Exploration Drilling
Environmental Impact Statement Addendum

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Falkland Oil and Gas Limited

ENVIRONMENTAL IMPACT STATEMENT ADDENDUM
EXPLORATION DRILLING

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Abbreviations

%	Percent
”	Inches
°	Degrees
°C	Degrees Celsius
$\mu g.g^{-1}$	Micrograms per gram
2D	Two Dimensional
ADCP	Acoustic Doppler Current Profiler
ALARP	As Low As Reasonably Practicable
API	American Petroleum Industry
boe	Barrels of oil equivalent
BHP	Broken Hill Proprietary Company Limited
BOP	Blow-out Preventer
B&S	Borders and Southern
CEFAS	Centre for Environment Fisheries and Aquaculture Science
CHARM	Chemical Hazard Assessment and Risk Management
$cm.s^{-1}$	Centimetres per second
CO_2	Carbon Dioxide
CPI	Carbon Preference Index
DP	Dynamically Positioned
E&P	Exploration and Production
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMP	Emergency Management Plan
ERP	Emergency Response Plan
FC	Falklands Conservation
FICZ	Falklands Inner Conservation Zone
FIDA	Falkland Islands Designated Area
FIFD	Falkland Islands Fisheries Department
FIG	Falkland Islands Government
FOC	Fractional Organic Compound
FOCZ	Falklands Outer Conservation Zone
FOGL	Falkland Oil and Gas Limited
FOSA	Falklands Offshore Sharing Agreement
FSL	Fugro Survey Limited
GC	Gas Chromatogram
GEL	Gardline Environmental Ltd.
HSES MS	Health, Safety, Environmental and Social Management System
HMCS	Harmonised Mandatory Control Scheme
HOCNF	Harmonised Offshore Chemical Notification Format
HQ	Hazard Quotients
HSE	Health, Safety and Environment
IPIECA	International Petroleum Industry Environmental Conservation Association
ITOPF	The International Tanker Owners Pollution Federation

IUCN	International Union for the Conservation of Nature
Kg	Kilogram
LAT	Lowest Astronomical Tide
LOI	Loss On Ignition
m	Metres
m^2	Square Metres
m^3	Cubic Metres
mm	Millimetres
MMO	Marine Mammal Observer
ms^{-1}	Metres per second
MSL	Mean Sea Level
$ng.g^{-1}$	Nanograms per gram
NNR	National Nature Reserves
NO_2	Nitrogen Oxide
NO_X	Nitrous Oxides
OCNS	Offshore Chemical Notification Scheme
OSPAR	Oslo / Paris Convention
PAH	Polycyclic Aromatic Hydrocarbons
PLONOR	Pose Little or No Risk to the environment
PON	Petroleum Operations Notices
ppg	Parts Per Gram
ppt	Parts Per Ton
PROTEUS	Pollution Risk Offshore Technical Evaluation System
PSA	Particle Size Analysis
PSD	Particle Size Distributions
Q1-4	Quarter 1-4
RAF	Royal Air Force
ROV	Remotely Operated Vehicle
RQ's	Risk Assessments
SIMPER	Similarity Percentage
SIMPROF	Similarity profile
SO_X	Sulphur Oxides
TD	Target Depth
THC	Total hydrocarbon concentrations
TOM	Total Organic Matter
TVD	Total Vertical Depth
UCM	Unresolved Complex Mixture
UKOOA	United Kingdom Offshore Operators Association
UK O&G	Oil and Gas UK
UNEP	United Nations Environment Programme
WBM	Water Based Mud

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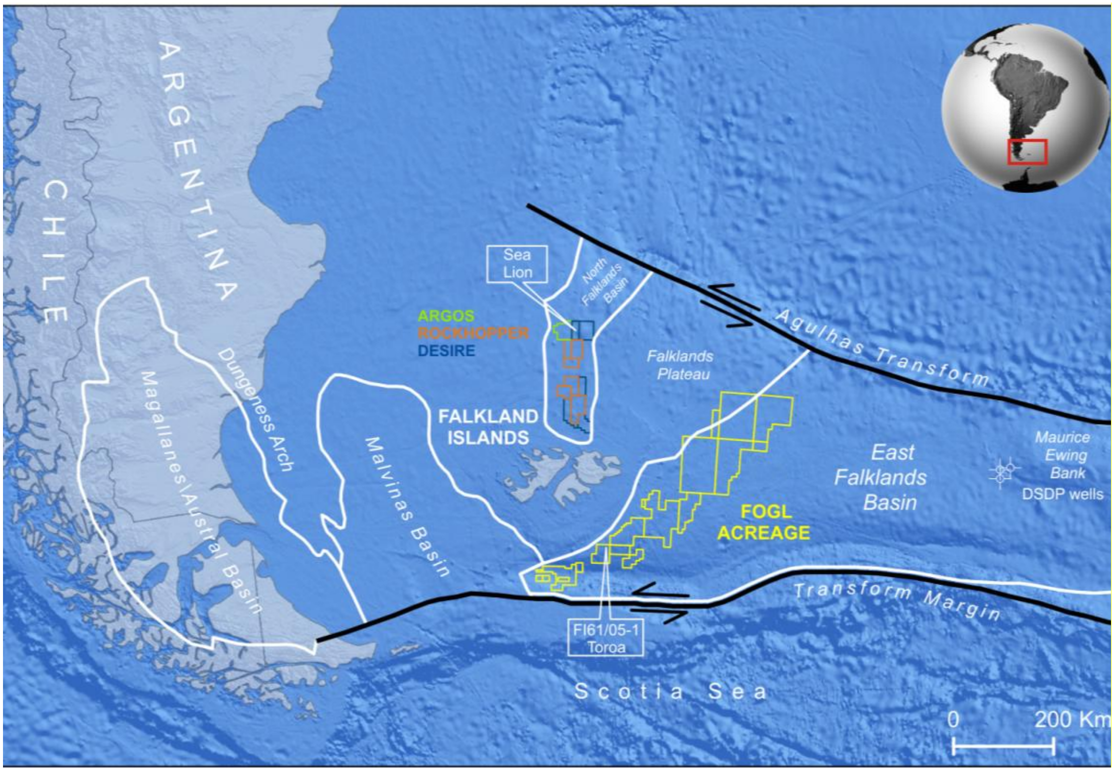
1 Introduction

1.1 The Project

Falkland Oil and Gas Limited (FOGL) is a UK-based, oil and gas exploration company operating in the South and East Falkland Basins, a potentially new petroleum province in the South Atlantic (Figure 1.1). The company holds 100% equity interest and operatorship of 13 exploration and production licences covering approximately 48,740 square kilometres and are located in water depths ranging from 500 to 2,000 metres.

Figure 1.1 Geographical positioning of FOGL Licence Blocks



FOGL plans to drill two exploration wells in the East Falklands Basin licence blocks. The first well will be on the Loligo prospect at location A or NW. The second well location has not been confirmed but will be one of the three potential locations: - a further well in the Loligo area (NW or A, dependent on which is drilled first), or the Nimrod-1 well, or the Scotia East D well. (Figure 1.2). The proposed wells lie to the east of the Falkland Islands. The well nearest to the shore is Nimrod (168 kilometres) and the furthest is Scotia East D (314 kilometres). The water depths at well locations vary between 1,300-1,800 metres.

It is anticipated that hydrocarbons, if discovered, would primarily comprise of oil with an API of 18-25^{o} for all wells apart from Scotia East D (API 30^{o}). Gas with condensate is a possible alternative.

Figure 1.2 Potential Well Locations

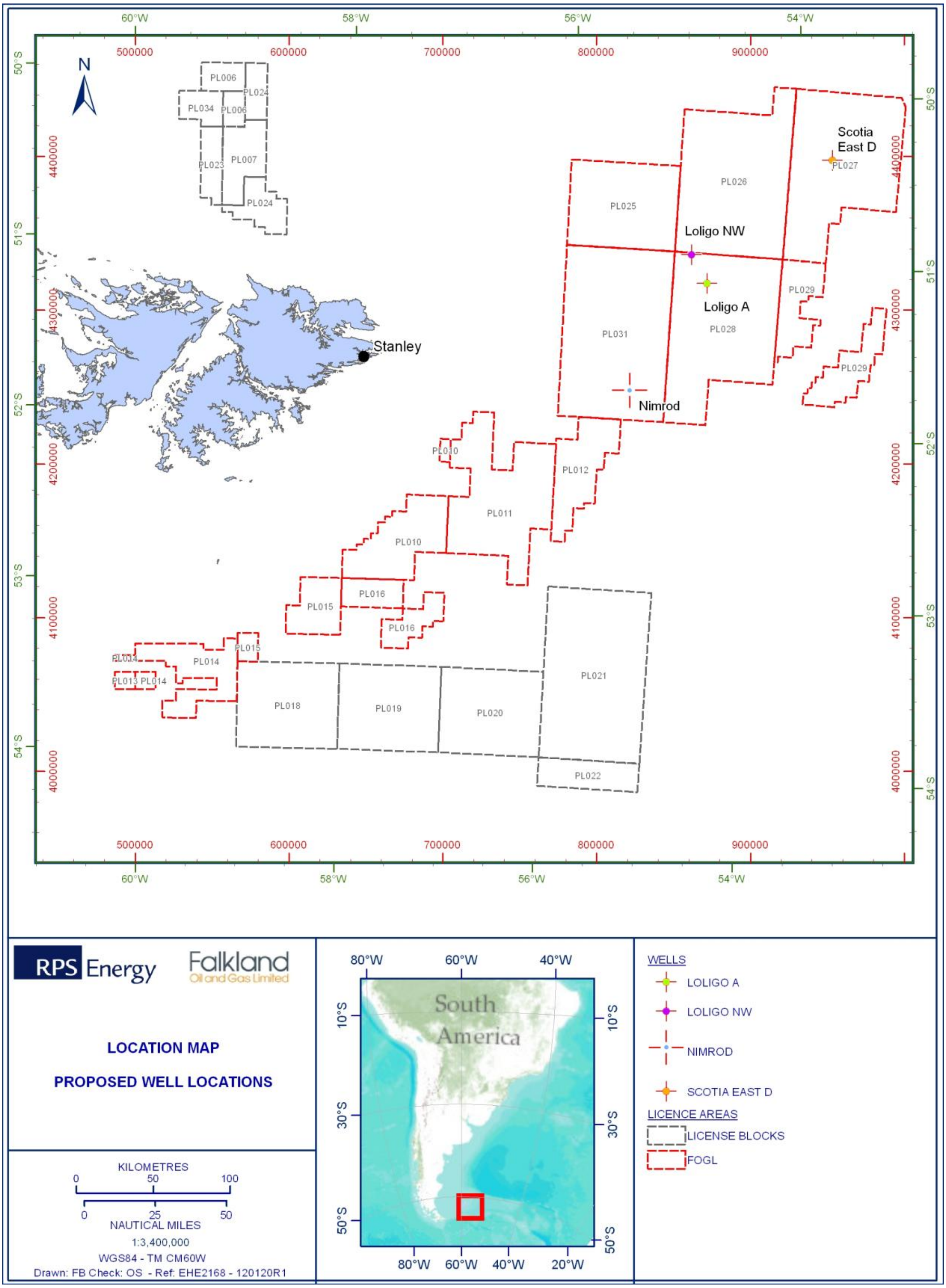
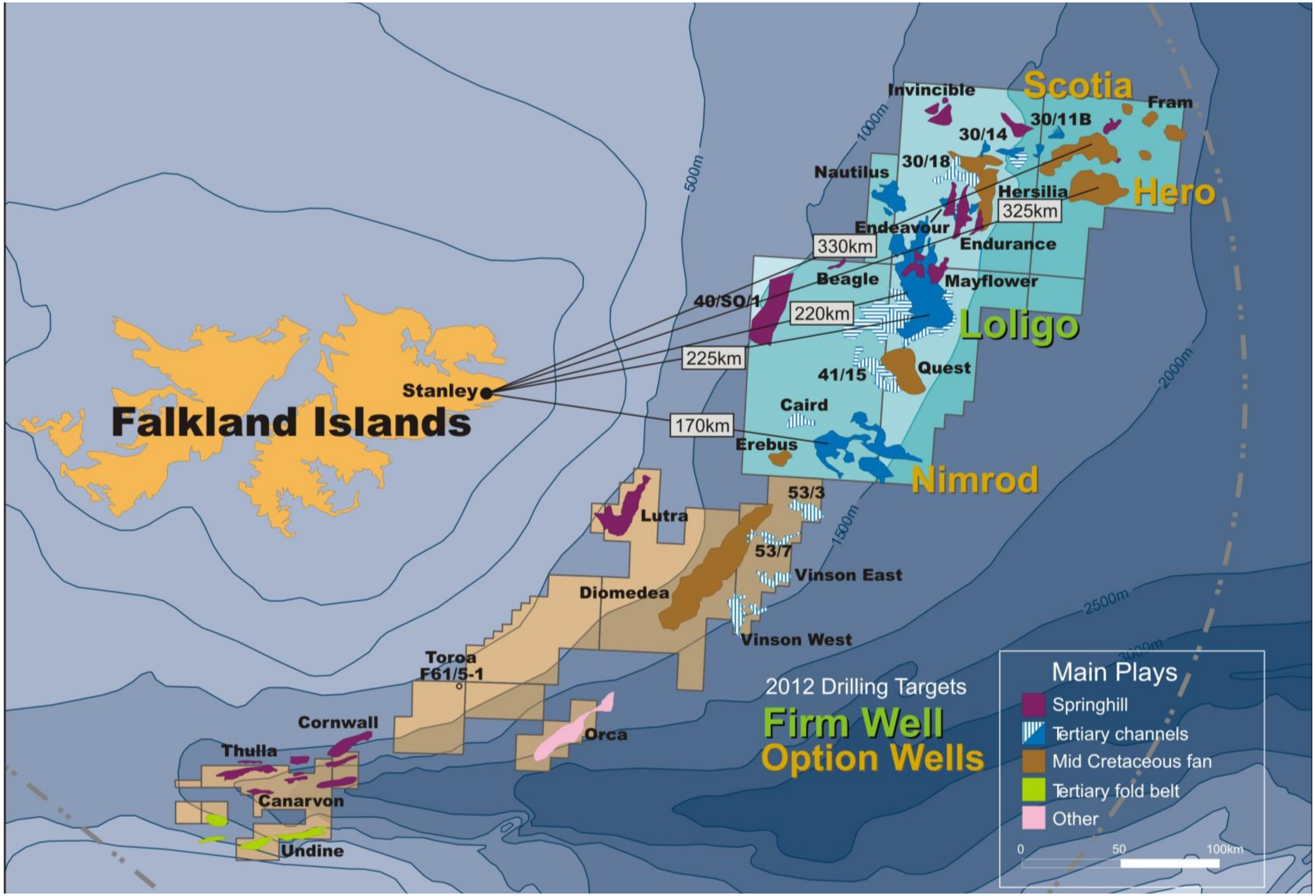


Figure 1.3 Falkland Islands Hydrocarbon Prospects Surveyed by FOGL



As part of the ongoing exploration campaign, FOGL acquired two dimensional (2D) seismic data over a number of licence blocks between 2005 and 2007, and conducted geotechnical and environmental site surveys for Loligo A, Nimrod-Garrodia, Toroa, and Endeavour prospects in 2008-2009 (Figure 1.3). The Toroa-1 (FI 61/05-1) well was drilled and abandoned, as a dry hole, in mid 2010. The 2011 site survey programme has been completed for the following prospects: Inflexible, Vinson West, Scotia East, Hero and Loligo NW (Figure 1.3). The results of these site surveys are discussed in Section 3, specifically for the four proposed well locations, but also compared with other survey areas to have an overall picture of benthic habitats offshore east of Falkland Islands.

FOGL has finalised a contract with the Ocean Rig drilling company for the use of the Leiv Eiriksson dynamically positioned fifth-generation semi-submersible rig. The rig has already been mobilised and has commenced drilling in the neighbouring southern blocks operated by Borders & Southern. The proposed drilling within the FOGL licence area is now anticipated to commence in May 2012 and will last for approximately 100 days (35-65 days per well). Following drilling, the wells will be plugged and abandoned in accordance with Oil and Gas UK Guidelines. The seabed structures will be dealt with according to FIG guidelines, taking account of the likelihood of this equipment posing a threat to ship anchors or over-trawling by fishing vessels.

Water-based mud will be used to drill all wells. Chemicals to be used during the drilling have been 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 category of 'E' (which are of low aquatic toxicity, readily biodegradable and non-bio accumulative) and are naturally occurring products (e.g. barite) that are either biologically inert or readily dispersible or biodegradable.

The drilling operations will be managed by AGR as well management contractor on behalf of FOGL. Two support vessels and two helicopters will be used throughout planned operations. Further operational details are included in Section 4.

1.2 Document Objective

This document constitutes the Operational Addendum to the following FOGL Offshore Drilling Environmental Impact Statement (EIS):

FOGL Exploration Drilling Environmental Impact Statement, submitted September 2011.

The EIS has been approved by the Falkland Islands Government (FIG) pending the submission of an Operational Addendum aimed to provide further details on the drilling programme and the environment unknown at the time of EIS preparation.

This Operational Addendum has been produced by RPS Energy on behalf of FOGL to meet the FIG conditions. As such, it aims to:

- Confirm drilling rig, well locations and other operational details;
- Discuss site survey results for the proposed well locations including physical / chemical characteristics of seabed sediments as well as benthic species and habitats present within the well vicinity. The findings from other well locations are used as supporting evidence for benthic habitat distribution.
- Review and update the impact assessment section to cover any additional hazards, effects and mitigation measures not discussed in the EIS.

The Operational Addendum does not cover any other environmental baseline data or seasonal sensitivities as these remain unchanged, and are detailed in the EIS.

The Waste Management Plan, prepared by AGR, will be submitted separately.

1.3 The Applicant

Falkland Oil and Gas Limited (FOGL) is an AIM-listed oil and gas exploration company operating in the south and east Falkland Basins. The company holds 100% equity interest and operatorship of 13 exploration and production licences.

FOGL is the designated operator for the proposed drilling campaign and is therefore ultimately responsible for all operations. All operations will be undertaken by contractors under FOGL's management and oversight.

1.4 Contact Address

Any questions, comments or requests for additional information regarding this EIS should be addressed to:

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2 Operational Section

2.1 Overview

FOGL plans to drill two exploration wells, the first of which will be Loligo (A or NW). The second well will be one of three locations – the alternate Loligo well, Nimrod-1 or Scotia East D. The selection will be determined based on the first well findings (Figure 1.2). The proposed wells lie offshore east of the Falkland Islands in water depths varying between 1,300 and 1,800 metres. The nearest well to the shore is Nimrod-1 (168 kilometres) and the furthest well is Scotia East D (314 kilometres).

It is anticipated that hydrocarbons, if discovered, would primarily comprise oil with an API of 18^{o} to 25^{o} (the 18^{o} API is a worst case and so has been used for modelling purposes) for all wells apart from Scotia East D (where an API of 30^{o} is anticipated). Gas with some condensate is a possible alternative but not considered in this drilling EIS as its presence would represent a best case scenario from the point of view of potential adverse environmental impacts.

Following drilling, the wells will be plugged and abandoned in accordance with Oil and Gas UK Guidelines). The seabed structures will be dealt with according to FIG guidelines, taking account of the likelihood of this equipment posing a threat to ship anchors or over-trawling by fishing vessels.

2.2 Target Reservoirs and Exploration Objectives

The objective of this project is to explore hydrocarbon reservoirs in the Tertiary Channel Play and Mid Cretaceous Fan Play of the south and east Falklands Basin through the drilling of two exploration wells.

The Tertiary Channel Play is the shallowest and youngest formation which is prospective for oil and gas. The play was developed when the Falkland Islands and surrounding region experienced a period of uplift after the end of the Cretaceous period – around 80 million years ago (Mercer H, 1983; Light *et al*, 1993). As a result of the uplift, sediments which had built up around the Falklands Plateau were shed into the basin. The sequence has been divided into 5 units, termed T1 to T5. The sediment type, total isopachs, thickness distribution and sediment transport direction are different for each unit within the gross sequence. The largest prospect in this play (Loligo) sits above an old basin high and this may act as a focussing mechanism for oil and gas which has been generated in the relatively recent past. This play is dominated by large stratigraphic traps which are supported by bright seismic signatures and Class III AVO (amplitude versus offset) responses.

There are many prospects within the Tertiary channel play but those with site surveys are: Loligo, the Nimrod Complex (Figure 1.3) and Vinson West. There are four separate site surveys on Loligo, three of which are down-dip over the main and southern parts of the prospect and one, up-dip to the northwest (Loligo NW).

The Loligo prospect covers an area in excess of 1000 square kilometres at the T1 horizon, in quadrants 30 and 42 (PL026, PL028). It is the largest prospect in the basin. There are multiple stacked targets within Loligo (several separate reservoir zones stacked on top of each other) and near the southern end of the prospect several independent prospects (Trigg Deep East, Three Bears, and South Loligo Deep) may be intersected with one exploration well (these additional prospects extend into quadrant 41, PL031). The Loligo target consists of sand sheets but within these layers the reservoir thickens and thins in a complex pattern due to deposition in a series of marine channels. The water depths at the potential well locations vary from 1300 metres to 1400 metres. The deepest well currently contemplated on the Loligo prospect is Loligo A to some 2710 metres below the sea bed. The shallowest well under consideration is Loligo NW, which targets the upper T1 and T2 Units, in an optimal location. It would reach target depth (TD) at 1319 metres below the sea bed. The Loligo well locations lie approximately 225 kilometres east of Stanley.

The Nimrod Complex lies at the southern end of Quadrants 41 and 42 (PL031 and PL028) and includes the Nimrod A, B and Garrodia features. The water depth at the potential well location is 1292 metres. The targets are relatively shallow and the TD of the well would be about 150 metres below the deepest target, at 1788 metres below the sea bed. There are many similarities between the Loligo and Nimrod prospects in terms of reservoir type, depositional style and the stacked nature of the target. Within the complex as a whole, prospective targets exist within the T1, T2, T3 and T5 Units. At the selected well Nimrod-1 location (on Garrodia), the prospects are within the T2 and T3 Units. The Nimrod complex is the second largest prospect in the basin. Nimrod and Loligo are both in the northern area licences. The Nimrod Complex lies approximately 170 kilometres southeast of Stanley.

The Mid Cretaceous Fan Play is well developed in the northern part of the FOGL acreage. This geological play was developed when the Falklands were still attached to the southern part of the African continent. A large amount of sediment, sourced from the continent and the Falklands Plateau area to the north, built up in near shore shallow seas. When a drop in sea level occurred, these sediments were deeply eroded and the reworked sands were shed far offshore into deep water. Several prospects have recently been mapped in this play in the northern licences. These are Hersillia, Scotia and Hero.

The Scotia prospect is located in quadrant 31 (PL027) (Figure 1.3). Although the area had been mapped on seismic data before, it was only when the entire data set was reprocessed in 2008-09 that Scotia stood out as an attractive prospect. A distinctive sandy unit overlaps the base of the old shelf. The formation dips to the south, which controls the spill point of the prospect, but it relies upon the pinchout of the sands in other directions to define the trap. The prospect has a strong element of structural control and is supported by a conformable AVO anomaly. The primary target is in Late - Mid Cretaceous age sandstones (about 100 million years old). The source rock for the oil sits just below this target and FOGL anticipates oil generation in the area. However, FOGL also recognises gas signatures on the seismic data and so either 'phase' is strictly possible. The Scotia well location sits in 1762 metres of water. The target is about 3,290 metres below the sea bed and the TD of the well is estimated to be at 3436 metres below the seabed. The Scotia well location lies approximately 330 kilometres east of Stanley.

2.3 Proposed Project Schedule

The updated project schedule is to commence operations in May 2012. The total average duration of the 2-well drilling campaign is approximately 100 days. The mobilisation of the Leiv Eiriksson rig will take 1-2 days, following drilling in the neighbouring southern blocks operated by Borders & Southern.

No well testing that involves flowing well fluids to the surface is planned. All evaluations will be undertaken by wireline methods. Following drilling, the wells will be plugged and abandoned, and all obstructions removed from the seabed.

2.4 Drilling Operations

2.4.1 Well Details

The key characteristics of the wells identified as possible candidates for the two well drilling campaign are summarised in the Table 2.1 below.

