Documents/P-Type%20(L).pdf [Accessed September 2014]

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. 2004. A comparative study of diet in three sympatric populations of Patagonotothen species (Pisces: Nototheniidae). Polar Biology. 63, 428-441.

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.

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. & Black, A.D. 2013. Non-target impacts of Phase II of the South Georgia rat eradication. Unpublished report to the Government of South Georgia and the South Sandwich Islands.

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.

Lewis, J.A. & Coutts, A.D.M. 2010. Biofouling invasions. In: Durr, S. and Thomason, J. C. (Eds). Biofouling. Oxford: Blackwell Publishing. Pg 348-358.

Long, D. (2006). BGS detailed explanation of seabed sediment modified folk classification.
Available online at:
http://www.searchmesh.net/PDF/BGS%20detailed%20explanation%20of%20seabed%20sediment%20modified%20folk%20classification.pdf

López-Martínez, J., Muñoz, A., Dowdeswell, J. a., Linés, C., & Acosta, J. (2011). Relict sea-floor ploughmarks record deep-keeled Antarctic icebergs to 45°S on the Argentine margin. Marine Geology, 288(1-4), 43–48. doi:10.1016/j.margeo.2011.08.002

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.

Marquenie, J. M., & van de Laar, F. 2004. Protecting migrating birds from offshore production. *Shell E&P Newsletter*: January issue.

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.

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.

Matthews, L.H. 1932. Lobster krill: anomuran crustacea that are food of whales. Discovery Reports. 5, 467-484.

McCauley, R.D. 1998. *Radiated Underwater noise measured from the drilling rig Ocean General, rig tenders Pacific Ariki and Pacific Frontier, Fishing vessel Reef Venture and natural sources in the Timor Sea, Northern Australia.* Shell Australia, 1998.

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

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 S1, 111-122

MoD, 2014. Falkland Islands Range and Avoidance Areas. Series: GSGS 5563, Edition 5.

Montagna, P.A., Baguley, J,G., Cooksey, C., Hartwell, I., Hyde, L.J., Hyland, J.L., Kalke, R.D., Kracker, L.M., Reuscher, M. & Rhodes, A.C.E. 2013 Deep-sea benthic footprint of the Deepwater Horizon Blowout. PloS one 8, e70540.

Montevecchi W.A. 2006. Influences of artificial light on marine birds. In: Rich, C.; Longcore, T. (eds.) Ecological consequences of artificial night lighting, pp. 94-113. Island Press, Washington, USA.

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.

Morris, P., & Therivel, R. eds. 2009. Methods of Environmental Impact Assessment. 3rd Edition. Natural and Built Environment Series. Routledge.

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 & marine mammal observations during well test flaring of Sea Lion 14/10-5 in the North Falkland Basin*. Unpublished report to Rockhopper Exploraion PLC.

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.

Nakamura, I., Inada, T., Takeda, M. & Hatanaka, H. 1986. Important Fishes Trawled off Patagonia. Tokyo: Japan Marine Fishery Resource Research Centre.

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 Aug 2014]

National Marine Fisheries Service. 2005. *Recovery Plan for the North Atlantic Right Whale*

National Research Council. 2003. *Oil in the Sea III: Inputs, Fates, and Effects*. Washington, DC: The National Academies Press, 2003.

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.

Nedwell, J.R., Turnpenny, A.W.H., Lovell, J., Parvin, S.J., Workman, R., Spinks, J.A.L. & Howell, D. 2007. A validation of the dB_{ht} as a measure of the behavioural and auditory effects of underwater noise. Subacoustech Report No. 534R1231, 24th October 2007

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. 73 pp. 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]

NEFL, 2015a Environmental Management Plan (EMP) – NEFL 2015, Document number: 010-15-EHSR-EMP-PA-T4

NEFL, 2015b Bird Strike Management Plan (BSMP) - NEFL 2015, Document number: 018-15-EHSR-BSp-PA-T4

NEFL, 2015c Biosecurity Management Plan (BSP) - NEFL 2015, Document number: 021-15-EHSR-BSP-PA-T4

NEFL, 2015d Waste Management Plan (WMPA) - NEFL 2015, Document number: 013-15-EHSR-WMP-PA-T4

NEFL, 2015e Offshore Discharge Program (ODPO) - NEFL 2015, Document number: 062-14-EHSR-ODP-PO-T3

NEFL, 2015f Wildlife Response Plan (WRP) - NEFL 2015, Document number: 022-15-EHSR-WRP-PE-T4

NEFL, 2015g Oil Spill Response Plan (OSRP) - NEFL 2015, Document number: 009-15-EHSR-OSR-PA-T3

NEFL, 2015h Emergency Management Plan (EMPA) – NEFL 2015, Document number: 211-13-EHSR-EMP-PA-T3

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.

Noble Energy/RPS, 2013. *ESHIA for Temporary Dock Facility Stanley Harbour, Falkland Islands*. Noble Energy ESIA, prepared by RPS Energy

Noble Energy/RPS, 2014. Environmental, Social and Health Impact Assessment (ESHIA) for Exploration Drilling Offshore the Falkland Islands. Noble Energy ESIA prepared by RPS Energy, Document number 050-14-EHSR-ESH-PA-T4

NSTF. 1993. North Sea Quality Status Report 1993. North Sea Task Force. Oslo and Paris Commissions, London

OGP/IPIECA, 2010 Alien invasive species and the oil and gas industry: Guidance for prevention and management.

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 Aug 2014]

Oilfield Chemical Technology Ltd. (2011). Sea Lion Underwater Blow Out Simulation dated 17th November 2011. Report RRH.003.

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

OSPAR. 2009a. *Overview of Impact of anthropogenic underwater sound in the marine environment.* Biodiversity Series , OSPAR Commission, 2009.

OSPAR, 2009b. Assessment of impacts of offshore oil and gas activities in the North-East Atlantic. http://qsr2010.ospar.org/media/assessments/p00453_OA3-BA5_ASSESSMENT.pdf [Accessed September 2014]

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]

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., Munro, G., Clausen, A. & Ingham, B. 2008. Falkland Islands State of the Environment Report 2008. Falkland Islands Government and Falklands Conservation, Stanley.

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., J. Smith, & 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.

Pale Maiden Consultancy. 2013. Summary Report: Fishing Activity over the Sea Lion Development Area. Report for Premier Oil.

Parry, M. E. V., Howell, K. L., Narayanaswamy, B. E., Bett, B. J., Jones, D. O. B., Hughes, D. J., Piechaud, N., Nickell, T. D., Ellwood, H., Askew, N., Jenkins, C. and Manca, E. (2015), A Deep-sea Section for the Marine Habitat Classification of Britain and Ireland. JNCC report No. 530.

Patin, S. 2004. Crude Oil Spills, Environmental Impact of, 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.

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, R.A., Silk, J.R.D., Croxall, J.P. and Afanasyev, V. 2006. Year-round distribution of white-chinned petrels from South Georgia: Relationships with oceanography and fisheries. Biological Conservation. 129, 336-347.

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.

PMO/NEFL, 2014. FI (TDF) Operations/Harbour Management Plan. Ducument number:

Polarcus. 2011. Marine Mammal and Sea bird observations during 3D seismic survey in the North Falkland Basin (Nov-10 to May-11). Report for Desire Petroleum Plc and Rockhopper Exploration.

Pompert , H. 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. pp 111.

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.

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.

Premier Oil Falkland Islands Business Unit. 2014. North Falklands Coastline Environmental Sensitivity for Oil Spill Response. September 2014. pp 154.

Premier Oil FIBU HSES Element Standard. FK-BU-HS-ST-0005

Pütz, K., R.J. Ingham & J.G. Smith 2000b Satellite tracking of the winter migration of Magellanic Penguins *Spheniscus magellanicus* breeding in the Falkland Islands. Ibis. 142, 614-622.

Pütz, K., R.J. Ingham & J.G. Smith 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.

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

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.

Reed, J.R., Sincock, J.L. & Hailman, J.P. 1985. Light attraction in endangered procellariiform birds: reduction by shielding upward radiation. Auk. 102, 377-383.

Regeneris Consulting Ltd (Regeneris). 2013. Socio-economic Study of Oil and Gas Development in the Falklands. Report for the Falkland Islands Government.

Reid, T.A. and 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.

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. <www.iucnredlist.org>. Downloaded on 25 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>. Downloaded on 13 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, vol. 20(2), April 1997

Richards, P.C. & Hillier,B.V., 2000 Post Drilling Analysis of the North Falkland Basin – Part 1: Tectono-Stratigraphic Framework. Journal of Petroleum Geology, vol. 23(3), July 2000

Richardson, W.J., Greene, C.R., Malme, C.I. & Thompson, D.H. 1995. *Marine ammals 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.

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 aphalopods 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

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.

Rosalind 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.

RPS Energy. 2009. Environmental Impact Statement for Offshore Drilling Licences PL032 & PL033 in the Falkland Islands. Report for Rockhopper Exploration.

RPS Energy. 2015. Rhea-1 Regional Environmental Habitat Assessment SUMMARY. Report for Noble Energy

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.

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.

Salazar, S. 2003. Impacts of the Jessica oil spill on sea lion (*Zalophus wollebaeki*) populations. Marine Pollution Bulletin. 47, 313-318.

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]

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.

Širović, A., Hildebrand, J.A. & Theile, D. 2006. Baleen whales in the Scotia Sea during January and February 2003. Journal of Cetacean Research and Management. 8, 161-171.

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.

Smit M.G.D., Holthaus K.I.E., Kaag N.B.H.M., Jak R.G. 2006. The derivation of a PNEC-water for weighting agents in drilling mud. ERMS Report no.6. TNO-Report 2006-DH-0044/A. http://www.sintef.com/project/ERMS/Reports/ERMS%20Report%20no%206_PNEC%20for%20weighting%20agents_TNO.pdf [Accessed September 2014]

SMRU (Sea Mammal Research Unit), 2001. Background Information on Marine Mammals Relevant to SEA 2. Technical Report produced for Strategic Environmental Assessment ⎵ SEA 2. Technical Report TR_006.

SMSG, 2011. *Survey report: Invasive species, March 2011*. Unpublished Shallow Marine Surveys Group report.

SMSG. 2013. 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. June - August, 2013.

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., and Tyack, P. 2007. Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. Aquatic Mammals. 33, 411-521.

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.

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. 2013. Falkland Islands Seabird Monitoring Programme Annual Report 2012/2013 (SMP20). Falklands Conservation (FC).

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.

Tarling, G. A., Ward, P. Shaeder, M. Willimas, J. A. & Symon, C. 1995. Distribution patterns of macrozooplankton assemblages in the southwest Atlantic. Marine Ecology Progress Series. 120, 29-40

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.

Tasker ML, Pienkowsk MW VULNERABLE Concetrations of Birds in the North Sea. Nature Conservation Council, cop., 1987.

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. & 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.

Tjallema, A., van der Nat, C., Grimmelius, H., & Stapersma, D. 2007. The road to eliminating operator related dynamic positioning incidents. In Dynamic Positioning Conference (pp. 1-17).

Tussenbroek, B.I. 1989. Seasonal growth ad composition of fronds of *Macrocystis pyrifera* in the Falkland Islands. Marine Biology. 100, 419-430.

U.S. Energy Information Administration (EIA). US Department of Energy - International Energy Statistics. http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=90&pid=44&aid=8 [Accessed Sept 2014]

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. UKOOA Drill Cuttings Initiative, Research and Development Programme. Report by Dames and Moore; and NIOZ.

Underhill, & Lohr, 2003. Controls on the Tectono Stratigraphic Evolution of the North Falkland Basin ERC Equipoise Limited 2013

Upson, R. 2012. Important Plant Areas of the Falkland Islands. Unpublished Report, Falklands Conservation. 80pp.

Vander Werf, E.A., Elliott, L. & Scott Fretz, J. 2005. Observations on the abundance and behaviour of seabirds of O'Ahu during the F/V *Ehime Maru* relocation and fuel spill. Elepaio. 65, 25-29 .

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., Griffiths, H.J. & Rodhouse, P.G. 2008. Remotely sensed spatial dynamics of the *Illex argentinus* fishery, Southwest Atlantic. Fisheries Research. 91, 196–202

Waluda, C.M., & Staniland, I.J. 2013. Entanglement of Antarctic fur seals at Bird Island, South Georgia. Marine Pollution Bulletin. 74, 244-252.

Warham, J. (1990). The Petrels: Their Ecology and Breeding Systems. London: Academic Press.

Warham, J. (1996). The Behaviour, Population Biology and Physiology of the Petrels. London: Academic Press.

Watkins, W.A. 1981. Activities and underwater sounds of fin whales. Scientific Reports of the Whales Research Institute. 33, 83-117.

WDCS 2006. Vessel collisions and cetaceans: What happens when they don't miss the boat? A Whale and Dolphin Conservation Society Report by Dolman, S., Williams-Grey, V., Asmutis-Silvia, R. and Isaac, S.

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

White, H. K., Hsing, P. Y., Cho, W., Shank, T. M., Cordes, E. E., Quattrini, A. M., & Fisher, C. R. 2012. Impact of the Deepwater Horizon oil spill on a deep-water coral community in the Gulf of Mexico. Proceedings of the National Academy of Sciences. 109, 20303-20308.

Whitehead, H. 2003. Sperm whales: Social evolution in the ocean. The University of Chicago Press.

Wiese, F.K. 2002. *Seabirds and Atlantic Canada's Ship-Source Oil Pollution: Impacts, Trends, and Solutions*. Prepared for World Wildlife Fund Canada. Toronto, Canada.

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.

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., 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. 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

Wursig, B. (1988). Cetaceans and Oil: Ecologic Perspectives. Synthesis of Effects of Oil on Marine Mammals. Report.

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.

Youngblood, W.W. & Blumer, M. 1975. Polycyclic aromatic hydrocarbons in the environment: homologues series in soils and recent marine sediments. Geochim Cosmochim 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.

Noble Energy Falkland Islands Limited

Rhea-1 Exploration Well
Environmental Impact Statement

APPENDICES

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Appendices Contents

Appendix A: Chemical and Heavy Metal Properties of North Falkland Basin Sediments

Table 1. Chemical Properties of North Falkland Basin Sediments and Comparative Data Sets

Location	No. Stations	Depth (m)	TOM (%)	TOC (%)	THC (µg/g^{-1})	UCM (µg/g^{-1})	total n-alkanes (µg/g^{-1})	NDP (µg/g^{-1})	PAH (µg/g^{-1})
NFB Sea Lion EBS GSL 2012									
Sea Lion Area Survey	54	426-456	5.6 ±0.5	0.9 ±0.1	9.7 ±2.7	8.4 ±1.5	0.55 ±0.1	0.05 ±0.01	0.12 ±0.02
NFB Sea Lion Post-Drill GSL 2012									
Rockhopper Well 14/10-2	8	448-450	5.6 ±0.3	0.9 ±0.1	8.3 ±2.8	7.6 ±2.4	0.67 ±0.61	0.05 ±0.02	0.10 ±0.03
Rockhopper Well 14/10-6	8	445-455	5.4 ±0.3	0.9 ±0.1	7.7 ±4.3	7.2 ±4.2	0.49 ±0.14	0.04 ±0.01	0.10 ±0.04
Rockhopper Well 14/10-9	6	440-449	5.5 ±0.5	0.9 ±0.1	9.9 ±2.4	9.1 ±2.2	0.75 ±0.34	0.06 ±0.01	0.15 ±0.01
Rockhopper Well 14/15-4a	6	432-438	4.9 ±0.6	0.8 ±0.1	9.2 ±1.8	8.4 ±1.5	0.80 ±0.32	0.05 ±0.01	0.13 ±0.02
Shell Well 14/10-1	6	440-446	5.6 ±0.4	1.0 ±0.1	7.0 ±2.1	6.4 ±2.1	0.59 ±0.17	0.05 ±0.01	0.13 ±0.03
Comparison Data									
FOSA 1998 Surveys									
NFB 14/09 Little Blue (GSL 1998a)	15	415-456	5.7 ±3.1	na	0.1 ±0.09	0.1 ±0.08	0.02 ±0.01	0.02 ±0.01	0.06 ±0.06
NFB Little Blue post-drilling (GSL 1998i)	14	416	3.2 ±1.7	na	0.66 ±0.4	0.60 ±0.4	0.05 ±0.04	0.07 ±0.05	0.15 ±0.09
NFB 14/05 B1 (GSL 1998b)	14	462-482	4.3 ±1.9	na	0.25 ±0.0.1	0.22 ±0.1	0.03 ±0.03	0.03 ±0.02	0.07 ±0.06
NFB 1414a (GSL 1998c)	14	358-397	3.8 ±1.6	na	0.15 ±0.07	0.12 ±0.06	0.04 ±0.02	0.02 ±0.01	0.06 ±0.03
NFB 14/23a (GSL 1998d)	13	215-285	1.8 ±1.4	na	1.2 ±0.8	0.92 ±0.8	0.20 ±0.07	0.03 ±0.03	0.09 ±0.05
NFB 14/24 Braela (GSL 1998e)	13	230-253	2.9 ±3.2	na	2.4 ±1.7	1.6 ±1.5	0.7 ±0.5	0.05 ±0.06	0.12 ±0.14
NFB F1 14/19a (GSL 1998f)	13	353-367	4.5 ±2.5	na	0.2 ±0.05	0.17 ±0.05	0.04 ±0.02	0.02 ±0.02	0.05 ±0.05
NFB Minke 14/13b (GSL 1998h)	13	371-394	3.2 ±0.7	na	4.6 ±4.1	2.8 ±2.9	1.6 ±1.25	0.20 ±0.20	0.72 ±0.86
Other Surveys on the Falklands Continental Shelf									
sNFB BSL 2008	77	140-285	1.7 ±0.4	0.46 ±0.13	4.3 ±1.4	92-97%	0.21 ±0.05	0.001 ±0.002	0.001 ±0.002
SFB (Burdwood Bank) B&S 2010	23	1,200-2,100	3.5 ±0.6	0.31 ±0.1	12.8 ±5.0	88.8-91.9%	1.17 ±0.41	0.16 ±0.06	0.30 ±0.12
SFB Toroa BHP 2009	6	620 ±44	6.0 ±0.8	0.73 ±0.05	8.7 ±1.1	5.7 ±0.6	0.65 ±0.09	0.17 ±0.02	0.22 ±0.02
EPB Endeavour BHP 2009	Unknown	1,372 ±36	4.8 ±0.5	0.36 ±0.04	5.4 ±1.0	3.2 ±0.6	0.41 ±0.06	0.07 ±0.02	0.08 ±0.02
EPB Nimrod BHP 2009	Unknown	1,284 ±14	6.8 ±0.8	0.27 ±0.02	3.7 ±0.3	2.4 ±0.3	0.31 ±0.05	0.06 ±0.01	0.07 ±0.01
EPB Loligo BHP 2009	3	1,412 ±41	5.3 ±0.5	0.27 ±0.04	3.0 ±1.0	2.0 ±0.8	0.25 ±0.06	0.10 ±0.05	0.12 ±0.05

Table 2. Heavy Metal Concentrations of North Falkland Basin Sediments and Comparative Data Sets

Location	**Al** (mg.g^{-1})	**As** (µg/g^{-1})	**Ba** (µg/g^{-1})	**Cd** (µg/g^{-1})	**Cr** (µg/g^{-1})	**Cu** (µg/g^{-1})	**Hg** (µg/g^{-1})	**Ni** (µg/g^{-1})	**Pb** (µg/g^{-1})	**Sn** (µg/g^{-1})	**V** (µg/g^{-1})	**Zn** (µg/g^{-1})
NFB Sea Lion EBS GSL 2012												
Sea Lion Area Survey	47.8 ±5	3.6 ±0.3	335 ±37	0.3 ±0.2	46 ±4	22 ±4	0.03 ±0.01	18 ±1	7.5 ±1.0	1.8 ±0.7	78 ±4	71±6
NFB Sea Lion Post-Drill GSL 2012												
Rockhopper Well 14/10-2	50.7 ±1.9	3.6 ±0.3	378 ±43	0.2 ±0.2	45 ±2	20 ±3	0.03 ±0.01	17 ±1	7.3 ±1.0	1.5 ±0.1	76 ±1.0	73 ±10
Rockhopper Well 14/10-6	51.5 ±1.0	3.4 ±0.3	380 ±34	0.2 ±0.1	42 ±1	18 ±1	0.03 ±0.01	16 ±1	6.7 ±0.2	1.2 ±0.1	75 ±3	67 ±2
Rockhopper Well 14/10-9	47.2 ±2.9	4.0 ±0.3	336 ±21	0.1 ±0.1	47 ±3	20 ±1	0.04 ±0.01	18 ±1	7.4 ±0.3	1.8 ±0.3	84 ±4	78 ±6
Rockhopper Well 14/15-4a	47.9 ±3.3	4.2 ±0.1	372 ±42	0.2 ±0.1	48 ±1	19 ±1	0.02 ±0.00	18 ±1	7.8 ±0.2	3.0 ±0.5	86 ±2	77 ±3
Shell Well 14/10-1	50.7 ±1.6	3.5 ±0.2	372 ±9	0.2 ±0.2	44 ±2	18 ±2	0.02 ±0.01	18 ±1	7.0 ±0.4	2.6 ±1.7	81 ±5	78 ±12
Comparison Data												
FOSA 1998 Surveys												
NFB Little Blue GSL 1998a	52.8 ±7.0	na	382 ±34	<0.5	45 ±4.6	14.1 ±2.5	1.1 ±0.7	15.3 ±1.4	1.3 ±0.7	na	<0.5	67 ±4.6
NFB Little Blue P.D GSL 1998i	92.9 ±7.9	na	386 ±27	<0.1	64 ±20	13.5 ±1.6	4.9	16.7 ±1.2	<0.1	na	73.1 ±7.0	52.8 ±6.2
NFB B1 GSL 1998b	57.1 ±6.1	na	383 ±23	<0.5	43 ±3.8	15.7 ±2.3	1.3 ±0.7	14.7 ±1.8	0.9 ±0.3	na	70 ±4.9	59 ±5.8
NFB 14/14a GSL 1998c	55.9 ±8.8	na	384 ±28	<0.5	47 ±4.1	15.3 ±2.5	1.1 ±0.9	15.5 ±1.7	<0.5	na	69 ±4.3	57 ±5
NFB 14/23a GSL 1998d	71.2 ±10.0	na	289 ±56	<0.5	36 ±2.7	3.2 ±0.9	<0.5	<0.5	<0.5	na	70.8 ±8.3	29 ±2.0
NFB 14/24 Braela GSL 1998e	55.8 ±7.7	na	311 ±30	<0.5	31 ±2.4	3.1 ±1.1	<0.5	<0.5	<0.5	na	69 ±6.2	26 ±2.4
NFB F1 14/19a GSL 1998f	53.3 ±7.3	na	374 ±28	<0.5-2.0	45 ±2.1	16.1 ±1.8	<0.5-1.0	15.6 ±1.1	<0.5	na	69 ±5.8	57 ±5.7
NFB Minke 14/13b GSL 1998h	60.8 ±6.4	na	391 ±29	<0.5	57 ±7.6	16.9 ±2.6	<0.5	7.4 ±1.9	<0.5-1	na	87 ±4.8	61 ±4.3
Other Surveys on the Falklands Continental Shelf												
sNFB BSL 2008	35.3 ±13.4	3.6 ±1.4	236 ±61	0.4 ±0.1	27 ±6.5	5.5 ±1.6	0.01	6.4 ±1.5	5.8 ±1.6	na	29 ±8.0	27 ±9.7
SFB (PL018) B&S 2010	40.8 ±7.4	9.8 ±6.5	782 ±548	na	44 ±11	14.6 ±2.9	0.16 ±0.07	8.4 ±1.4	9 ±3.1	na	59 ±7.3	60 ±7.4
SFB Toroa BHP 2009	59.4 ±2.5	na	407 ±9	1.0 ±0.0	32±4.5	13.7 ±1.4	na	12.2 ±1.3	6.2 ±0.7	na	54 ±0.9	42 ±3.7
EPB Loligo BHP 2009	30.3 ±7.0	na	329 ±51	0.9 ±0.0	150 ±31	13.9 ±2.7	na	14.3 ±1.1	7.2 ±0.6	na	38 ±0.7	40 ±1.3
EPB Nimrod BHP 2009	30.5 ±7.4	na	342 ±93	0.4 ±0.1	136 ±25	10.7 ±1.6	na	13.3 ±1.3	6.2 ±1.2	na	67 ±2.2	75 ±6.7
EPB Endeavour BHP 2009	23.5 ±5.9	na	307 ±69	1.1 ±0.1	129 ±28	9.1 ±2.0	na	7.5 ±0.6	6.1 ±0.8	na	37 ±1.9	55 ±16.3

Appendix B: Benthic Fauna

Table 1. The Ten Most Abundant Species In the Sea Lion Field

Species	Survey & species dominance ranking	
	2012a	2012b
Onuphis pseudoiridescens	1	1
Allotanais hirsutus	2	4
Yoldiella spp	3	2
Mendicula spp.	4	5
Fabriciinae sp 5	5	6
Phoxocephalidae sp H	6	3
Aricidea (Acmira) *minifica*	7	7
Phoxocephalidae sp M	8	8
Amphipoda sp D	9	-
Gammaridae sp Z	10	-
Amphipoda sp AI	-	9
Gammaridae sp L	-	10

Source: Gardline. 2012a baseline survey; 2012b post-drilling survey. Blue = Crustaceans; Red = Polychaetes; Yellow = Molluscs.