Table 2.1. Proposed Drilling Programme Well Characteristics

Aspect	Proposed Well Locations			
	Loligo A	Loligo NW	Nimrod-1	Scotia East D
Licence Area	PL028	PL028	PL031	PL027
Drilling Locations	51°10'23.75''S 54°40'48.40"W	51°00'45.63"S 54°50'28.90"W	51°49'44.25"S 55°20'6.8"W	50°23'54.50''S 53°37'11.61''W
Drill Rig	Leiv Eiriksson - 5th generation DP semi-submersible drill rig			
Support Location	Stanley			
Water Depth (m)	1382	1316	1292	1762
Drilling Depth (m)	2710	1319	1788	3436
Nearest Landfall (km)	214	208	168	314
Anticipated Spud date	May 2012		June 2012	
Estimated time to reach TD	50-55	35-40	40-45	60-65
Clean up and well testing	None Planned			
Anticipated Hydrocarbons	Oil, API 18 - 25°			Oil, API 30°
ITOPF Category	Group III			
Anticipated Weight of Cuttings (tonnes)	1091	843	985	1664

2.4.2 The Drilling Rig

FOGL has negotiated a contract assignment from Borders and Southern for the use of the Ocean Rig Leiv Eiriksson dynamically positioned fifth-generation semi-submersible rig (Figure 2.1). The rig specifications are summarised in Table 2.2 below and further detailed in Appendix A.

Figure 2.1. The Ocean Rig 'Leiv Eiriksson DP semi-submersible rig' (Appendix A)

Table 2.2. Specifications of the Leiv Eiriksson rig

Feature	Specification
Rig Type	Dynamically positioned Semi-submersible
Rig Design	Trosvik Bingo 9000
Year Built	2001
Yard Built	Dalian New Shipyard, China – baredeck Outfitted Friede Goldman Offshore, USA
Class	DP Class 3 DnV +1A1 Column Stabilised Drilling Unit (N) DYNPOS AUTRO, HELDK SH, CRANE, F-AM, DRILL
Safety Case	Norwegian AoC (SUT) and UK
Water Depth	7,500 ft (2286m)
Dimensions	391.68 ft (119.38m) by 278.88 ft (85.5m)

Feature	Specification
Drilling (Operating) Draft	77.9 ft (23.75m)
Transit Speed	6 – 7 knots
Variable Deckload Operating	7,222 mt
Variable Deckload Transit	6,534 mt
Number of Columns	6
Operating Displacement	53,393 mt
Mud Capacity	1,657 m^3
Bulk Mud / Cement Capacity	350 m^3
Bulk Cement Capacity	350 m^3
Drill Water Capacity	1,960 m^3
Potable Water Capacity	1,155 m^3
Fuel Oil Capacity	4,631 m^3
Base Oil Capacity	406 m^3
Brine Capacity	680 m^3
Drawworks	Continental Emsco Electrohoist III, 3000 hp
Derrick	Hydralift 170 ft by 40 ft by 40 ft 680 mt
Top Drive	Hydralift HPS 750 2E AC Electric Drive
Pipe Handling System	Hydralift
Fwd and Aft System	Hydralift
Rotary	Varco BJ RSTT 60 ½ inch
Mud Pumps	3 x Continental Emsco FC-2200HP, 7,500 psi
Main Engines	6 x Wartsila 18V32 diesel engines (total 61,200 hp)
Generators	6 x ABB ASG 900 XUB generators (total 43,800 kW)
Propulsion	6 x Rolls Royce UUC 7001 fixed pitch variable speed thrusters
BOP	Cameron 18 ¾ inch, 15,000 psi, H_2S service Annulars: 2 each; 10,000 psi BOP Rams: 4 each; 15,000 psi
Diverter	Vetco KFDS-CSO-500
Riser Tensioner	6 x Hydralift (Total Capacity 1,089 mt)
Motion Compensators	Hydralift 800-25 Passive/Active Crown Mounted Compensator
Crane	2 x Hydralift WOMCVC 3447; 75 mt
Accommodation	120 berths and hospital
Helideck	EH 101 Helicopter (Diameter = 22.8 metres)
Life Saving Equipment	4 x 70-person lifeboats 1 x Man Over-Board (MOB) boat Escape chute system (Selantic) with 8 life rafts (total capacity 240 men)

2.4.3 Well Construction

Wells are drilled in sections, with the diameter of each section decreasing with increasing depth. During the drilling of the upper well section the drill string (also called drill pipe) and drill bit are typically left open to the seawater. However, before drilling lower sections of the well, a lining called casing is run and cemented in the well and a riser pipe is used between the rig and the seabed with the drill string passing through the riser (from seabed back to rig) and the casing (below seabed).

Once the casing has been run, the drilling fluid can be returned to the rig in the space (annulus) between the drill string and the casing / open hole and back up the riser to the rig. 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 stability of the hole and also helps reduce fluid losses from the well bore into surrounding rock formations.

Well profiles are illustrated in Figures 2.3 to 2.6 and summarised in Tables 2.3 to 2.7. No casing is planned in the final hole sections for all of the proposed wells.

Table 2.3 Proposed Loligo A Well Profile

Hole Size		Casing size		Section Length	Proposed Mud Use
Inches	Metres	Inches	Metres	Metres	
42	1.07	36	0.91	76	Seawater
26	0.66	20	0.51	722.5	Seawater + Gel Sweeps
17 $^{1}/_{2}$	0.44	13 $^{3}/_{8}$	0.34	Contingency	WBM
12 ¼	0.31	9 $^{5}/_{8}$	0.24	840	WBM
8 ½”	0.22	-	-	1072	WBM
Total				2710	

Table 2.4. Proposed Loligo NW Well Profile

Hole Size		Casing size		Section Length	Proposed Mud Use
Inches	Metres	Inches	Metres	Metres	
42	1.07	36	0.91	76	Seawater
26	0.66	20	0.51	608	Seawater + Gel Sweeps
17 $^{1}/_{2}$	0.44	13 $^{3}/_{8}$	0.34	Contingency	WBM
12 ¼	0.31	-	-	635	WBM
Total				1319	

Table 2.5. Proposed Nimrod-1 Well Profile

Hole Size		Casing size		Section Length	Proposed Mud Use
Inches	Metres	Inches	Metres	Metres	
42	1.07	36	0.91	76	Seawater
26	0.66	20	0.51	680	Seawater + Gel Sweeps
17 $^{1}/_{2}$	0.44	13 $^{3}/_{8}$	0.34	Contingency	WBM
12 ¼	0.31	-	-	1032	WBM
Total				1788	

Table 2.6. Proposed Scotia East D Well Profile

Hole Size		Casing size		Section Length	Proposed Mud Use
Inches	Metres	Inches	Metres	Metres	
42	1.07	36	0.91	76	Seawater
26	0.66	20	0.51	962	Seawater + Gel Sweeps
17 $^{1}/_{2}$	0.44	13 $^{3}/_{8}$	0.34	1000	WBM
12 ¼	0.31	9 $^{5}/_{8}$	0.24	1000	WBM
8 ½"	0.22	-	-	398	WBM
Total				3436	

Figure 2.2. Proposed Loligo A Well Schematic

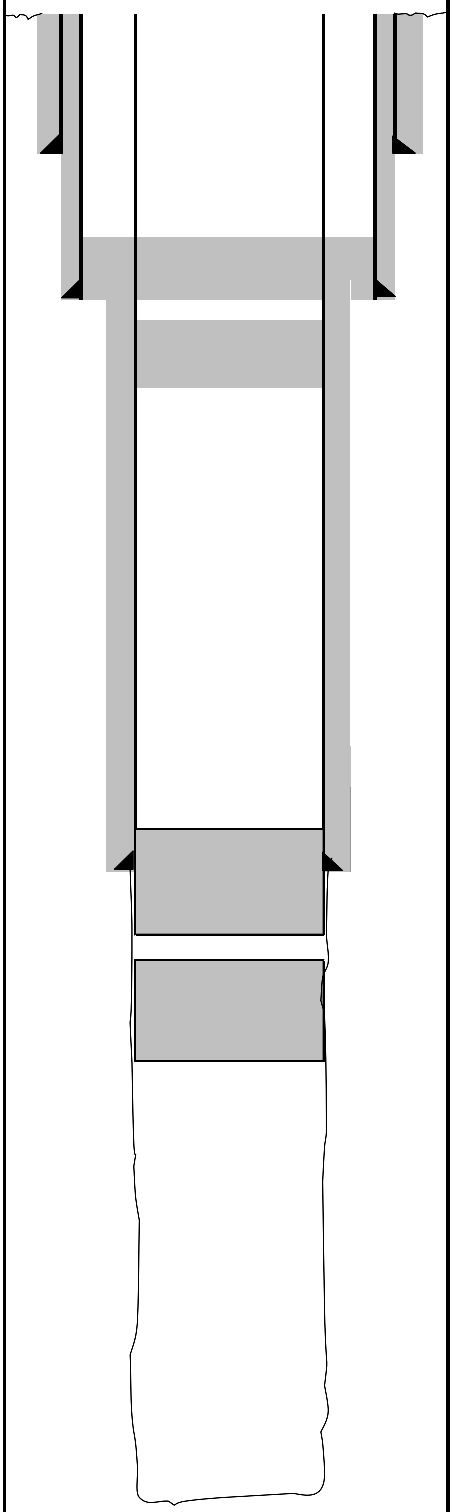
DEPTH (m MDBRT)	DEPTH (m TVDSS)	DOWNHOLE SCHEMATIC	DESCRIPTION
			Wellhead removed at seabed
1407.5	1381.5		**Seabed**
			TOC 30" Means of Verification: Visual Confirmation with ROV TOC 20" Means of Verification: Visual Confirmation with ROV
1483.5	1457.5		**36" Conductor Shoe**
1906	1880		TOC 9 5/8" Means of Verification: Volumes and Pressure, Sonic Log
2206	2180		**20" Shoe** 20" Cemented to Seabed
			Cement plug 3 in 9 5/8" casing across 20" shoe depth - 100m long, Tagged and pressure tested
			Cement plug 2 in 9 5/8" casing above reservoir depth depth - 100m long, Tagged and pressure tested
			WBM left in hole
3046	3020		**9 5/8" Casing Shoe**
			Cement plugs 1a/1b etc as required across sand intervals & 100m into 9 5/8". Maximum single plug length 250m Top Plug tagged and pressure tested.
4118	4092		**TD**

Figure 2.3. Proposed Loligo NW Well Schematic

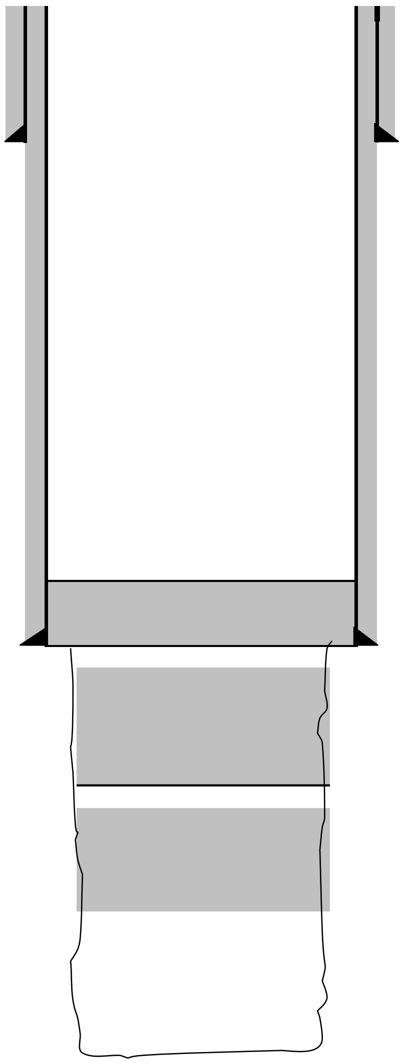
DEPTH (m MDBRT)	DEPTH (m TVDSS)	DOWNHOLE SCHEMATIC	DESCRIPTION		
			Wellhead removed at seabed		
1341	**1316**		**Seabed**		
			TOC 30"	Means of Verification:	Visual Confirmation with ROV
			TOC 20"	Means of Verification:	Visual Confirmation with ROV
1418	**1392**		**36" Conductor Shoe**		
			13 3/8" Cemented to seabed		
			WBM left in hole		
			Cement plug 2 100m across 13 3/8" shoe depth, tagged and tested		
2026	**2000**		**20" Shoe**		
			Cement plugs 1a and 1b etc as required across sand intervals Tagged		
2661	**2635**		**TD**		

Figure 2.4. Proposed Nimrod-1 Well Schematic

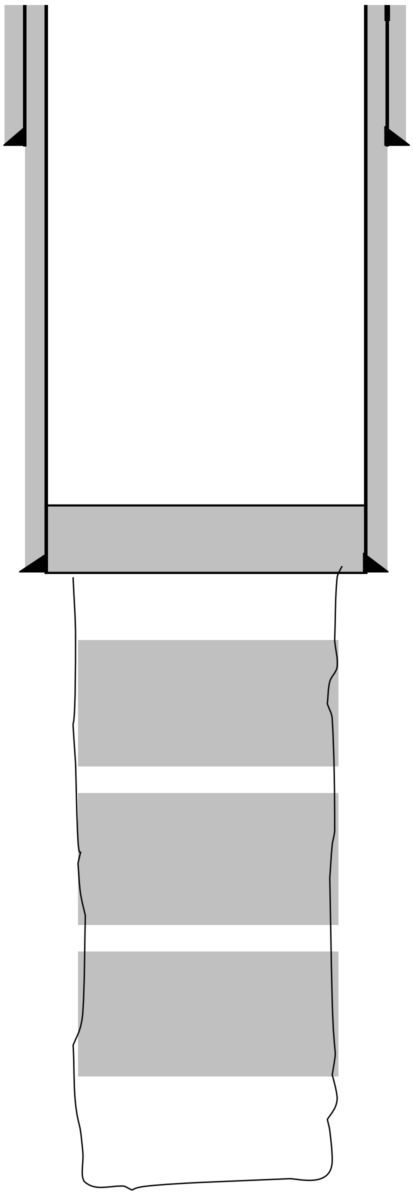
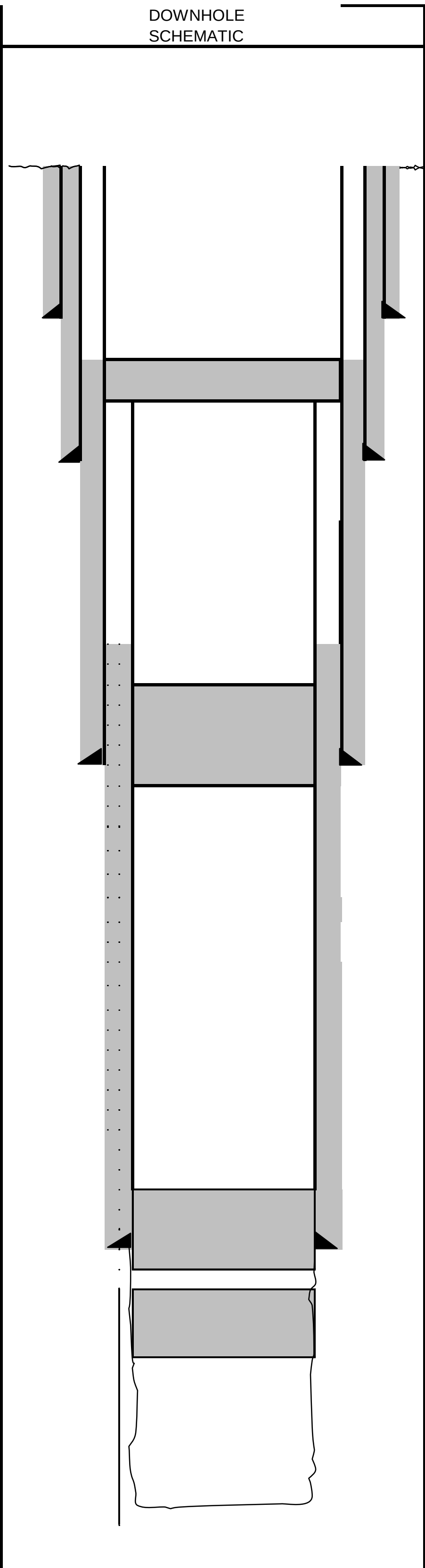
DEPTH (m MDBRT)	DEPTH (m TVDSS)	DOWNHOLE SCHEMATIC	DESCRIPTION
			Wellhead removed at seabed
1318	1292		**Seabed**
			TOC 30" Means of Verification: Visual Confirmation with ROV
			TOC 20" Means of Verification: Visual Confirmation with ROV
1394	1368		**36" Conductor Shoe**
			13 3/8" Cemented to seabed
			WBM left in hole
			Cement plug 2 100m across 13 3/8" shoe depth, tagged and tested
2074	2048		**20" Shoe**
			Cement plugs 1a and 1b etc as required across sand intervals Top plug tagged
3106	3080		**TD**

Figure 2.5. Proposed Scotia East D Well Schematic



DEPTH (m MDBRT)	DEPTH (m TVDSS)	DESCRIPTION
		Wellhead removed at seabed
1788	**1762**	**Seabed**
		TOC 30" Means of Verification: Visual Confirmation with ROV TOC 20" Means of Verification: Visual Confirmation with ROV
1864	**1838**	**36" Conductor Shoe** 20" Cemented to Seabed TOC 13 3/8"
2526	2500	13-3/8" cemented 300m into 20" Cement plug 3 100m on 9-5/8" stub 9-5/8" cut and recovered from 2600m
2826	**2800**	**20" Surface Casing Shoe**
TBC	TBC	
3526	3500	TOC 9 5/8" 9 5/8" cemented 300m into 13 3/8"
3826	**3800**	**13 3/8" Casing Shoe** Cement Plug 2 in 9-5/8" casing across 13-3/8" shoe depth - 200m long Tagged and pressure tested
		WBM left in hole and annuli
4826	**4800**	**9 5/8" Casing Shoe** Cement plug 1a/1b across reservoir intervals as required & 100m into 9-5/8" Tagged and pressure tested
5224	**5198**	**TD**

2.4.4 Disposal of Drill Cuttings

The two top hole sections will be drilled open to the seabed and the cuttings generated whilst doing so will be swept out of the hole using seawater. These will be deposited around the well bore. In the lower sections (apart from the bottom end) the wells will be cased and drilled using a riser whilst circulating drilling mud to remove cuttings, to condition the well bore and provide hydrostatic pressure in the wellbore.

Whilst drilling the wells, a riser will be set between the wellhead and the rig, with a blow-out preventer fitted on the wellhead at the bottom of the riser. The mud and cuttings will be returned to the rig where they pass through the cleaning system (refer to Appendix A). This reduces the amount of drilling fluid retained on the cuttings to between 5 and 15 percent. The cuttings will be discharged to the sea. The cuttings are variously sized particles of rock cut from the strata as the drill bit progresses down the well bore and will be comprised of sedimentary rock.

Estimated amounts of cuttings that will be generated for the proposed wells are detailed in Tables 2.7 to 2.10.

Table 2.7. Estimate of Cuttings Generated for Proposed Loligo A Well

Hole Size (inches)	Hole Size (m)	Length (m)	Volume (m^3)	Weight (tonnes)
42	1.07	79	68.3	177.7
26	0.66	722.5	247.2	642.8
17 1/2	0.44	Contingency	-	-
12 ¼	0.31	840	63.4	164.9
8 ½"	0.22	1072	40.8	106.0
Total cuttings from Loligo A well			**419.7**	**1091.4**
Discharged at Seabed			315.5	820.5
Discharged at Surface			104.2	270.9
Returned to Shore			0	0

Note: Weight of cuttings for all wells is calculated assuming density of 2.6 tonnes per cubic metre

Table 2.8. Estimate of Cuttings Generated for Proposed Loligo NW Well

Hole Size (inches)	Hole Size (m)	Length (m)	Volume (m^3)	Weight (tonnes)
42	1.07	76	68.3	177.7
26	0.66	608	208.0	540.9
17 1/2	0.44	Contingency	-	-
12 ¼	0.31	635	47.9	124.6
Total cuttings from Loligo NW well			**324.3**	**843.2**
Discharged at Seabed			276.3	718.6
Discharged at Surface			47.9	124.6
Returned to Shore			0	0

Table 2.9. Estimate of Cuttings Generated for Proposed Nimrod-1 Well

Hole Size (inches)	Hole Size (m)	Length (m)	Volume (m^3)	Weight (tonnes)
42	1.07	76	68.3	177.7
26	0.66	680	232.7	604.9
17 1/2	0.44	Contingency	-	-
12 ¼	0.31	1032	77.9	202.5
Total cuttings from Nimrod-1 well			**378.9**	**985.1**
Discharged at Seabed			301	782.6
Discharged at Surface			77.9	202.5
Returned to Shore			0	0

Table 2.10. Estimate of Cuttings Generated for Proposed Scotia East D Well

Hole Size (inches)	Hole Size (m)	Length (m)	Volume (m^3)	Weight (tonnes)
42	1.07	76	68.3	177.7
26	0.66	962	329.2	855.8
17 1/2	0.44	1000	152.1	395.4
12 ¼	0.31	1000	75.5	196.3
8 ½"	0.22	398	15.1	39.3
Total cuttings from Scotia East D well			**640.2**	**1664.5**
Discharged at Seabed			397.5	1033.5
Discharged at Surface			242.7.6	631.0
Returned to Shore			0	0

2.4.5 Drilling Mud and Casing Cement

The proposed wells will be drilled using only water based muds (WBM). On the rig, the composition of the cleaned mud will be monitored and adjusted to ensure that its properties remain as specified and it will be recycled through the well. No low toxicity oil based mud (LTOBM) will be used in either of the proposed wells.

The drilling mud is specifically formulated for each section of the well to suit the conditions in the strata being drilled. The selection is made according to the technical requirements for the mud and the environmental credentials of the chemical (refer to Section 2.4.7). The mud components proposed for drilling are listed in Tables 2.11 to 2.12.

Once each section of the well has been drilled, the drill string is lifted and the casing is lowered into the hole and cemented into place. The cement is formulated specifically for each section of the well and contains small volumes of additives that are required to improve its performance (refer to Table 2.13). It is mixed into slurry on the rig and is then pumped down the string and forced up the space between the well bore and the casing. To ensure that sufficient cement is in place and that a good seal is achieved, a certain amount of extra cement is pumped and some of this will be discharged to the seabed in the immediate vicinity of the wellhead, only in cases where cementing back to seafloor surface (e.g. the upper most section of the well). Typically not more than 10-15% of cement will be lost during normal cementing operations. If a problem does occur and a cement job has to be aborted, it is necessary to circulate the entire cement volume from the well releasing it into the sea. In the unlikely event of this taking place, the cement usage would double and discharge would equal the usage presented in Table 2.13.

2.4.6 Well Testing, Completion and Abandonment

FOGL plan to plug and abandon the exploration wells drilled in the forthcoming campaign. Well testing is not planned in this campaign.

The wells will be plugged and abandoned (P&A) in accordance with Oil and Gas UK Guidelines. A detailed P&A programme, with schematics, will be submitted to the independent Well Examiner and FIG regulator for approval prior to abandonment, taking account of final casing depths, subsurface and geological conditions encountered during drilling of the relevant well.

The objectives of the P&A programme are to:

- Prevent the escape of subsurface fluids (water and any hydrocarbons) to the sea floor and into the sea water column.
- Remove potential seabed obstructions capable of interfering with later fishing activity.

Fluid Escape prevention

Cement plugs will be set as follows:

- Lower open hole section (8 ½ inch or 12 ¼ inch hole size, dependent on well) – to seal off open reservoirs encountered. Dependent on the length of section and reservoir intervals encountered, more than one plug may be required. The likely length of individual plug is anticipated to be about 150 metres. Potential cement volume per plug would be between 6 cubic metres and 12 cubic metres depending on hole size, making a total possible cement volume range of between 6 and 36 cubic metres.
- Cased hole section – plugs will be set at intervals within the cased section – from the base/seat of the last casing (9 5/8 inch or 13 3/8 inch casing dependent on well) to seabed/mud line. Typically, one or two 150 metre length plugs would be set and a plug would also be set near the seabed. Cement volume per plug would be between 6 and 12 cubic metres, with a total possible cement volume range of between 12 and 36 cubic metres.

The cement to be used would normally be Class G cement. Additives to assist cement setting may be incorporated into the cement mix. These would be drawn from a UK approved list of additives.

The above volumes are indicative and will be finalised in the formal P&A programmes. The cement plugs would be tested to ensure seal (the prior casing seat cement will have been tested during drilling).

Removal of seabed obstructions

Standard practice in areas of commercial fishing, where seabed or near seabed netting or trawling are anticipated, is to remove the well head and surface casing to below 3 metres of seabed. This avoids damage or loss of such equipment by fishing vessels. The removal of surface casing to 3 metres below seabed is to avoid later potential exposure, and projection above the seabed, due to scour of surrounding soft sediments by seabed currents.

At present there is no commercial fishing in the offshore Falkland Islands with nets or trawls at FOGL location depths. Experimental fishing may be carried out in the future to about 1200 metres. Long line squid fishing lines are unlikely to be affected at the well location depths of about 1300 metres to 1800 metres.

In similar water depth areas of petroleum exploration activity around the world, without commercial fishing at these depths, it is common practice to leave the wellhead in place, as it is considered very unlikely that commercial fishing could be impacted.

In UK waters, where commercial fishing activity is widespread, it is a regulatory requirement to remove the wellhead and cut the surface casing 3m below the seabed, regardless of water depth.

FOGL will comply with FIG regulator requirements on removal of wellhead and near seabed casing to below the seabed.

2.4.7 Chemical Use and Discharge

Drilling offshore the Falkland Islands will follow the same model of chemical use as in the UK, which is regulated through The Offshore Chemical Regulations 2002 (as amended), which apply the provisions of the Decision by the Convention for the Protection of the Marine Environment of the Northeast Atlantic (the OSPAR Convention) for a Harmonised Mandatory Control System for the use and discharge of chemicals used in the offshore oil and gas industry. The Offshore Chemical Notification Scheme (OCNS) ranks chemical products according to Hazard Quotient (HQ), i.e. the ratio of Predicted Effect Concentration against No Effect Concentration, which is calculated using the CHARM (Chemical Hazard and Risk Management) model (refer to Appendix B for further information).

In the UK, the Centre for Environment, Fisheries & Aquaculture Science (CEFAS) maintains a list of chemicals under the OCNS that have been approved for use offshore for specific functions. Only chemicals on this list may be chosen for use when selecting the components of the drilling mud, cement, completion and general rig chemicals. Chemicals are therefore selected on their technical merits and are screened so that the collateral environmental effects are minimised as far as practicable.

All of the planned chemicals, which FOGL currently propose to use for the drilling campaign, appear on this Ranked Lists of Products approved under the OCNS. The vast majority of the proposed chemicals are considered to 'pose little or no risk' to the environment (PLONOR) with a chemical label code 'PLO'. The majority of chemicals also have an OCNS category of 'E', or have a Gold HQ band (i.e. are least toxic) and are naturally occurring products (e.g. barite) that are either biologically inert or readily dispersible or biodegradable.

Chemicals with the chemical label code 'SUB' have a substitution warning, and have been avoided wherever possible during chemical selection for the FOGL drilling programme. Chemicals may have a substitution warning attached due to their positional for bioaccumulation, or the presence of hazardous substances. A high Risk Quotient (RQ) may also render a chemical a candidate for substitution.

Tables 2.11 and 2.12 summarise the planned chemicals to be used during drilling operations, specifically for Loligo A and Scotia East D which are worst case wells out of the four proposed wells, based on their depths and higher chemicals use. The total weight of WBM chemicals to be used and discharged for Loligo A and Scotia East D are 1637 and 2042 tonnes, respectively.

The estimated use of cementing chemicals is provided in Table 2.13. Certain chemicals will be required for specific purposes on the drilling rig, for example, lubricant for the drill string threads and detergent to periodically wash rig equipment (Table 2.14).

Other contingency chemicals may be required if problems or emergencies are encountered during drilling or cementing operations (Table 2.15). One of the contingency chemicals, SAFE-SCAV HSB, is a hazardous class substance.

Table 2.11. Estimated Chemical Use and Discharge for Loligo A Well

Chemical Name	Chemical Function Group	Chemical Label Code	Estimated Use (tonnes)	Estimated Discharge (tonnes)	HQ Band / OCNS group
42 inch section					
Caustic Soda	WB Drilling Fluid Additive	Inorganic	0.25	0.25	E
M-I BAR (All Grades)	Weighting Chemical	PLO	58.00	58.00	E
M-I GEL	Viscosifier	PLO	21.00	21.00	E
GUAR GUM	Viscosifier	PLO	0.50	0.50	E
Soda Ash	Other	PLO	0.15	0.15	E
26 inch section					
Caustic Soda	WB Drilling Fluid Additive	Inorganic	0.53	0.53	E
M-I BAR (All Grades)	Weighting Chemical	PLO	575.00	575.00	E
M-I GEL	Viscosifier	PLO	41.00	41.00	E
GUAR GUM	Viscosifier	PLO	1.90	1.90	E
POLYPAC - All Grades	Viscosifier	PLO	4.68	4.68	E
Soda Ash	Other	PLO	0.53	0.53	E
17 ½ inch section					
Potassium Chloride	WB Drilling Fluid Additive	PLO	70.00	70.00	E
M-I BAR (All Grades)	Weighting Chemical	PLO	86.00	86.00	E
SAFE-CIDE	Biocide	-	0.48	0.48	GOLD
MEG	Gas Hydrate Inhibitor	PLO	46.20	46.20	E
EMI-2224	Defoamer (Drilling)		0.48	0.48	Gold
ULTRAHIB	Shale Inhibitor / Encapsulator	-	25.52	25.52	SUB
ULTRACAP	Shale Inhibitor / Encapsulator	-	3.50	3.50	GOLD
ULTRAFREE NS	Drilling Lubricant	-	19.88	19.88	GOLD
FLO-TROL	Fluid Loss Control Chemical	PLO	4.65	4.65	E
POLYPAC - All Grades	Viscosifier	PLO	2.33	2.33	E
DUO-VIS	Viscosifier	-	1.83	1.83	GOLD
Sodium Chloride Brine	WB Drilling Fluid Additive	PLO	139.87	139.87	E
SAFE-CARB (ALL GRADES)	Weighting Control	PLO	33.00	33.00	E
12 ¼ inch section					
Potassium Chloride	WB Drilling Fluid Additive	PLO	40.00	40.00	E
M-I BAR (All Grades)	Weighting Chemical	PLO	75.00	75.00	E
SAFE-CIDE	Biocide	-	0.28	0.28	GOLD
MEG	Gas Hydrate Inhibitor	PLO	26.40	26.40	E
EMI-2224	Defoamer (Drilling)		0.275	0.28	Gold
ULTRAHIB	Shale Inhibitor / Encapsulator	-	14.74	14.74	SUB
ULTRACAP	Shale Inhibitor / Encapsulator	-	2.00	2.00	GOLD
ULTRAFREE NS	Drilling Lubricant	-	11.41	11.41	GOLD
FLO-TROL	Fluid Loss Control Chemical	PLO	2.68	2.68	E
POLYPAC - All Grades	Viscosifier	PLO	2.68	2.68	E
DUO-VIS	Viscosifier	-	1.35	1.35	GOLD
Sodium Chloride Brine	WB Drilling Fluid Additive	PLO	294.99	294.99	E
SAFE-CARB (ALL GRADES)	Weighting Control	PLO	28.00	28.00	E
TOTALS:			**1637.09**	**1637.09**	

Table 2.12. Estimated Chemical Use and Discharge for Scotia East D Well

Chemical Name	Chemical Function Group	Chemical Label Code	Estimated Use (tonnes)	Estimated Discharge (tonnes)	HQ Band / OCNS group
42 inch section					
Caustic Soda	WB Drilling Fluid Additive	Inorganic	0.25	0.25	E
M-I BAR (All Grades)	Weighting Chemical	PLO	58.00	58.00	E
M-I GEL	Viscosifier	PLO	21.00	21.00	E
GUAR GUM	Viscosifier	PLO	0.50	0.50	E
Soda Ash	Other	PLO	0.15	0.15	E
26 inch section					
Caustic Soda	WB Drilling Fluid Additive	Inorganic	0.73	0.73	E
M-I BAR (All Grades)	Weighting Chemical	PLO	798.00	798.00	E
M-I GEL	Viscosifier	PLO	57.00	57.00	E
GUAR GUM	Viscosifier	PLO	2.78	2.78	E
POLYPAC - All Grades	Viscosifier	PLO	6.53	6.53	E
Soda Ash	Other	PLO	0.73	0.73	E
17 ½ inch section					
Potassium Chloride	WB Drilling Fluid Additive	PLO	106.00	106.00	E
M-I BAR (All Grades)	Weighting Chemical	PLO	130.00	130.00	E
SAFE-CIDE	Biocide	-	0.70	0.70	GOLD
MEG	Gas Hydrate Inhibitor	PLO	70.40	70.40	E
EMI-2224	Defoamer (Drilling)		0.70	0.70	Gold
ULTRAHIB	Shale Inhibitor / Encapsulator	-	38.94	38.94	SUB
ULTRACAP	Shale Inhibitor / Encapsulator	-	5.30	5.30	GOLD
ULTRAFREE NS	Drilling Lubricant	-	29.99	29.99	GOLD
FLO-TROL	Fluid Loss Control Chemical	PLO	7.07	7.07	E
POLYPAC - All Grades	Viscosifier	PLO	7.07	7.07	E
DUO-VIS	Viscosifier	-	3.53	3.53	GOLD
Sodium Chloride Brine	WB Drilling Fluid Additive	PLO	212.09	212.09	E
SAFE-CARB (ALL GRADES)	Weighting Control	PLO	49.00	49.00	E
12 ¼ inch section					
Potassium Chloride	WB Drilling Fluid Additive	PLO	22.00	22.00	E
M-I BAR (All Grades)	Weighting Chemical	PLO	5.00	5.00	E
SAFE-CIDE	Biocide	-	0.15	0.15	GOLD
MEG	Gas Hydrate Inhibitor	PLO	14.30	14.30	E
EMI-2224	Defoamer (Drilling)		0.15	0.15	Gold
ULTRAHIB	Shale Inhibitor / Encapsulator	-	8.14	8.14	SUB
ULTRACAP	Shale Inhibitor / Encapsulator	-	1.13	1.13	GOLD
ULTRAFREE NS	Drilling Lubricant	-	6.35	6.35	GOLD
FLO-TROL	Fluid Loss Control Chemical	PLO	1.50	1.50	E
POLYPAC - All Grades	Viscosifier	PLO	1.50	1.50	E
DUO-VIS	Viscosifier	-	0.75	0.75	GOLD
Sodium Chloride Brine	WB Drilling Fluid Additive	PLO	163.88	163.88	E
SAFE-CARB (ALL GRADES)	Weighting Control	PLO	16.00	16.00	E
8 ½inch section					
Potassium Chloride	WB Drilling Fluid Additive	PLO	15.00	15.00	E
M-I BAR (All Grades)	Weighting Chemical	PLO	26.00	26.00	E

SAFE-CIDE	Biocide	-	0.10	0.10	GOLD
MEG	Gas Hydrate Inhibitor	PLO	9.90	9.90	E
EMI-2224	Defoamer (Drilling)		0.1	0.10	Gold
ULTRAHIB	Shale Inhibitor / Encapsulator	-	5.50	5.50	SUB
ULTRACAP	Shale Inhibitor / Encapsulator	-	0.75	0.75	GOLD
ULTRAFREE NS	Drilling Lubricant	-	4.24	4.24	GOLD
FLO-TROL	Fluid Loss Control Chemical	PLO	1.00	1.00	E
POLYPAC - All Grades	Viscosifier	PLO	1.00	1.00	E
DUO-VIS	Viscosifier	-	0.50	0.50	GOLD
Sodium Chloride Brine	WB Drilling Fluid Additive	PLO	120.24	120.24	E
SAFE-CARB (ALL GRADES)	Weighting Control	PLO	10.00	10.00	E
TOTALS:			**2041.62**	**2041.62**	

Table 2.13. Proposed Cement Chemicals and Ratings (average per well)

Chemical Name	Estimated Use (tonnes)	Estimated Discharge (tonnes)	HQ Band / OCNS group
Cement Class G D907	109.50	109.50	E
Special Deepwater Blend B2300	13.95	13.95	E
D095 Cement Additive	0.06	0.06	E
D600G GASBLOK* Gas Migration Control Additive	1.14	1.14	Gold (sub)
D500-LT GASBLOK* Gas Migration Control Additive	5.52	5.52	Gold
Environmentally Friendly Dispersant B165	0.72	0.72	E
Liquid Antifoam B411	0.41	0.41	Gold
Silicate Additive D75	1.19	1.19	E
Anti-settling Agent D153	0.01	0.01	
UNIFLAC-L D168	1.50	1.50	Gold
Viscosifier for MUDPUSH II spacer B174	0.18	0.18	E
Dye B275	0.04	0.04	Gold
Low Temperature Retarder D081	0.09	0.09	E
Antifoam Agent D206	0.02	0.02	Gold (sub)
AccuSET D197	1.82	1.82	Gold
Low Temperature Cement Set Enhancer D186	0.91	0.91	Gold
Low Temperature Dispersant D185	0.48	0.48	Gold
TOTALS:	**917**	**137.5**	

Table 2.14. Planned Rig Chemicals (estimated average per well)

Chemical Name	Chemical Function Group	Chemical Label Code	Estimated Use (tonnes)	Estimated Discharged (tonnes)	HQ Band / OCNS group
Jet Lube NCS-30 ECF	Pipe Dope	-	0.0162	0.01219	E
Pelagic 50 BOP Fluid Concentrate	Hydraulic Fluid	-	8.19	8.19	E
Pelagic Stack Glycol V2	Other	PLO	43	43	E
Tristar Eco Rig Wash HD-E	Detergent / Cleaning Fluid	PLO	2.497	2.497	E
TOTALS:			**53.70**	**53.70**	

Table 2.15. Contingency Chemicals

Chemical Name	Chemical Function Group	Chemical Label Code	HQ Band / OCNS group
MAGNESIUM OXIDE	Acidity Control Chemical	PLO	E
Citric Acid	Water based Drilling Fluid Additive	PLO	E
Dyna Red Seepage Control Fiber	Fluid Loss Control Chemical	PLO	E
Form-A-Blok	Lost Circulation Material	SUB	GOLD
G-Seal	Lost Circulation Material	PLO	E
Conqor 404NS	Corrosion Inhibitor	-	GOLD
Koplus LL	Pipe Release Chemical	PLO	E
KWIKSEAL	Lost Circulation Material	PLO	E
LIME	OPF Additive	PLO	E
Mica	Lost Circulation Material	PLO	E
Nutshells - All Grades	Lost Circulation Material	PLO	E
SAFE-COR EN	Corrosion Inhibitor	-	GOLD
SAFE-SCAV HSB	Hydrogen Sulphide Scavenger	-	SILVER
SAFE-SURF E	Detergent / Cleaning Fluid	SUB	GOLD
SAFE-SCAV NA	Oxygen Scavenger	PLO	E
SAPP	Water based Drilling Fluid Additive	PLO	E
Sodium Bicarbonate	Water based Drilling Fluid Additive	PLO	E
Sugar	Water based Drilling Fluid Additive	PLO	E
SUPER SWEEP	Lost Circulation Material	SUB	GOLD

2.5 Resource Use

2.5.1 Equipment and Chemicals

The remote drilling locations will require sufficient materials and chemicals, equipment, spares and contingency supplies to be ordered in advance and shipped prior to rig mobilisation. These will be sourced in advance, mostly from outside the Falkland Islands.

2.5.2 Fuel

The Ocean Rig Leiv Eiriksson dynamically positioned semi-submersible rig is likely to consume 30 tonnes of diesel fuel a day during drilling operations. The rig will be mobilised from the southern Falkland Islands licence area and would take 1-2 days. Two Platform Safety Support vessels (PSSVs) and one Emergency Response and Rescue vessel (ERRV) will support drilling operations. Each of the vessels is estimated to consume approximately 10 tonnes of diesel a day. In total it is therefore estimated that the drilling campaign will require approximately 6,000 tonnes of diesel fuel, based on 100 days average campaign duration. The fuel will be sourced from the Falkland Islands.

Helicopter trips for crew changes and other *ad hoc* purposes will occur 3-4 times per week on average (30 round trips per well). The type of aircraft to be used is likely to be the Super Puma. Estimated fuel consumption is 3 tonnes per 1000 kilometres, assuming possible use of larger helicopters, (S-92), flying between Mt. Pleasant Airport to rig with round trip estimated distances of 460 and 660 kilometres for Loligo A and Scotia East D locations, respectively. Total aviation fuel use is estimated at 100 tonnes for the 2-well campaign.

2.5.3 Water

The exploration wells will require 1600 cubic metres and 2,000 cubic metres of fresh water for the top hole sections of Loligo A and Scotia East D, respectively. The deeper sections of the wells will be drilled with Ultradrill water based mud that utilises seawater. Availability of water has been confirmed with the Falkland Islands Government. A shortage of water may occur in dry summer seasons, but the drilling campaign is taking place during autumn/winter, therefore interference with public water consumption is unlikely.

It is estimated that 30 m^3 of sea water per day will be treated through the on-board desalination plant for galley and drinking purposes.

2.5.4 Waste Disposal

Waste disposal facilities in Falkland Islands are limited to 2 non-engineered non-hazardous landfill sites, with more than 50% capacity utilised. Therefore, only non-hazardous and inert waste streams generated during drilling will be recycled where possible and disposed of locally. All hazardous waste will be exported to the UK for treatment.

Hazardous waste is waste that is, or may be considered to be, "so dangerous or difficult to dispose of that special provision is required for its disposal". The following list provides an example of hazardous waste that may result from the proposed FOGL drilling operations (but is not considered to be an exhaustive list):

- Waste paint and paint thinners;
- Waste oil;
- Oiled waste, including oil filters, oily rags, etc.
- Contaminated oil;
- Spent batteries;
- Waste anti-freeze;

- Used pipe dope/grease;
- Used light bulbs/tubes;
- Heli-fuel waste;
- All hazardous waste packaging.

Hazardous waste generated from wells varied with a typical exploration well generating between 2 to 100 tonnes of hazardous waste (average of 65 tonnes). This estimate is based on North Sea wells. Given that no low toxicity muds are to be utilised by FOGL, it is assumed that the volume of hazardous waste generated per well on average would be in the range of 10 tonnes. Non-hazardous waste is estimated at 30 tonnes per well.

Specific waste handling/disposal routes and procedures are detailed in a Waste Management Plan to be submitted separately by FOGL.

2.6 Support Operations

The drilling rig will be supported by two Platform Safety Support Vessels (PSSVs). The vessels will rotate between the rig and the onshore supply base in Stanley. The Emergency Response and Rescue Vessel's (ERRV) primary role will be to remain in the vicinity of the rig at any time as safety standby vessel. It will be in close liaison with the drilling rig and will continuously monitor other vessel movements in the area. It will warn off vessels on a course that is likely to bring them into or near the safety exclusion zone around the rig. The supply vessels will provide the bulk logistics and transport materials required for drilling. All three vessels will carry an approved chemical dispersant for Tier 1 oil spill emergencies.

Rig crews will be transferred to and from the rig by helicopter. A helicopter from CHC Helicopters, based at Stanley Airport will be dedicated to FOGL throughout the drilling programme. Crew changes are anticipated to take place once every two weeks when approximately 60 personnel will be crew changed in one day requiring 4 helicopter flights between Stanley and the Rig carrying an average of 15 personnel per flight. On arrival at Mt. Pleasant Airport, the crews will transfer by road to Stanley Airport. Crews departing the rig will arrive at Stanley Airport and transfer by road to Mt. Pleasant Airport. Each crew change flight consists of a round trip distance of 460 and 660 kilometres for Loligo A and Scotia East D, respectively.

All routes used by vessels and aircraft will be pre-planned to avoid creating unnecessary disturbance to sensitive receptors along their routes.

During routine crew changes, part of the incoming crew will normally be transferred directly to the rig. However, the remainder of the crew will need to be temporarily accommodated on the Islands as they wait for their flights, later that day. It is noted that there is limited accommodation available on the Falkland Islands, although operations will take place at a low tourist season. Currently, FOGL intend to have a permanent arrangement for housing and leasing rooms in the local hotels. This accommodation will be used on a routine basis for operational personnel and management on an *ad hoc* basis. During a crew change operation if either the incoming or outgoing rig crew become stranded in Stanley, accommodation facilities outside the permanent arrangement discussed above will be utilised. The table below outlines the potential emergency accommodation currently identified. The utilisation of accommodation at the F.I.D.F. is only intended for rig emergency situations. It is not intended to be used as routine accommodation during crew change delays. During normal operations it is anticipated that 40 to 60 crew members will change out during crew change operations. Table 2.16 below summarises the crew change arrangements.

Table 2.16. Accommodation arrangements for crew change procedures

Name	Rooms	Number of Beds
Lookout Lodge	64	64
Shortys Motel	6	10
Lafone House	5	8
Bennett House	3	7
Kay's B & B	2	3
Susanna Binnie's Homestay	1	2
Waterfront Hotel	8	9
Sub Total: Number of Rooms and Beds	**89**	**103**
F.I.D.F.	Could accommodate up to 200	70 presently but could be easily increased

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2.7 Total Emissions Summary

Illustrative summaries of estimated emissions and discharges arising from routine operations associated with the drilling of Loligo A and Scotia East D wells are provided in Figures 2.6 to 2.7. These two wells are the deepest and furthest from the shore of the 4 proposed alternatives hence represent worst case scenarios. The calculations are based on 50 to 60 days of the rig deployment at Loligo A and Scotia East D, respectively.

Figure 2.6. Estimated Emissions Summary for Loligo A Well (based on 50 days rig deployment)

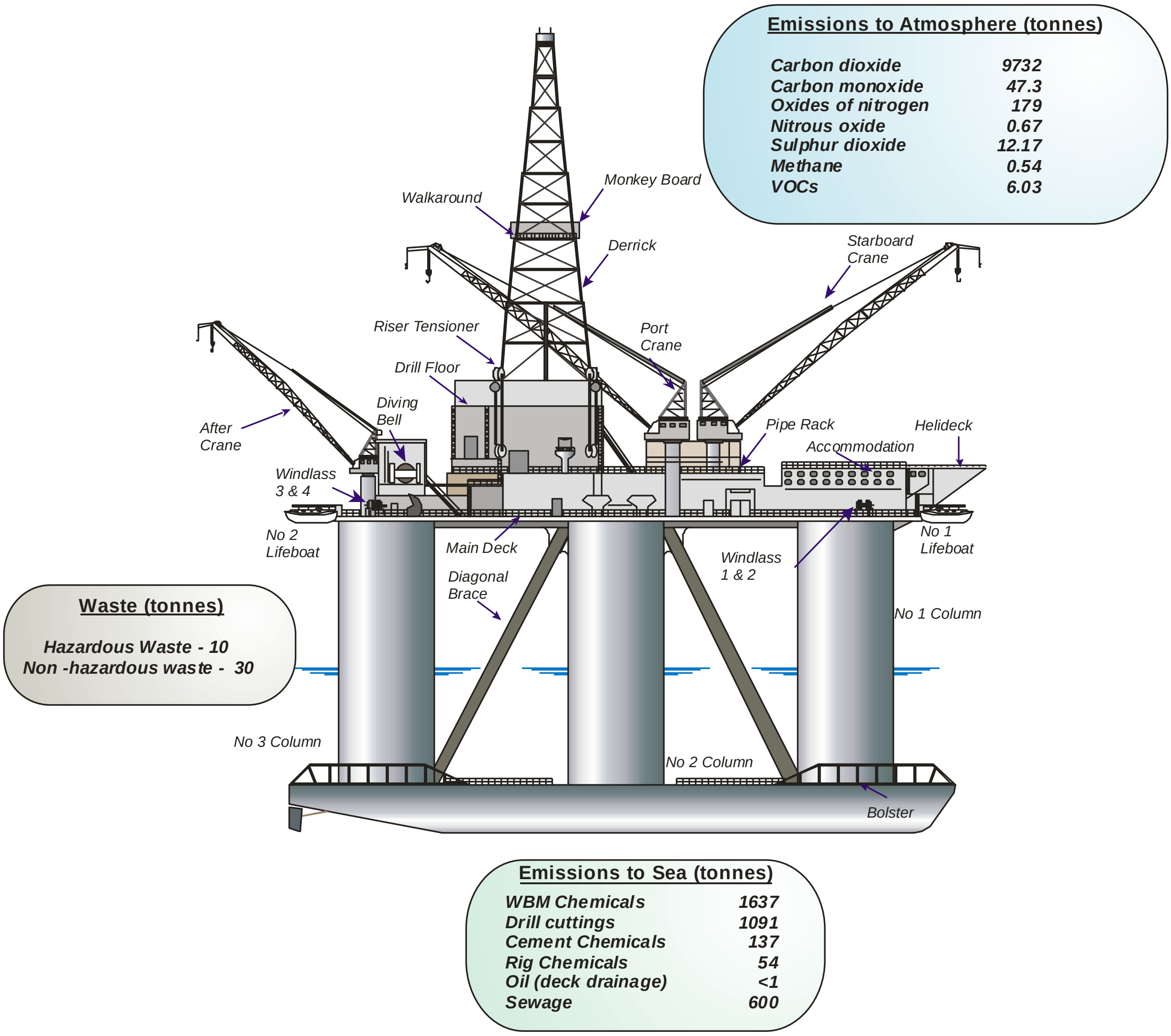
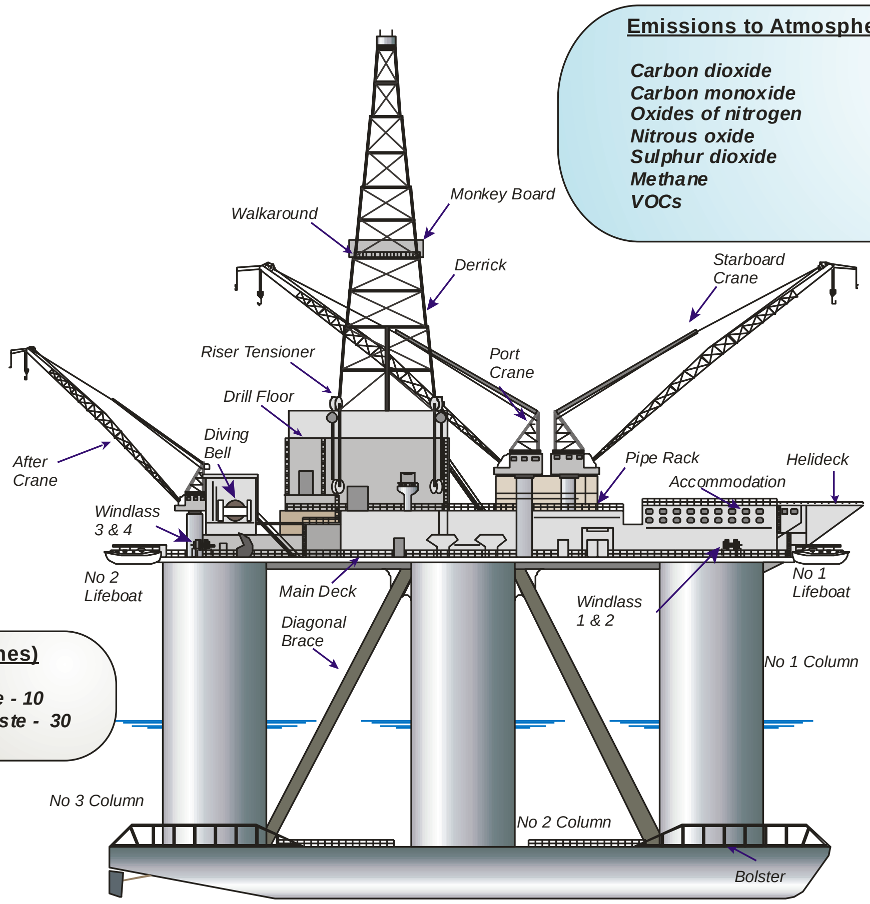


Figure 2.7. Estimated Emissions Summary for Scotia East D Well (based on 60 days rig deployment)

Emissions to Atmosphere (tonnes)

Carbon dioxide	11070
Carbon monoxide	53.7
Oxides of nitrogen	203
Nitrous oxide	0.76
Sulphur dioxide	13.84
Methane	0.62
VOCs	6.85



Waste (tonnes)

Hazardous Waste - 10
Non -hazardous waste - 30

Emissions to Sea (tonnes)

WBM Chemicals	2042
Drill cuttings	1664
Cement Chemicals	137
Rig Chemicals	54
Oil (deck drainage)	<1
Sewage	720

3. Baseline Environment

3.1 Introduction

The physical, biological and socio-economic characteristics of the environment within the project influence area (the area that can be potentially impacted by the proposed drilling operations) have been discussed in detail in the EIS.