Table 2. Number of Taxa and Species of Each Taxonomic Group at each Survey Station, and Percentage of the Total Each Group Forms, During 1998 FOSA Surveys.

Site*	Taxa	Annelida		Crustacea		Mollusca		Echinodermata		Foraminifera		Other
		Species	%	Species	%	Species	%	Species	%	Species	%	%
A	144	63	43.8	36	25	20	13.8	7	4.9	7	4.9	7.6
B	127	53	41.7	34	26.8	16	12.6	7	5.5	6	4.7	13.4
C	179	60	33.5	58	32.4	26	14.5	17	9.5	-	-	10.1
D	124	56	42.5	33	26.6	15	12.1	15	7.3	-	-	12.4
E	144	61	42.4	44	30.6	19	13.2	8	5.6	-	-	8.2
F	157	61	38.9	43	27.4	19	12.1	15	9.6	-	-	12
H	171	68	39.8	52	30.4	15	8.8	17	9.9	-	-	11.1
I	154	65	42.25	42	27.3	18	11.7	8	5.2	8	5.2	8.4

*A = Little Blue A; B = B1; C = 14/14-A; D = 14/23-A; E = Braela 14/24; F = F1 14/19-A; H = Minke 14/13; I = Little Blue post-drill

Table 3. The Ten Most Dominant Species at Each Survey Station during the 1998 FOSA Surveys.

Species	**Sample location* and species dominance ranking**							
	A	**B**	**C**	**D**	**E**	**F**	**H**	**I**
Archaeotanais hirsutus	1	-	-	-	-	-	-	1
Onuphis aff holobranchiata	2	-	3	-	-	2	1	2
Foraminiferan sp C	3	1	4	-	-	5	5	3
Cyclammina spp.	4	7	5	5	6	4	4	4
Urothoe spp	5	4	2	3	3	3	2	5
Edwarsiidae spp.	6	-	-	-	-	-	-	6
Lumbrineris sp.B	7	-	-	-	-	-	-	7
Mediomastus sp.	8	-	-	-	-	-	-	8
Aricidea sp B	9	8	7	6	-	6	-	9
Phoxocephalidae sp A	10	3	1	4	5	1	3	10
Spiophanes spp	-	2	-	-	-	-	6	-
Scoloplos spp	-	5	-	-	-	-	-	-
Sternapsis scutata	-	6	-	-	-	-	-	-
Cirriformia spp	-	9	-	-	-	-	-	-
Phoxocephalidae sp B	-	10	10	-	-	-	-	-
Sabellidae sp A	-	-	6	-	-	7	8	-
Nematoda spp	-	-	8	-	-	8	9	-
Melythasides spp	-	-	9	-	-	-	-	-
Aricidea sp C	-	-	-	1	1	-	10	-
Cirratulidae spp	-	-	-	2	2	-	-	-
Aricidea sp D	-	-	-	7	7	-	-	-
Levinsemia spp.	-	-	-	8	4	-	-	-
Ophelina sp A	-	-	-	9	8	-	-	-
Ophiuroidea sp A	-	-	-	10	-	-	-	-
Thyasira spp.	-	-	-	-	9	-	-	-
Ampelisea spp.	-	-	-	-	10	-	-	-
Lumbrineris sp A	-	-	-	-	-	9	7	-
Amphiura spp.	-	-	-	-	-	10	-	-

*A = Little Blue A; B = B1; C = 14/14-A; D = 14/23-A; E = Braela 14/24; F = F1 14/19-A; H = Minke 14/13; I = Little Blue post-drill; Red = Polychaetes, blue = Crustaceans; yellow = Molluscs; green = Foraminifera; grey = Anthozoa; purple = Echinodermata

Appendix C: Marine Mammal Survey Data

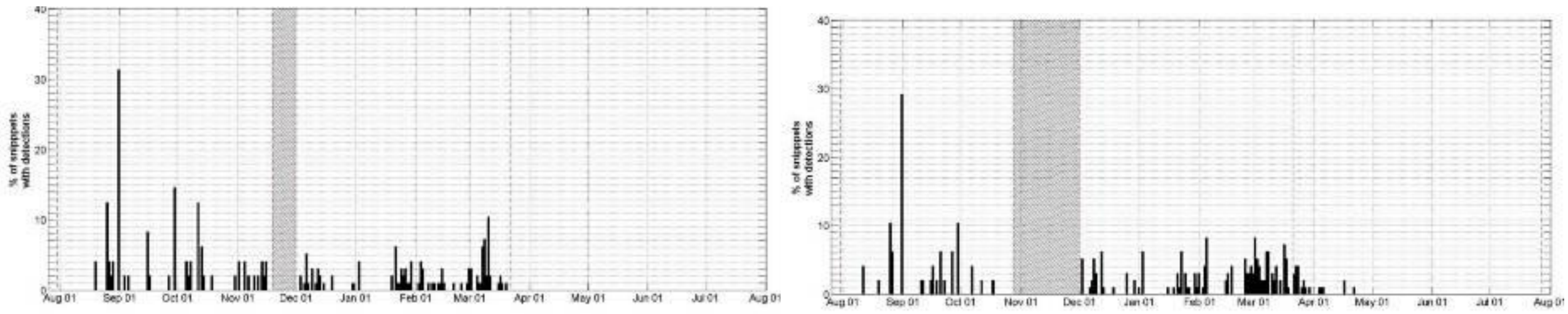


Figure 1: Daily proportion of fin whale call detections, AMAR 1 – left, AMAR 2 - right. Grey dashed bar indicates deployment dates, shaded area indicated data gaps (Hipsey et al., 2013).

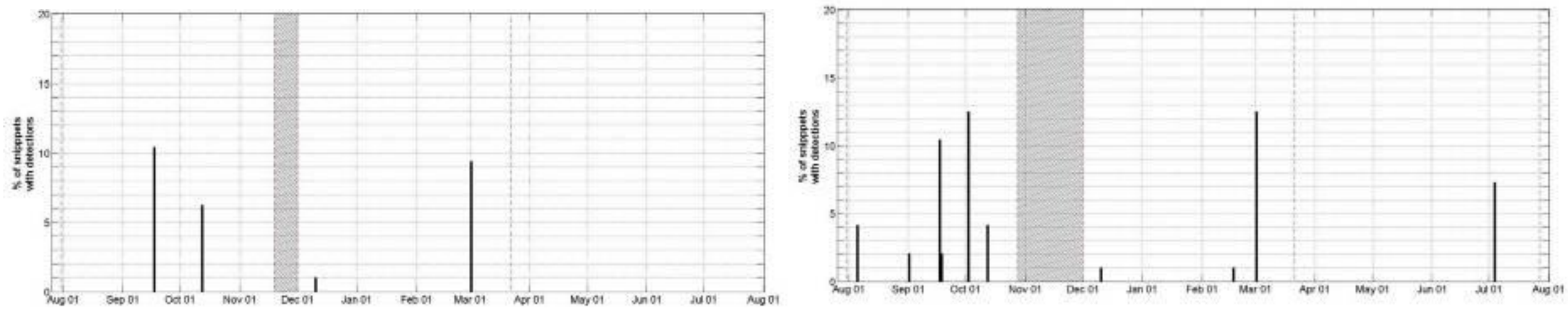


Figure 2: Daily proportion of killer whale call detections, AMAR 1 – left, AMAR 2 - right. Grey dashed bar indicates deployment dates, shaded area indicated data gaps (Hipsey et al., 2013).

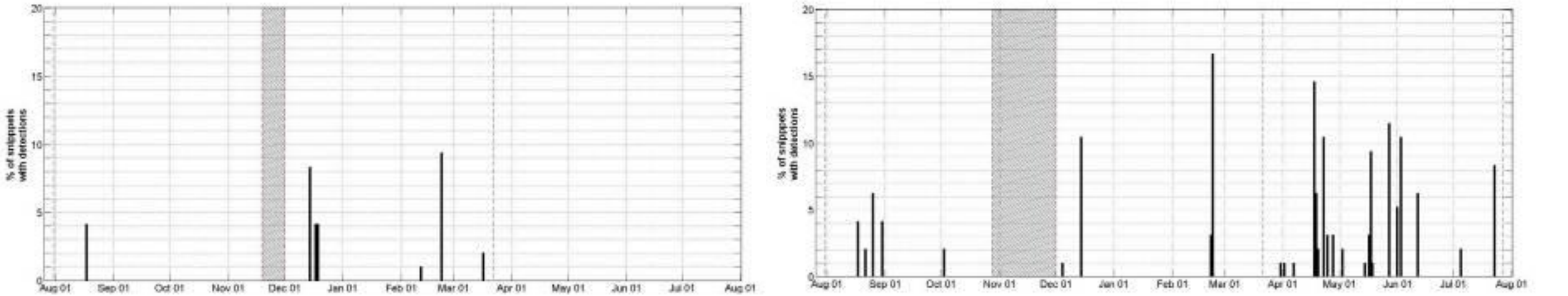


Figure 3: Daily proportion of pilot whale call detections, AMAR 1 – left, AMAR 2 - right. Grey dashed bar indicates deployment dates, shaded area indicated data gaps (Hipsey et al., 2013).

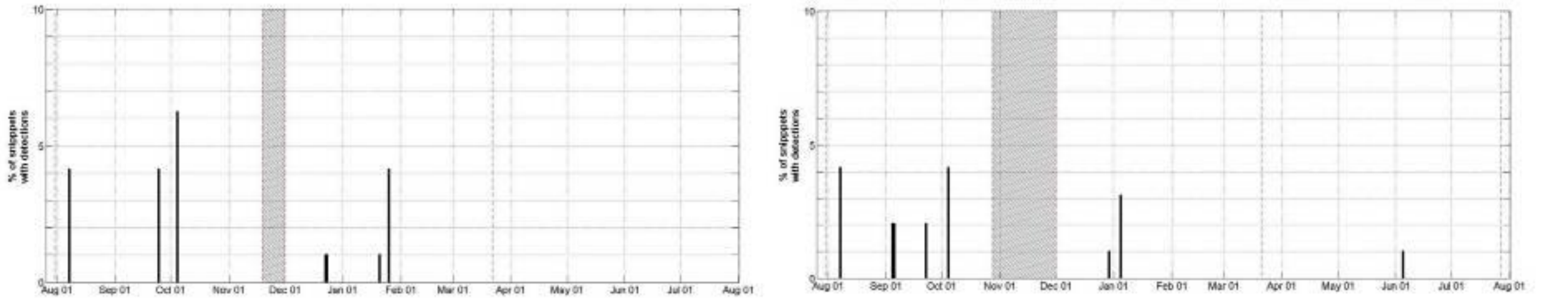


Figure 4: Daily proportion of Southern right whale call detections, AMAR 1 – left, AMAR 2 - right. Grey dashed bar indicates deployment dates, shaded area indicated data gaps (Hipsey et al., 2013).

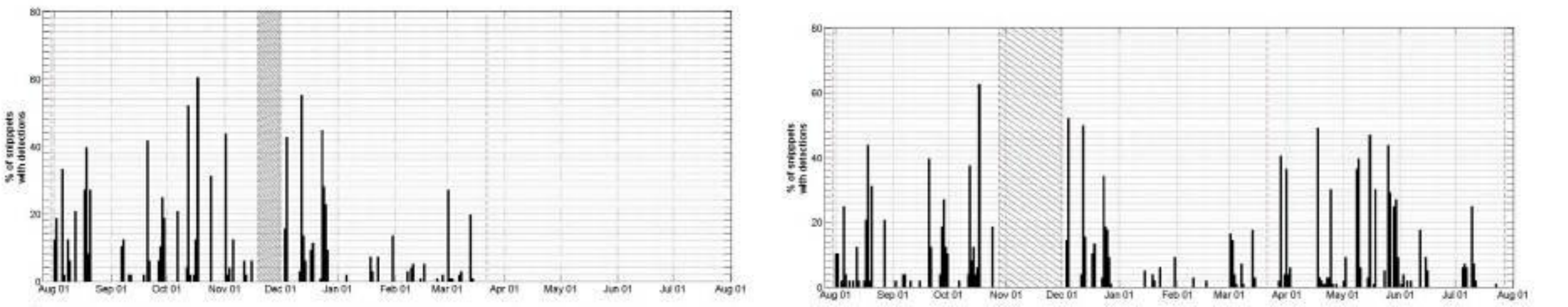


Figure 5: Daily proportion of sperm whale call detections, AMAR 1 – left, AMAR 2 - right. Grey dashed bar indicates deployment dates, shaded area indicated data gaps (Hipsey et al., 2013).

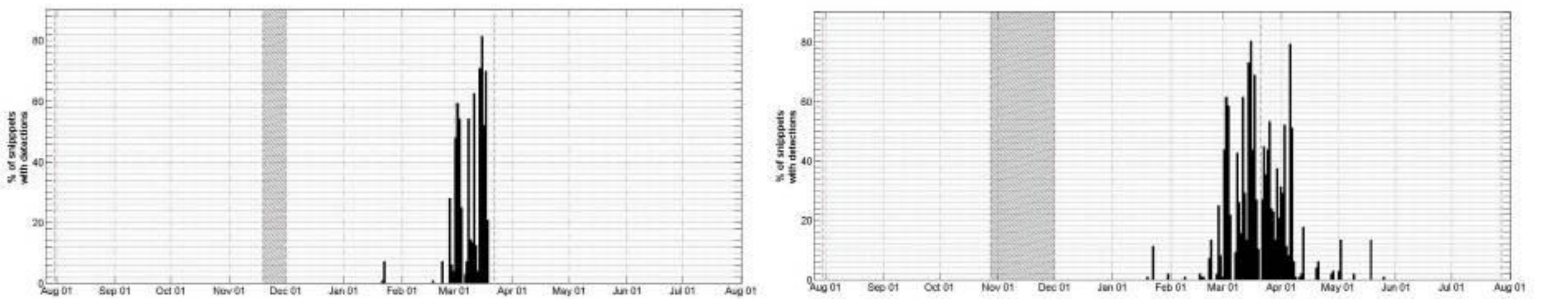


Figure 6: Daily proportion of leopard seal call detections, AMAR 1 – left, AMAR 2 - right. Grey dashed bar indicates deployment dates, shaded area indicated data gaps (Hipsey et al., 2013).

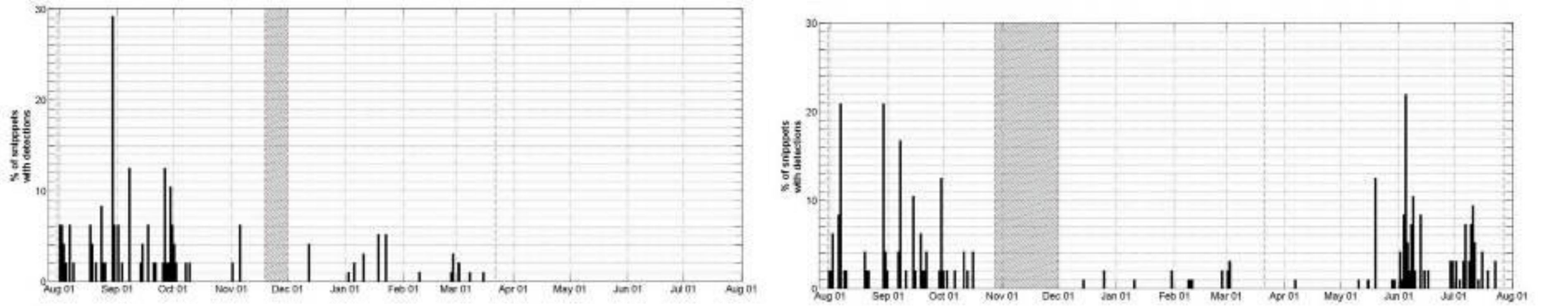


Figure 7: Daily proportion of unidentified odontocete call detections, AMAR 1 – left, AMAR 2 - right. Grey dashed bar indicates deployment dates, shaded area indicated data gaps (Hipsey et al., 2013).

Table 1: Summary of the Number of Individuals and Sightings of Marine Mammals from the JNCC At-Sea Survey and the Number of Marine Mammals Strandings (Otley et al., 2011 & 2012) on the Falkland Islands, with their Conservation Status

Species Common Name	Scientific name	Number of animals	Number of sightings	Number of stranding	IUCN	CMS	CITES
Peale's dolphin	*Lagenorhynchus australis*	2617	864	-	DD	Appendix II	Appendix II
Fur seal species	*Arctocephalus spp.*	937	442	-	LC	Appendix II	Appendix II
Hourglass dolphin	*Lagenorhynchus cruciger*	886	177	-	LC	-	Appendix II
Long-finned pilot whale	*Globicephala melas*	872	27	-	DD	Appendix II	Appendix II
Commerson's dolphin	*Cephalorhynchus commersonii*	336	100	-	DD	Appendix II	Appendix II
Southern right whale dolphin	*Lissodelphis peronii*	231	5	-	LC	-	Appendix II
Dolphin species	*n/a*	184	57	-	-	-	-
South American sea lion	*Otaria flavescens*	81	77	-	LC	Appendix II	-
Minke whale	*Balaenoptera acutorostrata*	68	60	-	LC	Appendix II	-
Fin whale	*Balaenoptera physalus*	57	27	-	EN	Appendix I, II	-
Unidentified pinniped	*n/a*	56	46	-	-	-	-
Sei whale	*Balaenoptera borealis*	45	31	-	EN	Appendix I, II	Appendix I
Large whale species	*n/a*	44	40	-	-	-	-
Southern bottlenose whale	*Hyperoodon planifrons*	34	18	5	LC	-	Appendix I
Sperm whale	*Physeter macrocephalus*	28	21	-	VU	Appendix I, II	Appendix I
Killer whale	*Orcinus orca*	18	7	-	DD	Appendix II	Appendix II
Beaked whale species	*Mesoplodon species*	17	7	-	-	-	-
Southern elephant seal	*Mirounga leonina*	13	13	-	LC	-	Appendix II
Medium/small whale species	*n/a*	12	10	-	-	-	-
Humpback whale	*Megaptera novaeangliae*	7	5	-	LC	Appendix I	Appendix I
Southern right whale	*Eubalaena australis*	7	6	-	LC	Appendix I	Appendix I
Arnoux's beaked whale	*Berardius arnuxii*	-	-	4	DD	-	Appendix I
Andrews' beaked whale	*Mesoplodon bowdoini*	-	-	3	DD	-	Appendix II
Gray's beaked whale	*Mesoplodon grayi*	-	-	4	DD	-	Appendix II

Species Common Name	Scientific name	Number of animals	Number of sightings	Number of stranding	IUCN	CMS	CITES
Hector's beaked whale	*Mesoplodon hectori*	-	-	3	DD	-	Appendix II
Strap-toothed whale	*Mesoplodon layardii*	-	-	10	DD	-	Appendix II
Cuvier's beaked whale	*Ziphius cavirostris*	-	-	4	DD	-	Appendix II
Dusky dolphin	*Lagenorhynchus obscurus*	-	-	4	DD	Appendix II	Appendix II
Bottlenose dolphin	*Tursiops truncatus*	-	-	4	LC	Appendix II	Appendix II
Spectacled porpoise	*Phocoena dioptrica*	-	-	3	DD	Appendix II	Appendix II
Pygmy right whale	*Caperea marginata*	-	-	1	DD	Appendix II	Appendix I
False killer whale	*Pseudorca crassidens*			2	DD	-	Appendix II

*IUCN Status Key – DD – Data deficient, LC – Least Concern, VU – Vulnerable, EN - Endangered

Appendix D: Seabird Sightings at Sea – PL001 and NFB Survey 2011

Bird Species Common name	PL001: 11/01/11 - 02/05/11[1]			NFB: 25/11/10 - 05/05/11[2]			Falklands Breeding Population Size[3]	Global Population Size[4]	% Global Population Size[3]	CMS App II, ACAP Annex I[3]	IUCN Red List Category[3]	Global Population Trend[3]	IBA[3]
	Rank	No. of Birds	No. of group sightings	Rank	No. of Birds	No. of group sightings							
Black-browed albatross	1	3118	1790	1	5043	1733	500,000 pairs[5]	700,000 pairs	76%	YES	**NT**	Decreasing	A1 A4ii
Great shearwater	2	2106	1325	3	1004	336	15 pairs	5,000,000 pairs	<0.1%	-	LC	Stable	-
Soft-plumaged petrel	3	1257	1000	6	318	255	ND	5,000,000 individuals	-	-	LC	Stable	-
White-chinned petrel	4	1100	1011	2	1633	698	1,000 pairs	1,200,000 pairs	<0.1%	YES	**VU**	Decreasing	A1
Prion spp. (inc Blue petrel)	5	552	454	5	488	325	ND	3,000,000 individuals	-	-	LC	Stable	-
Giant petrel species	6	411	370	4	574	391	-	-	-	-	LC	Increasing	-
Sooty shearwater	7	338	144	11	17	15	100,000 pairs	20,000,000 pairs	0.1%	-	**NT**	Decreasing	A1 A4ii
Wilsons storm-etrel	8	229	213	7	262	166	ND	4-10,000,000 pairs	-	-	LC	Stable	-
Atlantic petrel	9	173	161	23	2	2	ND	1,800,000 pairs	-	-	**EN**	Decreasing	-
Southern royal albatross	10	172	138	12	16	16	ND	7,900 pairs, 27,200 individuals	-	YES	**VU**	Stable	-
Cape petrel	11	170	105	20	4	3	ND	2,000,000 individuals	-	-	LC	Stable	-
Manx shearwater	12	158	9	NR	NR	NR	ND	1,000,000 individuals	-	-	LC	Decreasing	-
Southern giant petrel	13	132	127	NR	NR	NR	19,810 pairs	46,800 pairs	41%	YES	LC	Increasing	A1 A4ii
Northern giant petrel	14	125	111	NR	NR	NR	ND	11-14,000 pairs	-	-	LC	Increasing	-
Falkland Islands skua	15	78	62	NR	NR	NR	ND	ND	-	-	LC	Stable	-
Large albatross species	16	65	49	13	14	10	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Large skua	17	64	47	16	7	7	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Bird Species Common name	PL001: 11/01/11 - 02/05/11[1]			NFB: 25/11/10 - 05/05/11[2]			Falklands Breeding Population Size[3]	Global Population Size[4]	% Global Population Size[3]	CMS App II, ACAP Annex I [3]	IUCN Red List Category[3]	Global Population Trend[3]	IBA[3]
	Rank	No. of Birds	No. of group sightings	Rank	No. of Birds	No. of group sightings							
Wandering albatross	18	59	58	10	20	14	ND	6,100 pairs	-	YES	**VU**	Decreasing	-
Southern fulmar	19	52	42	9	22	17	ND	4,000,000 individuals	-	-	LC	Stable	-
Grey-backed storm-petrel	20	44	40	NR	NR	NR	ND	200,000 individuals	-	-	LC	Decreasing	-
Magellanic penguin	21	42	22	8	70	28	c.140,000 pairs	1,300,000 pairs	c. 10%	-	**NT**	Decreasing	A1
Tern species	22	25	1	22	2	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Northern royal albatross	23	14	14	NR	NR	NR	ND	17,000 individuals	-	ACAP Annex I	**EN**	Decreasing	-
Grey-headed albatross	24	13	13	NR	NR	NR	ND	250,000 individuals	-	YES	**EN**	Decreasing	-
Arctic skua	25	9	8	NR	NR	NR	ND	500,000-10,000,000 individuals	-	-	LC	Stable	-
Rock shag	26	9	7	17	6	6	ND	ND	-	-	LC	Unknown	-
Storm-petrel species	27	9	9	14	14	13	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Diving-petrel	28	6	6	18	5	5	ND	16,000,000 individuals	-	-	LC	Decreasing	
Royal albatross species	29	6	6	NR	NR	NR	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Fairy prion	30	4	4	NR	NR	NR	+1,000 pairs	5,000,000	<0.01%	-	LC	Stable	-
Little shearwater	31	4	3	27	1	1	ND	900,000 individuals	-	-	LC	Decreasing	-
White-bellied storm-petrel	32	3	3	NR	NR	NR	ND	300,000 individuals	-	-	LC	Decreasing	-
Gentoo penguin	33	2	2	24	2	2	121,500 pairs	387,000 pairs	39%	-	**NT**	Decreasing	A1, A4ii
Grey petrel	34	2	2	NR	NR	NR	ND	80,000 pairs	-	YES	**NT**	Decreasing	-
Rockhopper penguin	35	2	2	15	11	6	320,000 pairs	1,230,000 pairs	36%	-	**VU**	Decreasing	A1 A4ii
Terrestrial species	36	2	2	NR	NR	NR	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Long-tailed skua	37	1	1	NR	NR	NR	ND	150,000-5,000,000 individuals	-	-	LC	Stable	-

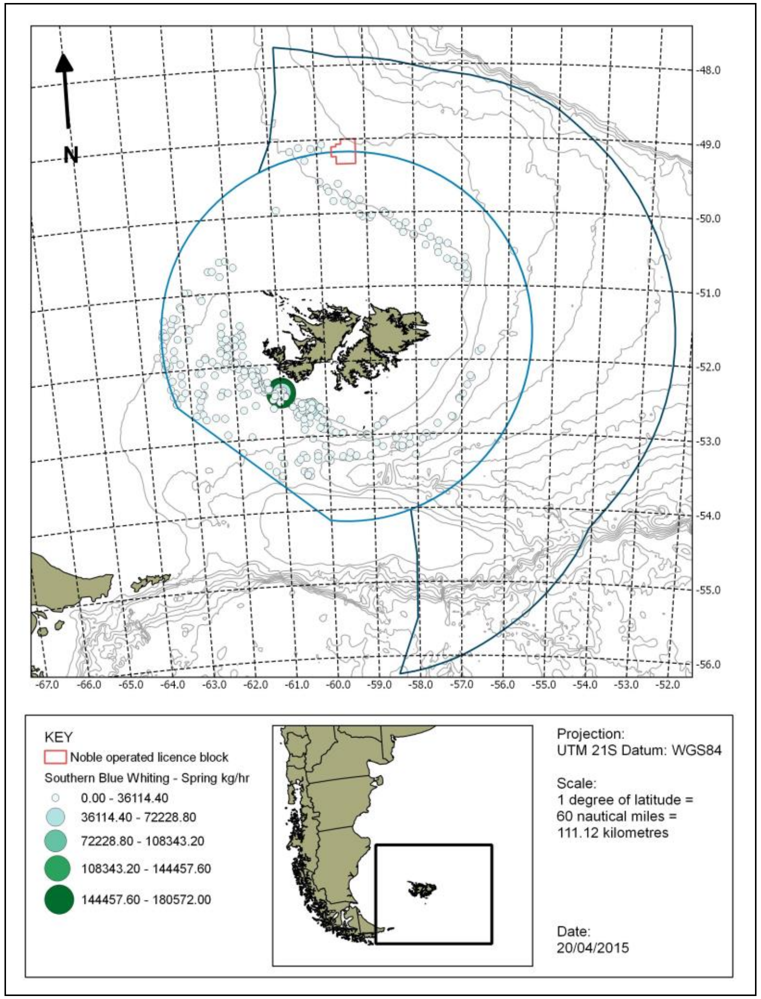
Bird Species Common name	**PL001: 11/01/11 - 02/05/11[1]**			**NFB: 25/11/10 - 05/05/11[2]**			**Falklands Breeding Population Size[3]**	**Global Population Size[4]**	**% Global Population Size[3]**	**CMS App II, ACAP Annex I[3]**	**IUCN Red List Category[3]**	**Global Population Trend[3]**	**IBA[3]**
	Rank	**No. of Birds**	**No. of group sightings**	**Rank**	**No. of Birds**	**No. of group sightings**							
South American tern	38	1	1	NR	NR	NR	6,000-12,000 pairs	ND	-	-	LC	Decreasing	-
Black-bellied storm-petrel	NR	NR	NR	21	3	2	ND	500,000 individuals	-	-	LC	Decreasing	-
Cattle egret	NR	NR	NR	30	1	1	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Diomedea albatross sp.	NR	NR	NR	25	1	1	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Peregrine falcon	NR	NR	NR	29	1	1	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Shy albatross	NR	NR	NR	26	1	1	ND	15,350 pairs	-	YES	NT	Unknown	-
Snowy sheathbill	NR	NR	NR	28	1	1							
Unidentified penguin	NR	NR	NR	19	5	5	n/a	n/a	n/a	n/a	n/a	n/a	n/a

*IUCN Status Key – DD – Data deficient, LC – Least Concern, NT – Near Threatened, VU – Vulnerable, EN - Endangered
Falkland Islands IBA Location
Black-browed Albatross - FK001, FK003, FK019, FK007, FK008, FK011, FK014, FK017
White-chinned Petrel - FK009, FK011
Sooty Shearwater - FK003, FK009, FK013, FK015, FK020, FK016
Southern Giant Petrel - FK002, FK004, FK005, FK007, FK010, FK012, FK013, FK015, FK016
Magellanic Penguin - FK002, FK022, FK004, FK018, FK005, FK019, FK007, FK008,
Gentoo Penguin - FK001, FK002, FK022, FK004, FK018, FK019, FK007, FK008, FK010, FK011, FK012, FK013, FK014, FK015, FK020, FK016, FK021, FK017
Rockhopper Penguin - FK001, FK003, FK004, FK019, FK006, FK007, FK008, FK009, FK011, FK012, FK013, FK014, FK015, FK020, FK017

[1] Geomotvie and MRAG 2011.
[2] Polarcus 2011.
[3] Birdlife 2013.
[4] Breeding pairs or mature individuals
[5] Recorded in 2010 (Wolfaardt 2012).

Appendix E: Fish Distribution Maps

The following maps show the catch per unit effort of the key commercial species within Falklands waters. Figures derived from Falkland Islands Government Fisheries Department research cruises and commercial vessels with scientific observers on board. Note that the scale is not consistent between maps.



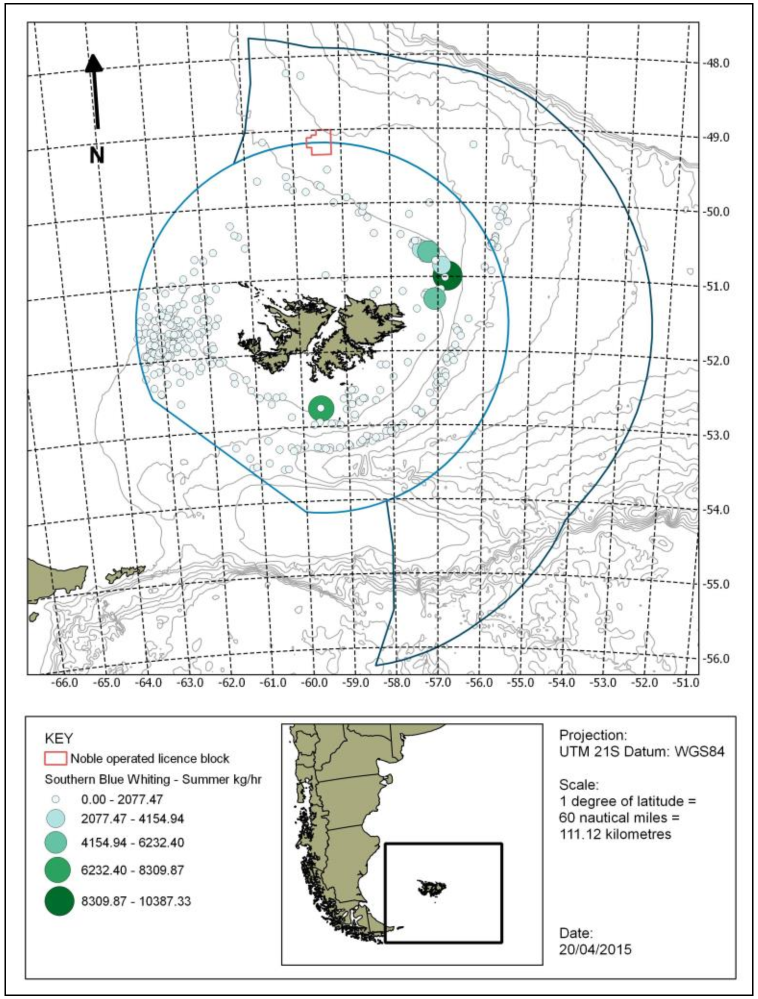
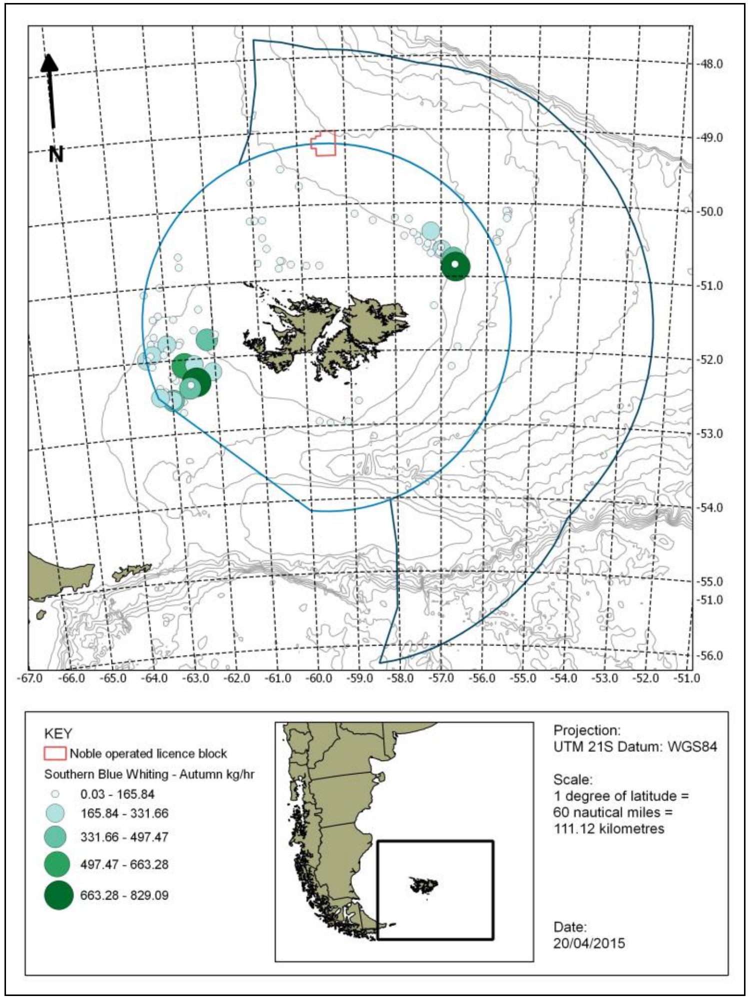


Figure 1 and 2: Distribution of Southern Blue Whiting (*Micromesistius australis autralis*) during the Spring and Summer Months.



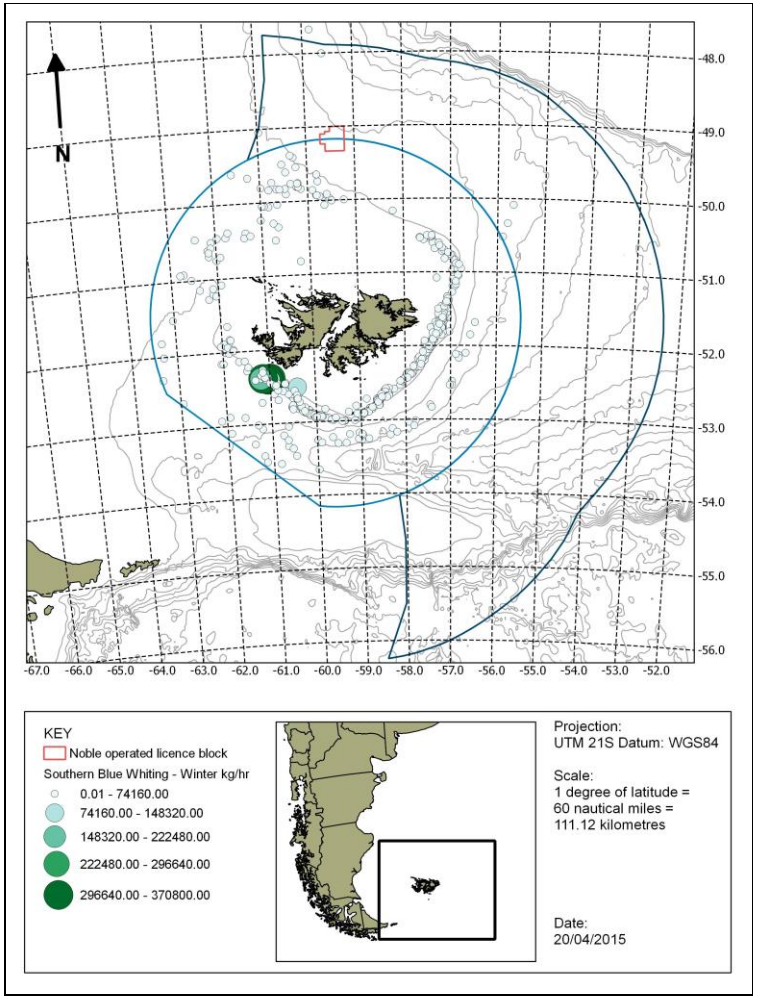
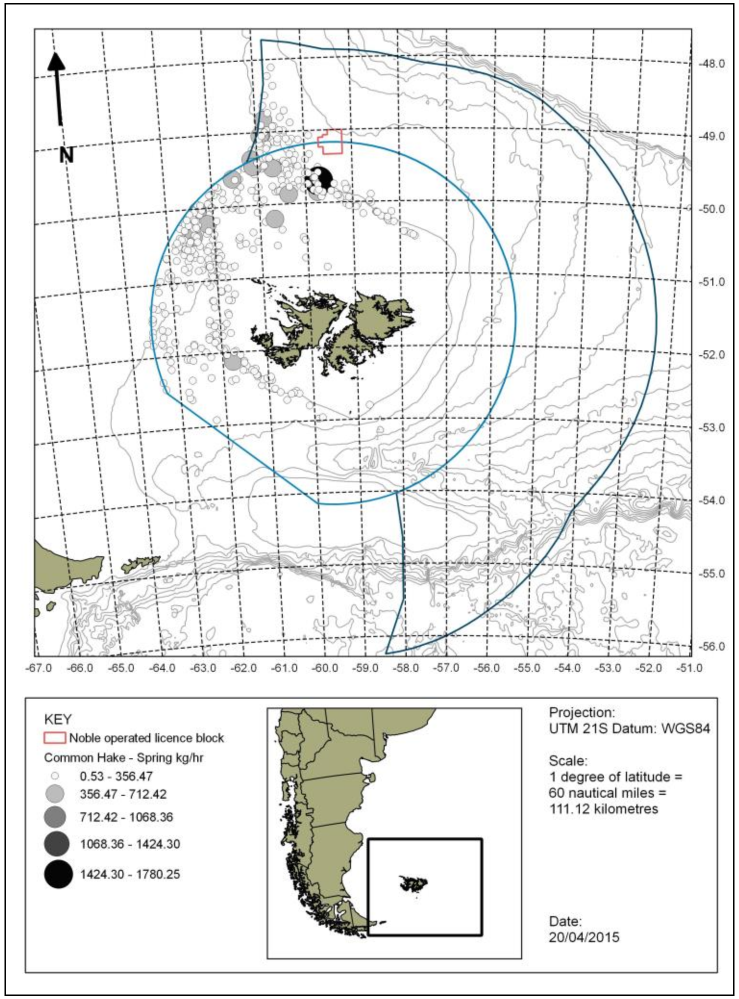


Figure 3 and 4: Distribution of Southern Blue Whiting (*Micromesistius australis autralis*) during the Autumn and Winter Months.



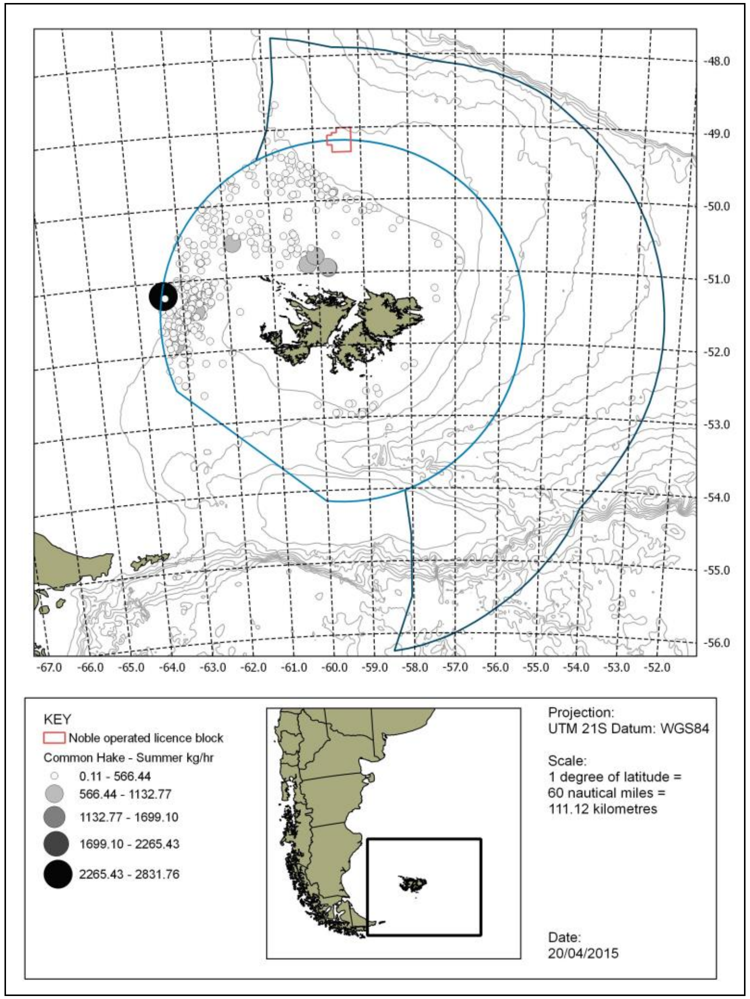
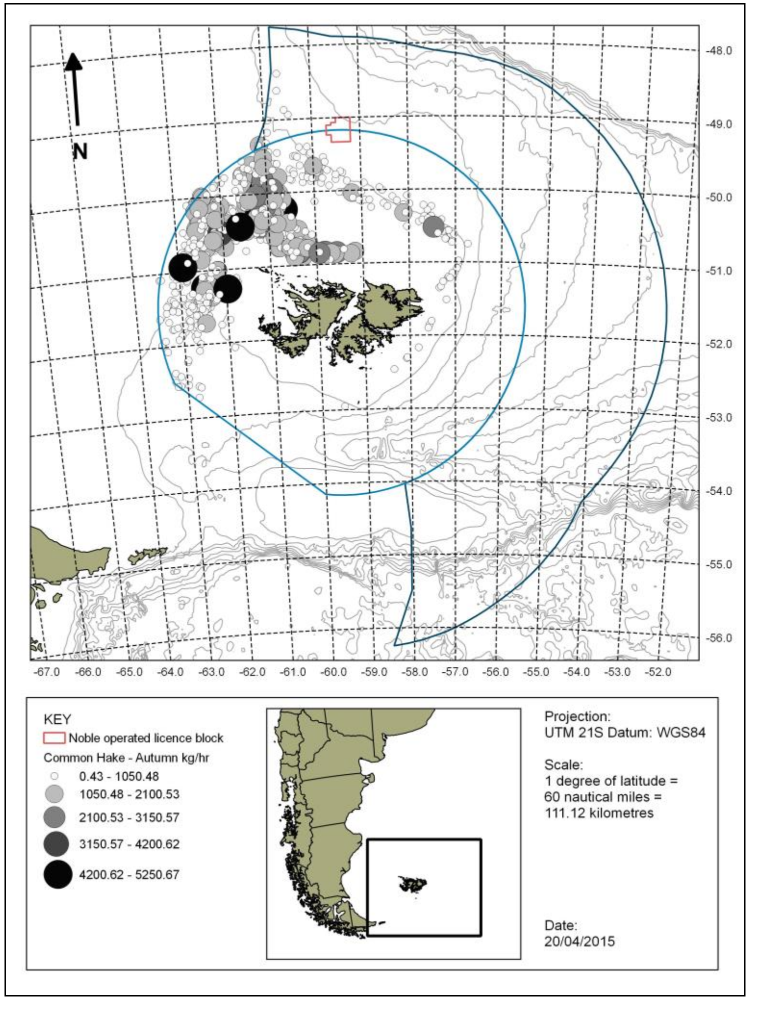


Figure 5 and 6: Distribution of Common Hake (*Merluccius hubbsi*) during the Spring and Summer Months.