This Addendum reports the findings of the environmental site surveys carried out by Fugro Survey Ltd (FSL) at Loligo A[1] and Nimrod prospects in January-February 2009, and by Gardline Environmental Ltd. (GEL) at Loligo NW and Scotia East in March-May 2011 on behalf of FOGL. Full survey reports are provided in Appendices C-F.

The site survey results are presented below and are grouped into the following categories:

- Bathymetry and Seabed Morphology
- Water Column Profiles
- Seabed Sediments
- Macrofauna and Habitat Assessment

Where relevant, a comparison is drawn with benthic data for other sites (Endeavour and Hero) surveyed in the close proximity to the proposed drilling locations.

3.2 Bathymetry and Seabed Morphology

The Falkland Islands are situated on a projection of the Patagonian continental shelf, which is bound to the north by a steep slope (the Falklands Escarpment), separating it from the Argentine Abyssal Plain. A gently north-eastward sloping area between the Falkland Islands and the Falklands Escarpment, at water depths of between 150 and 1,800 metres, is known as the north Falklands Basin. To the south, a deep east-west trough (the Falklands Trough) divides the Falklands Plateau from the Burdwood Bank. The Burdwood Bank is one of a number of elevated areas bound by submarine ridges and troughs, which were formed as a result of compression during the Cenozoic era along the northern margins of the Scotia Sea (*Otley et.al., 2008*).

The bathymetry map for the region is provided in Figure 3.1. Site specific bathymetric profiles for the proposed drilling areas are presented in Figures 3.2-3.5. All water depths are referenced to LAT (Lowest Astronomical Tide).

3.2.1 Loligo A Site Survey Results

Water depths within the survey area ranged from approximately 1,305 metres in the north-western corner to 1,488 metres at the base of a prominent escarpment in the central portion of area.

The study area (Figure 3.2) can be divided into two distinct zones based on general seafloor morphology and character. The two areas were generally separated by a prominent escarpment (approximately 70 metres in height) that trends regionally north-north-east through the centre of the area, although locally the trace of the escarpment is highly sinuous with an average gradient of 20 degrees (locally exceeded 30 degrees in places). The deepest water depths in the Loligo area occurred in a broad moat that follows the base of the escarpment. In the centre of the area, to the west of the main escarpment, the western morphologic zone is incised by a closed circular escarpment that forms the perimeter of a broad pit 85 metres deep with an average diameter of about 2,700 metres. The seafloor morphology inside the pit (1435 metres) is similar to that of the eastern morphologic zone.

[1] Reference to the **Loligo A** site survey is used to differentiate from **Loligo NW** site survey area; the real survey area has a wider coverage (see Figure 3.1)

The western morphological zone was generally characterised by smooth to slightly undulating seafloor topography that sloped regionally down to the south-east at an average gradient of approximately 0.3 degrees. The seafloor in the eastern zone was notably more irregular in contrast to the western zone. Superimposed on the irregular topography were a number of local peaks, depressions and scarps. Seafloor gradients in the eastern zone are variable, mostly ranging between 0 and 5 degrees, but locally exceeding 20 degrees on some of the more prominent topographic features.

For further details refer to Appendix C (FSL, 2009a).

3.2.2 Nimrod Site Survey Results

Water depths in the survey area ranged from approximately 1240 metres in the western corner of the area to approximately 1316 metres at the base of an escarpment in the northern portion of the site. Seafloor topography was generally smooth to somewhat irregular, but was locally complex with several escarpments, hummocks, pinnacles and basins (Figure 3.3). The seafloor gradients associated with these features were generally moderate, rarely exceeding 10 degrees. The most complex topography was found in the northern and western areas of the site. The topography was smoother to the south and east of the site and where most smoothly sloping to the south a mean seafloor gradient of 0.4 degrees could be measured. The seafloor morphology was interpreted as being the result of extensive erosion during geologic history.

For further details refer to Appendix D (FSL, 2009b).

3.2.3 Loligo NW Site Survey Results

The seabed was essentially flat across the proposed Loligo NW well location. Within the survey area water depths ranged between 1299 metres on the top of a distinct scarp feature in the southwest, to a maximum of 1343 metres within a broad elongated depression at the base of the aforementioned scarp (Figure 3.4).

The seabed in general gently undulated with a series of broad bathymetric highs and deeps, being up to 16 metres shallower and 27 metres deeper than at the proposed Loligo NW well location. The distinct scarp feature occurs 1638 metres southwest of location over which the seabed drops 44 metres at a maximum gradient in excess of 18 degrees. The closest bathymetric highs occurred 720 metres north and 740 metres west south west of the proposed Loligo NW location, the seabed shoaling approximately 11 metres with gradients less than 3 degrees. Other smaller shoals occurred much further to the southeast.

For further details refer to Appendix E (GEL, 2011a).

3.2.4 Scotia East Site Survey Results

The seabed within Scotia East survey area was dominated by a number of large depressions or bathymetric lows, typically around 1 kilometres wide and up to 100 metres deep (Figure 3.5). These are thought to be current related erosional features; Station ENV5 was selected within one of these depressions. All four original potential Scotia East well locations, and therefore Stations ENV1 to ENV4, were positioned on bathymetric highs between these depressions, where seabed gradients ranged between 1 and 3 degrees. However, the steepest flanks of these depressions or bathymetric lows had a gradient of up to 35 degrees in the west of the site as the seabed shoaled to a large plateau. This steep slope was investigated at Station ENV6 which appeared to begin as a surface concretion, eroded below and dropping away vertically beyond the sight of the camera. This feature was likely caused by current-related erosion with bottom currents of up to 10 centimetres per second. The camera frame reached the seabed between a further 20 metres and 30 metres depth. This was indicative of a potential rocky reef feature.

For further details refer to Appendix F (GEL, 2011b).

Figure 3.2Figure 3.1. Falkland Islands Regional Bathymetry

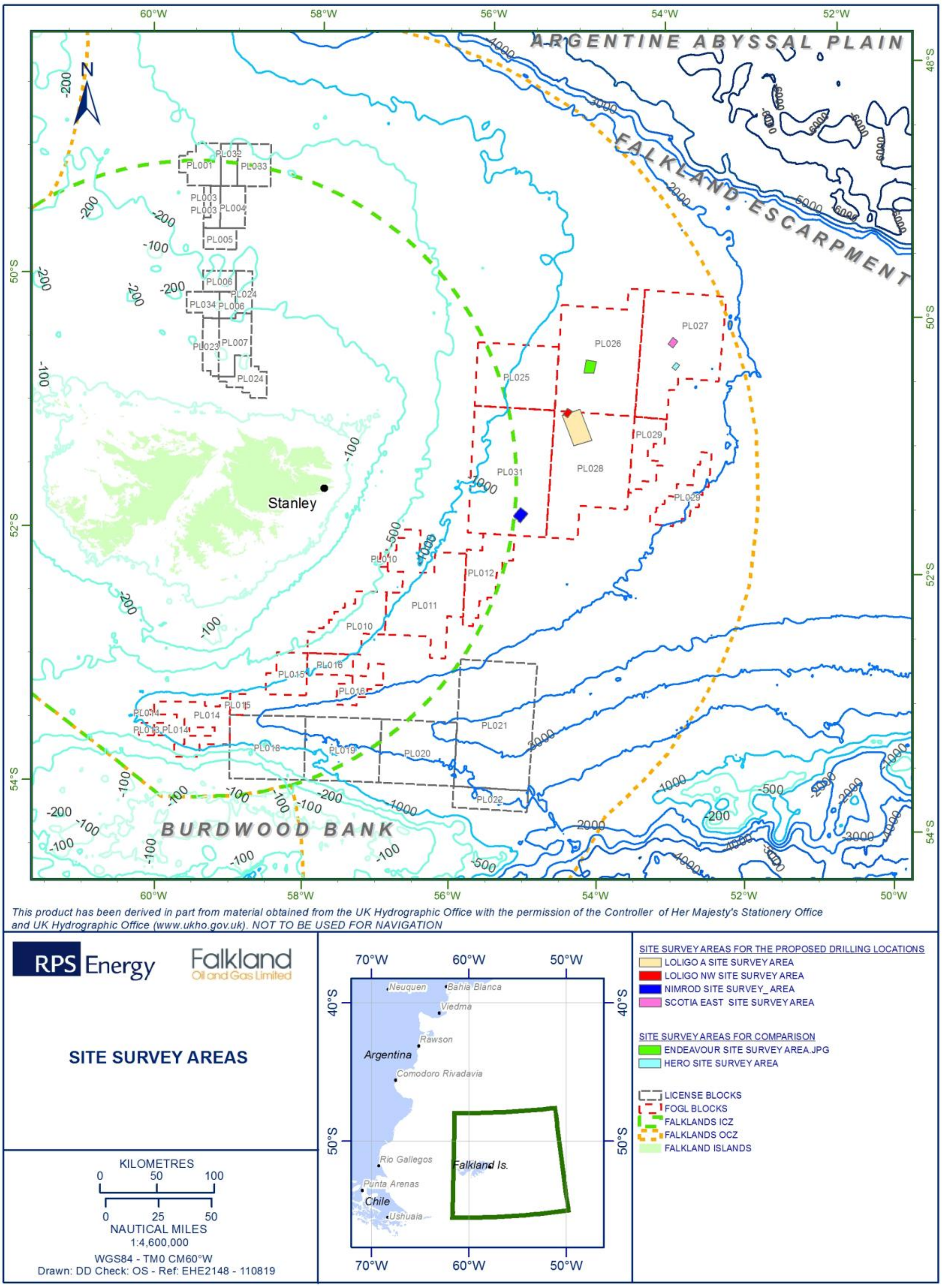


Figure 3.2. Loligo A Site Survey Area: Bathymetry and Sampling Stations (FSL, 2009a)

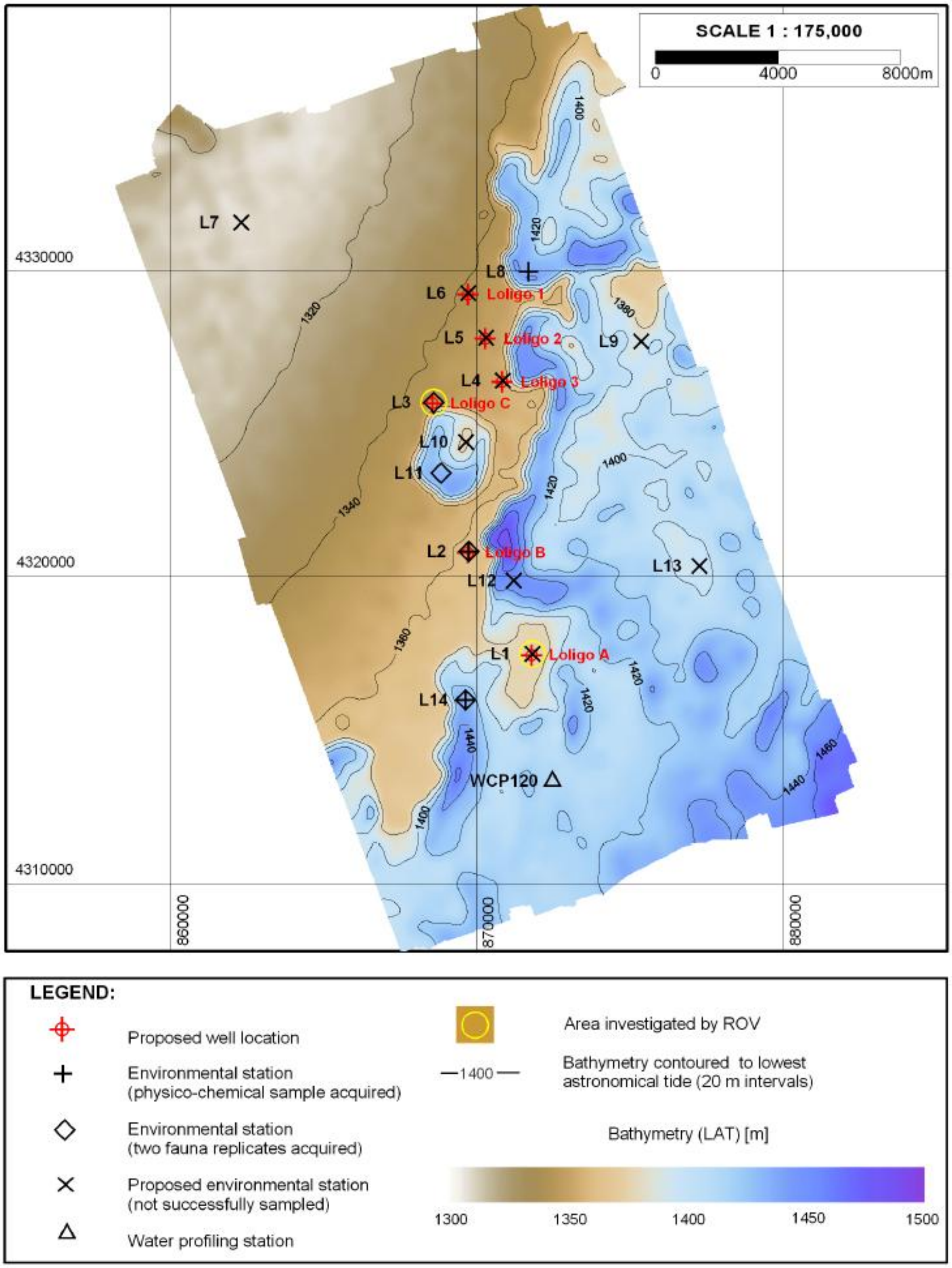


Figure 3.3. Nimrod Site Survey Area: Bathymetry and Sampling Stations (Nimrod-1 well location is positioned 254 meters of Nimrod-B; FSL, 2009b)

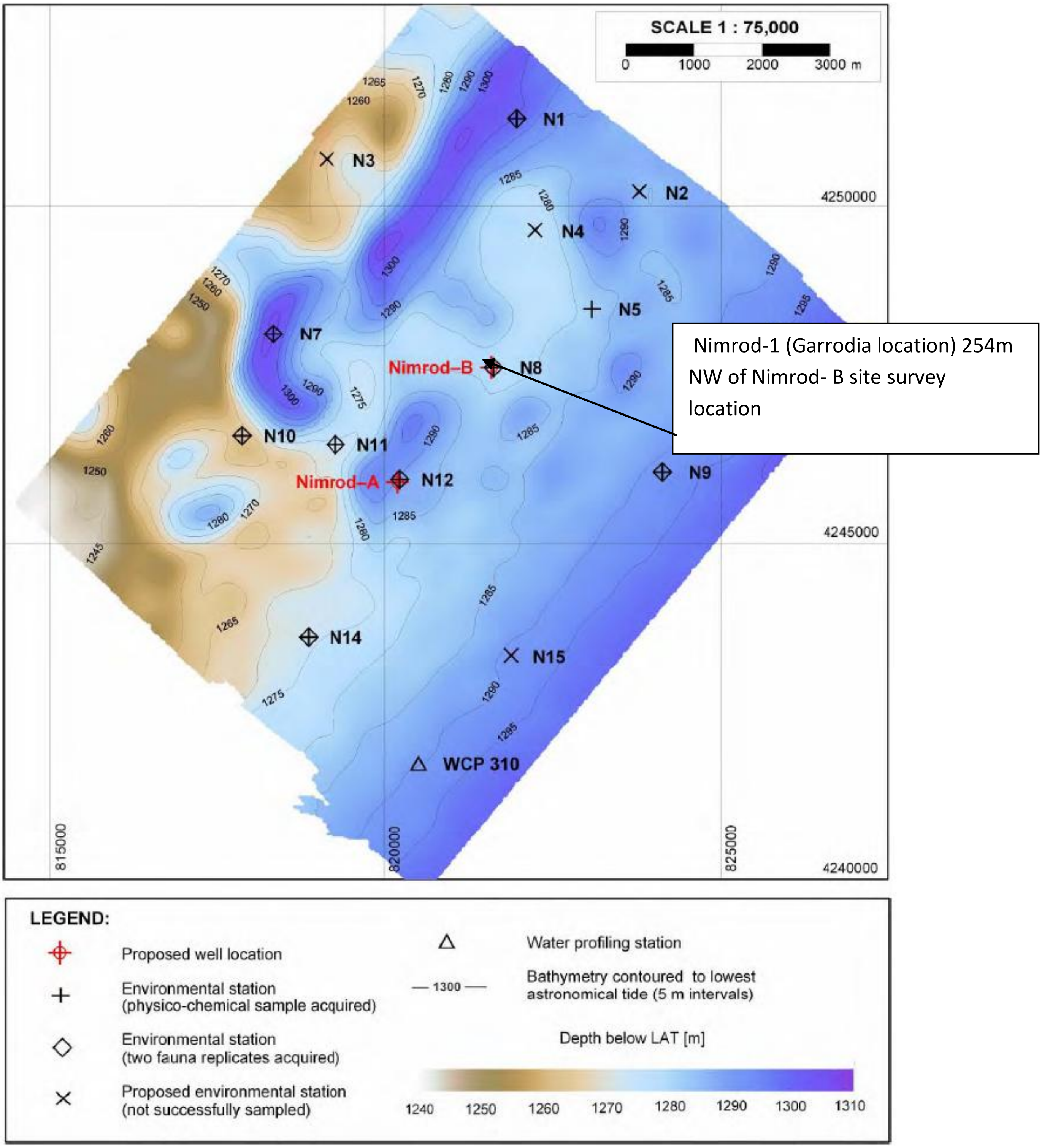


Figure 3.4. Loligo NW Site Survey Area: Bathymetry and Sampling Stations (GEL, 2011a)