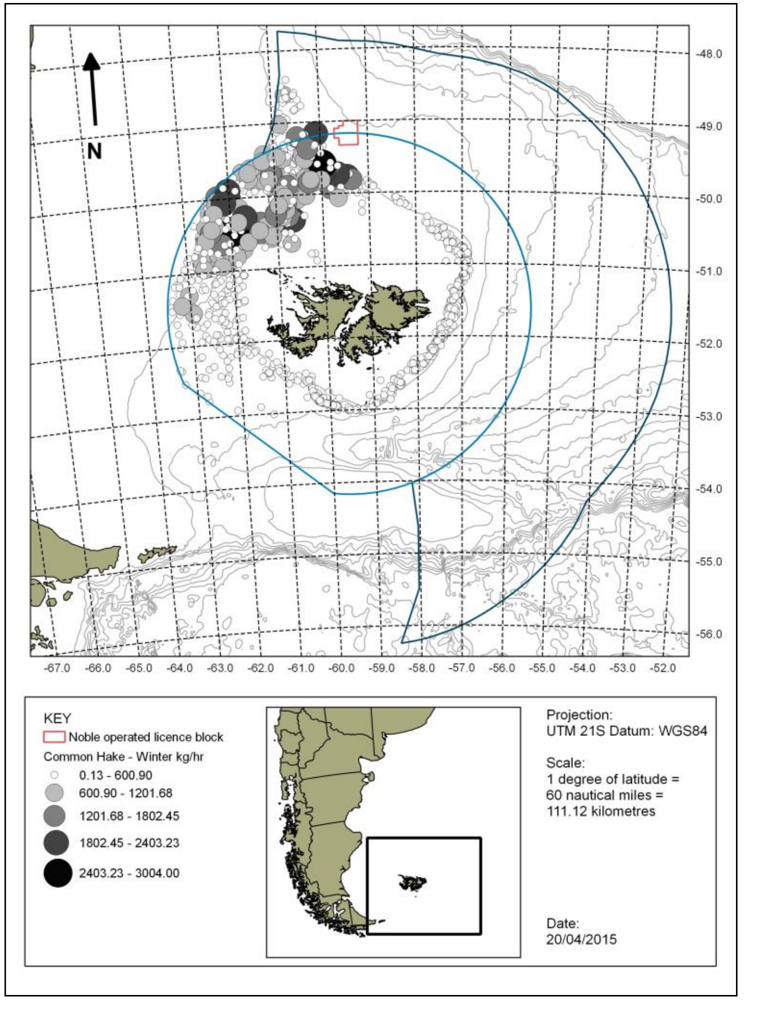
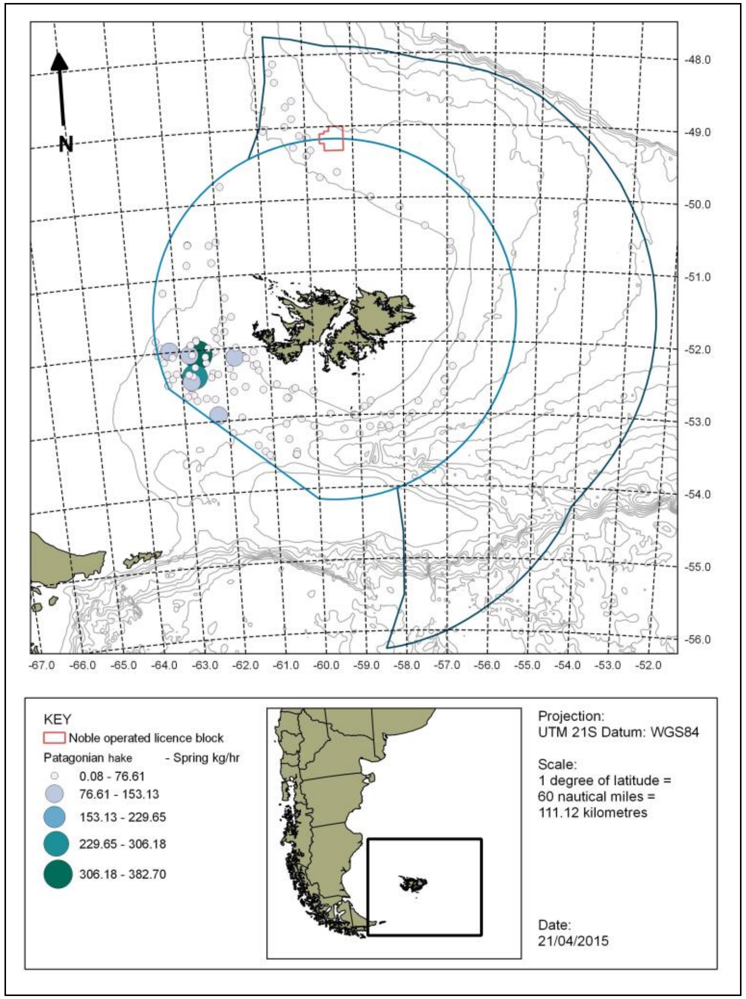


Figure 7 and 8: Distribution of Common Hake (*Merluccius hubbsi*) during the Autumn and Winter Months.



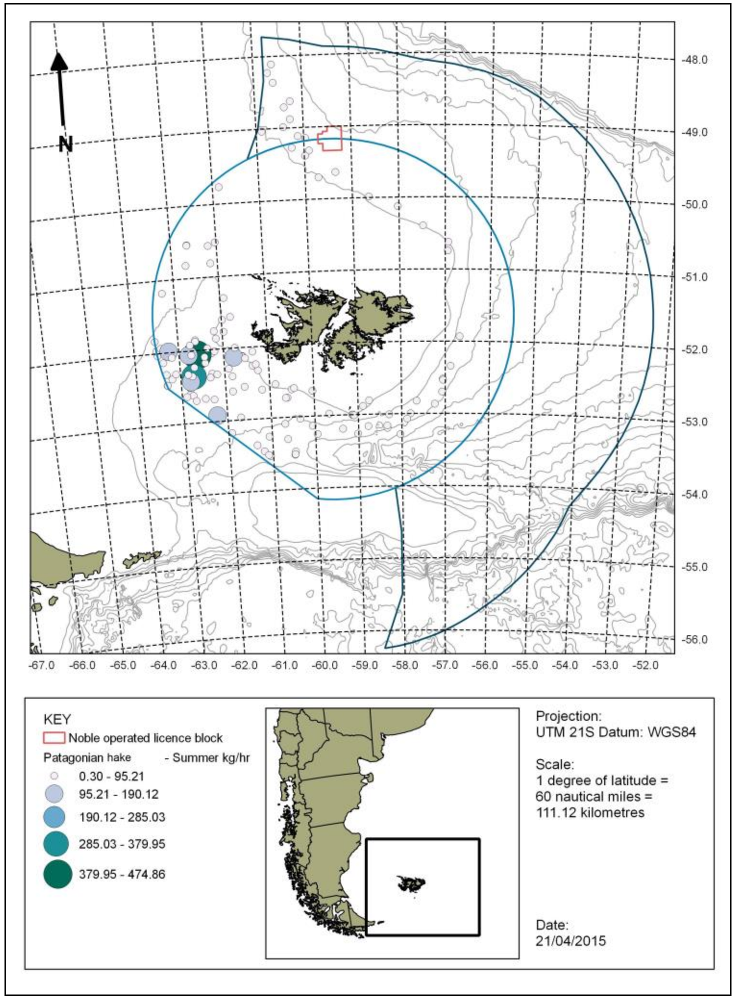
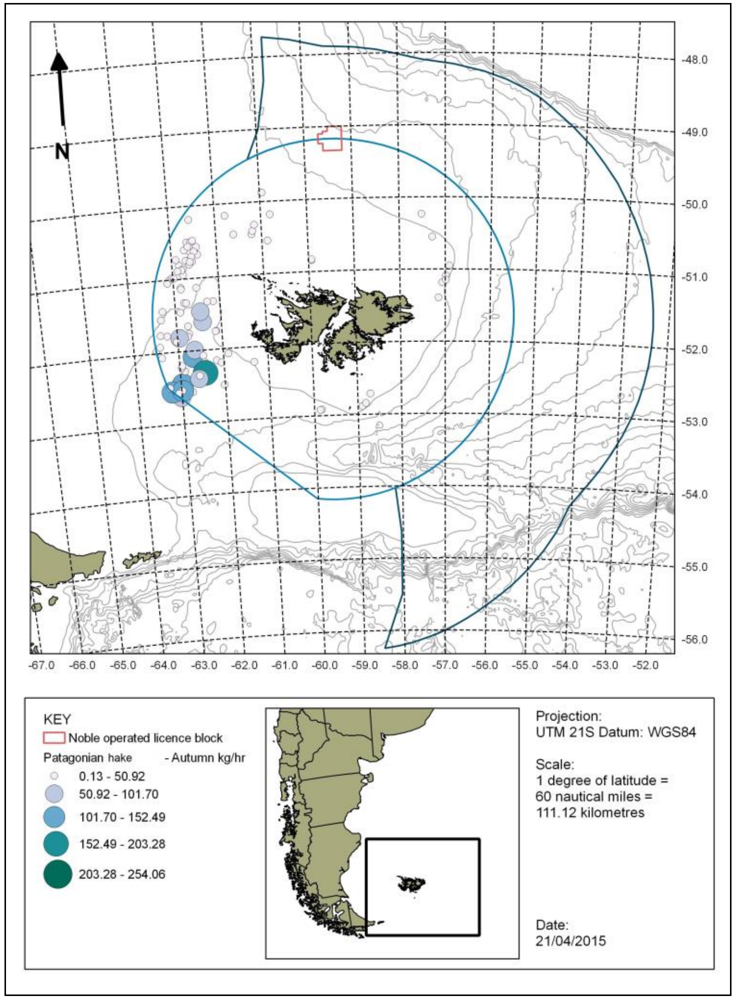


Figure 9 and 10: Distribution of Patagonian Hake (*Merluccius autralis*) during the Spring and Summer Months.



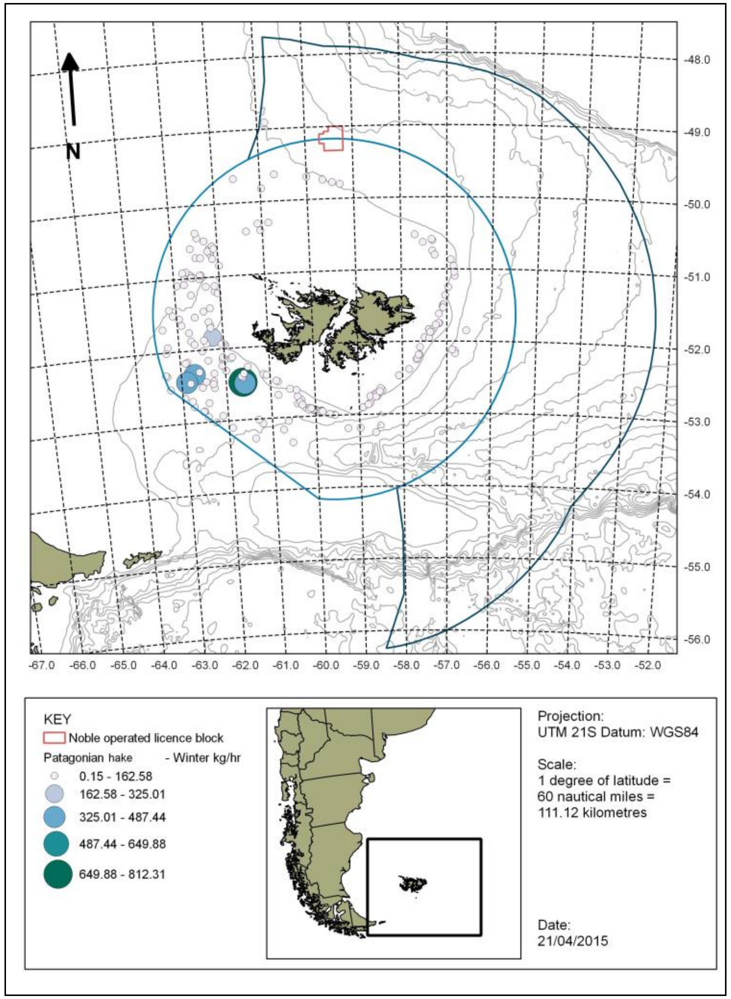
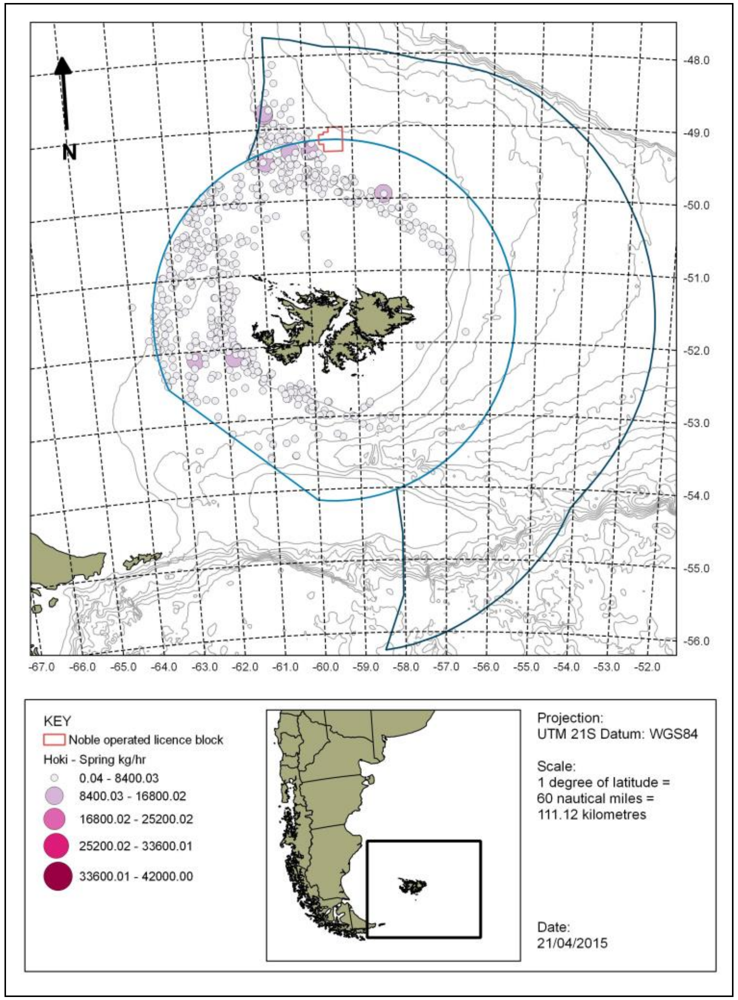


Figure 11 and 12: Distribution of Patagonian Hake (*Merluccius autralis*) during the Autumn and Winter Months.



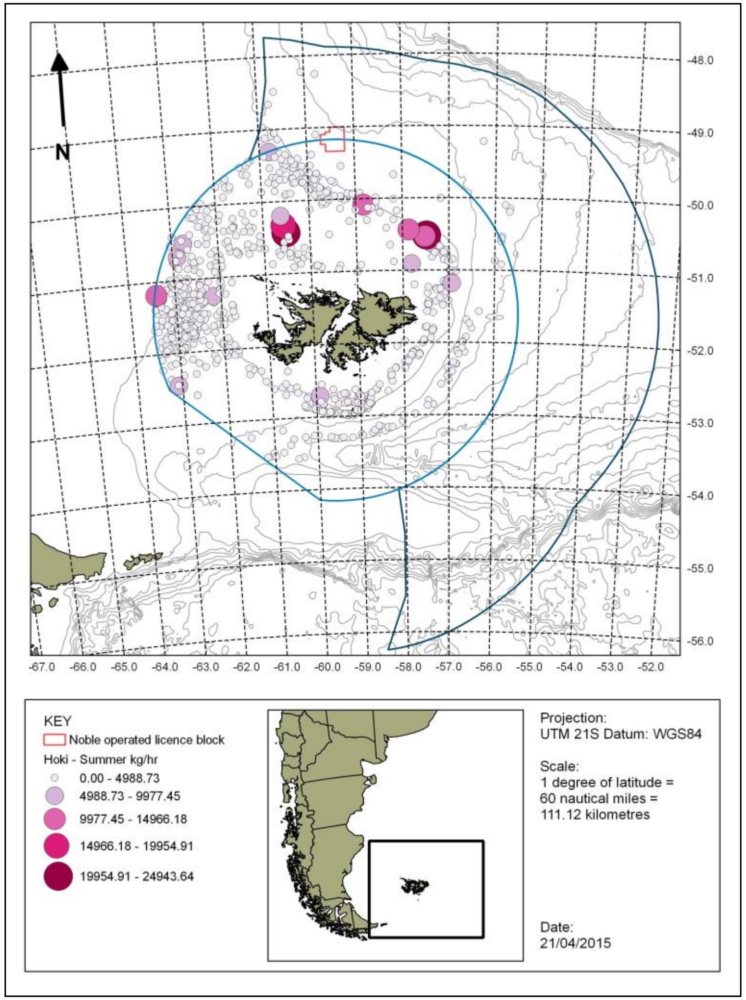
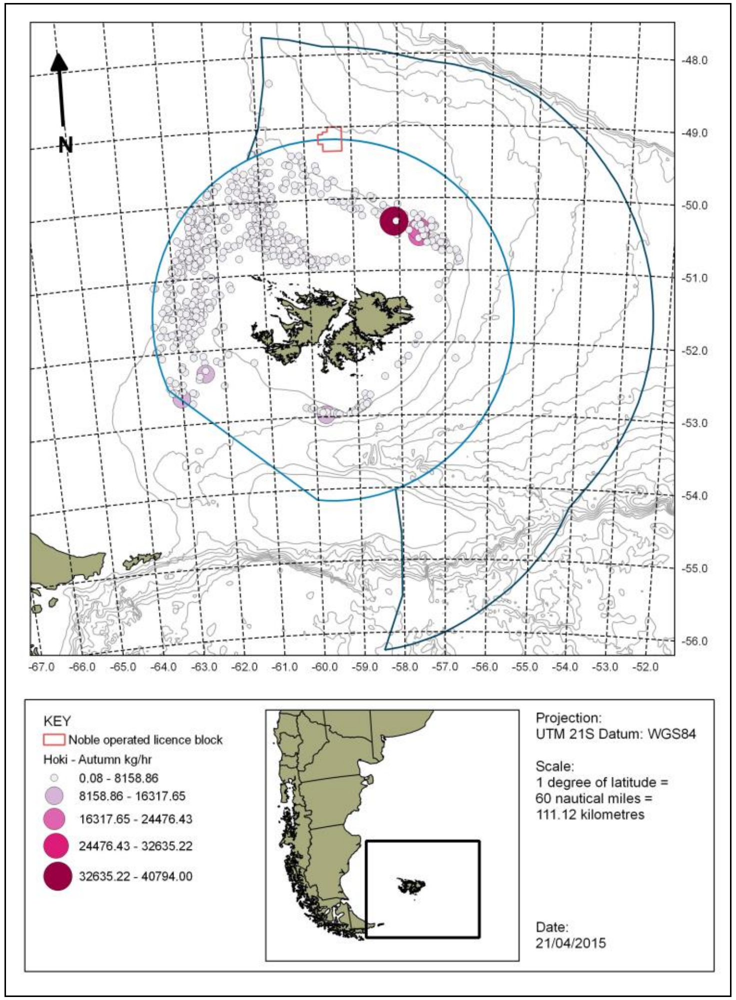


Figure 13 and 14: Distribution of Hoki (*Macruronus magellanicus*) during the Spring and Summer Months.



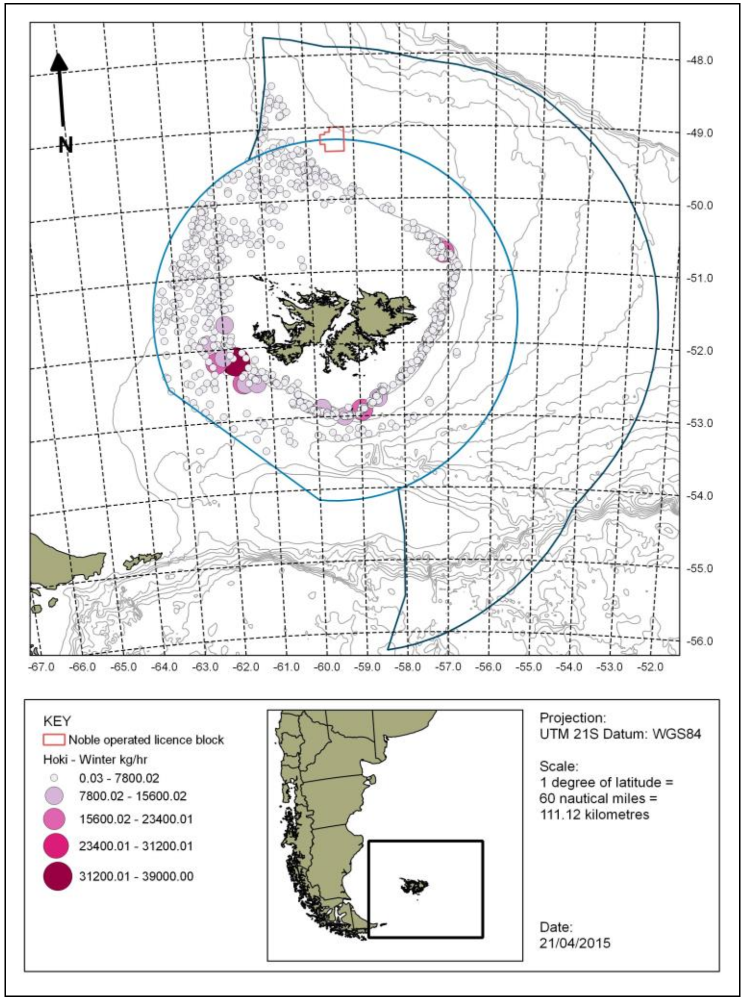


Figure 15 and 16: Distribution of Hoki (*Macruronus magellanicus*) during the Autumn and Winter Months.