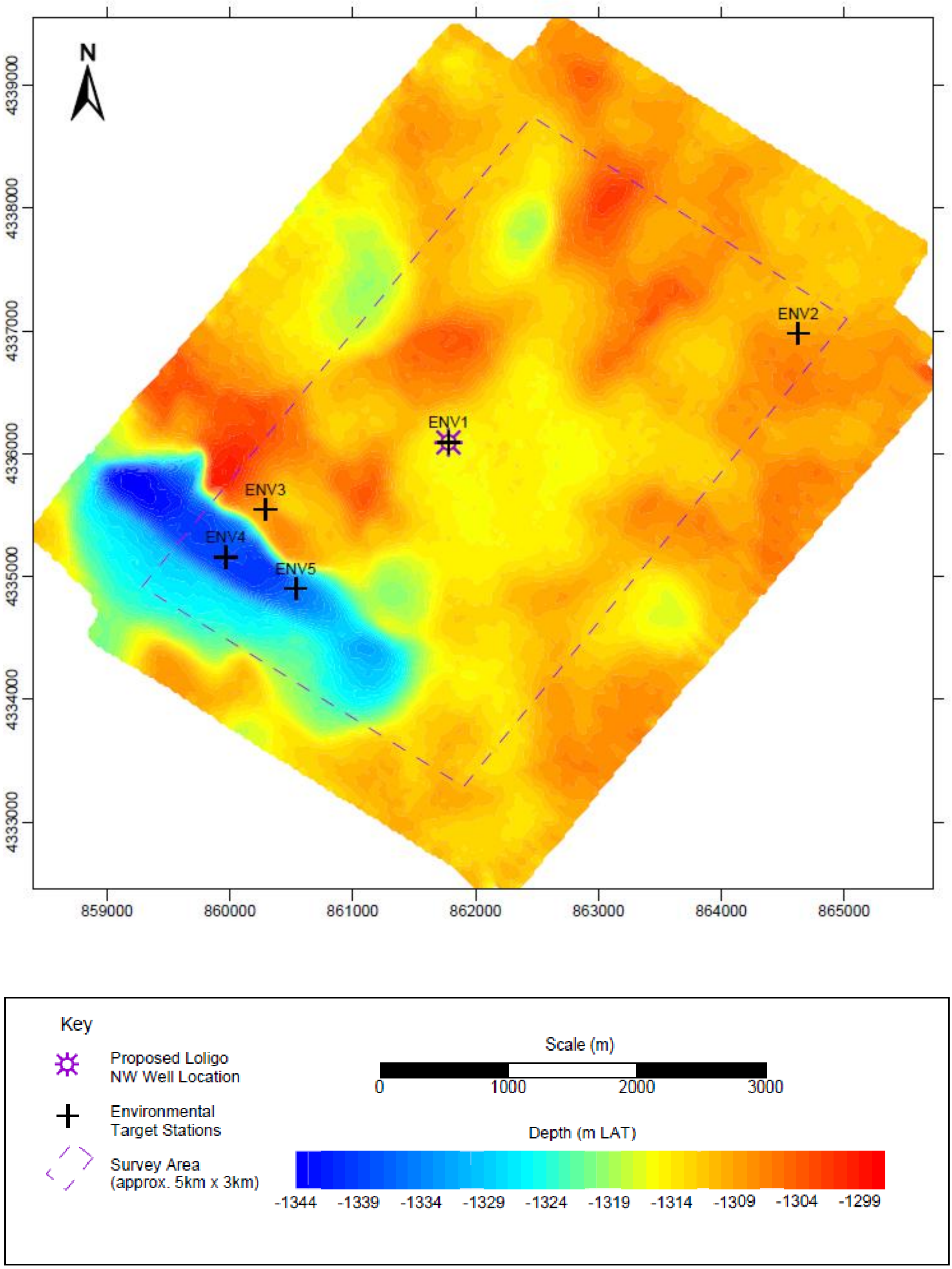
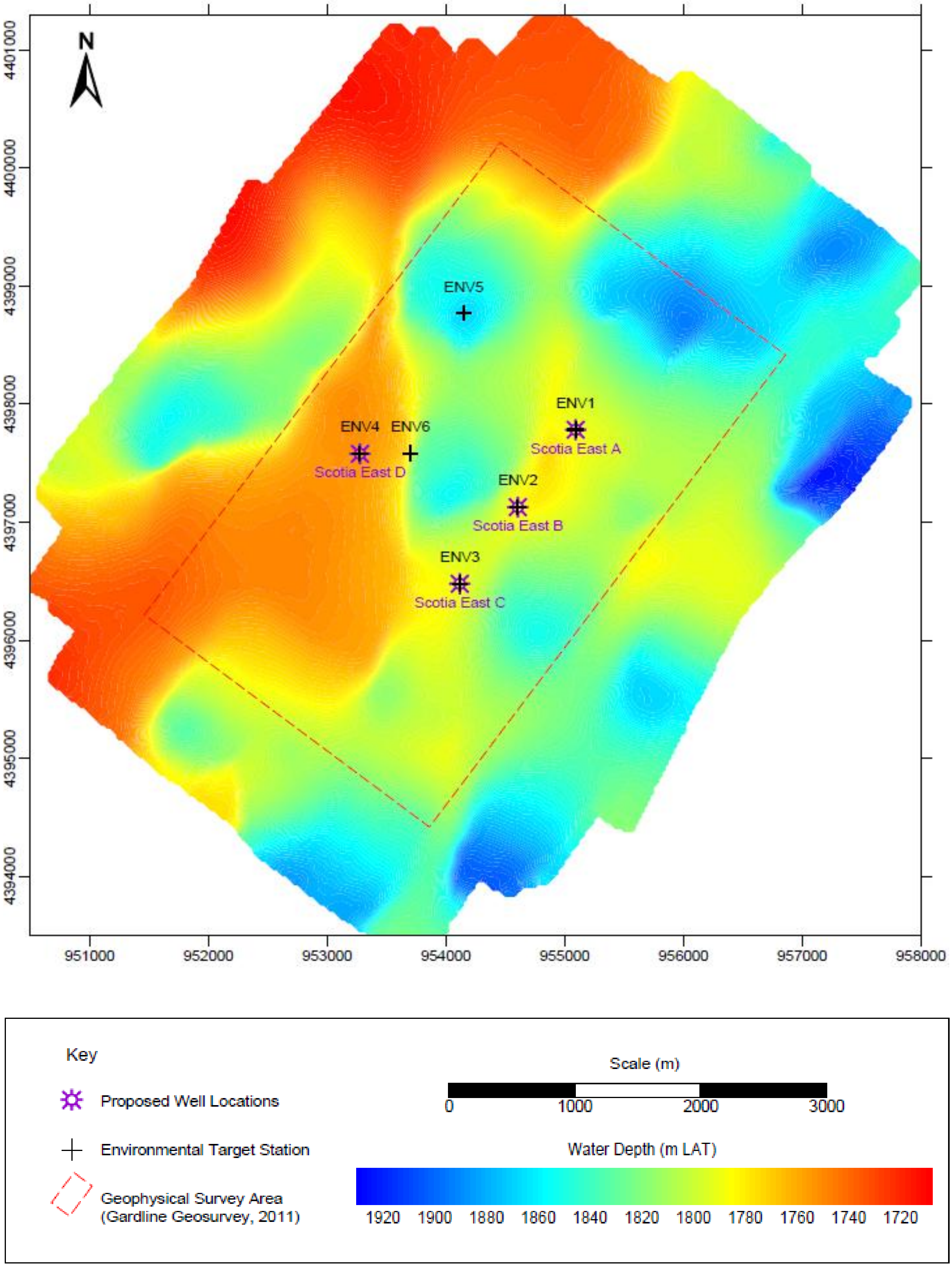


Figure 3.5. Scotia East Site Survey Area: Bathymetry and Sampling Stations (GEL, 2011b) *Note Scotia East D is selected well location.*

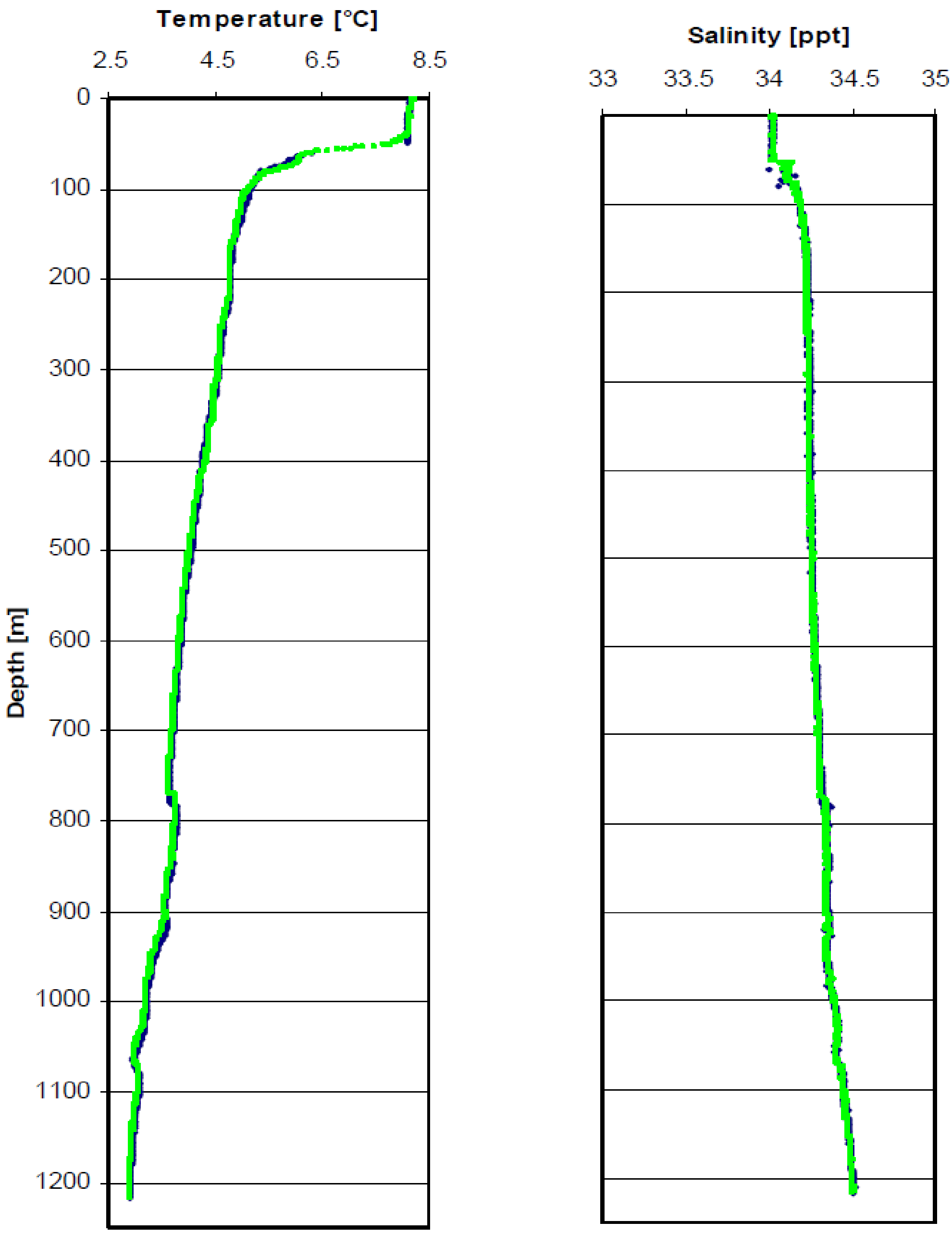


3.3 Water Column Profiles

3.3.1 Loligo A Site Survey Results

Water profile data within the Loligo A survey area was acquired on 2nd February 2009 (Figure 3.6). The surface temperature was approximately 8.2°C and this remained relatively constant in the mixed upper layers of the water column (between the surface and approximately 50 metres depth). Below this well mixed layer there was a distinct thermocline over which the water temperature rapidly descended to 5.3°C at approximately 90 metres depth. Below the thermocline the temperature declines gradually to a depth of approximately 760 metres, where there is a slight temperature inversion, over which the temperature increases from 3.6°C to 3.8°C. Below this inversion temperature generally declines, although there are a series of slight temperature increases and decreases that suggested some mixing and / or stratification. These effects may indicate the influence of a different water body below this depth. The minimum temperature of 2.9°C was recorded just above the seabed (1217 metres depth).

Figure 3.6. Water Column Profiles Recorded in February 2009 at Loligo A site (FSL, 2009a)



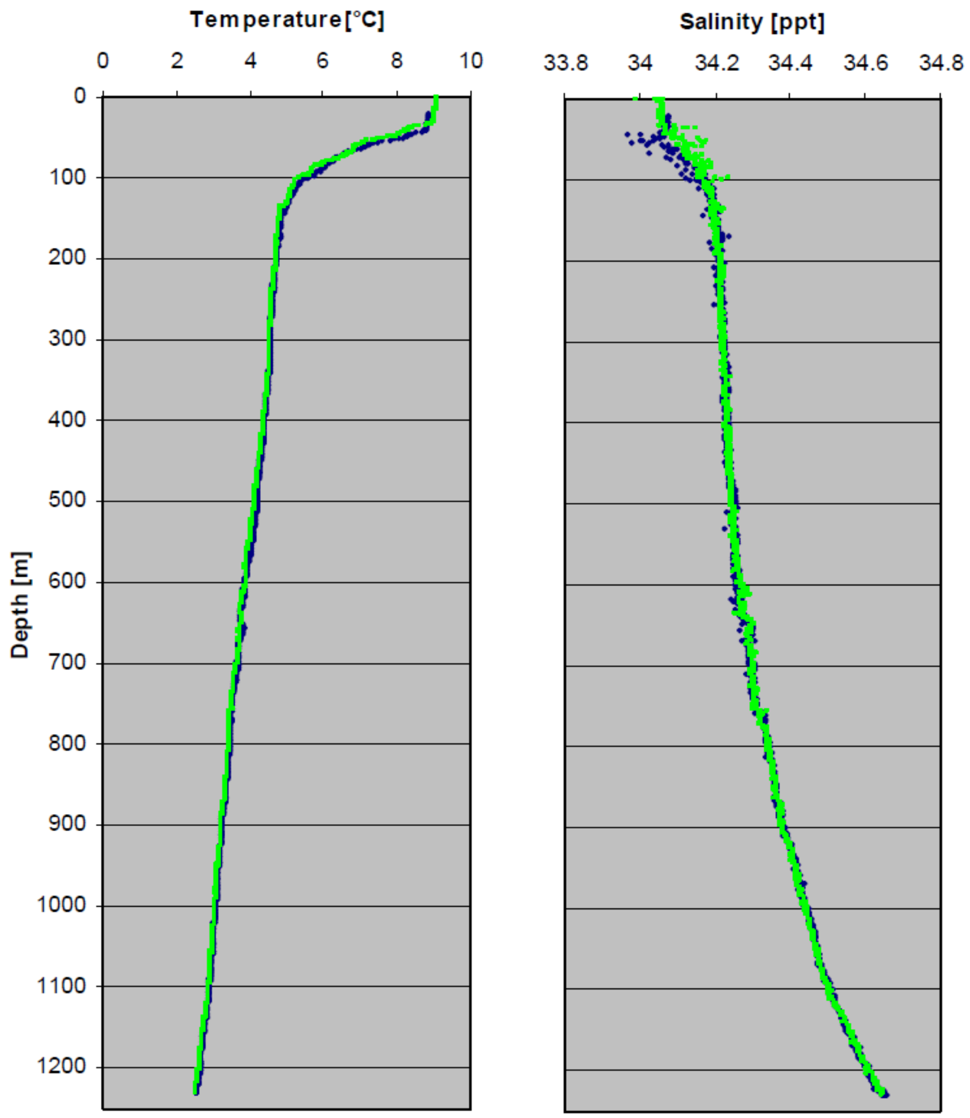
Although salinity showed minimal variation throughout the water column, ranging from a minimum of 34.0 ppt at the surface to 34.5 ppt at the seabed, it appeared to have a strong negative relationship with temperature. In the well mixed surface layers salinity remained constant; it then showed a small but distinct decrease over the course of the thermocline to approximately 34.2. From here it increased gradually to the temperature inversion at approximately 760 metres depth, where it showed a sharp stepped increase, before fluctuating slightly but showing a general trend of increase to the seabed. The slight increase of salinity at the temperature inversion suggested inflow of a slightly more saline (and thereby denser) water body below this depth.

For further details refer to Appendix C (FSL, 2009a).

3.3.2 Nimrod Site Survey Results

Water profile data within the Nimrod survey area was acquired on 3rd February 2009 (Figure 3.6).

Figure 3.6. Water Column Profiles Recorded in February 2009 at Nimrod site (FSL, 2009b)



The surface temperature at the time of data collection was approximately 8.8°C and this remained relatively constant in the well mixed upper layers of the water column (between the surface and approximately 40 metres depth). Below this well mixed layer there was a distinct thermocline over which the water temperature rapidly descended to 5.0°C at approximately 130 metres depth. Below the thermocline the temperature declined gradually to approximately 500 metres depth. From this depth the temperature showed a general trend of decrease with minor variability, showing layers of constant temperature or slight but sharp increases and decreases to a depth of approximately 750 metres. Below this depth temperature declined gradually to the seafloor, the minimum temperature of 2.5°C being recorded at 1230 m depth.

Although salinity showed minimal variation throughout the water column, ranging from a minimum of 34.01 ppt at the surface to 34.66 ppt at the seabed, it showed the expected strong negative relationship with temperature. In the well mixed surface layers salinity remained constant at between 34.04 ppt to 34.08 ppt, it then showed a small but distinct increase over the course of the thermocline to approximately 34.2 ppt and then an extremely gradual increase to the seafloor.

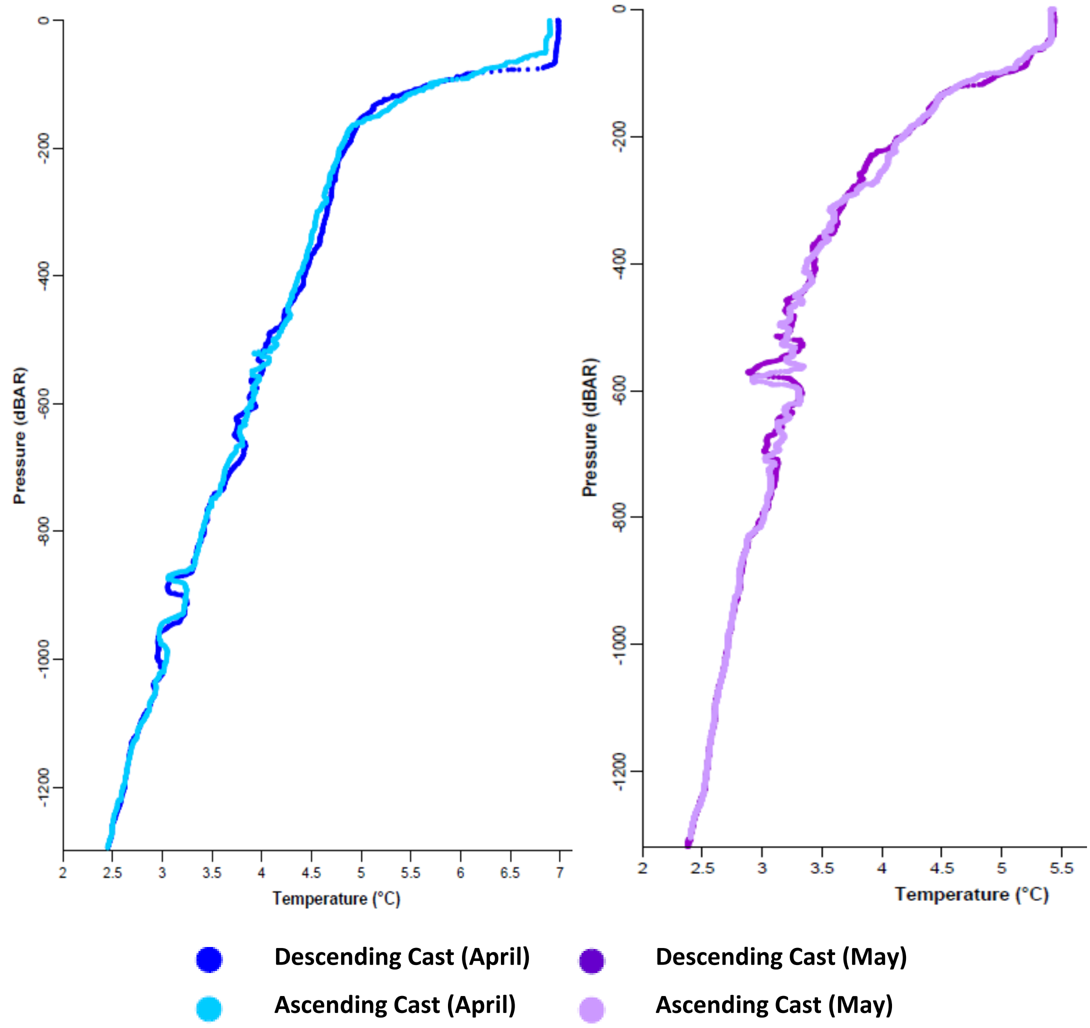
For further details refer to Appendix D (FSL, 2009b).

3.3.3 Loligo NW Site Survey Results

Water profile data within the Loligo NW survey area was acquired in 18th April and 13th May 2011.

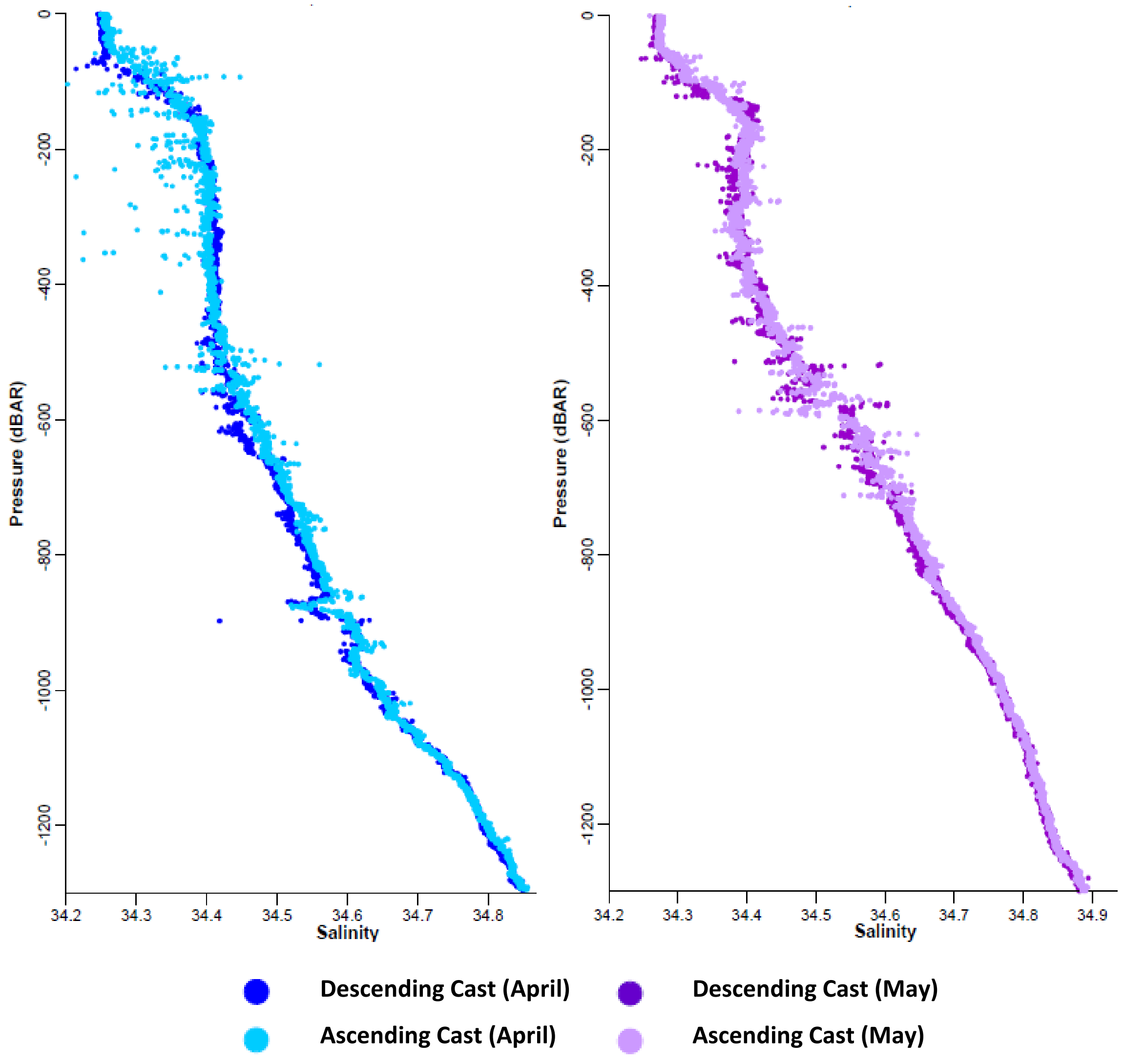
Temperature for both casts, displayed in Figure 3.7, show a distinct thermocline within approximately the first 150 metres of the water column. April cast displayed a thermocline between approximately 50 metres and 160 metres deep, with surface temperatures decreasing from 6.9°C to 5.0°C, while May cast displayed a thermocline between approximately 50 metres and 130 metres, with surface temperatures decreasing from 5.5°C to 4.3°C. Both temperature profiles then continued to decrease gently to a temperature of approximately 2.5°C at the seabed.

Figure 3.7. Water Column Temperature Profiles Recorded in April and May 2011 at Loligo NW site (GEL, 2011a)



Both casts displayed a far greater fluctuation with regards to their salinity profiles presented in Figure 3.8, with a reasonably steep halocline observed between depths of approximately 50 metres and 170 metres, at which point the salinity increased slowly to the seabed.

Figure 3.8. Water Column Salinity (ppt) Profiles Recorded in April and May 2011 at Loligo NW site (GEL, 2011a)



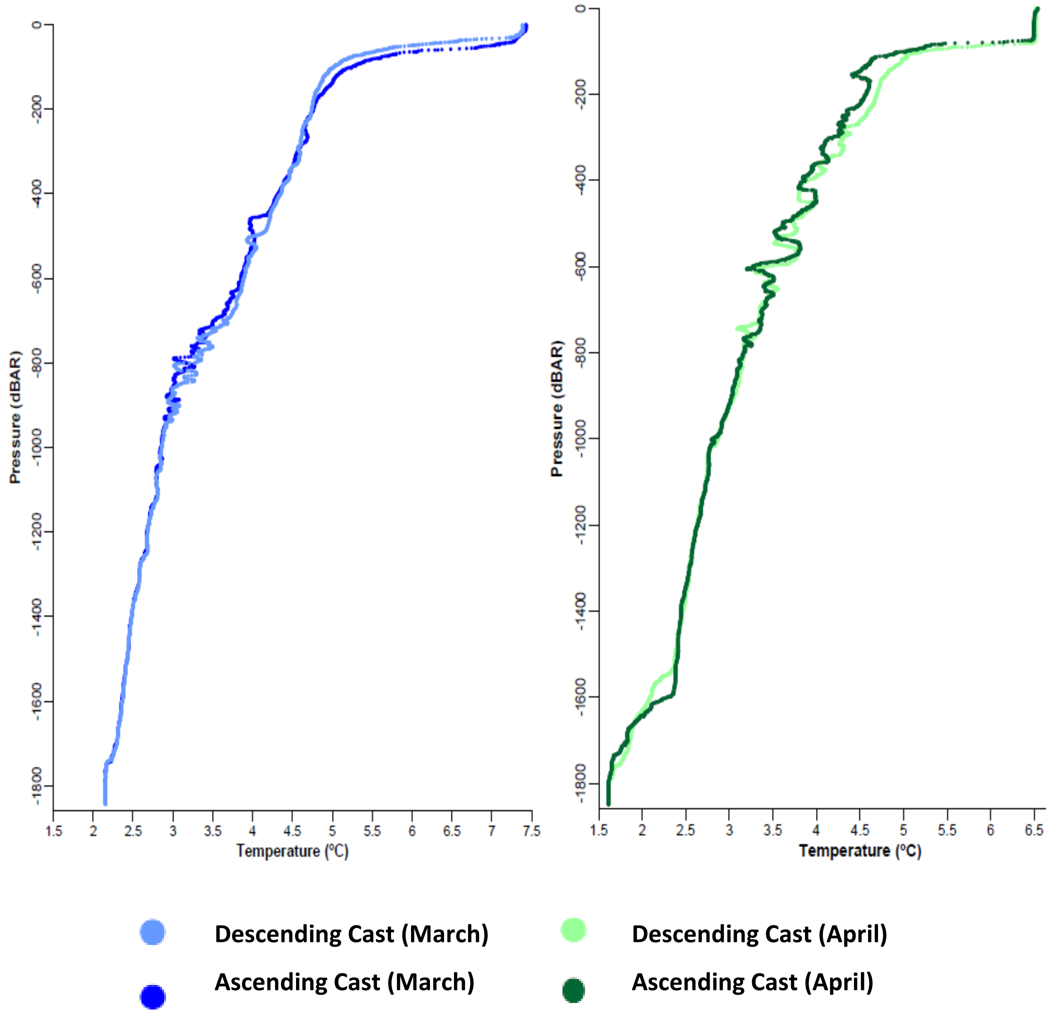
For further details refer to Appendix E (GEL, 2011a).

3.3.4 Scotia East Site Survey Results

Water profile data within the Scotia East survey area was acquired on 21st March and 10th April 2011.

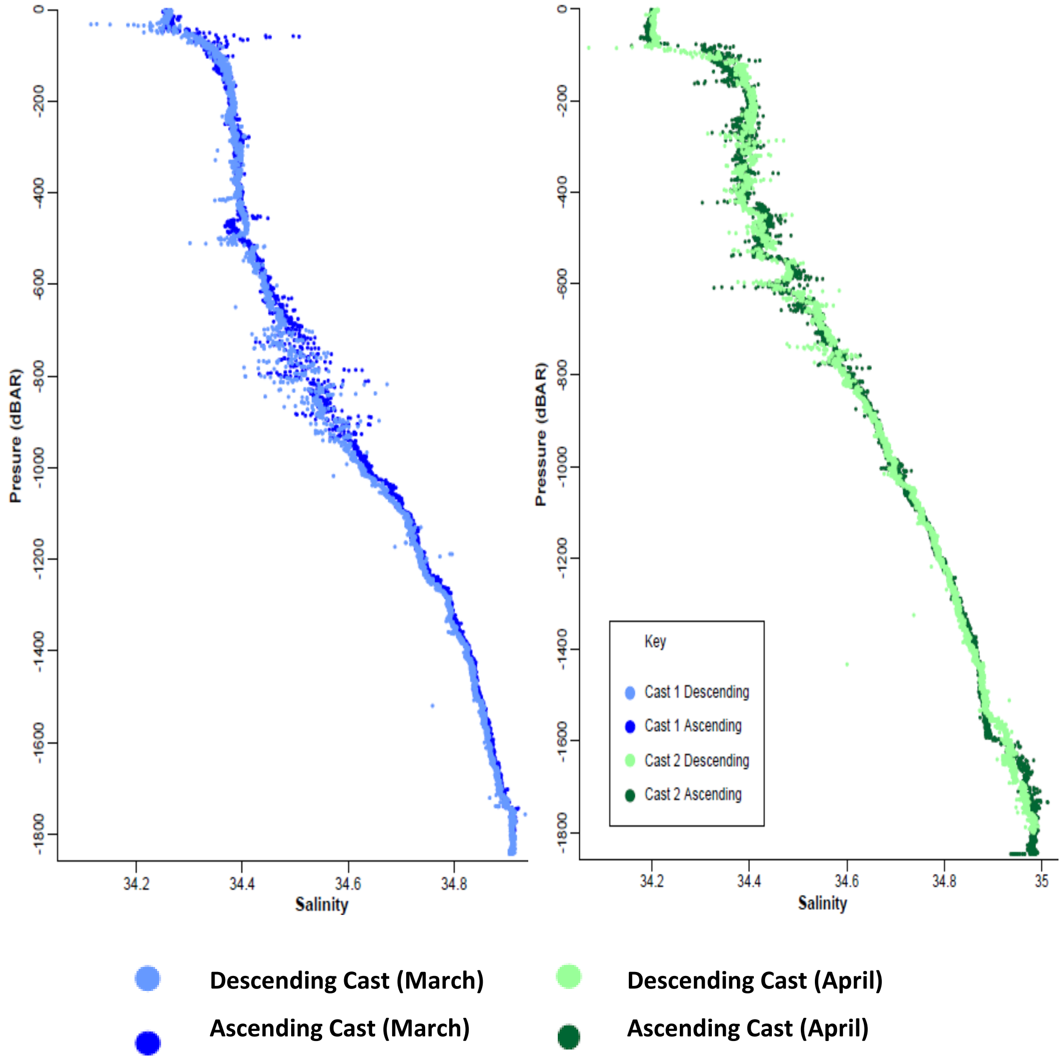
Temperature profiles were generally similar for both casts (Figure 3.9), displaying a thermocline within the top 150 metres of the water column. The March cast displayed a surface temperature of approximately 7.4°C, while the April cast recorded a cooler surface layer, with a temperature of 6.5°C throughout the first 80 metres of the water column. Both temperature profiles had decreased to 5°C at a depth of 130 metres. Between this depth and 800 metres the temperature declined gradually in both casts and was 0.5°C cooler for April. Between 800 metres and 1500 metres both profiles were very similar, gradually decreasing to 2.4°C. Below this, the April cast recorded cooler water with temperatures as low as 1.6°C near seabed compared with 2.2°C in March. Temperature profiles collected at other locations (Loligo A, Loligo NW and Nimrod) and from a regional survey of the Burdwood Bank and South Falkland Basin (BSL, 2009), were also consistent with the current survey, where the thermocline appeared within the first 200 m of the water column.

Figure 3.9. Water Column Temperature Profiles Recorded in March and April 2011 at Scotia East site (GEL, 2011b)



There was low variability with regards to the salinity profiles (Figure 3.10). The cooler surface layer noted in the April cast, was also slightly less saline than that of the March cast, although a halocline was apparent within both casts with salinity increasing to 34.4 ppt at a depth of 130 metres, from which point there was little variation in salinity until a depth of approximately 500 metres. Below 500 metres, the salinity from both casts increased steadily to the seabed with a final salinity of 34.9 and 35.0 in Casts 1 and 2, respectively. Both salinity profiles were comparable to those profiles found within other survey areas (Loligo A, Loligo NW and Nimrod), as well as the salinity profile identified within the Burdwood Bank (BSL, 2009).

Figure 3.10. Water Column Salinity (ppt) Profiles Recorded in March and April 2011 at Scotia East site (GEL, 2011b)



For further details refer to Appendix F (GEL, 2011b).

3.4 Seabed Sediments

3.4.1 Loligo A Site Survey Results

The evidence of the gravity coring, drilling and ROV programs suggested that seafloor materials predominantly consisted of fine to coarse sand or gravel throughout the Loligo A site survey area. These sediments may also have been cemented in parts of the area. The high-relief topographic features identified in the eastern morphologic zone may have represented un-eroded remnants of locally harder or cemented seafloor materials.

ROV footage showed that variable proportions of rock material, ranging in size from pebbles to small boulders, were present and the ROV recovered a number of very dense rocks with a rounded shape. Analysis of these rocks suggested that they may have been transported by icebergs before being dropped to the seafloor.

Of the three stations successfully sampled for particle size analysis, all showed similar levels of clay and silt particles. However only stations L2 and L4 had similar sediment types in which particles in the 1 phi unit to 3 phi unit (medium to fine sand) size range were particularly prevalent. The sediment sample acquired at L8 was observed to have a distinctly different sediment type, in which pebble particles (-2 to -4 phi units) were dominant. This sample had substantially lower proportions of both sand and fine material than stations L2 and L14. This would suggest similar oceanographic regimes at all stations with a thinner Holocene layer at L8.

Both fractionated organic carbon (FOC) and total organic matter by loss on ignition (TOM by LOI) concentrations appeared relatively consistent across the Loligo A sampling stations, the former ranging from 0.24% to 0.31% (stations L8 and L2, respectively) and the latter from 4.8% to 5.7% (stations L14 and L8, respectively). Total hydrocarbon concentrations (THC) were low at all stations, ranging from 2.3 $\mu g.g^{-1}$ (micrograms per gram) to 4.2 $\mu g.g^{-1}$ (stations L2 and L14, respectively). Total n-alkane and individual aliphatic concentrations reflected THC in being low, but were at their greatest at station L14. The lack of carbon-number preference in the n-alkanes (all stations having CPIs close to unity) was thought to be due to natural processes.

Total Polycyclic Aromatic Hydrocarbons (PAH) concentrations were low and showed the same general pattern as was observed for total hydrocarbons, with higher concentrations being recorded from stations L2 and L14 (133 $ng.g^{-1}$ (nanograms per gram) and 162 $ng.g^{-1}$, respectively) than from station L8 (61 $ng.g^{-1}$). These levels of PAHs were lower than typical levels found in the North Sea and, given the remoteness of the region, these concentrations fall within expected levels.

The concentrations of heavy and trace metals appeared consistent across the site. Concentrations of heavy and trace metals at each station were lower than North Sea UKO&G values, indicating typical background levels for an unimpacted environment.

For further details refer to Appendix C (FSL, 2009a).

3.4.2 Nimrod Site Survey Results

The evidence of the box and gravity corer sampling suggested that surficial sediments throughout much of the site comprised clayey sands. In the box core samples these were frequently seen to overly coarse (gravel and pebble) material. The seismic data suggested that coarser materials (identified as higher amplitude reflectors) occurred predominantly in the deeper areas of the site. The scarps identified may have comprised consolidated or cemented materials as seen during ROV operations at the Loligo site.

Seabed sediments were shown to be extremely homogeneous across the site, the sediments of all stations being classifiable as poorly to very poorly sorted fine sand (Wentworth classification of the graphical means). Sand fractions were dominant in all samples, though a moderate proportion (16.4% to 28.1%) of fine material was also recorded. Although relatively low proportions of coarse material were identified from the particle size analysis, gravel and pebble particles were seen underlying the predominantly sandy surficial material at most stations.

Both FOC and TOM concentrations appeared relatively consistent across the sampling stations, the former ranging from 0.24% (stations N1 and N9) to 0.31% (station N5) and the latter from 6.0% (stations N9 and N14) to 8.6% (station N8).

THC ranged from 3.2 µg.g-1 to 4.2 µg.g-1 (stations N11 and N7, respectively), total n-alkane concentration ranged from 0.27 µg.g-1 (stations N7 and N8) to 0.43 µg.g-1 (station N14) and total polycyclic aromatic hydrocarbon (PAH) concentration from 56 ng.g-1 (stations N9 and N12) to 91 ng.g-1 (station N1). The concentrations of the hydrocarbon constituents measured, are consistent with UK background levels. The detailed analyses of individual alkanes and PAHs, suggested that there were diffuse natural petrogenic inputs to the site, possibly from hydrocarbon seeps.

The concentrations of heavy and trace metals appeared consistent across the site, none being found at concentrations that suggested point source anthropogenic metal contamination.

For further details refer to Appendix D (FSL, 2009b).

3.4.3 Loligo NW Site Survey Results

An interpretation of the geophysical pinger and backscatter data together with seabed imagery acquired at the five environmental stations and along a transect extending between Stations ENV3 and ENV4 revealed a relatively uniform seabed consisting of silty sand with areas of gravel, cobbles and boulders. These were seen throughout the surveyed area and interpreted as being independent of the underlying geology.

Recovered sediment samples appeared to be mostly homogenous, described as containing white and/or grey sandy silt with coarser black fine to medium sand closer to the surface. There was also gravel and occasional small cobbles on the surface, and samples were described as being slightly cohesive. This supported the geophysical interpretation of the predominant sediment type and was consistent with observations from seabed imagery investigations.

Particle size analyses revealed relative homogeneity in the sediments sampled. All samples were very poorly sorted, with the exception of Station ENV4, which was extremely poorly sorted. Under the Modified Folk classification, sediments were recorded as slightly gravelly muddy sand (ENV1), gravelly muddy sand (ENV2, ENV3 and ENV5) and muddy sandy gravel (ENV4). Stations were dominated by sand sized particles, which accounted for more than 59% of the sediment within the samples, with the exception of Station ENV4, which contained 38% sand. The proportional contribution of gravel sized material (greater than 2mm) was variable across the survey area; ranging between 1% and 11.2% of the sediment at Stations ENV1 to ENV3, increasing to 33.4% and 21.9% at Stations ENV4 and ENV5, sampled within the elongated depression in the southwest of the survey area.

Total organic matter (TOM) and total organic carbon (TOC) contents within sediments ranged from 3.7% to 4.7% and 0.38% to 0.43%, respectively, while total inorganic carbon (as calcium carbonate, $CaCO_3$) ranged from 7.4% to 27.0%. It is suggested that the proportion of calcium carbonate recorded may be related to the variation in presence and abundance of Bryozoa recorded, together with other biogenic material including broken shell.

Total hydrocarbon concentrations (THC) ranged from 1.0µg g-1 to 3.0µg g-1 across the five stations and were indicative of background concentrations. Gas chromatograms (GC) displayed similar profiles for all stations, showing small resolved peaks over individual alkanes and very limited unresolved complex mixture (UCM). Total polycyclic aromatic hydrocarbons (PAH) were also found in low concentrations. Naphthalenes, phenanthrenes and dibenzothiophenes (NPD, 2 to 3 ring PAH) and 4 to 6 ring PAH derivatives were fairly equal in proportion and were predominantly alkylated. This suggested that PAHs were of petrogenic origin, likely from low-level diffuse inputs such as natural seeps. Hydrocarbon indices were found to be comparable to the previous surveys conducted in the region (FSL 2009a; FSL 2009b).

Some of the metals were naturally higher than the comparative background concentrations (BCs) in Europe (i.e. OSPAR, 2005). Although OSPAR BCs of the seabed are not entirely relevant for this region, they have been used in this instance as an inference of whether metal concentrations are generally high or low. As, Cu, Pb, Hg, Ni and Zn were all low when compared to their respective OSPAR (2005) BCs, Cd was below OSPAR BC values at all stations excluding ENV2, while Cr was found to be elevated above the OSPAR BC. Vanadium appeared to be quite high, and it is thought to be natural in origin considering the mature pristine nature of the environment.

Concentrations of analysed elements were reasonably variable when compared to other closest survey areas (Loligo A (FSL, 2009a) and Endeavour (FSL, 2009c). Overall the concentrations identified for Loligo NW were more analogous to those concentrations identified within the Endeavour survey.

For further details refer to Appendix E (GEL, 2011a).

3.4.4 Scotia East Site Survey Results

The site was dominated by a rocky substrate interspersed with gravel and small sandy patches overlying coarser black sand. Seabed imagery also revealed the presence of numerous cobbles and boulders. Recovered sediment consisted mainly of dark sandy sediment, with a component of lighter grey finer material and some coarser material ranging from fine gravel to cobbles. At Station ENV3 there was some concreted, clay-like sediment recovered.

Particle size analysis (PSA) showed Stations ENV3 and ENV4 to have similar characteristics, described as gravelly sand whilst the sediment at Station ENV5 exhibited a higher proportion of fine material and classified as gravelly muddy sand under the Modified Folk Classification. This is most likely due to variation in water depth; Station ENV5 was sampled in a bathymetric depression in the northwest of the survey area.

Total organic matter (TOM) and total organic carbon (TOC) within sediment ranged from 4.1% to 4.7% and 0.14% to 0.18% respectively, with total inorganic carbon (as calcium carbonate, CaCO3) ranging between 4.7% and 16.0%. Overall, sediments found within the current survey were broadly comparable to the previous surveys conducted within the wider Falkland region.

THC values ranged from 0.5µg g-1 to 1.1µg g-1 across the three stations and were indicative of background concentrations. Gas chromatograms (GC) displayed similar profiles for all stations, showing small resolved peaks over individual alkanes and a very limited unresolved complex mixture (UCM). PAH were undetected at Station ENV3 and recorded a maximum concentration of 0.013µg g-1 at Station ENV5. Naphthalenes, phenanthrenes and dibenzothiophenes (NPD; 2 to 3 ring PAH) / 4 to 6 ring PAH ratios at Stations ENV4 and ENV5 suggested the PAHs were predominantly of petrogenic derivation (likely to be natural seeps of thermogenic origin), albeit at very low levels. Hydrocarbon indices were generally found at lower concentrations than the comparison surveys.

The current survey had the greatest average concentrations of Cr, Cu, Fe, Ni, V and Zn when compared to the above site surveys. Metal concentrations were generally within or near their respective OSPAR BCs; however threshold values were exceeded for Zn, Cr and Fe at all three stations. OSPAR BCs were not available for Al, Ba, Sn and Sr. Although some metal concentrations appeared to be reasonably high, these are thought to be natural in origin considering the pristine nature of the environment.

For further details refer to Appendix F (GEL, 2011b).

3.5 Macrofauna and Habitat Assessment

The macrofaunal investigation in this survey is designed to provide a description of the benthic infauna in the survey area. Marine benthic invertebrate communities have been shown to be sensitive to environmental change, particularly environmental degradation as a result of anthropogenic contamination (Davies *et al.*, 1984; Warwick and Clarke, 1991). Analysis of faunal datasets may therefore provide insight into the deleterious effects of point source pollutants.

The information presented below is based on the site survey reports (FSL 2009a-b; GEL, 2011a-b) included in Appendices C-F.

3.5.1 Loligo A Site Survey Results

Epifauna/ Pelagic Fauna

The most prominent colonial epifauna encountered across the site were Cnidarians, including at least two species of gorgonian (soft corals) and at least one species of scleractinian (hard or stony coral). The gorgonians included a characteristic "sea fan" form, which was found throughout the site on both isolated cobbles and boulders (Figure 3.11- Plates 3 and 4) and on outcrops of consolidated sediment (Figure 3.11- Plate 6). A less frequently encountered gorgonian form were "sea whips", which tended to be restricted to consolidated sediment areas (with or without a veneer of sand) (Figure 3.11- Plates 4 and 5). While not as widely distributed as the gorgonians, scleractinians were occasionally seen in considerable density, forming low thickets over the consolidated sediments of the scarp seen to the south of Loligo (Figure 3.11- Plate 1).

Examination of the ROV footage (Figure 3.11, Plate 1) and coral fragments recovered in the box corer (Figure 3.11, Plate 2) suggested that the coral was at least superficially similar to the cold water coral *Lophelia pertusa*, a widely distributed species which has previously been recorded as far south as the Brazilian slope (OBIS, 2009). Unlike most tropical scleractinians *L. pertusa* is azooxanthellate (it does not rely on symbiotic algae to obtain nutrients) and this allows it to extend well below the photic zone (upper layers of the water column which light can penetrate). Existing ecological data for *L. pertusa* suggest that its range would not extend to the Falkland slope due to the low seabed temperature recorded (2.9°C). ICES (2002) state that *L. pertusa* prefers oceanic waters with a temperature of between 4°C and 12°C and a relatively high tidal flow (to facilitate filter feeding); the coral identified from Loligo may instead be a superficially similar Antarctic species, capable of withstanding colder waters.

Figure 3.11. ROV Footage, Showing Examples of Epifaunal Taxa at Loligo A prospect (FSL, 2009a)

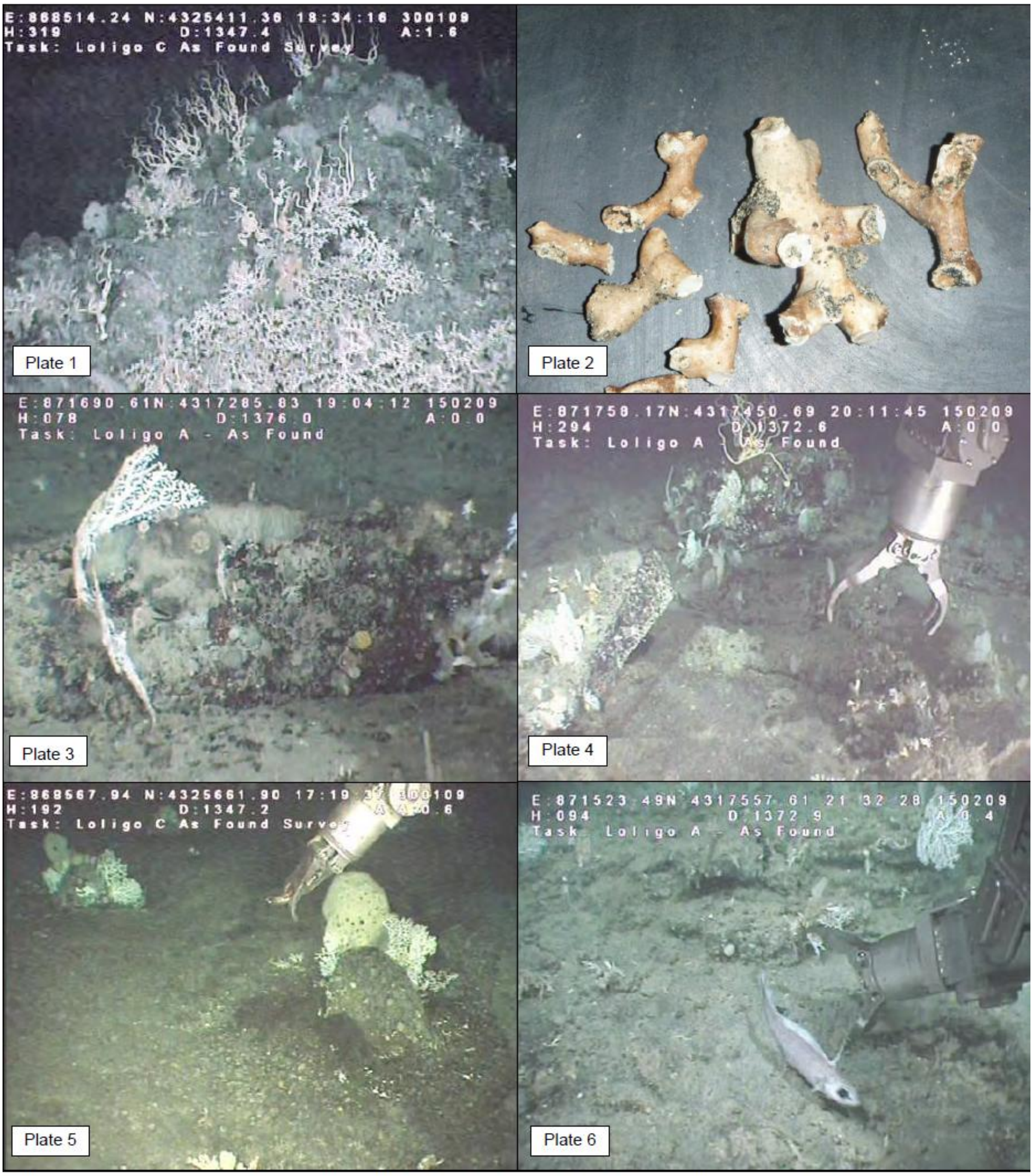


Plate 1: Dense coverage of a hard coral (possibly *Lophelia pertusa*) with filter-feeding brittle-stars (Ophiuroidea) on a consolidated sediment outcrop in the depression near Loligo C

Plate 2: Fragments of dead hard coral (possibly *L. pertusa*) taken in a box corer sample

Plate 3: A gorgonian and a faunal turf comprising Hydrozoa / Bryozoa and sponges (Porifera)

Plate 4: A sea fan (Gorgonacea), brittle-star (Ophiuroidea) and a faunal turf comprising Hydrozoa / Bryozoa and juvenile hard coral colonies seen near Loligo A

Plate 5: Sponges (Porifera) and hard corals on cobbles near Loligo C

Plate 6: A fish (possibly the threadfin rockling *Gaidropsarus ensis*), with sea fans (Gorgonacea) and hard corals on a consolidated sediment outcrop near Loligo A

The observations of sparse soft and hard coral colonies in low densities, do not provide sufficient evidence to classify these as habitats of conservation significance (Annex 1 habitats described in the EC Habitats Directive 92/43/EEC).

In addition to Cnidaria, the Phylum Porifera (sponges) was also well represented at a number of sites (Figure 3.11. Plates 3 and 5). Hexactinellidae were recorded only in fragmentary form, although the presence of numerous spicules in the sediments belonging to this class indicates that they are more common than indicated from the samples. This also applied to the Tetraxonida, where only one species was recorded, with one specimen of Tetilla. Also of interest was the lithistid sponge *Gastropharella* sp. These sponges, a polyphyletic group, have a virtually solid skeleton of "Desmas" with a compliment of other spicules, in this case Tylota.