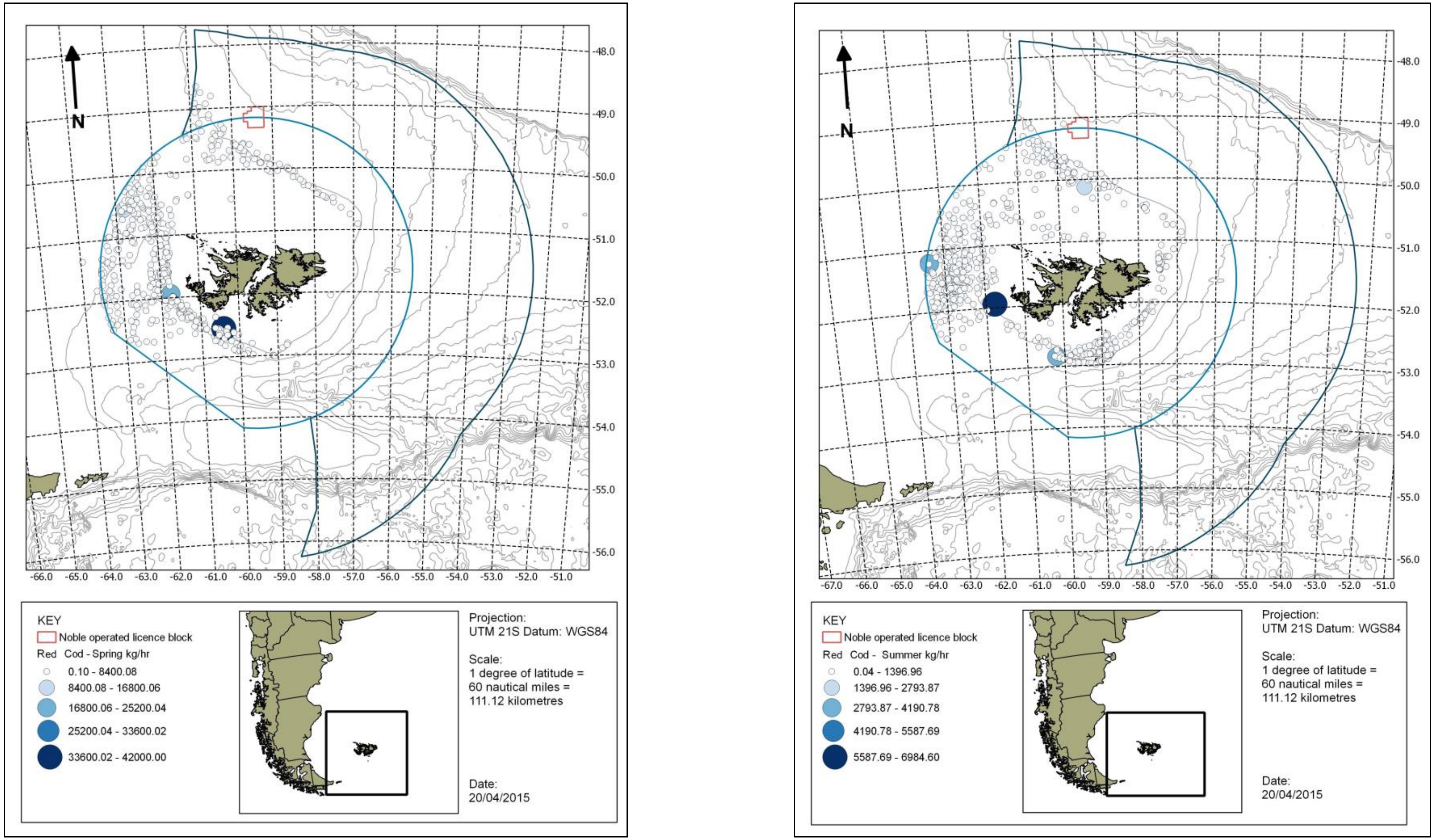
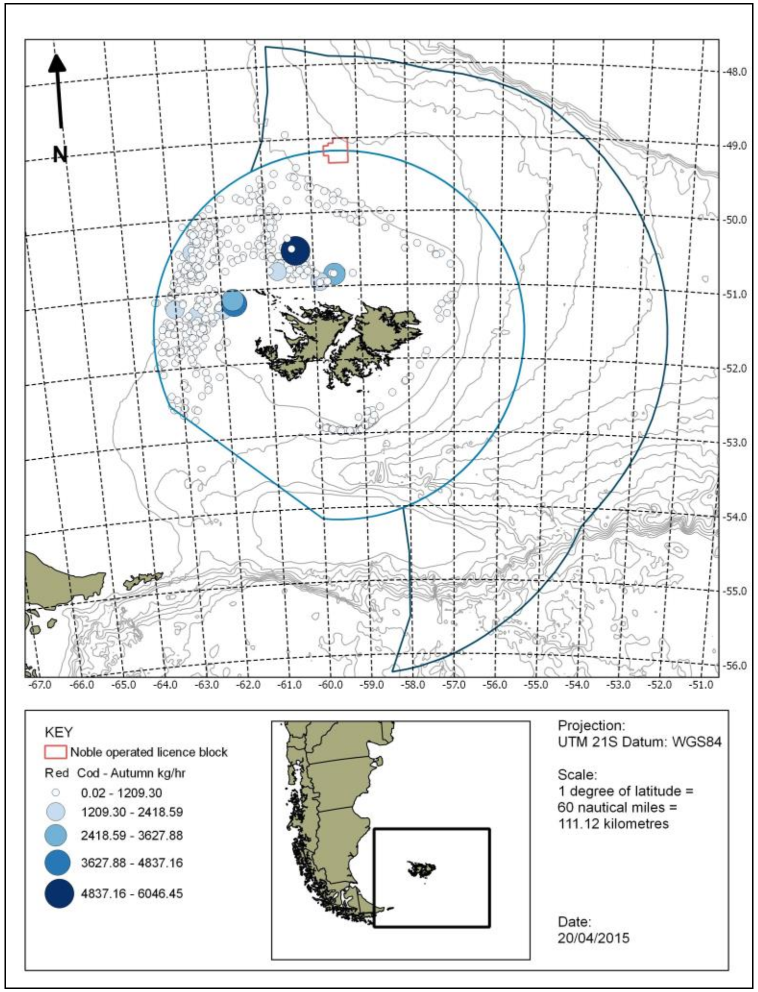


Figure 17 and 18: Distribution of Red Cod (*Salilota australis*) during the Spring and Summer Months



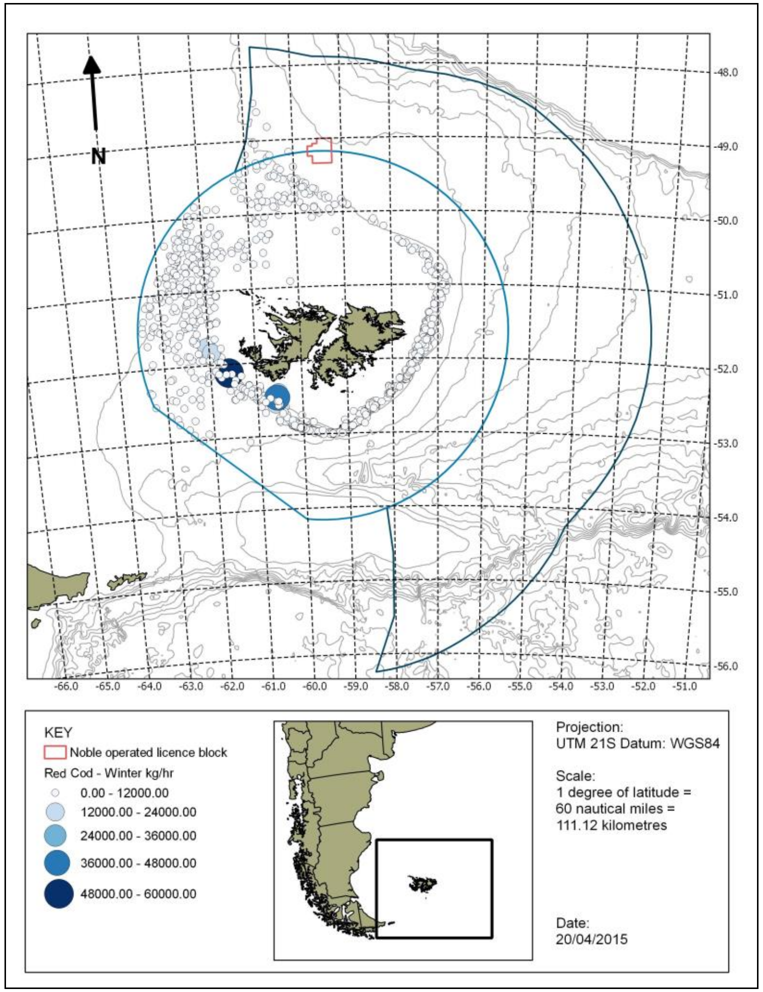
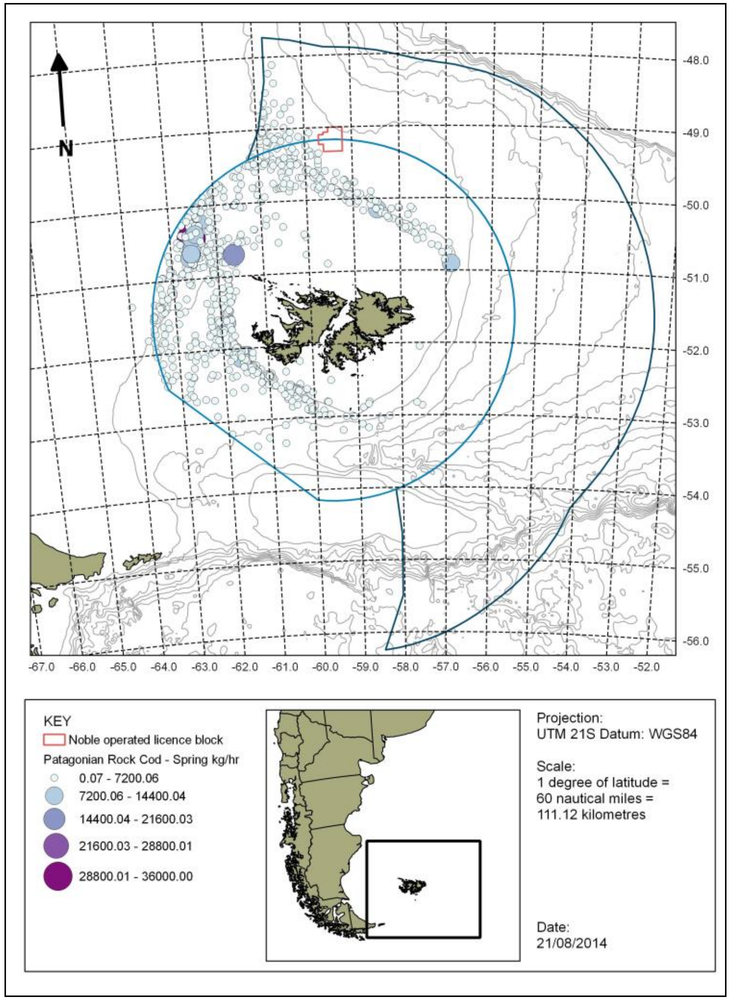


Figure 19 and 20: Distribution of Red Cod (*Salilota australis*) during the Autumn and Winter Months.



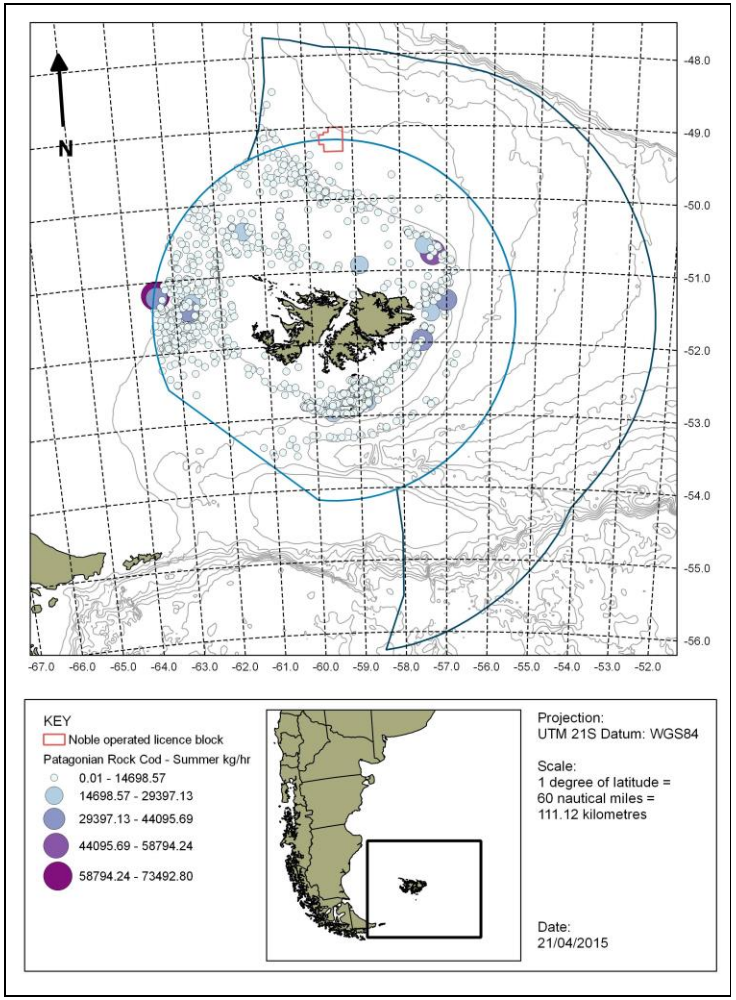
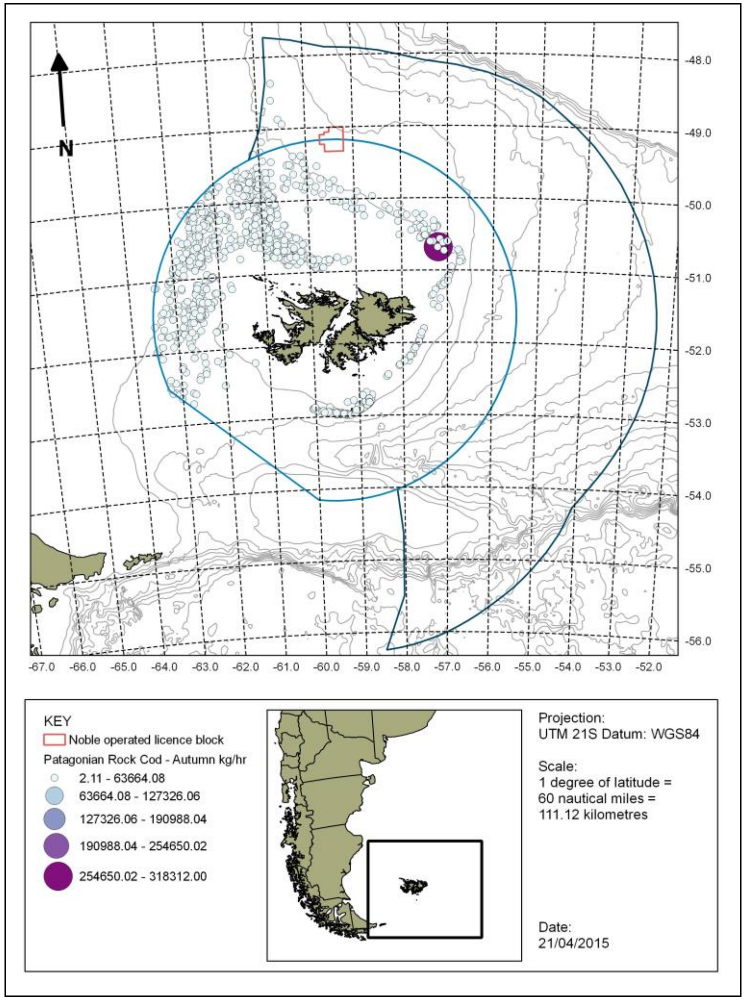


Figure 21 and 22: Distribution of Patagonian Rock Cod (*Patagonotothen ramsayi*) during the Spring and Summer Months



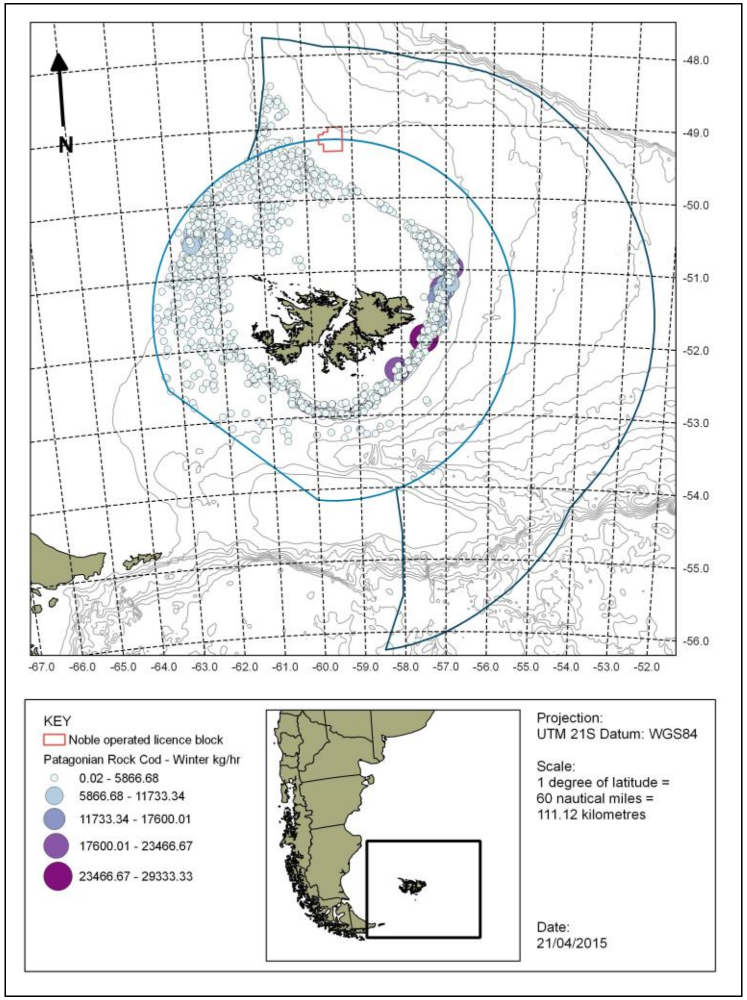
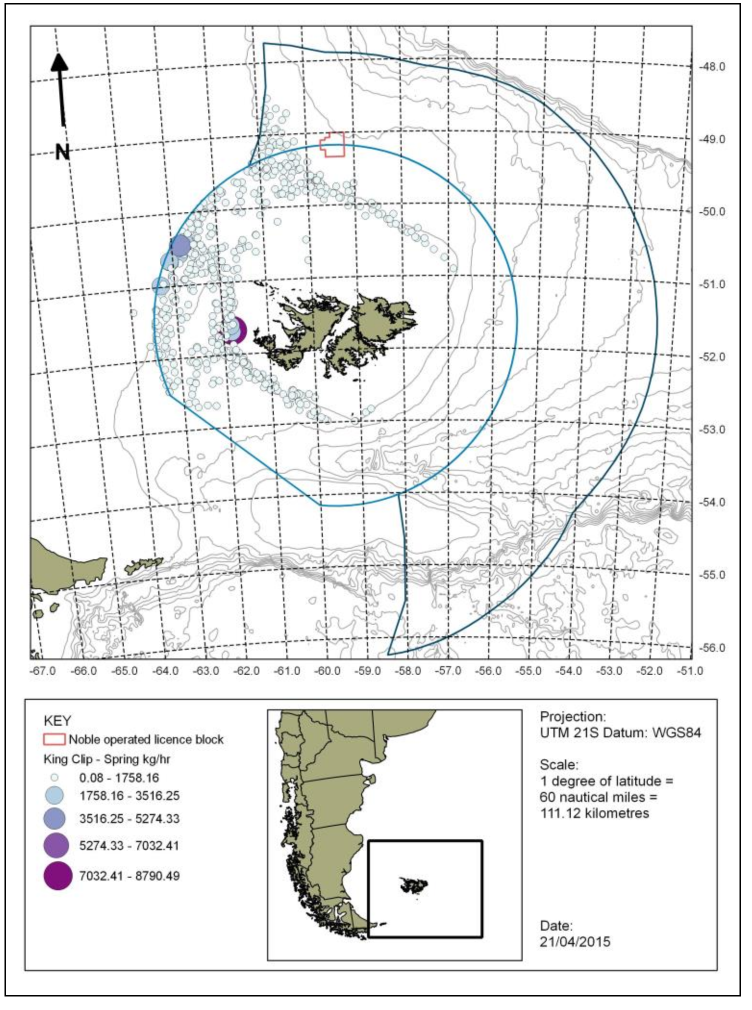


Figure 23 and 24: Distribution of Patagonian Rock Cod (*Patagonotothen ramsayi*) during the Autumn and Winter Months.



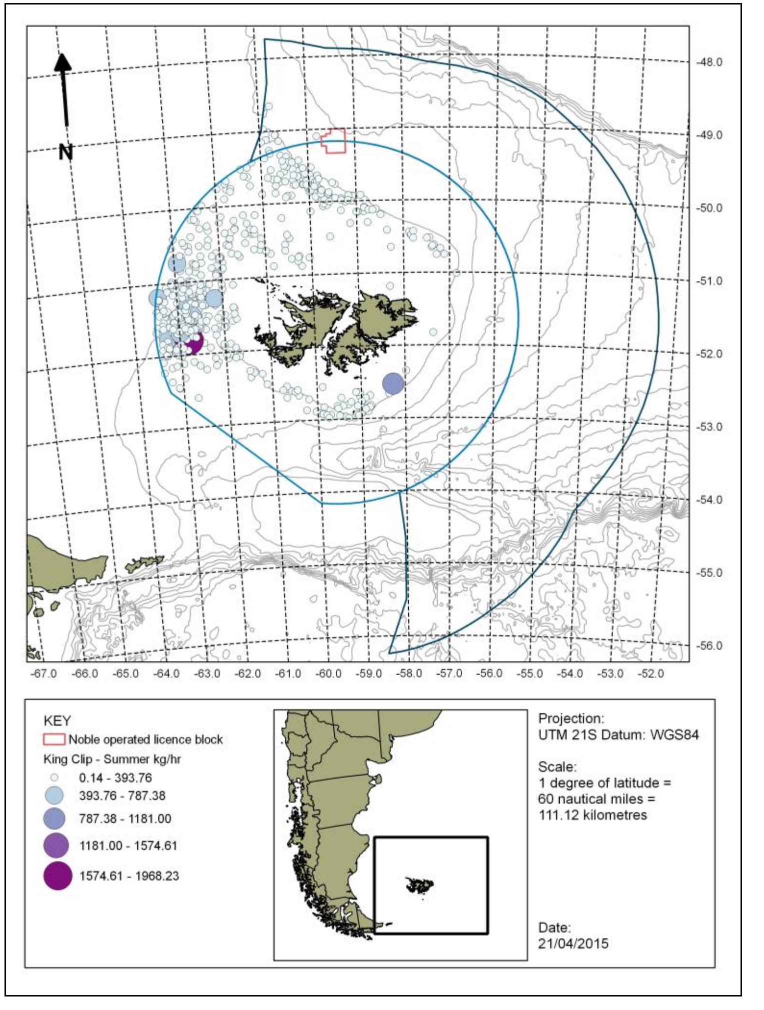
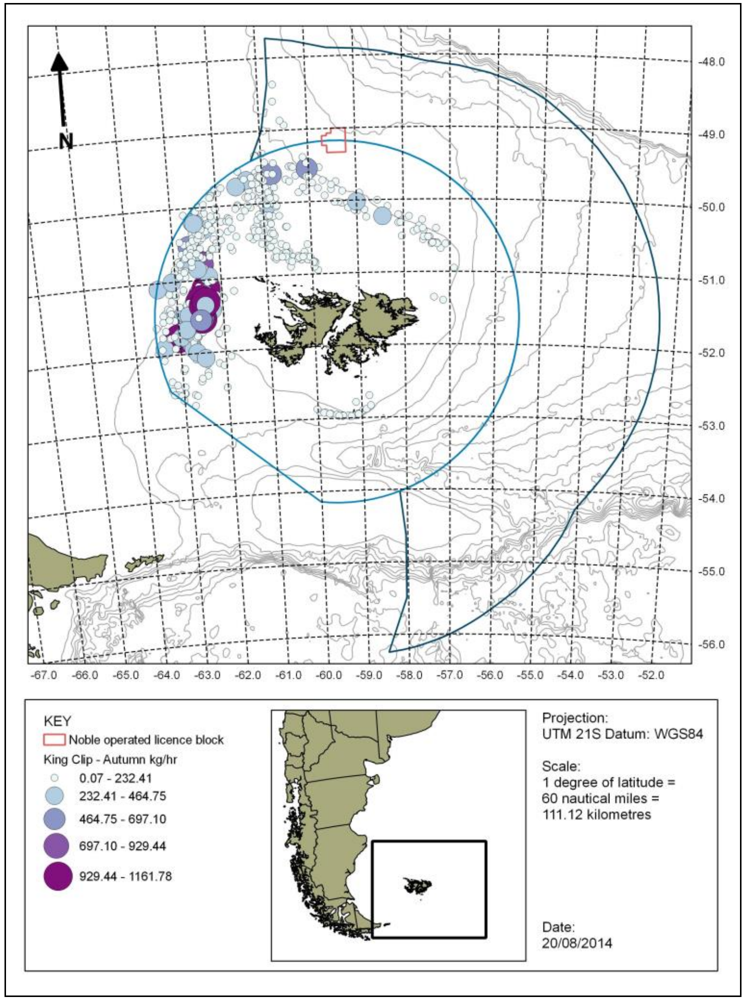


Figure 25 and 26: Distribution of King Clip (*Genypterus blacodes*) during the Spring and Summer Months