A common sponge genus throughout the deeper waters of the Atlantic is *Asbestopluma* sp, which was well represented in the current study. These sponges are upright branching forms without the normal canal system and rely on a carnivorous mode of feeding. Their microscleres (anisochelae) catch small crustaceans which are then surrounded by tissue and digested.

Of the free-living taxa recorded, the most abundant were brittle stars (class Ophiuroidea), which sometimes formed dense aggregations on consolidated sediment outcrops (Figure 3.11. - Plate 1).

Infauna

Two 0.1 m^2 macrofaunal box core samples were analysed from each of the four stations successfully sampled (stations L2, L3, L11 and L14; Figure 3.2), giving a total of eight samples. Macrofaunal data were derived from the taxonomic analysis of all of these samples, with individuals of macrofaunal taxa being identified, enumerated and expressed as abundance per sample (0.1 m^2) and per station (0.2 m^2).

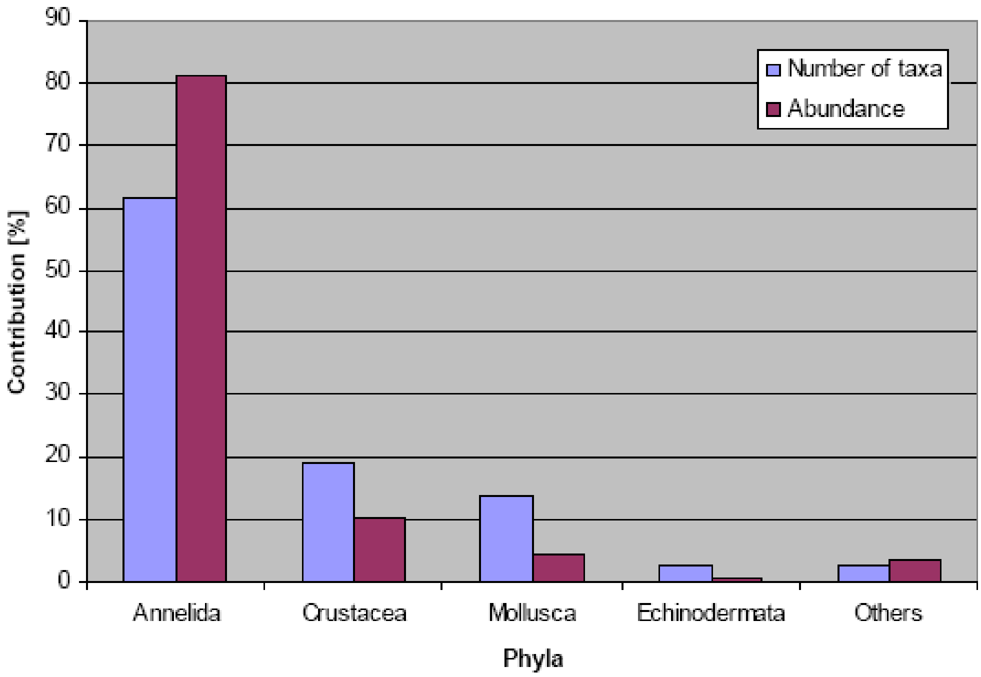
A total of 73 discrete macrofaunal taxa were found during the course of this survey, excluding the two juvenile and three indeterminate taxa. Newly settled juveniles of benthic species may at times dominate the macrofauna, but due to heavy natural post-settlement mortality, they should be considered an ephemeral component and not representative of prevailing bottom conditions (OSPAR Commission, 2004). Subsequent analysis was undertaken on data that excluded juveniles, in keeping with the procedures recommended by OSPAR. The same methodology was applied in the analysis of data collected during other site surveys presented in this section.

Of the taxa recorded 61.6% were annelid, 20.5% were crustacean, 13.7% were molluscan and 2.7% were echinoderm (Figure 3.12).

In terms of abundance the Annelida were overwhelmingly dominant, representing 81.1% of the 312 individuals recorded in total from the samples. The Crustacea, which contributed 10.6% of the total abundance, were the second most abundant phylum, followed by the Mollusca (4.5%) and representatives of other phyla (4.7%). Echinoderms contributed just 0.6% of the total faunal abundance recorded. Percentage abundances of phyla identified in the current survey were generally comparable to those determined by Blake and Narayanaswamy (2004) in Antarctica; 67% Polychaeta, 20% Crustacea and 13% remaining phyla.

The most abundant species overall, the onuphid polychaete *Kinbergonuphis oligobranchiata*, was first described from the slope off Argentina (Fauchald, 1982) and appears limited in distribution to the Southwest Atlantic, where it has previously been recorded from depths ranging from 512 m to 903 m (Smithsonian Institution, 2009). It is presumed that *K. oligobranchiata* is, like other onuphids, an omnivorous scavenger (Fauchald and Jumars, 1979). The second most abundant species overall, the ampharetid polychaete *Melinna* sp. 1, belongs to a sub-family (Melinninae) that is largely restricted to deep water; ampharetids are all surface deposit feeders (Rouse and Pleijel, 2001). Of the remaining dominant taxa all but two were polychaetes, the exceptions being sipunculans (peanut worms) and the tanaid crustacean *Apseudes*? sp. 1. Although the majority of dominant taxa within the survey areas community were deposit feeders, omnivorous scavengers were also present (the onuphids *K. oligobranchiata* and *Nothria anoculata* and tanaid *Apseudes*? sp. 1), as were filter feeders (the sabellid polychaetes *Chone* / *Jasmineira* sp. 1 and *Euchone* sp. 1 and the chaetopterid polychaete *Spiochaetopeterus typicus*).

Figure 3.12. Contributions of taxonomic groups for Loligo area (FSL, 2009a)



Crude abundance, dominance and univariate analyses of the infaunal data suggested that a single community occurred throughout the survey area. These findings were corroborated by the multivariate CLUSTER and SIMPROF analyses, which showed that all sample data could be grouped within a single statistically undifferentiated cluster.

All of the samples acquired from the comparably deep sites (Loligo, Endeavour and Nimrod) were grouped within a single statistically undifferentiated cluster, suggesting that a single benthic community was present throughout these deeper areas. Despite this lack of statistically significant differentiation there did appear to be clear grouping of the samples according to the site from which they were acquired. Examination of the data suggested this resulted from variations in the abundance of taxa, rather than from differing taxonomic composition.

3.5.2 Loligo NW Site Survey Results

Epifauna

The epifaunal community was notably more diverse on and around cobbles and boulders, such as those seen at Station ENV3, along the transect, and at Station ENV5. Observed fauna associated with this coarser material included Cnidaria (unidentified sea pen *Pennatulacea, Primnoidae* species, possible *Stylaster* sp. *Actiniaria* sp. *Octocorallia* sp. and other unidentified Cnidaria species), Polychaeta (possibly Serpulidae), unidentified Porifera in various forms (globose, encrusting and branching including possible *Antho dichotoma* and *Phakellia ventilabrum*), Chordata (Tunicata sea squirt, possibly *Phallusia mammallita*), Bryozoan (unidentified fan species), Echinoderm (possibly pencil sea urchin *Cidaris cidaris*). There were no confirmed sightings of *Lophelia pertusa* or *Madrepora* sp.

Observed fauna in the areas of muddy sand sediment, such as that found across stations ENV1 and ENV2 included Porifera (possible *Chondrocladia gigantean* and other unidentified species), unidentified Crustacea (including possible Isopoda *Serolis* sp.) and Cnidaria species (possible sea anemone Actiniaria sp and possible sea pen *Funiciulina quadranularis*), Mollusca (tusk shell Scaphopoda spp), Echinodermata (possible sea cucumber Holothuroidea spp).

A selection of seabed images, together with descriptions and positions are given in Figure 3.13.

Both acoustic data and seabed imagery collected during the survey did not indicate the presence of any potential Annex 1 habitat types (EC Habitats Directive 92/43/EEC) within the survey area. Although hard and soft coral colonies were observed attached to hard substrates, they were not in sufficient densities to be considered to form a biogenic reef and there was no evidence of submarine structures made by leaking gas. Hard corals such as *L. pertusa* are unlikely to be present in Falklands waters (see section 5.5.1) therefore coral species identified at Loligo NW area may instead be a superficially similar species, capable of withstanding colder waters.

Figure 3.13. Seabed Photographs at Loligo NW prospect (GEL, 2011a)

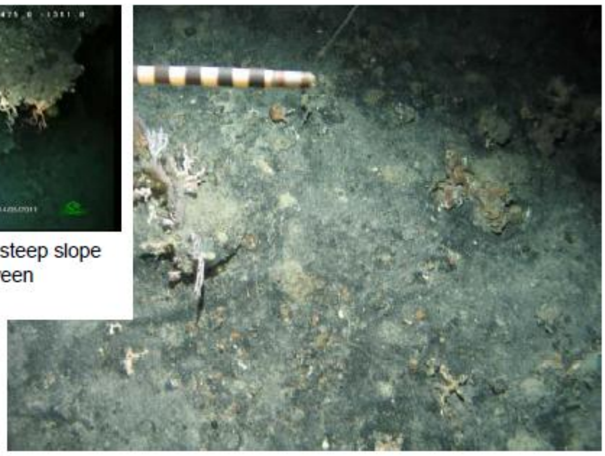
Fix: 21 **Depth:** 1315m **Location:** 860374E 4335551N

Fix: 34 **Depth:** 1312m **Location:** 860240E 4335452N

Fix 21: *Cnidaria spp. (anemone – Actiniaria and possible Pennatulacea, Primnoidae spp.), Polychaeta (possible Serpulidae spp.), indet. globose, encrusting and branching Porifera (possible Antho dichotoma), Tunicata (possible Phallusia mammallita), possible Polychaete worm tubes, indet. Fan Bryozoa spp., evidence of bioturbation.*

Fix 34: *Cnidaria spp. (unidentified Actiniaria spp. And Primnoidae spp., possible Stylaster spp.), Echinoderm (pencil-spine urchin Cidaris cidaris), Polychaeta (possible Serpulidae spp.), branching Porifera (possible Antho dichotoma) and unidentified encrusting Porifera, Tunicata (sea squirt – possible Phallusia mammallita), possible Polychaete worm tubes, unidentified Fan bryozoan species, and evidence of bioturbation.*

Rocky overhang on steep slope along transect between ENV3 and ENV4



Fix: 37 **Depth:** 1312m **Location:** 860208E 4335429N

Fix: 45 **Depth:** 1330m **Location:** 860145E 4335377N

Fix 37: *Cnidaria (possible possible sea-pen Pennatulacea, Primnoidae spp., unidentified anemone, unidentified Cnideria spp.), Porifera branching Porifera (Antho dichotoma), unidentified encrusting Porifera, unidentified Porifera spp., Tunicata (possible Phallusia mammallita), Polychaeta (possible Serpulidae spp.) and Polychaete worm tubes.*

Fix 45: *Cnidaria (Funiculina quadrangularis, Leptopsammia pruvoti, octocoral), Polychaeta (possible Serpulidae spp.) unidentified Cnidaria spp., branching Porifera (Antho dichotoma), unidentified Porifera spp., Tunicata (sea squirt -possible Phallusia mammallita), Polychaete worm tubes.*

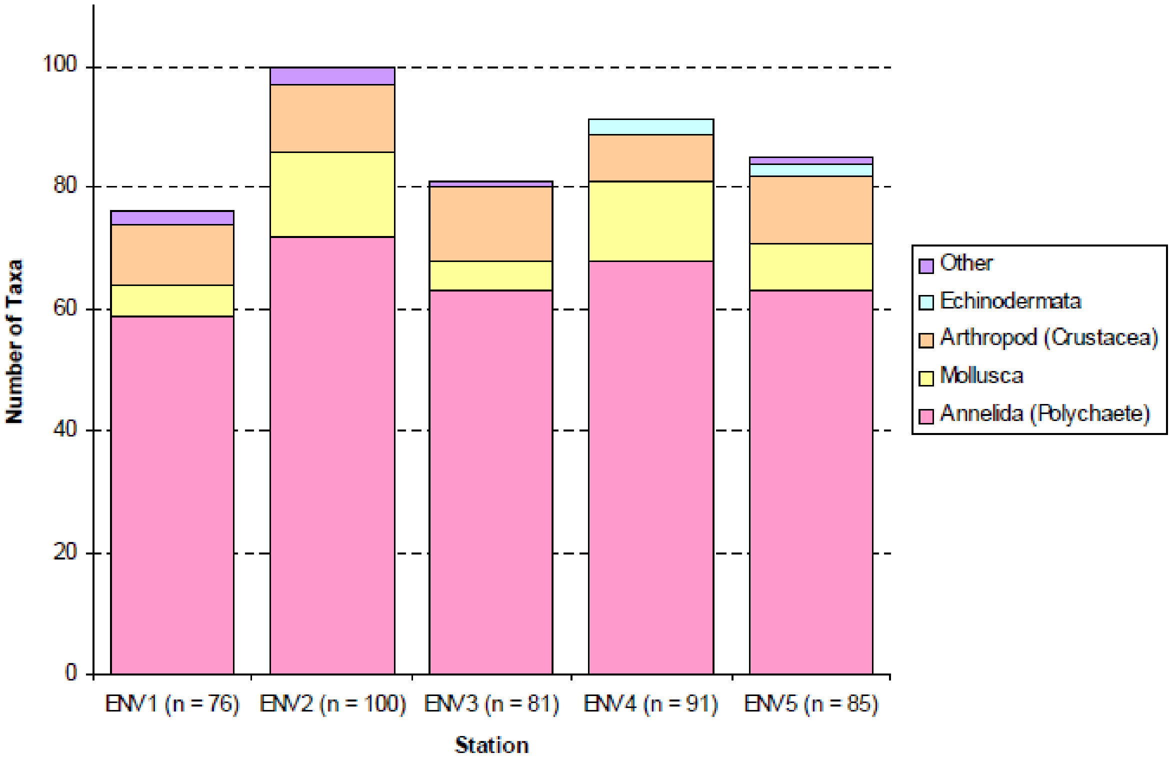
Infauna

Three discrete 0.1 m^2 faunal samples were collected from Stations ENV3, ENV4 and ENV5 using the modified double 0.1 m^2 van Veen grab. Two 0.1 m^2 faunal sub-samples were collected from Stations ENV1 and ENV2 using a box corer, both of which were worked up. (Figure 3.4 shows sampling stations).

A total of 1259 individuals representing 192 taxa were recorded in the retained samples. A total of 36 juvenile individuals were recorded, representing five taxa (3% of the total number of individuals and taxa). The faunal community at all stations was heavily dominated by polychaetes, contributing between 81% (ENV3) and 85% (ENV4) of the total number of individuals and 70% (ENV2) to 76% (ENV1 and ENV3) of the total number of identified taxa (Figure 3.14). This high proportion of polychaetes was not however due to a high proportion of any particular species. Polychaete dominance is generally considered typical for soft sediment continental regions, where they are generally found to account for at least 50% of the total number of macrofaunal individuals (Eleftheriou and Basford, 1989). This pattern was comparable to the proportional contribution of polychaetes in the datasets of the other surveys conducted in the area (Loligo A, Endeavour, Nimrod).

Overall, the proportions of the five taxonomic groupings were reasonably consistent between the five stations (Figure 3.14), although the number of individuals present varied somewhat between stations.

Figure 3.14. Contributions of taxonomic groups (GEL, 2011a)



The highest macrofaunal density was recorded at Station ENV2, accounting for 350 ind. per 0.2 m^2, while the remaining four stations showed a macrofaunal density of between 179 and 257 ind. per 0.2 m^2 within the adult dataset. Of the 187 adult taxa found within the current survey, a total of 77 taxa were found at only one station, with 74 of these taxa found in only one sample, 60 of which (32% of total adult taxa) were represented by a single individual.

These unique records were not limited to any particular station, with all samples having at least three exclusive faunal representatives. This is generally indicative of an absence of any notable contamination or disturbance, as under such scenarios it is expected that these taxa would be replaced by high abundance of a limited suite of tolerant species (Clarke and Warwick, 2006). In total, twenty-three of the adult taxa were found at every station, and in contrast to the high proportion of unique records, only three taxa of polychaetes (*Melinna* sp. 1, *Anchinothria pycnobranchiata* and *enchytraeidae* sp. 1) were present in every sample. This high number of single and low abundance taxa, suggested that the community found at and around the Loligo NW drilling location has been subjected to relatively little, if any, pollution or disturbance events and/or stress.

The abundance of individual taxon within the samples was generally low. The largest number of individuals in any one 0.1 m^2 sample was the polychaete *Chone* sp. 2, representing 49 individuals, 21% of the total, within samples collected at ENV2 location. *Chone* sp. 2 was also the most abundant taxa over all within the full dataset, accounting for 111 individuals, 9% of the total number of individuals, followed by 84 individuals of *A. pycnobranchiata* and 64 individuals of *Melinna* sp. 1. Little information could be found about the ecology of *Chone* sp., however the polychaete *A. pycnobranchiata* is commonly found within Antarctic waters to depths of 4758 m (WoRMS, 2011). Several of the polychaete annelids identified within the current survey were typical of deep Antarctic waters and commonly found to depths well exceeding those within the current surveys (Wilson, 2003; RAMS, 2010; Appeltans *et al.,* 2011).

Very little, if any information has been compiled with regards to the species commonly found around the Falkland Islands and their tolerances. The vast majority of published information pertaining to the present taxa relate to identification and classification as opposed to ecology. Information has therefore been gathered for the represented genus rather than species in an attempt to determine general tolerance for some of the taxa present within the current survey. Many of the twenty-three taxa found at every station were generally found within sandy and muddy sediments and Hiscock *et al.,* (2005) showed that nine of these genera were either tolerant or intolerant to certain stresses and contaminants. *Melinna* sp., *Aphelochaeta* sp., *Exogone* sp. and *Enchytraeidae* sp. for example, are reportedly highly intolerant to synthetic chemicals and some metals, while *Aricidea* sp are reported to be intolerant to hydrocarbon contamination. Overall the species assemblage provides no indication of a response to any anthropogenic disturbance event. This corroborated the chemistry data, in suggesting that no anthropogenic contamination event has occurred at or around the Loligo NW survey area.

Overall, the macrofaunal analyses suggest a relatively even spread of individuals across the area surveyed, albeit at low abundance with evidence of limited species fidelity. The community sampled was found to be relatively diverse, with low species dominance. The number of low abundance and unique records of taxa identified within this survey suggested a relatively stable homogenous community. This is broadly consistent with the findings of other comparable surveys (Loligo A, Endeavour and Nimrod).

Multivariate analyses could not statistically distinguish between the faunal community at the five stations, despite Stations ENV4 and ENV5 containing a greater proportion of granular material than at the remaining stations.

3.5.3 Nimrod Site Survey Results

Epifauna

As no seabed video data were acquired at Nimrod, the information available on its epifaunal community was based on the box core sample data and still photographs. Example photographs of epifaunal taxa recovered from the samples are provided in Figure 3.15.

The epifauna encountered included a dead colonial hard coral similar to the cold water coral *Lophelia pertusa* (Figure 3.15, Plate 1). Hard corals such as *L. pertusa* are unlikely to be present in Falklands waters (see section 5.5.1) therefore coral species identified at Nimrod location may instead be a superficially similar species, capable of withstanding colder waters. Figure 3.15 (Plate 2) shows what appeared (from its gross morphology at least) to be a different hard coral species.

Other attached epifaunal taxa included a solitary cup coral (order Scleractinia), an athecate hydroid and at least two species of encrusting bryozoa (Figure 3.15, Plate 4). The sea cucumber (*Ypsilothuridae indet*) shown in Figure 3.15, Plate 4 was the largest infaunal species encountered during the survey.

Figure 3.15. Photographs of samples recovered by box corer at Nimrod prospect (FSL, 2009b)

Plate 1: A hard coral (possibly Lophelia pertusa) recovered at Station 11

Plate 2: A hard coral recovered at Station 5

Plate 3: A cup coral (Scleractinia) sample recovered at Station 14

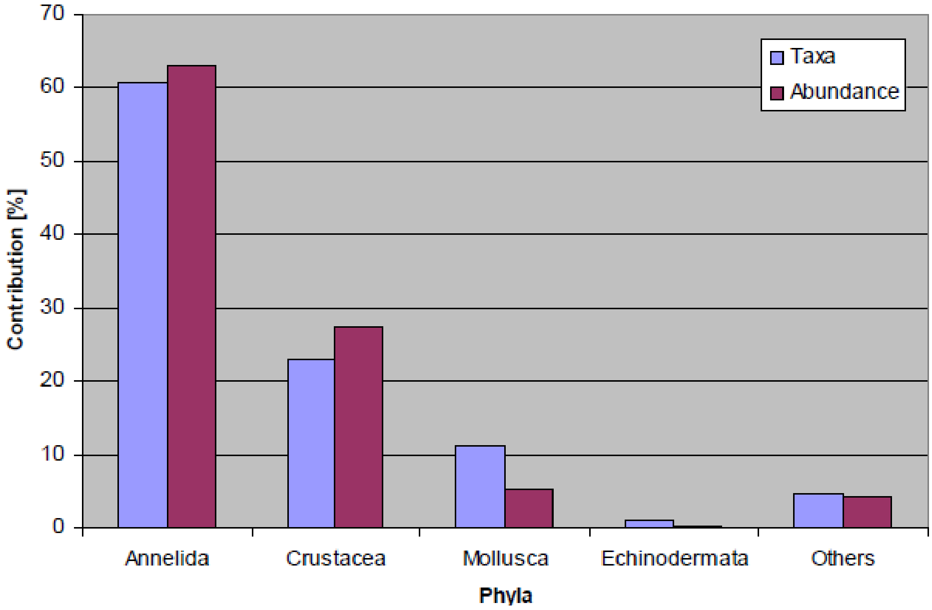
Plate 4: A hydroid (Athecata), at least 2 species of bryozoan and sea cucumber of the family Ypsilothuridae (infaunal) recovered at Station 14.

Infauna

Two 0.1 m^2 macrofaunal grab samples were acquired from seven of the eight stations sampled and a single 0.1 m^2 sample taken from the remaining station (station N11), giving a total of 15 samples (see Figure 3.3). Macrofaunal data were derived from the taxonomic analysis of all of these samples, with individuals of macrofaunal taxa being identified, enumerated and expressed as abundance per sample (0.1 m^2) and, where possible, per station (0.2 m^2).

A total of 109 discrete macrofaunal taxa were found during the course of this survey, excluding the single juvenile and three indeterminate taxa, records for which were not included in the analysis. Of the taxa recorded 66 (60.6%) were annelid, 25 (22.9%) were crustacean, 12 (11.0%) were molluscan and one (0.9%) was echinoderm. Representatives of the Nemertea, Sipuncula, Echiura, Chelicerata and Brachiopoda made up the five taxa (4.6% of the total) which belonged to other phyla (see Figure 3.16). In terms of abundance the Annelida were highly dominant, representing 63.0% of the 457 individuals recorded in total from the samples. The Crustacea, which contributed 27.4% of the total abundance, were the second most abundant phylum, followed by the Mollusca (5.3%) and representatives of other phyla (4.2%). Echinoderms contributed just 0.2% of the total faunal abundance recorded. Percentage abundances of phyla identified in the current survey were generally comparable to those determined by Blake and Narayanaswamy (2004) in Antarctica; 67% Polychaeta, 20% Crustacea and 13% remaining phyla.

Figure 3.16. Abundance of taxonomic groups (FSL, 2009b)



The dominant taxa recorded from the survey area are shown in Figure 3.16. Of these dominant taxa most were polychaetous annelids, although within the listed taxa there were also sipunculans (peanut worms) and five crustaceans taxa (the amphipods Ampeliscidae, Haustoridae sp. 1 and Phoxoocephalidae sp. 3, the cumacean *Diastylis* sp. 1 and the isopod Arcturidae sp. 1). The most abundant species overall was the onuphid polychaete *Kinbergonuphis oligobranchiata*, which was recorded at a mean abundance of 5.5 individuals per sample. The second most abundant taxon comprised amphipods of the family Ampeliscidae, which were present at a mean abundance of 2.4 individuals per sample. Although the taxon Ampeliscidae was created by merging taxa originally recorded, all but two individuals within this merged unit were of the species *Ampelisca* sp. 2, a species that occurred commonly throughout the three deeper survey areas (Loligo, Endeavour and Nimrod). The remainder of the dominant taxa occurred at mean abundances of 0.9 individuals per sample or less.