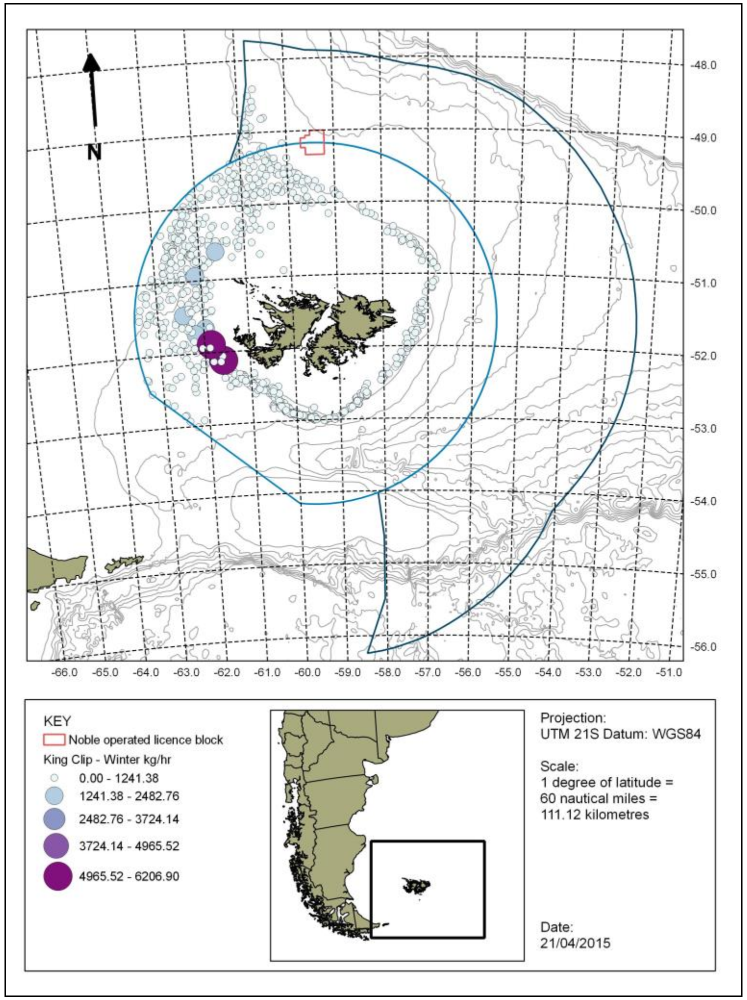
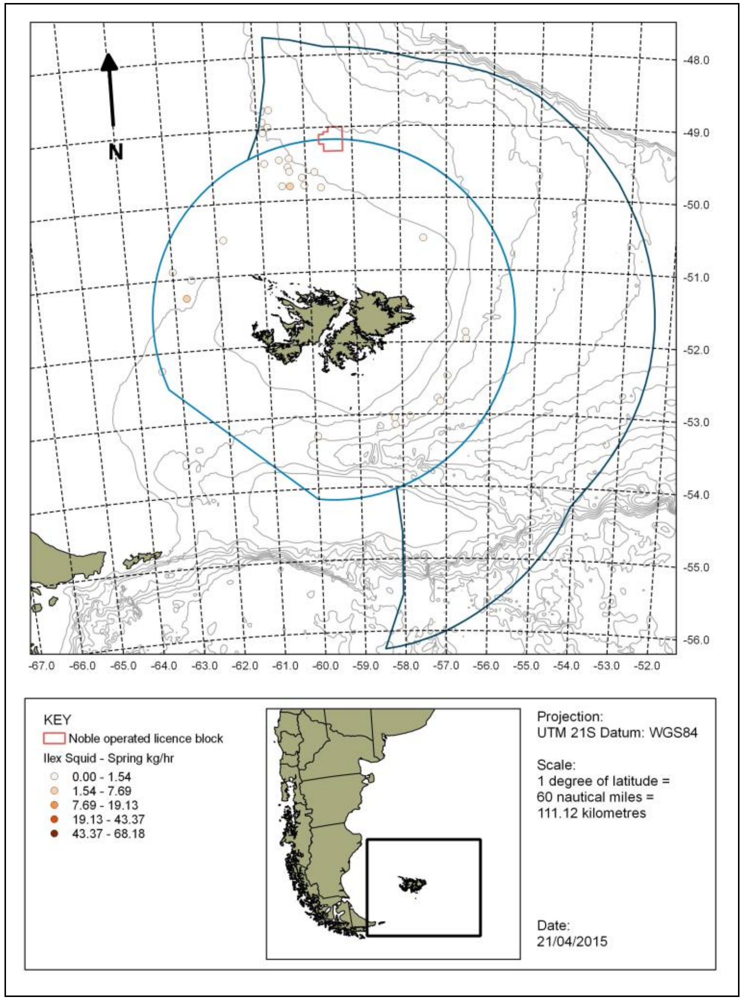


Figure 27 and 28: Distribution of King Clip (*Genypterus blacodes*) during the Autumn and Winter Months.



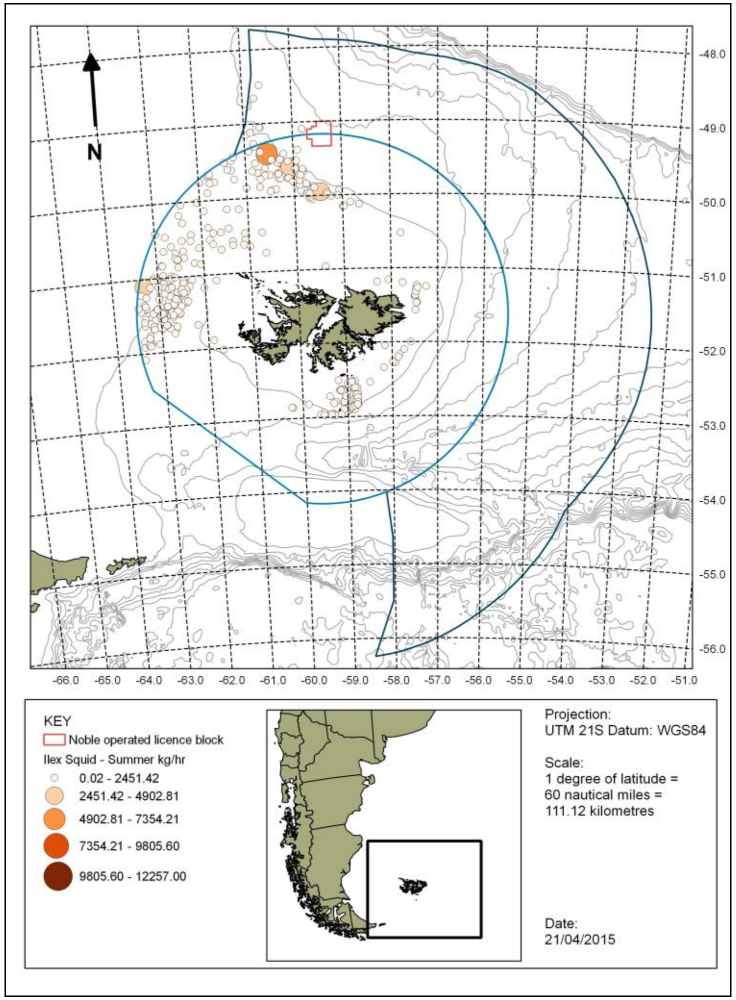
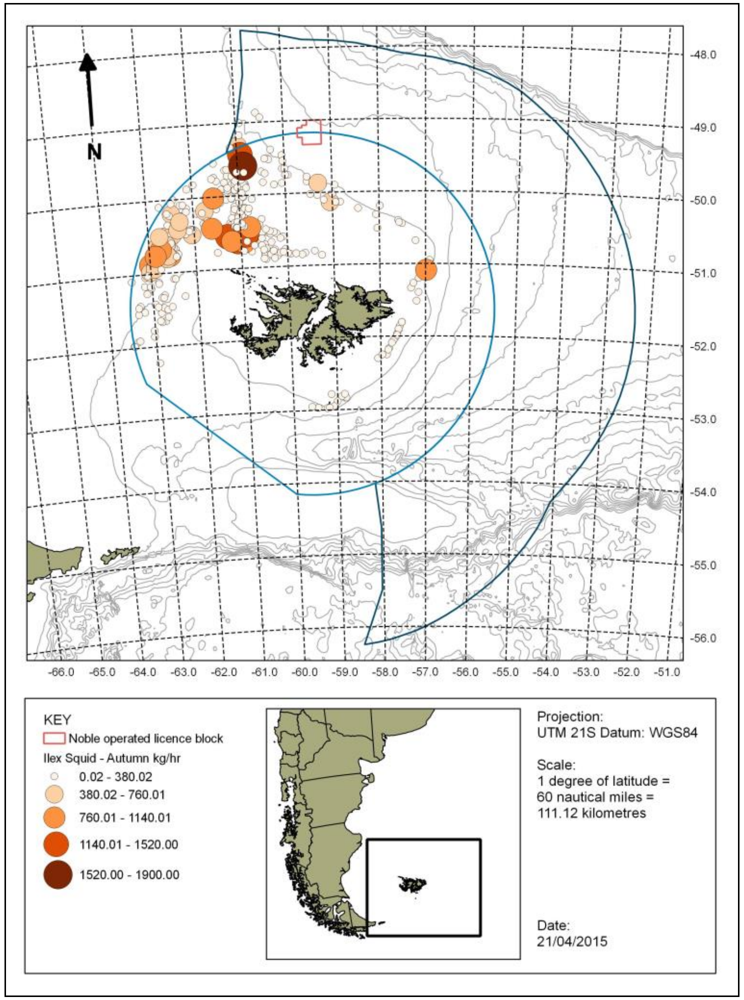


Figure 29 and 30: Distribution of Argentine shortfin squid (*Illex argentinus*) during the Spring and Summer Months



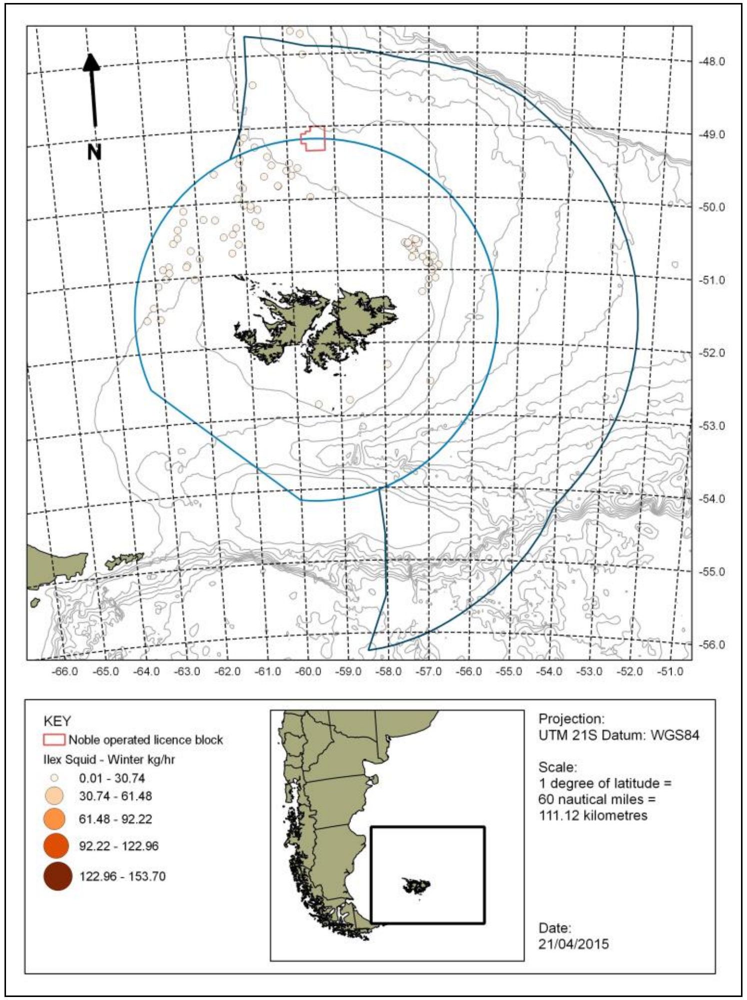
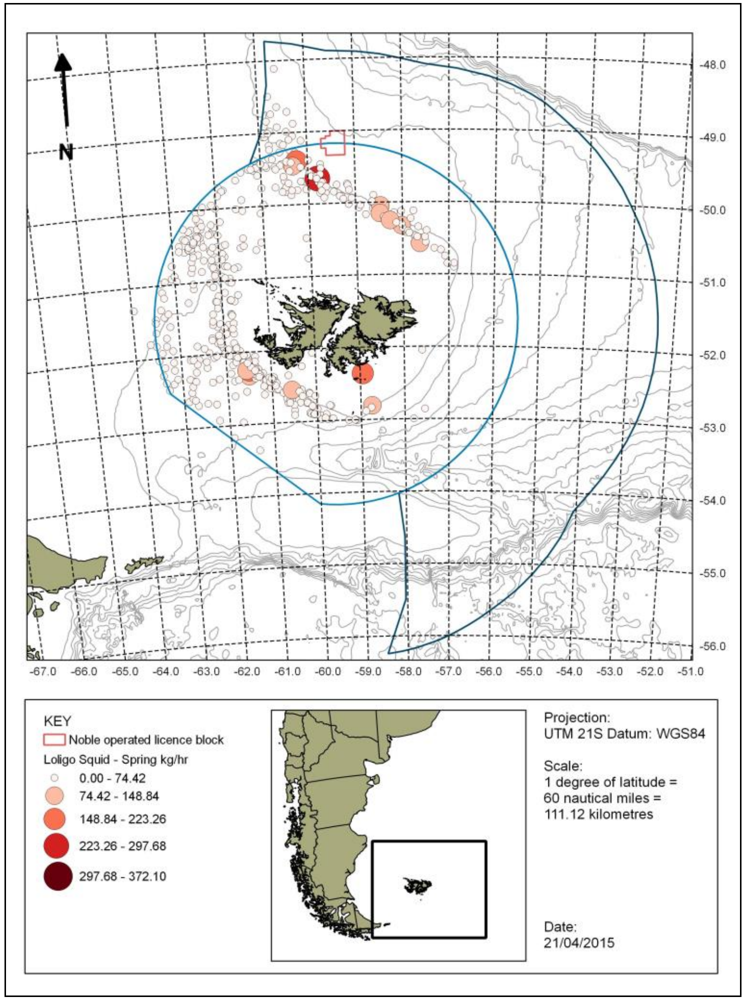


Figure 31 and 32: Distribution of Argentine shortfin squid (*Illex argentinus*) during the Autumn and Winter Months



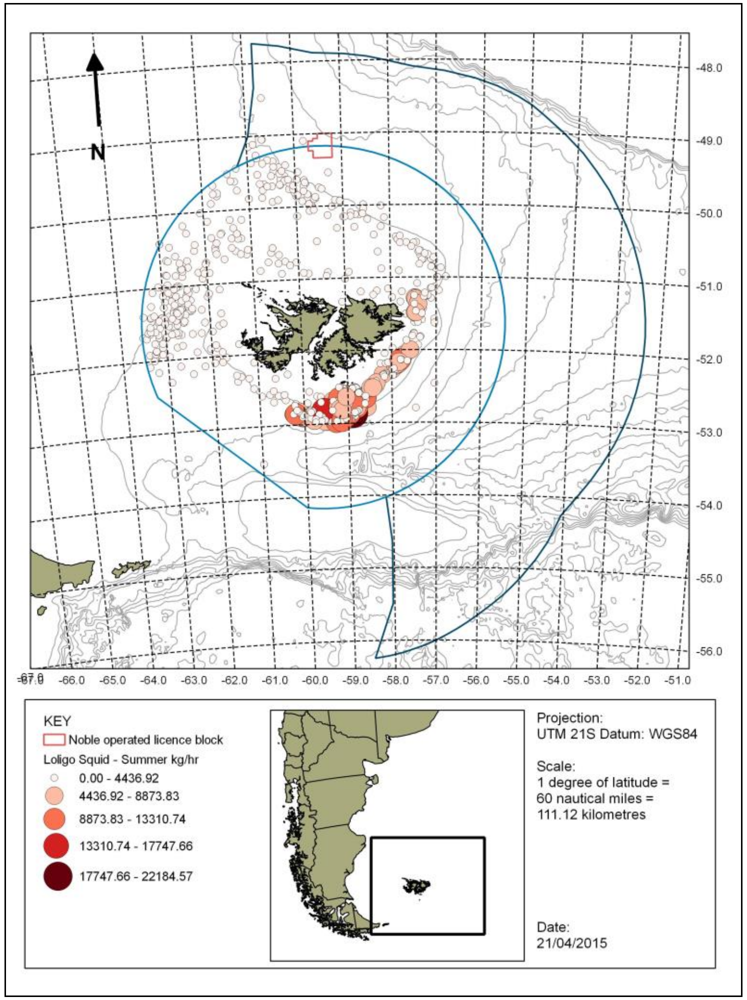
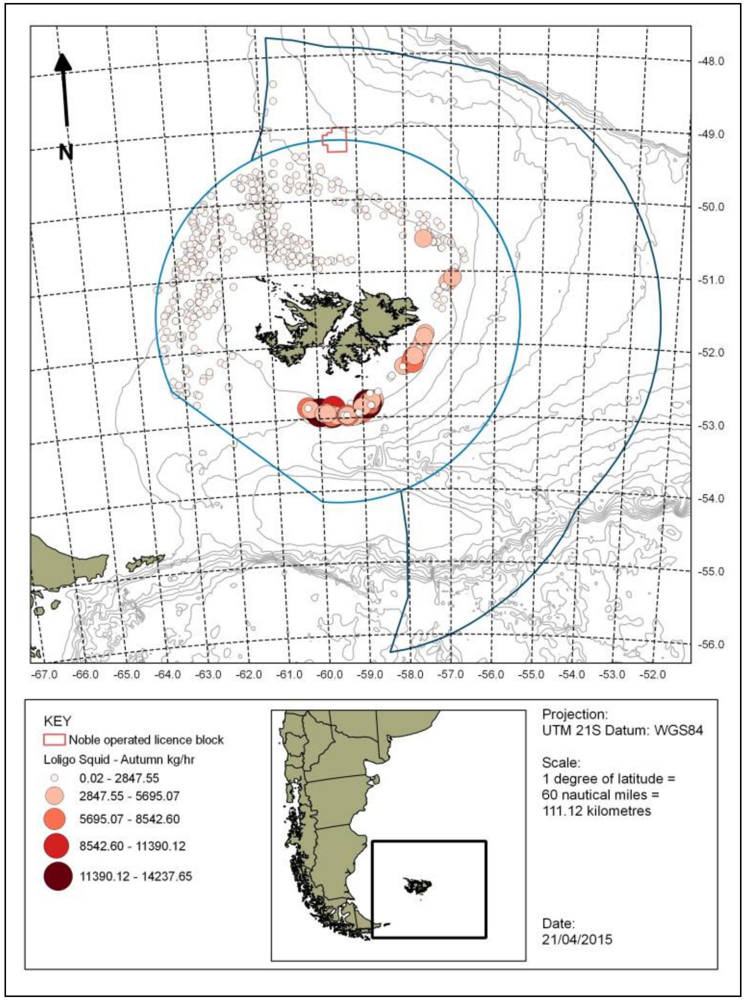


Figure 33 and 34: Distribution of Loligo Squid (*Doryteuthis gahi*) during the Spring and Summer Months



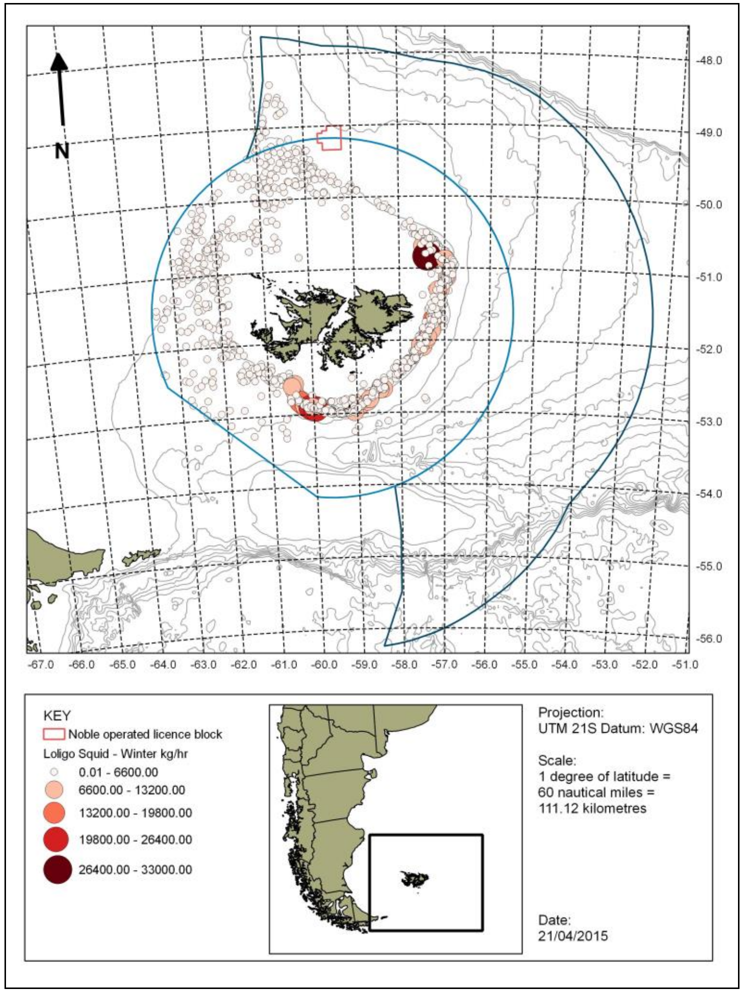
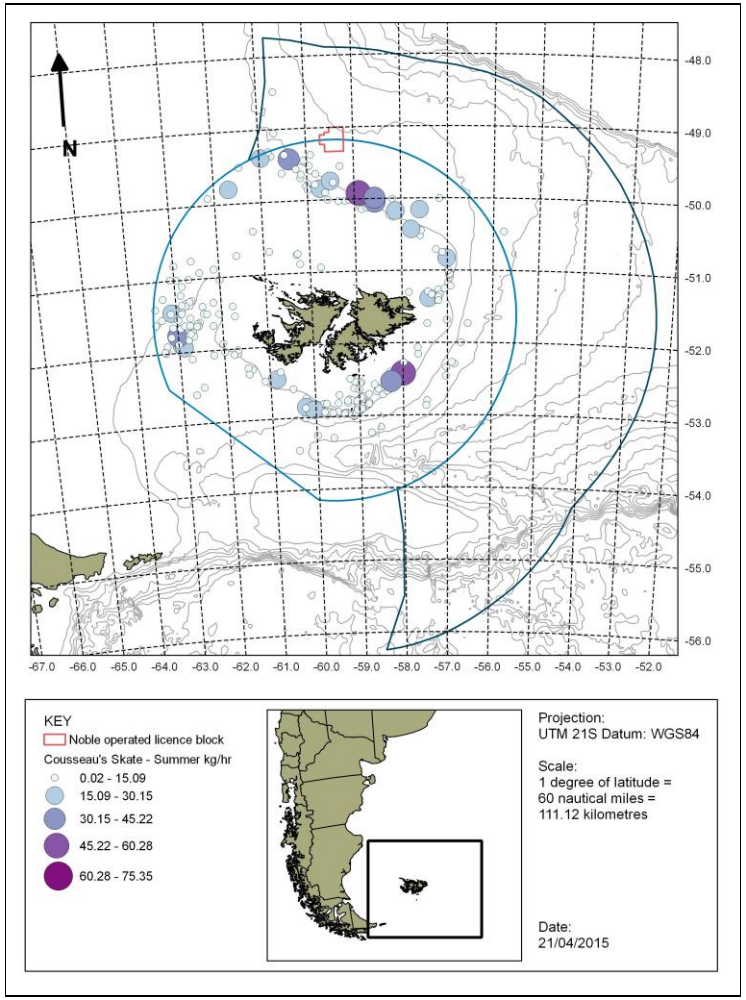


Figure 35 and 36: Distribution of Loligo Squid (*Doryteuthis gahi*) during the Autumn and Winter Months



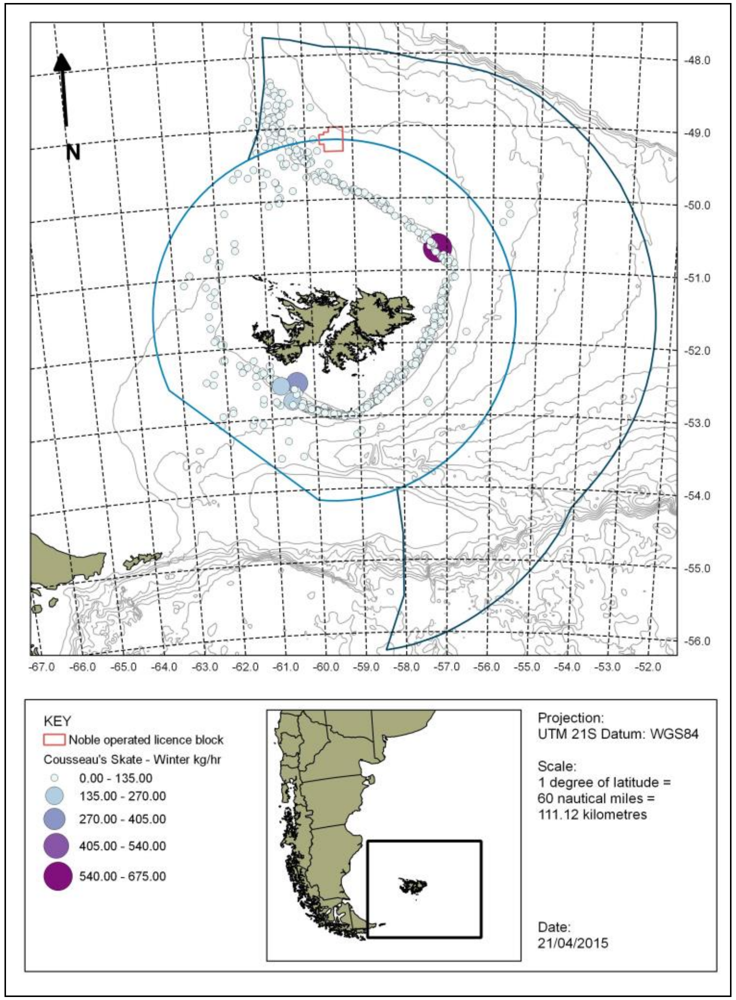
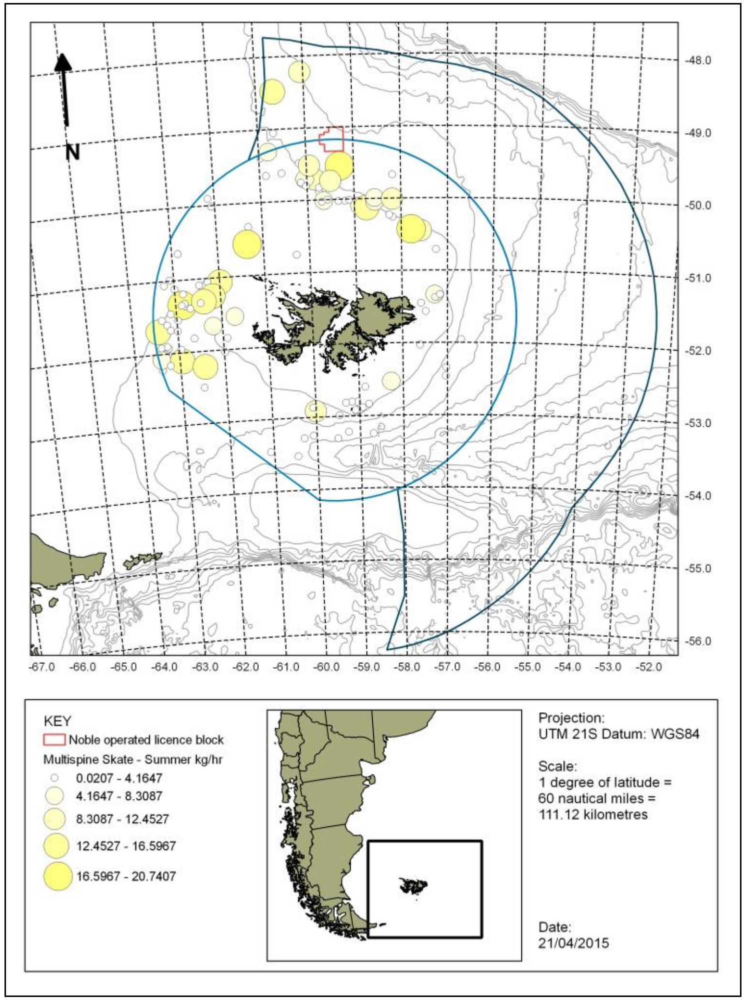


Figure 37 and 38: Distribution of Cousseau's Skate (*Bathyraja cousseauae*) during the Summer and Winter Months



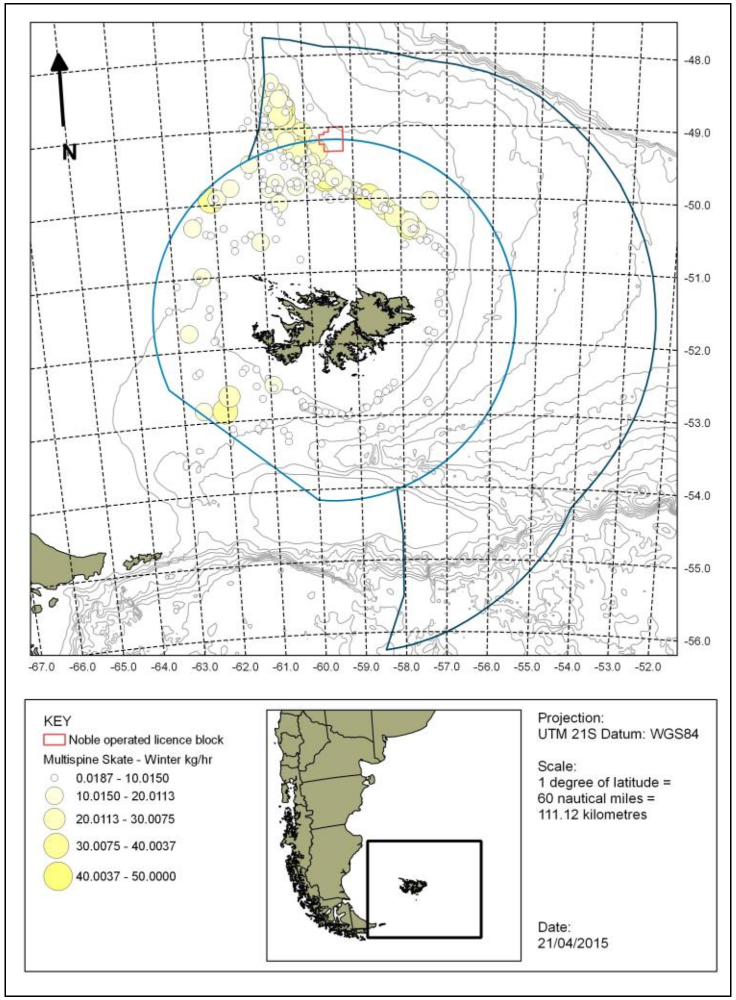
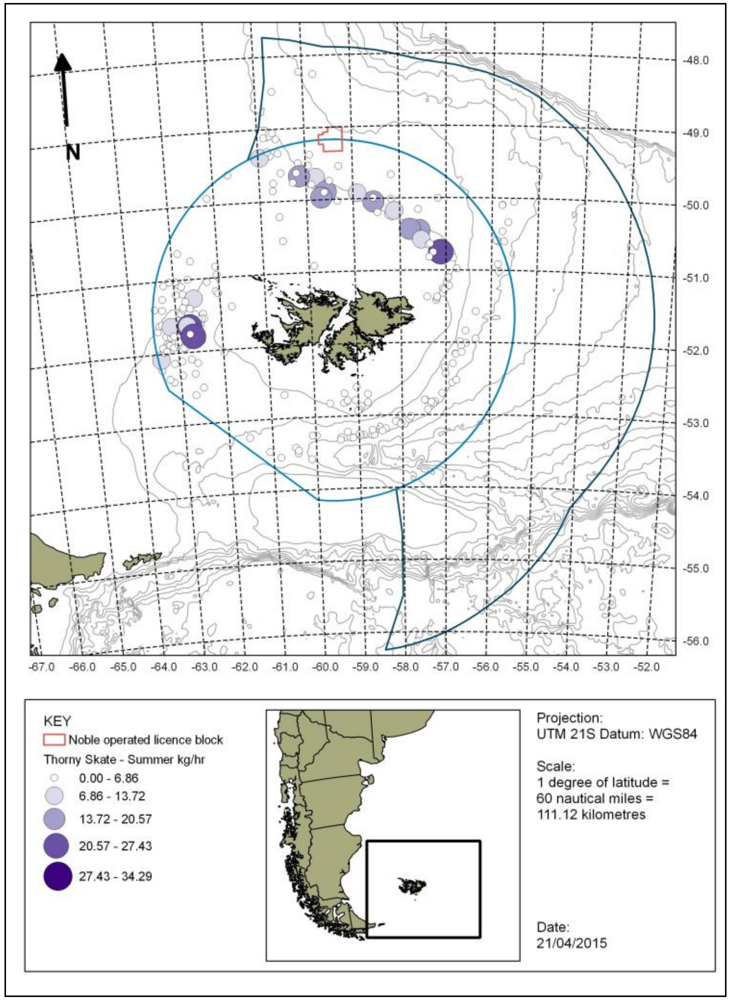


Figure 39 and 40: Distribution of Multispine Skate (*Bathyraja multispinis*) during the Summer and Winter Months



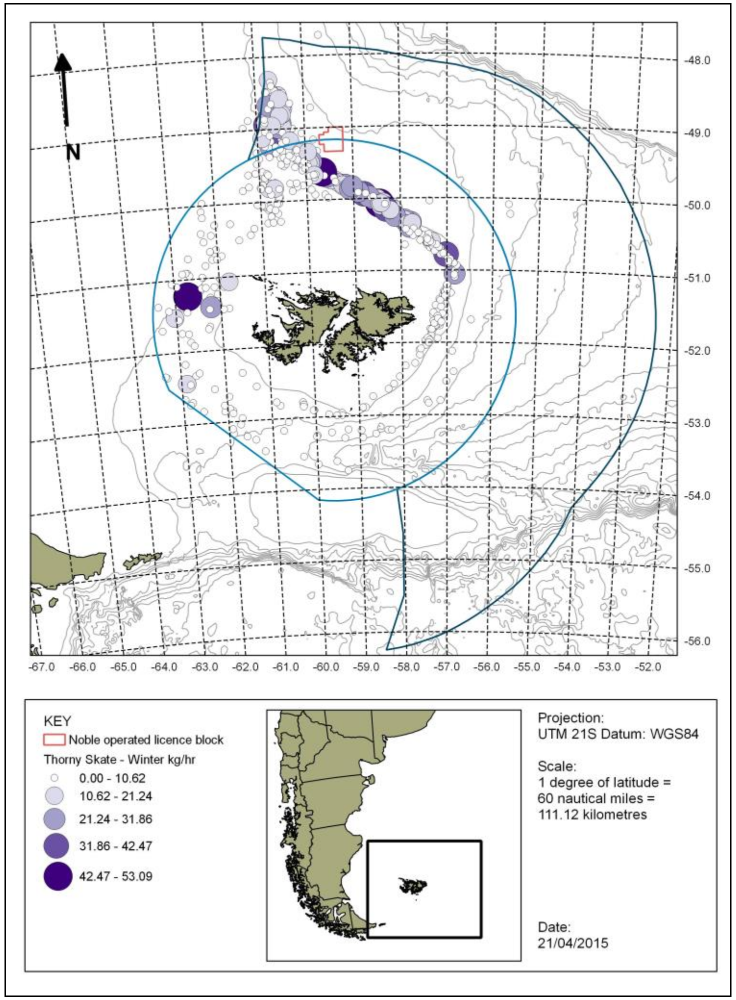
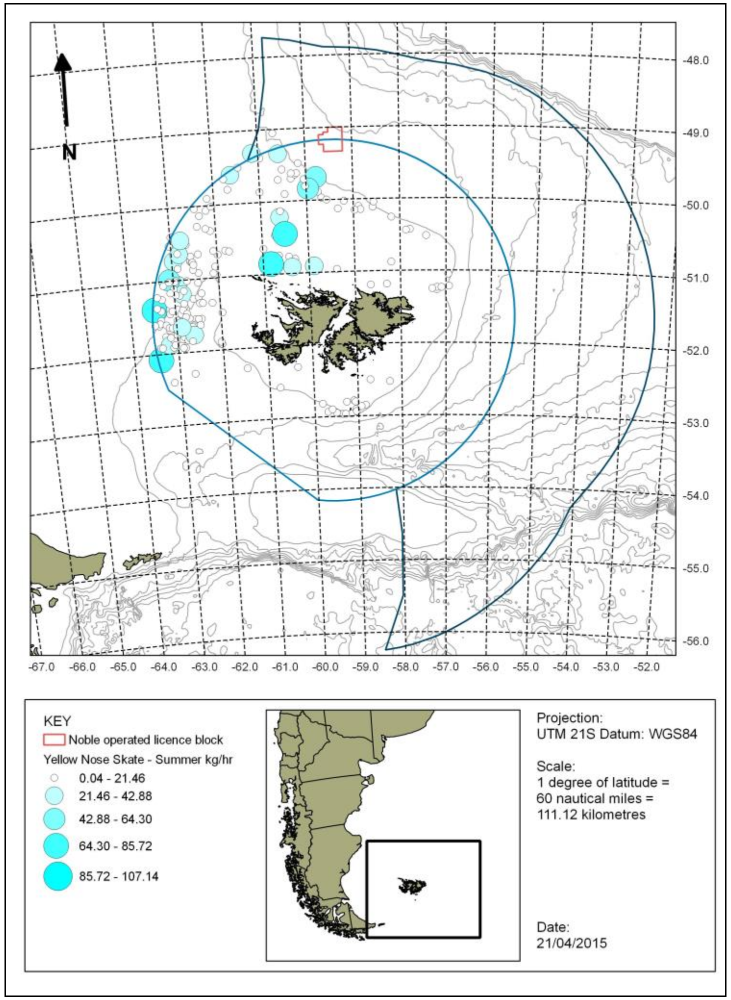


Figure 41 and 42: Distribution of Thorny Skate (*Amblyraja doellojuradoi*) during the Summer and Winter Months



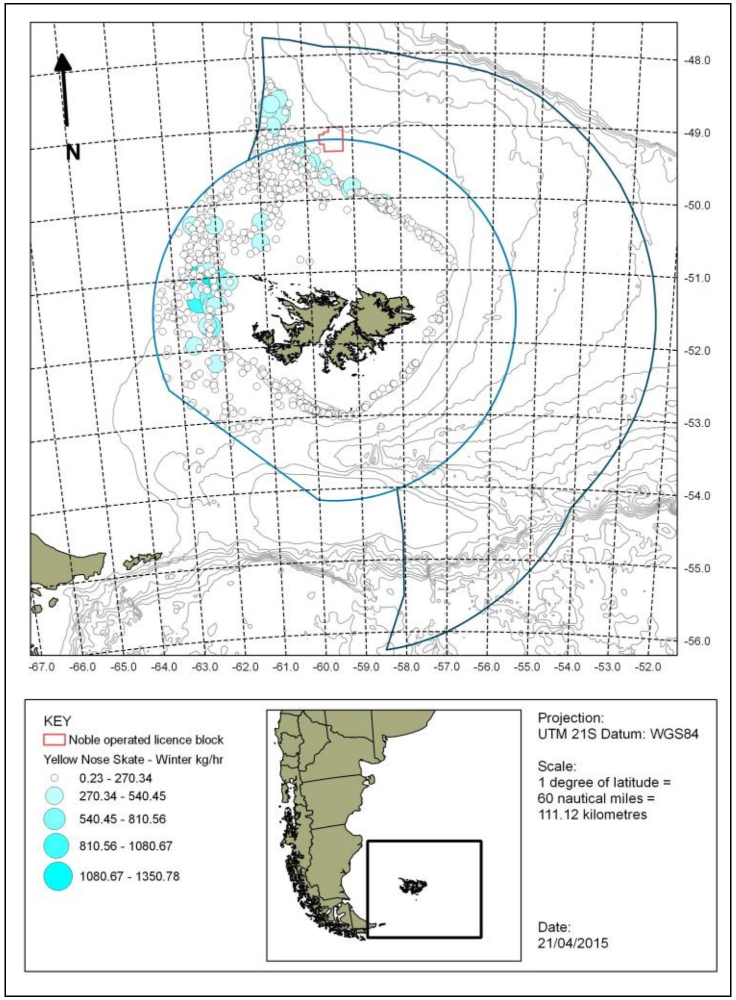


Figure 43 and 44: Distribution of Yellownose Skate (*Zearaja chilensis*) during the Summer and Winter Months

Appendix F: Environmental Impact Assessment Summary Table

<table>
<tr><th>Aspect</th><th>Source</th><th>Activity Description</th><th colspan="4">Potential Effects and Significance</th><th>Legislation/NEFL policy/Mitigation</th><th>Residual Impact / Concern</th></tr>
<tr><td rowspan="3">All Aspects</td><td rowspan="3">Generation of atmospheric emissions from vessel movements, drilling</td><td rowspan="3">Combustion of fuel contributing to greenhouse gases (direct CO_2, CH_4, N_2O, indirect NOx, SO_2, CO, VOCs); local air quality (via photochemical pollution formation (NO_X, SO_2, VOCs)); and ocean acidification (CO_2)</td><td colspan="4">Total greenhouse gases generated from the campaign would be ~0.01% of total UK emissions.
The offshore conditions in the North Falkland Basin would rapidly dissipate any effects on air quality, which would be temporary and localised. CO_2 generated during the campaign would have a negligible effect on the oceans pH.</td><td rowspan="3">All vessels used during the campign will comply with MARPOL and the Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2008, which controls the levels of pollutants entering the atmosphere.
Vessel will be audited. Well schedules will be optimised to minimise time drilling.</td><td rowspan="3">Low</td></tr>
<tr><td>Severity</td><td>Sensitivity</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Slight</td><td>Very Low</td><td>LOW</td><td>Certain</td></tr>
<tr><td rowspan="3">Rig and Vessel operations</td><td rowspan="3">Underwater noise from rig and vessel movements, drilling and VSP</td><td rowspan="3">Vessel activities produce predominantly low frequency (<1,000 Hz) continuous sounds that are less than 190 dB re.1µPa at source. VSP airguns produce high intensity (230-240 dB re.1µPa), low frequency (10-150 Hz) pulsed sounds.</td><td colspan="4">Marine mammals are considered to be of the greatest conservation concern in relation to underwater noise pollution, they are protected species that are known to use sound to communicate over large distances, navigate and detect potential prey or predators. Marine animals within 100 m of the airgun could experience hearing loss, which in terms of the North Falkland Basin is a very localised area.</td><td rowspan="3">JNCC guidance will be followed, marine mammal observers will be deployed to search for marine mammals within a mitigation zone (500 m radius) for a period of 60 minutes prior to firing of airguns, soft-start procedures will be followed and VSP activity will commence during daylight hours.
Sources of man-made noise will be quantified with acoustic equipment to inform future EIAs</td><td rowspan="3">Moderate</td></tr>
<tr><td>Severity</td><td>Sensitivity</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Moderate</td><td>High</td><td>MODERATE</td><td>Probable</td></tr>
</table>

<table>
<tr><th>Aspect</th><th>Source</th><th>Activity Description</th><th colspan="4">Potential Effects and Significance</th><th>Legislation/NEFL policy/Mitigation</th><th>Residual Impact / Concern</th></tr>
<tr><td rowspan="3">Rig and Vessel operations</td><td rowspan="3">Placement of rig clump weight on the seabed</td><td rowspan="3">A clump weight is a relatively small (465 kg) weight that sits on the seabed and is connected to the rig by a tension wire. This system is used to automatically maintain the rig's position.</td><td colspan="4">The deployment of a clump weight will cause a degree of disturbance to the seabed. This represents such a small area it was regarded as insignificant.</td><td rowspan="3">A Longbase Line (LBL) system will be used, which relies on the accurate positioning of transponders. This also minimises disturbance on the sea bed.</td><td rowspan="3">Low</td></tr>
<tr><td>Severity</td><td>Sensitivity</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Slight</td><td>Very Low</td><td>LOW</td><td>Certain</td></tr>
<tr><td rowspan="3">Rig and Vessel operations</td><td rowspan="3">Physical presence of rig</td><td rowspan="3">The presence of the rig and its 500 m radius exclusion zone could potentially interfere with commercial fishing or shipping.</td><td colspan="4">All vessels will be excluded from a 500 m radius of the rig. This will cause virtually no impact as the well locations are not on busy shipping lanes or fishing grounds.</td><td rowspan="3">All vessels in the area will be informed of the rig's position and intentions by radio broadcast and AIS, which will allow vessels to reroute with minimal disruption. An ERRV will be present in the field during drilling operations and will enforce the 500m exclusion zone.</td><td rowspan="3">Low</td></tr>
<tr><td>Severity</td><td>Sensitivity</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Slight</td><td>Very Low</td><td>LOW</td><td>Certain</td></tr>
<tr><td rowspan="3">Rig and Vessel operations.

Drilling operations</td><td rowspan="3">Generation of artifical light on rig and support vessels</td><td rowspan="3">Attraction of marine life, e.g. plankton, fish, squid and seabirds to artifical light offshore. Subsequent collision risk for seabirds with the rig or vessels.</td><td colspan="4">Impact on zooplankton, fish and squid very small and localised - minor severity. Impact on seabirds localised and short-term, less than 1% of the local population at risk</td><td rowspan="3">The use of blackout blinds/curtains will eliminate light from living spaces. The majority of lights on the rig will be directed inwards to allow safe working conditions, however, outward facing lights are necessary for navigation and safety. Implementation of NEFL's Bird Strike Management Plan (BSMP). All lights that do not need to be on will be turned off at night.</td><td rowspan="3">Low</td></tr>
<tr><td>Severity</td><td>Sensitivity</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Minor</td><td>Low</td><td>LOW</td><td>Probable</td></tr>
</table>

Aspect	Source	Activity Description	Potential Effects and Significance				Legislation/NEFL policy/Mitigation	Residual Impact / Concern
Rig and Vessel operations	Discharges of vessel drainage, firewater, sewage and galley waste from rig and vessels	Release of contaminants leading to deterioration in seawater quality and localised increase in Biological Oxygen Demand (BOD) around the discharge point	Impact on water quality, plankton, fish and squid will be very small, localised and temporary.				Sewage will be treated prior to disposal at sea. Vessels will be audited to ensure compliance. Food waste will be macerated as required by MARPOL and The Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008. Rig/vessel MARPOL compliance audits will be carried out. Implementation of NEFL's Offshore Discharge Program (ODPO).	Low
			Severity	Sensitivity	Significance	Certainty		
			Slight	Very Low	LOW	Certain		
Rig and Vessel operations	Discharge of closed drains following separation, and firewater foam to sea during system test	Release of contaminants leading to deterioration in seawater quality and localised increase in BOD around the discharge point	Impact on water quality, plankton, fish and squid will be very small, localised and temporary.				Main deck, helideck, machinery spaces drainage routes to the closed drains. Drainage water is treated to remove oil content down to 15 ppm of oil concentration prior to discharge in accordance with MARPOL 73/78 Annex I requirements. Rig/vessel MARPOL compliance audits will be carried out. Implementation of NEFL's ODPO.	Low
			Severity	Sensitivity	Significance	Certainty		
			Slight	Very Low	LOW	Certain		

<table>
<tr><th>Aspect</th><th>Source</th><th>Activity Description</th><th colspan="4">Potential Effects and Significance</th><th>Legislation/NEFL policy/Mitigation</th><th>Residual Impact / Concern</th></tr>
<tr><td rowspan="3">Drilling operations</td><td rowspan="3">Discharge of drill cuttings, WBM, cement and chemicals, to marine environment</td><td rowspan="3">Increased turbidity in the water column, sedimentation leading to smothering of benthic organisms, modification of sediment particle size and habitat.</td><td colspan="4">Discharges would impact small areas of seabed and small volume of water relative to the available habitat on the Northern Slope. Impacts would be short term, with potential for rapid recovery. Modification of sedments would persist for over 10 years in a very small area.
The significance of the impact on all environmental receptors was assessed to be Low except for 'Benthic Fauna'. The significance of the impact on 'Benthic Fauna; was assessed as Moderate (see below).</td><td rowspan="3">Drilling fluids will be recirculated and cuttings separated from the mud for re-use of the mud to minimise discharges. The majority of WBM chemicals will Pose Little Or NO Risk (PLONOR) to the environment, where safety or operational criteria dictates non-PLONOR chemcials use will be monitored and minised.
ROV surveys of the proposed drilling location for the Rhea-1 well will be conducted prior to commencing drilling activities. Should any sensitive habitats or species be identified, DMR will be notified and agreement to move the well location will be sought.
Sediment traps will be deployed around the drilling location during operations to assess and validate the model sedimentation predictions.
Implementation of NEFL's ODPO.</td><td rowspan="3">Low</td></tr>
<tr><td>Severity</td><td>Sensitivity</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Moderate</td><td>Moderate</td><td>MODERATE</td><td>Probable</td></tr>
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<tr><td rowspan="3">Drilling operations</td><td rowspan="3">Generation of non-hazardous and hazardous waste for disposal in UK/FI</td><td rowspan="3">Use of landfill resource in the UK.</td><td colspan="4">The majority of waste generated during the campaign will be transported back to the UK in the returning coaster vessels for landfill in the UK.</td><td rowspan="3">Small quantities of waste may be disposed of in the Falkland Islands, in line with NEFL's WMPA, and will not include direct disposal of waste to Eliza Cove or Mary Hill Quarry.</td><td rowspan="3">Low</td></tr>
<tr><td>Severity</td><td>Sensitivity</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Slight</td><td>Very Low</td><td>LOW</td><td>Certain</td></tr>
<tr><td rowspan="3">Drilling operations</td><td rowspan="3">Intake of seawater</td><td rowspan="3">Potential organism uptake in seawater intakes</td><td colspan="4">Plankton and possibly fish eggs or larvae could be removed from the ecosystem. This is on such a small scale that it is insignificant, in comparison with the overall egg/larval production, more an issue in terms of the potential for machinery to over heat due to blocked filters.</td><td rowspan="3">Guards and filters are used to reduce the number of marine organisms that enter with seawater.</td><td rowspan="3">Low</td></tr>
<tr><td>Severity</td><td>Sensitivity</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Slight</td><td>Very Low</td><td>LOW</td><td>Certain</td></tr>
<tr><td rowspan="3">Drilling operations</td><td rowspan="3">Discharge of heated seawater from heating /cooling medium or Reverse Osmosis unit</td><td rowspan="3">Warm water or increase saline water discharges have the potential to impact seawater quality and marine organisms.</td><td colspan="4">Discharges to surface waters will dilute and disperse rapidly in the offshore environment. Plankton may experience small, short-term, localised effects. Fish are highly mobile species and are expected to avoid temperatures outside their tolerance range.</td><td rowspan="3">Discharges will be in line with NEFL's discharge programme, all applicable regulations, and all previous drilling rigs in the Falklands and rig's water maker will reduce use of in-country water resources.</td><td rowspan="3">Low</td></tr>
<tr><td>Severity</td><td>Sensitivity</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Slight</td><td>Very Low</td><td>LOW</td><td>Certain</td></tr>
<tr><td rowspan="3">Shore based operations</td><td rowspan="3">Physical presence of laydown yard</td><td rowspan="3">The use of land resources and the impact on native flora and fauna.</td><td colspan="4">Disturbance of native flora. A short length of track will has been laid to join the existing road with the TDF.</td><td rowspan="3">The majority of the infrastructure was in place prior to the start of the campaign.</td><td rowspan="3">Low</td></tr>
<tr><td>Severity</td><td>Sensitivity</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Slight</td><td>Very Low</td><td>LOW</td><td>Certain</td></tr>
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<tr><td rowspan="3">Shore based operations</td><td rowspan="3">Waste</td><td rowspan="3">Generation of domestic waste from operations at the laydown yard</td><td colspan="4">The majority of waste generated during the campaign will be transported back to the UK in the returning coaster vessels for landfill in the UK.</td><td rowspan="3">The majority of waste from the laydown yard will be shipped to the UK with the waste generated offshore. Small quantities of waste may be disposed of in the Falkland Islands, in line with NEFL's WMPA, and will not include direct disposal of waste to Eliza Cove or Mary Hill Quarry.</td><td rowspan="3">Low</td></tr>
<tr><td>Severity</td><td>Sensitivity</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Slight</td><td>Very Low</td><td>LOW</td><td>Certain</td></tr>
<tr><td rowspan="3">Shore based operations.

Drilling operations</td><td rowspan="3">Use of electrical and freshwater resources</td><td rowspan="3">Domestic electrical and freshwater use in support of laydown yard activity.

Use of local water supply for preparation of drilling mud.</td><td colspan="4">Emissions from electricity generation, added burden on the freshwater supply. The scale of the electricity and water use is considered insignificant</td><td rowspan="3">The TDF has freshwater storage tanks which will be constantly trickle-fed with water from the Moody Brook reservoir. This will disconnect any peak in campaign demands from the supply to Stanley.</td><td rowspan="3">Low</td></tr>
<tr><td>Severity</td><td>Sensitivity</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Slight</td><td>Very Low</td><td>LOW</td><td>Certain</td></tr>
<tr><td rowspan="3">Shore based operations</td><td rowspan="3">Generation of light during 24hr operations in relation to local population and wildlife</td><td rowspan="3">Artifical light can attract and disorientate seabirds.

Stakeholder raised concerns that the potential for east-facing lighting from the TDF and bright lighting on vessels facing into the prevailing westerly winds may affect night-time flying at Stanley Airport.</td><td colspan="4">The laydown yard will be located on the outskirts of Stanley, artifical light from the base is not expected to significanlty add to light emitted by FIPASS. Potential for disruption by night flights causes concern for local residents.</td><td rowspan="3">Permanent lighting will be designed and implemented in accordance with the Health and Safety in Ports (SIP009) Guidance on Lighting, prepared by Port Skills and Safety and UK HSE. Consultation with FIGAS to minimise impacts through lighting design.</td><td rowspan="3">Low</td></tr>
<tr><td>Severity</td><td>Sensitivity</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Moderate</td><td>Moderate</td><td>MODERATE</td><td>Probable</td></tr>
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<tr><td rowspan="3">Shore based operations</td><td rowspan="3">Generation of noise during 24hr operations in relation to local population and wildlife</td><td rowspan="3">Noise arising from vessel engines moored alongside the TDF, vessel loading/unloading activities and operation of forklift trucks at the laydown yard, may be a nuisance to local residents.</td><td colspan="4">Noise modelling undertaken for the TDF indicated operations at the laydown yard and TDF on a calm dry night would have barely detectable impacts to Stanley residents, approximately one kilometre away.</td><td rowspan="3">Vessel movements will be reduced where possible through optimised planning, making efficient use of vessel loads. All vessel engines shall be switched off whilst not in use and not left to idle, where possible. Loading or unloading operations at night shall not normally occur and if necessary will be minimised where practicable</td><td rowspan="3">Low</td></tr>
<tr><td>Severity</td><td>Sensitivity</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Minor</td><td>Low</td><td>LOW</td><td>Probable</td></tr>
<tr><td>Shore based operations</td><td>Demands for temporary accommodation in Stanley</td><td>During the campaign approximately 85 additional personnel will be based in Stanley, which will place pressure on the limited number of available beds in Stanley for visitors.</td><td colspan="4">A temporary accommodation block for the exclusive use of the 2015 drilling campaign has been constructed on a brown field site to the south of Stanley (near Stanley Services).</td><td>This facility will satisfy the bulk of the Rhea-1 well campaign's accommodation needs, and will also be able to cope with the eventuality of delayed flights, for instance due to bad weather, when 'emergency' accommodation may be required.</td><td>N/A</td></tr>
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Aspect	Source	Activity Description	Potential Effects and Significance				Legislation/NEFL policy/Mitigation	Residual Impact / Concern
Inshore operations	Physical presence of vessels interfering with other users of Stanley Harbour	Vessels associated with the campaign will increase traffic in Stanley Harbour. Space for manoeuvering in the harbour is limited and the additional traffic could disrupt exisiting fishing and cargo use of the harbour.	During the campaign an estimated six vessel refueling visits will be required at FIPASS, lasting approximately 6-20 hrs each. Consequently the disruption to other users is considered to be moderate given the limited space at FIPASS.				The TDF has a Marine Superintendent to liaise with the Harbour Master, FIPASS management, Stanley Services and other users to keep everyone well informed. A harbour management plan has been produced.Management Plan.	Low
			Severity	Sensitivity	Significance	Certainty		
			Minor	Moderate	MODERATE	Certain		
Unplanned Event	Introduction of marine invasive species	Non-native species may be transported and introduced through ballast water and biofouling on the hull of vessels.	Marine invasive species typically impact inshore benthic communities of native species. Invasive species may not be evident for a number of years, but their long-term impacts could be severe and irreversible. Vessel will be required to follow IMO guidelines for ballast water and biofouling				The *Eirik Raude* and support vessels will comply with IMO Guidelines. However, there remains a residual risk largely due to uncertainties in the assessment. Monitoring will be required to keep a check on the potential presence of marine invasive species, settlement plates will be attached to the TDF to provide an early warning. NEFL have an Exploratory Drilling Biosecurity Plan (BMP) in place to manage the risks. NEFL will also work within the Temporary Dock Facility Biosecurity Plan (BSP)	Moderate
			Overall Impact	Likelihood	Significance	Certainty		
			Moderate	Remote	MODERATE	Probable		

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<tr><td rowspan="3">Crew Transport</td><td rowspan="3">Generation of noise, flight path over sensitive seabird colonies and local communities</td><td rowspan="3">Low flying helicopters over sensitive breeding colonies of penguins can invoke strong responses leading to trampling of adults, chicks and eggs. Helicopters may also be a nuisance to local settlements and disturb livestock on farms.</td><td colspan="4">The impact of a single helicopter is likely to be short-term and rapidly reversible. However the combined impact of numerous daily flights could have serious implications for the survival of moutling birds and young livestock. The severity to local residents is considered to be low and as direct flight lines do not pass over settlements, sensitivity is low. The risk assessment below pertains to seabirds and livestock.</td><td rowspan="3">NEFL will use the flight avoidance map as the basis for flight planning, follow the FI Low Flying Handbook Guidance, and brief helicopter pilots in flight avoidance protocols.</td><td rowspan="3">Low</td></tr>
<tr><td>Severity</td><td>Sensitivity</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Moderate</td><td>High</td><td>MODERATE</td><td>Certain</td></tr>
<tr><td rowspan="3">General presence of industry</td><td rowspan="3">Presence of oil industry could have adverse effect on tourism</td><td rowspan="3">The presence of oil and gas activites in the Falkalnd Islands could have an adverse effect on the image as a wilflide destination.</td><td colspan="4">The drilling operation is currently planned to occur over the Falkland Islands winter, within the main drilling activity occuring offshore to the north of the Islands out of view of visiting tourists.</td><td rowspan="3">The campaign is currently scheduled for the winter – spring months which is outwith the prime tourist season.</td><td rowspan="3">Low</td></tr>
<tr><td>Severity</td><td>Sensitivity</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Slight</td><td>Moderate</td><td>LOW</td><td>Certain</td></tr>
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<tr><td rowspan="3">Unplanned Event</td><td rowspan="3">Dropped object</td><td rowspan="3">Large items that are accidentally dropped overboard during drilling operations could pose a hazard to trawl fishing in the area.</td><td colspan="4">Oil and gas industry historical data indicate that the risk of an incident is relatively low at about 1 incident in 60 drilling campaigns. Annual fishing statistics show that there is very little fishing in the area.</td><td rowspan="3">Best practise for preventing serious events will be followed during the campaign and include; secure all tools, material and equipment; take measures to prevent dropped objects when working over grating; remove tools on completion of the job; erect barriers around drop zones; inspect structures and equipment at risk of falling.</td><td rowspan="3">Low</td></tr>
<tr><td>Overall Impact</td><td>Likelihood</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Very Low</td><td>Possible</td><td>LOW</td><td>Certain</td></tr>
<tr><td rowspan="3">Unplanned Event</td><td rowspan="3">Accidental minor spill of diesel, oil, chemical during loading operations</td><td rowspan="3">Release of contaminants leading to deterioration in seawater quality and toxic impacts on marine life.</td><td colspan="4">Diesel spill would only remain in surface waters for a short time, but releases toxic substances that will have small a localised impact on water quality, plankton, fish and squid. The presence of the rig may attract birds that are more vulnerable to toxic surface pollution and several species in the area are classifed as Endangered.</td><td rowspan="3">All diesel transfer hoses will be fitted with dry-break seals, where possible, which will limit the amount discharged in the event a hose is accidentally disconnected. Additionally NEFL will provide working procedures which outline control and preventative measures.</td><td rowspan="3">Moderate</td></tr>
<tr><td>Overall Impact</td><td>Likelihood</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>High</td><td>Rare</td><td>MODERATE</td><td>Probable</td></tr>
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<tr><td rowspan="3">Unplanned Event</td><td rowspan="3">Storm water overwhelming rig deck drains resulting in discharge of contaminated water

Unplanned discharge from rig open or closed drain system</td><td rowspan="3">Release of contaminants leading to deterioration in seawater quality and toxic impacts on marine life.</td><td colspan="4">Drainage management will be in place on the rig via processes and procedures to minimise overloading of the oily water separator during storms and heavy rain.</td><td rowspan="3">NEFL will provide working procedures which outline controls and preventative measures.</td><td rowspan="3">Low</td></tr>
<tr><td>Overall Impact</td><td>Likelihood</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Low</td><td>Remote</td><td>LOW</td><td>Certain</td></tr>
<tr><td rowspan="3">Unplanned Event</td><td rowspan="3">Collision between support or supply vessel with marine mammals</td><td rowspan="3">An increase in general shipping traffic throughout the campaign could lead to an increase in the risk of vessel collisions with marine mammals.</td><td colspan="4">Large numbers of marine mammals are present in inshore waters coinciding with the period of the campaign. Of these whales, sei whales are Endangered. The campaign will increase shipping near Stanley by 6%, however lack of historically reported incidents suggests that few collisions occur around the Falkland Islands.</td><td rowspan="3">Mariners should be made aware of the issue and how it relates to the Falkland Islands (see IFAW (2013) leaflet).
Along with the usual duties of a watch keeper, additional vigilance is required to detect cetaceans in inshore waters.</td><td rowspan="3">Low</td></tr>
<tr><td>Overall Impact</td><td>Likelihood</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Moderate</td><td>Remote</td><td>MODERATE</td><td>Probable</td></tr>
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<tr><td rowspan="3">Unplanned Event</td><td rowspan="3">Introduction of terrestrial alien species at laydown yard via equipment import from UK</td><td rowspan="3">Risk of introducing invertebrates, seeds and soil (containing micro-organisms) that can adhere to the outside of containers or be hidden in cargo. Species that may be transported in cargo from the UK are very likely to survive.</td><td colspan="4">If invasive species were introduced the impact through parasites, disease, competitors or predators may not be immediately evident. Long-term implications could be severe and difficult to reverse. Vessels will be arriving throughout the campaign and a large amount of cargo will be brought onshore. The introduction of invasive species has happened in industry elsewhere.</td><td rowspan="3">All materials are clean when packed or loaded in the port of origin, particularly items of fresh fruit and vegetables. Personnel will be briefed on the significance of non-native species. Falkland Islands Biosecurity Guidelines will be adhered to. Cargo will be inspected on arrival for biosecurity breaches. NEFL will also work within the Temporary Dock Facility Biosecurity Plan (BSP)</td><td rowspan="3">Moderate</td></tr>
<tr><td>Overall Impact</td><td>Likelihood</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Moderate</td><td>Possible</td><td>MODERATE</td><td>Probable</td></tr>
<tr><td rowspan="3">Accidental Event</td><td rowspan="3">Vessel collision in Stanley Harbour, potential for small leaks or tanks to overflow during re-fueling leading to loss of diesel</td><td rowspan="3">Whilst Stanley Harbour is not recognised as a habitat of great conservation value, it is home to steamer ducks and other coastal species, as well as Commerson's dolphin, and is used recreationally by Stanley residents.</td><td colspan="4">Collision with a fully re-fueled vessel could lead to a total inventory loss of 800 tonnes diesel. This would be spread between various segregated tanks and would be very unlikely that all or any would be lost. However as a worst-case this could represent a sizeable spill in sheltered coastal waters.</td><td rowspan="3">The same precautionary measures that apply to all vessels bunkering at FIPASS will apply to the rig supply vessels.
A Harbour mangement plan and oil spill response plan are in place.
The support vessels will be fully equipped to deal with spills offshore and the same equipment would be used to deal with small spills inshore. Oil spill respone equipment available at the TDF.</td><td rowspan="3">Low</td></tr>
<tr><td>Overall Impact</td><td>Likelihood</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Moderate</td><td>Remote</td><td>MODERATE</td><td>Certain</td></tr>
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<tr><td rowspan="3">Accidental Event</td><td rowspan="3">Major loss of containment/ blow-out of hydrocarbons</td><td rowspan="3">Prolonged release of crude oil to the water column which could impact water quality, plankton, benthic organisms, seabirds, marine mammals, fish and fisheries, coastal fauna and tourism.</td><td colspan="4">The predicted oil is very waxy and has a high viscosity and is expected to form waxy droplets on the surface following release. However, a lighter oil could be encountered. Impacts to plankton are considered to be short-term and recoverable. Impacts to benthic filter feeders are unknown. Seabirds and marine mammals are not considered significantly at risk due to the semi-solid nature of the wax droplets, although this may differ if a different hydrocarbon is encountered. The direction of the prevailing conditions is likely to spread the spill over fishing areas and could result in short-term closed areas. The coastline of East Falkland is at greatest risk of beaching. The impact to tourism is considered to be major.</td><td rowspan="3">The well design will be peer reviewed by NEFL's well examiner and the Health and Safety Executive to ensure that the risk of an uncontrolled release is minimised.
The well will be fitted with a blow-out preventer that will seal the well in the event of a major incident.
NEFL is preparing an Oil Spill Response Plan that would initiate a tiered response in the event of a spill.</td><td rowspan="3">Moderate</td></tr>
<tr><td>Overall Impact</td><td>Likelihood</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Very High</td><td>Remote</td><td>MODERATE</td><td>Probable</td></tr>
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<tr><td rowspan="3">Accidental Event</td><td rowspan="3">Loss of containment of WBM from the riser</td><td rowspan="3">Increased turbidity in the water column, sedimentation leading to smothering of benthic organisms, modification of sediment particle size and habitat.</td><td colspan="4">Discharges would impact small areas of seabed and a small volume of water relative to the available habitat on the Northern Slope. Impacts would be short term, with potential for rapid recovery. Modification of sediments would persist for over 10 years in a very small area.</td><td rowspan="3">Redundancy is designed in to ensure DP related equipment are always available. DP trials will be undertaken when the rig reaches location. An exclusion zone of 500m will be maintained. Mariners will be advised of the rig location to avoid collision, Meteorological analysis of extreme weather events will be assessed. Continual monitoring of long-range and short-range weather forecasts.</td><td rowspan="3">Low</td></tr>
<tr><td>Overall Impact</td><td>Likelihood</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Low</td><td>Remote</td><td>LOW</td><td>Probable</td></tr>
<tr><td rowspan="3">Accidental Event</td><td rowspan="3">Loss of containment/ blow-out</td><td rowspan="3">Waste management during clean-up</td><td colspan="4">If a major spill occurred, the clean-up operation would generate a large volume of hazardous waste (oil, contaminated materials, PPE etc.), which would have to be disposed of responsibly. This would potentially have a serious environmental impact in its own right but under the circumstances of a major incident, the impact would be relatively insignificant.</td><td rowspan="3">Contaminated waste from a spill clean-up would be managed in line with NEFL's Waste Management Plan. It is expected that waste of this kind will be exported to the UK</td><td rowspan="3">Low</td></tr>
<tr><td>Overall Impact</td><td>Likelihood</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Slight</td><td>Remote</td><td>LOW</td><td>Probable</td></tr>
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<tr><td rowspan="3">Accidental Event</td><td rowspan="3">Loss of containment/ blow-out</td><td rowspan="3">Air Quality would be affected by light oils, such as diesel, which evaporate quickly and release noxious compounds into the atmosphere. Heavier crude oil takes longer to breakdown and therefore releases gases slowly over a period of weeks or months.</td><td colspan="4">Following an oil spill, Volatile Organic Compounds, Polycyclic Aromatic Hydrocarbons, Hydrogen Sulphide and other noxious compounds are released, which all impact on air quality. In the offshore environment, atmospheric pollution is rapidly dispersed.</td><td rowspan="3">The impacts of a blow-out would be far reaching but air quality was not deemed to be of great significance.</td><td rowspan="3">Low</td></tr>
<tr><td>Overall Impact</td><td>Likelihood</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>Minor</td><td>Low</td><td>LOW</td><td>Certain</td></tr>
<tr><td rowspan="3">Accidental Event</td><td rowspan="3">Major incident such as collision with another vessel resulting in loss of rig inventory</td><td rowspan="3">Loss of the total diesel fuel inventory, 4,631m^3. Resulting in release of contaminants and subsequent deterioration in seawater quality and toxic impacts on marine life.</td><td colspan="4">Spilt diesel only remains in surface waters for a short time, but releases toxic substances that would have a small localised impact on water quality, plankton, fish and marine mammals. The presence of the rig may attract birds that are more vulnerable to toxic surface pollution and several species in the area are classifed as Endangered. The risk to the coastline is slight as diesel quickly evaporates and disperses from surface waters therefore is unlikely to reach the coastline.</td><td rowspan="3">An exclusion zone of 500m will be maintained. Mariners will be advised of the rig location to avoid collision. All vessels in the area will be informed of the rig's position and intentions by radio broadcast and AIS. The ERRV will patrol the 500m exclusion zone and ensure other vessels do not approach.</td><td rowspan="3">Moderate</td></tr>
<tr><td>Overall Impact</td><td>Likelihood</td><td>Significance</td><td>Certainty</td></tr>
<tr><td>High</td><td>Remote</td><td>MODERATE</td><td>Probable</td></tr>
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Aspect	Source	Activity Description	Potential Effects and Significance				Legislation/NEFL policy/Mitigation	Residual Impact / Concern
Accidental Event	Major incident resulting in loss of rig	Disruption to shipping in the area	There is very little vessel traffic in the area.				Mariners and FIGFD will be advised of the rig location to avoid collision. Meteorological analysis of extreme weather events will be assessed.	Low
			Overall Impact	Likelihood	Significance	Certainty		
			Slight	Very Low	LOW	Certain		