The frequencies of occurrence calculated showed that only *K. oligobranchiata* occurred in all of the samples acquired, although ampeliscids were recorded from all but one sample (99.3%). The remainder of the dominant taxa occurred in no more than 10 (66.7%) of the samples. Examination of the data suggested that these relatively low frequencies were indicative of patchiness in the distributions of individual taxa, rather than of the presence of multiple, spatially differentiated communities, as there was clear overlap in the abundance distributions across the different samples.

The phyletic composition of the community recorded was similar to that found in studies of the shelf and slope of the Weddell Sea Basin and South Sandwich Slope. Blake and Narayanaswamy (2004) found that annelids dominated the infauna here (contributing 67% of the total diversity), followed by the Crustacea (20% of the total diversity). Population density on the comparably deep (1000 metres) western slope of the Weddell Sea was far higher than in the current survey (260 individuals per 0.1 m^2 sample).

The density of fauna at Nimrod appeared lower than within Loligo, Endeavour and Scotia prospects with a mean abundance of 30.5 individuals per sample. The number of taxa recorded and univariate parameters were all closely comparable to those of the other survey areas.

Crude abundance / dominance and univariate analyses of the macrofaunal data suggested that a single community occurred throughout the survey area. These findings were corroborated by the multivariate CLUSTER and SIMPROF analyses, which showed that all sample data (and aggregated station data) could be grouped within a single statistically undifferentiated cluster. SIMPER analysis showed that the greatest degree of similarity within this cluster was contributed by the numerically dominant *Kinbergonuphis oligobranchiata* and Ampeliscidae, which cumulatively contributed approximately 40% of the inter-sample Bray-Curtis similarity.

A meta-analysis of sample data across all of the sites surveyed showed that the assemblage identified at Nimrod could not be statistically differentiated from those of the other comparably deep sites at Loligo and Endeavour prospects. This community was shown by SIMPER analysis to be dominated by *Kinbergonuphis oligobranchiata*. Although the overarching SIMPER analysis suggested a very high degree of dominance by *K. oligobranchiata*, the analyses conducted for the individual sites showed that the polychaete *Melinna* sp. 1 was sufficiently abundant to be considered co-dominant at Loligo and Endeavour and ampeliscids could be considered co-dominant at Nimrod.

3.5.4 Scotia East Site Survey Results

Epifauna

Seabed imagery revealed the presence of numerous cobbles and boulders. The site was dominated by a rocky substrate interspersed with gravel and small sandy patches overlying coarser black sand. Epifauna were observed at all stations, with observed fauna including cnidarians, crustaceans, echinoderms, molluscs, tunicates, poriferans, bryozoans and polychaetes worms (Figure 3.17).

Acoustic data indicated a distinct feature of interest, namely steep slopes and rocky flanks at the edge of a plateau in the west of the survey area. Further investigation with the digital camera system and sampling equipment revealed hard and soft coral colonies attached to hard substrates, but they were not in sufficient densities to be considered to form a biogenic reef (classified as Annex 1 habitats under the EC Habitats Directive 92/43/EEC) and there was no evidence of submarine structures made by leaking gas. There were no confirmed sightings of threatened species observed within the surveyed area. Hard corals such as *L. pertusa* are unlikely to be present in Falklands waters (see section 5.5.1) therefore coral species identified within the Scotia East area may instead be a superficially similar species, capable of withstanding colder waters.

It should be noted that identified reef habitats, if found within a wider area, may be considered to be of conservation significance. It is suggested therefore that this possible feature of environmental interest should be investigated more widely in the event that a development plan be considered. This concern is supported by the findings of the survey carried out at the Hero prospect, 20 kilometres southwards from Scotia East. The steep ridge in the southern corner of the Hero survey area showed resemblance to a stony or bedrock reef with boulders on top of bedrock and occasional complex rocky structures seen on video footage (GEL, 2011c). However, there was no indication of any biogenic reef development at the Hero site.

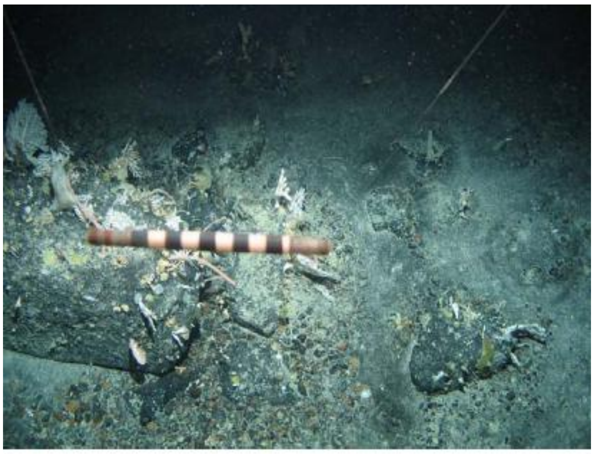
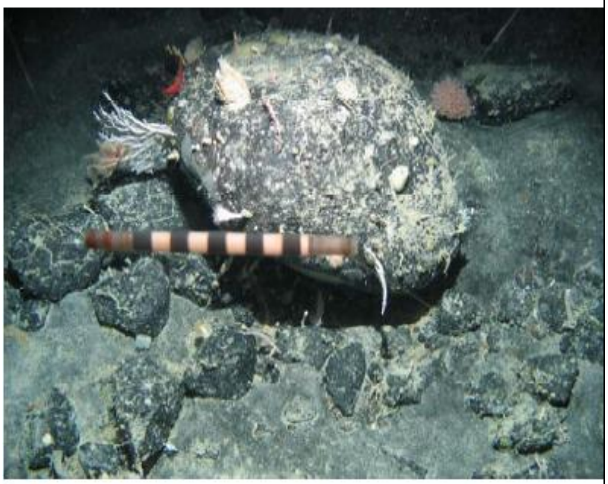
Infauna

Three 0.1 m^2 faunal samples were collected from Station ENV5, two of which were processed for macro-invertebrate content with the third retained as a spare and appropriately stored. Two samples were collected from Station ENV4 and a single sample was collected from Station ENV3, all of which were worked up. Figure 3.5 shows sampling locations.

A total of 189 individuals representing 90 taxa were recorded from within the retained samples. A total of two juvenile individuals were recorded, both from the Onuphidae family. The proportional contributions of the major taxonomic groups to the abundance of individuals and taxa are presented in Figure 3.18 with polychaetes being the most dominant group.

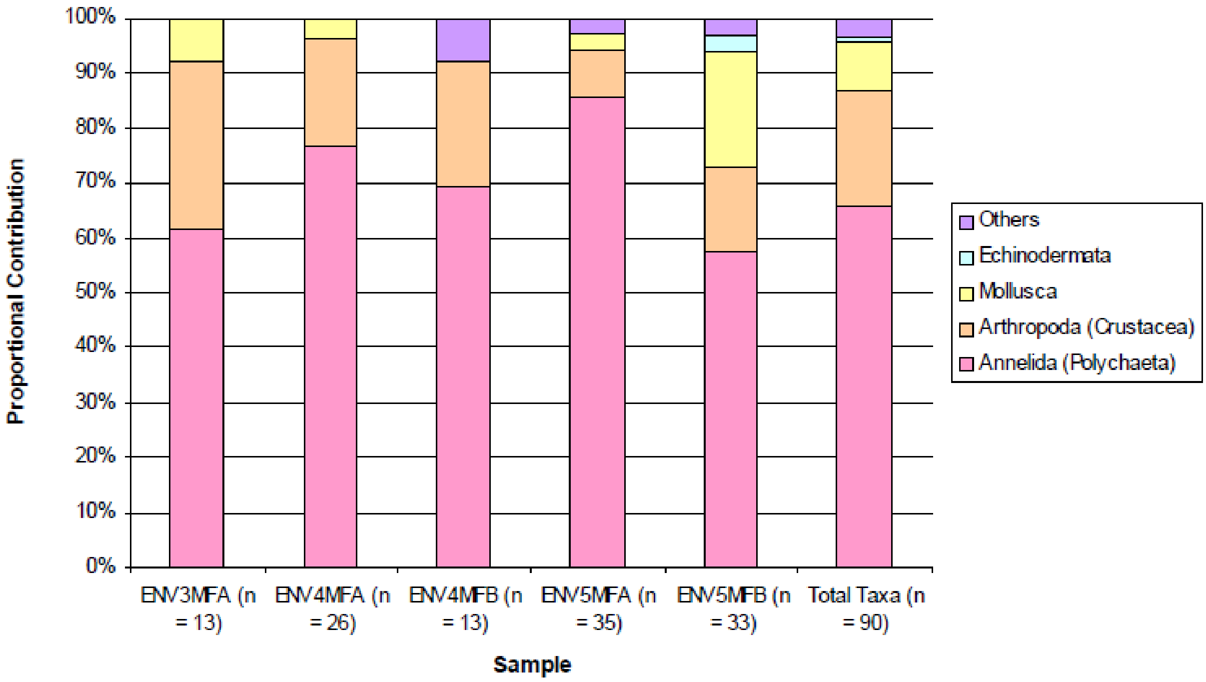
The highest macrofaunal density was recorded at ENV5 (66 individuals per 0.1 square metre), while the remaining four samples showed a macrofaunal density of between 15 and 49 individuals per 0.1 square metre. Of the 90 taxa found within the current survey, a total of 68 were found in a single sample, 54 of which (60% of total taxa) were represented by a single individual. These unique records were not limited to any particular sample, with all samples having at least four exclusive faunal representatives. This is generally indicative of an absence of any notable contamination or disturbance, as under such scenarios it is expected that these taxa would be replaced by high abundances of a limited suite of tolerant taxa (Clarke and Warwick, 2006). In contrast to the high proportion of unique records, only one species, the polychaete *Anchinothria pycnobranchiata*, was found in every sample.

Figure 3.17. Seabed Photographs at Scotia East prospect (GEL, 2011b)

 **Fix:** 22 **Depth:** 1789m **Location:** 954092 E 4396326 N	 **Fix:** 29 **Depth:** 1786m **Location:** 954025 E 4396304 N
Fix 22: *Cnidarians (indet. Anemone, soft corals, sea pens and sea fans), bryozoans, tunicates, crustacean (probable Euphausiidae sp), echinoderm (brittlestar) and polychaete worm tubes.*	***Fix 29:*** *Cnidarians (anemones, soft coral, sea fans and sea pens), echinoderm (indet. urchin sp), bryozoans, tunicates, poriferan and polychaete worms.*
 **Fix:** 46 **Depth:** 1786m **Location:** 954588 E 4397191	 **Fix:** 73 **Depth:** 1761m **Location:** 953246 E 4397560 N
Fix 46: *Cnidarians (indet. Anemone, soft coral, sea fan, sea pens), crustacean (Euphausiidae sp and probable isopod -Serolid sp?), polychaete worms, bryozoans*	***Fix 73:*** *Cnidarians (anemones, soft coral and sea pen), molluscs (indet. conical shell sp and bivalve sp) bryozoans, tunicates, poriferan and polychaete worms.*

Of the ten most dominant fauna, there were seven taxa of Polychaeta and three Crustacea taxa, with *A. pycnobranchiata* being the highest ranked taxon. There was considerable re-ordering of the species when ranked by abundance, with only *A. pycnobranchiata* unaffected, suggesting a generally uneven distribution of these taxa. Fidelity scores for the dominant fauna were relatively variable with only two taxa, *A. pycnobranchiata* and *Spionidae* sp. 1, having a value between >0.8 and <1.2, indicative of a generally even distribution of individuals across the five samples. However, following examination of the raw data, these two taxa still displayed evidence of patchiness across the samples. This uneven distribution of taxa across the surveyed area is not unexpected considering the number of low abundance and unique records of taxa found within the macrofaunal community. Two taxa, *A. pycnobranchiata*, and *Jasmineira* sp. 4 (inc. Fabriciinae sp. 2) described as *Jasmineira* sp., were found within the ten most dominant taxa from the previous comparison surveys (Loligo A, Loligo NW, Endeavour and Nimrod), with *A. pycnobranchiata*, also being the most dominant taxa within the comparison survey of Loligo NW. This lack of mutual dominant taxa is unsurprising due to the differences in spatial distance, water depth and sediment type, in conjunction with the low abundance and unique taxa across the wider Falkland area.

Figure 3.18. Abundance of taxonomic groups (GEL, 2011b)



The number of taxa per 0.1 m^2 ranged from 13 (ENV3) to 35 (ENV5), with an average of 24 (± 11 SD). The univariate statistics indicate that the faunal communities sampled were relatively diverse (H' > 3.46) and even (J > 0.91) with little species dominance (λ < 0.11). These results are generally consistent with those observed within the comparison surveys (Table 3.1).

Multivariate analyses classed all samples as statistically indistinguishable from one another, despite Station ENV5 containing a finer sediment. In summary, the multivariate analysis supports the findings of the fauna analyses suggesting a relatively sparse, yet diverse heterogeneous faunal community across the survey area. Only two taxa were found within both the current survey and at least one of the comparison surveys (Loligo NW, Nimrod, Endeavour), although this was not unexpected considering the low species abundances observed across all of these.

Overall, the macrofaunal analyses suggest a relatively even spread of individuals across the area surveyed, albeit at low abundances with evidence of limited species fidelity. The community sampled were found to be relatively diverse, with low species dominance. The number of very low abundance and unique records of taxa within the stations suggested a stable homogeneous community. This corroborated the chemistry data in suggesting that no anthropogenic contamination event has occurred at or around the Scotia East survey area.

Table 3.1. Faunal Univariate Statistics (GEL, 2011b)

Sample	Station Designation	n Taxa	n Individuals	Simpson's Dominance (λ)	Pielou's Evenness (J)	Shannon Wiener Diversity (H)
ENV3 MFA	Scotia East C	13	22	0.11	0.93	3.46
ENV4 MFA	Scotia East D	26	37	0.05	0.96	4.52
ENV4 MFB		13	15	0.08	0.98	3.64
ENV5 MFA	1364 NW[1]	35	66	0.05	0.92	4.71
ENV5 MFB		33	49	0.07	0.91	4.59
Scotia East	Minimum	13	15	0.05	0.91	3.46
	Maximum	35	66	0.11	0.98	4.71
	Mean	24	38	0.07	0.94	4.18
	±SD	11	21	0.02	0.03	0.59
Loligo NW (GEL, 2011a)	Minimum	47	91	0.03	0.84	4.94
	Maximum	75	237	0.06	0.95	5.56
	Mean	57	126	0.04	0.91	5.29
	±SD	9	45	0.01	0.03	0.2
Loligo A (FSL, 2009a)	Minimum	10	13	0.04	0.80	2.61
	Maximum	28	71	0.2	0.96	3.88
	Mean	17.6	39.0	0.11	0.86	3.44
	±SD	6.8	22.2	0.05	0.08	0.48
Endeavour (FSL, 2009c)	Minimum	15	23	0.03	0.72	3.16
	Maximum	27	57	0.22	0.96	4.51
	Mean	21	40	0.07	0.90	3.95
	±SD	4	11	0.05	0.07	0.35
Nimrod-1 (FSL, 2009b)	Minimum	12	19	0.03	0.84	3.04
	Maximum	26	51	0.18	0.98	4.49
	Mean	20	30	0.08	0.94	3.95
	±SD	5	8	0.04	0.04	0.46

4 Impact Assessment

The potential environmental impacts from the proposed drilling programme have been reviewed in light of additional operational details and benthic survey results. It has been concluded that the significance of project impacts would remain at the levels of the initial evaluation presented in the EIS. A number of minor variables not covered in the EIS are discussed below in the context of seabed discharges and oil spill events.

An updated environmental management plan mitigation register is included in Appendix G.

4.1 Seabed Discharges

The proposed well designs have been refined to indicate that smaller amount of drill cuttings will be discharged (Table 4.1) compared to the volumes provided in the EIS. Although a larger volume of drill cuttings can be generated from the Scotia East D well, greater water depths would enhance their dispersion through the water column, and cuttings footprint is not expected to be larger than that predicated for Loligo A using PROTEUS model (refer to Section 6.5 of the EIS).

Table 4.1. Drill Cuttings Discharge for the Proposed Wells

Well	Total Cuttings Discharge (tonnes)
Loligo A	1091
Loligo NW	843
Nimrod-1	985
Scotia East D	1664

The nature of impacts from drill cuttings on the marine environment including alteration of physico-chemical characteristic of sediments and smothering of benthic flora and fauna are discussed in the EIS. The net impact is expected to be a short-term change in the composition of the benthic community over a wider area and possibly a longer-term change within an area centred around the wellheads.

Site specific benthic surveys for all four well locations confirmed the absence of biogenic reefs classified as protected Annex 1 habitats under the EC Habitats Directive 92/43/EEC, however soft and hard corals were observed in low densities at all well locations, including a distinct feature of interest, namely steep slopes and rocky flanks at the Scotia East site. The latter should be investigated in the event that development of this site is considered.

No significant effects on the benthic community are expected outside the area affected by materials discharged at the wellheads.

4.2 Potential Oil Spills

The proposed wells will target oil reservoirs, and therefore the main spill risks associated with drilling operations are accidental loss of hydrocarbons from the reservoir or an accidental loss from the drilling rig fuel oil inventory, the worst case being a total loss of well control (i.e. blow-out), or a total loss of the fuel inventory from the rig. Spilled oil can have a number of environmental and economic impacts, the most conspicuous of which are on seabirds, marine mammals, fisheries and coastal habitats (refer to Section 6.10 of the EIS).

In the rare event of a loss of well control from an exploration well, the amount lost per unit time would depend on the unrestricted open hole flow rate. Oil spill modelling data presented in the EIS was based on the maximum open flow rate of 47,000 barrels per day for all modelled wells. The initial estimates were made whilst reservoir engineering studies were underway. However, as FOGL revised reservoir parameter input into its resources estimates during mid 2011, it was felt that the most likely net:gross ratio should be used, rather than a P5 (Probability 5%) case. It was concluded that a figure of 47,000 barrels per day covered the majority of likely 'worst case' flow rates, and exceeded a number of modelled cases. It also covered reduced seabed flow rates, with the assumption that all oil effectively reached the surface at this rate. However, it was recognised that the reservoir target in the Loligo A prospect could potentially flow at higher rates of up to 70,000 barrels per day. As a result, additional oil spill modelling was carried out to reflect the higher release rate for Loligo A and also to include the Nimrod-1 scenario which was not covered in the EIS. The Loligo NW well was not modelled given its proximity to the Loligo A well (20 kilometres north) and lower expected blow out rates. The summary of the modeling results are presented below.

4.2.1 Trajectory Oil Spill Modelling Results

Trajectory modelling is undertaken to establish minimum oil spill response times. An arbitrary worst case wind is modelled, driving an oil spill to shore. In the UK, and so here too, this is taken as a 30 knot wind (15.6metres per second). Using the worst case wind speed, trajectory runs were performed towards both the Falkland Islands and the median line with Argentina. A summary of results is provided in Table 4.2 and Figures 4.1 to 4.3, 4.7. The time taken for oil to reach the Median line from each well location is noted in Table 4.3.

The worst case, 18° API, oil is a heavy oil expected from Loligo A, Loligo NW and Nimrod-1 wells. This oil is persistent and will tend to form a stable, water in oil emulsion, following spillage into the sea. The cold temperatures of the South Atlantic will increase the time taken for it to weather. Conversely the high winds and high ‘energy’ at the sea surface will tend to assist the natural weathering process. Under these conditions the heavy oil 10-days release from the Loligo A location beached in 152 hours and from the Nimrod-1 location in 121 hours (Table 4.2; Figures 4.1-4.2). The heavy nature of the crude means that at best, it will only be amenable to chemical dispersion very shortly after it has been spilt.

30°API oil, a light crude, is expected from the Scotia East D well. It is relatively volatile, and will tend to form a water in oil emulsion, but this degrades relatively quickly. The 10-days release from the Scotia East D location completely weathered before reaching the shore (Figure 4.3). Blow-outs lasting for longer than the modelled period may result in beaching.

4.2.2 Stochastic Oil Spill Modelling Results

Stochastic modelling is used to apply the range of typical wind and current conditions recorded at a location to oil spill scenarios. With the prevailing easterly winds and north-easterly currents, all proposed wells are upwind and up current from the coast.

Scotia East D well, is located furthest to the north-east and is the most distant from the Falkland Islands, of the other three well locations. It also has the lightest expected oil. The modelling illustrates that from this well location the 10-day oil spill would not be expected to beach and would weather completely at sea (Figure 4.6).

The oil from the **Loligo A** well is a persistent oil and would be expected to endure for longer at sea, giving it a greater opportunity to reach land. The modelling shows that there is a very low probability that it could beach on the Argentine coast (0.3% probability after more than 339 to 569 hours at sea) or on South Georgia (5.5% probability after more than 555 hours at sea). The combined probability of oil beaching anywhere is 5.8 percent (Figure 4.4). Modelling of **Loligo A** also covers a potential spill from **Loligo NW** at lower rates.

The oil from the **Nimrod-1** well is a persistent oil and would be expected to endure at sea, giving it a greater opportunity to reach land. The modelling shows that there is a very low probability that it could beach on the Argentine coast (0.2% probability after more than 376 hours at sea) or on South Georgia (5.5% probability after more than 580 hours at sea). The combined probability of oil beaching anywhere is 5.7 percent (Figure 4.5).

Any worst case releases for longer than 10 days will result in higher volumes of oil beaching.

Table 4.2. Oil Spill Modelling Results for the proposed Wells

From Location	Oil Type	Release Rate, m3/hour	Scenario	Wind Conditions	Fate of Spill	Figure
Worst Case Scenario						
Loligo A	Crude 18° API	470	Uncontrolled flow release over 240 hours	Trajectory: 30 knot onshore wind towards FI	The oil quickly forms a water in oil emulsion which then weathers very slowly. Oil beaches in 152 hours. 112,800 m^3 spilt, 103,000m^3 reach the shore.	4.1
Nimrod-1	Crude 18° API	311	Uncontrolled flow release over 240 hours	Trajectory: 30 knot onshore wind towards FI	The oil quickly forms a water in oil emulsion which then weathers very slowly. Oil beaches in 121 hours. 74,640 m^3 spilt, 34,680 m^3 reach the shore.	4.2
Scotia East D	Crude 30° API	311	Uncontrolled flow release over 240 hours	Trajectory: 30 knot onshore wind towards FI	Oil disperses offshore within 157 hours. During this time the slick is driven some 180 km to the SW. However it is completely dispersed 150km offshore. 74,640 m^3 spilt, 0 m^3 reach the shore.	4.3
Typical wind conditions blow-out scenarios						
Loligo A	Crude 18° API	470	Uncontrolled flow release over 240 hours	Typical wind conditions (stochastic)	Oil driven by prevailing winds and currents to the NE. There is a low probability of the oil beaching in central Argentina and on South Georgia. The total probability of oil beaching is 5.8 percent. Total probability of beaching on South Georgia is 5.5% with a 3.5% probability of up to 4,100 cubic metres coming ashore. Beaching time 555 to 573 hours from the start of the incident. Total probability of beaching on Argentina is 0.3% with a 0.1% probability of up to 17,800 cubic metres coming ashore. Beaching time 339 to 569 hours from the start of the incident.	4.4
Nimrod-1	Crude 18° API	311	Uncontrolled flow release over 240 hours	Typical wind conditions (stochastic)	Oil driven by prevailing winds and currents to the NE. There is a low probability of the oil beaching in central Argentina and on South Georgia. The total probability of oil beaching is 5.7 percent. Total probability of beaching on South Georgia is 5.5% with a 3.3% probability of 34 cubic metres coming ashore. Beaching time more than 580 hours from the start of the incident. Total probability of beaching on Argentina is 0.2% with a 0.2% probability of up to 13,000 cubic metres coming ashore. Beaching time 378 hours from the start of the incident.	4.5
Scotia East D	Crude 30° API	311	Uncontrolled flow release over 240 hours	Typical wind conditions (stochastic)	Oil driven by prevailing winds and currents to the NE. The position of the well and the light oil would result in it all dispersing offshore. There is a zero probability of oil beaching.	4.6

Table 4.3. Time (hours) taken for oil to reach the Falkland Islands/Argentina Median Line with worst case 30 knots wind blowing towards Argentina.

From Location	Oil Type	Wind Conditions	Time to median line (hrs)
Loligo A	18°API	30 knots. 15.6 m/s at 90°	260
Loligo NW	18°API	30 knots. 15.6 m/s at 90°	265
Nimrod-1	18°API	30 knots. 15.6 m/s at 90°	285
Scotia East D	30°API	30 knots. 15.6 m/s at 90°	Does not reach median line

Figure 4.1. Loligo A: Trajectory model run of the largest possible rate of spillage from a blow-out (470m^3 per hour, for 240 hours); 18°API crude oil with 30 knot onshore wind towards the Falkland Islands (black and red lines/points indicate oil movement offshore and beaching onshore).

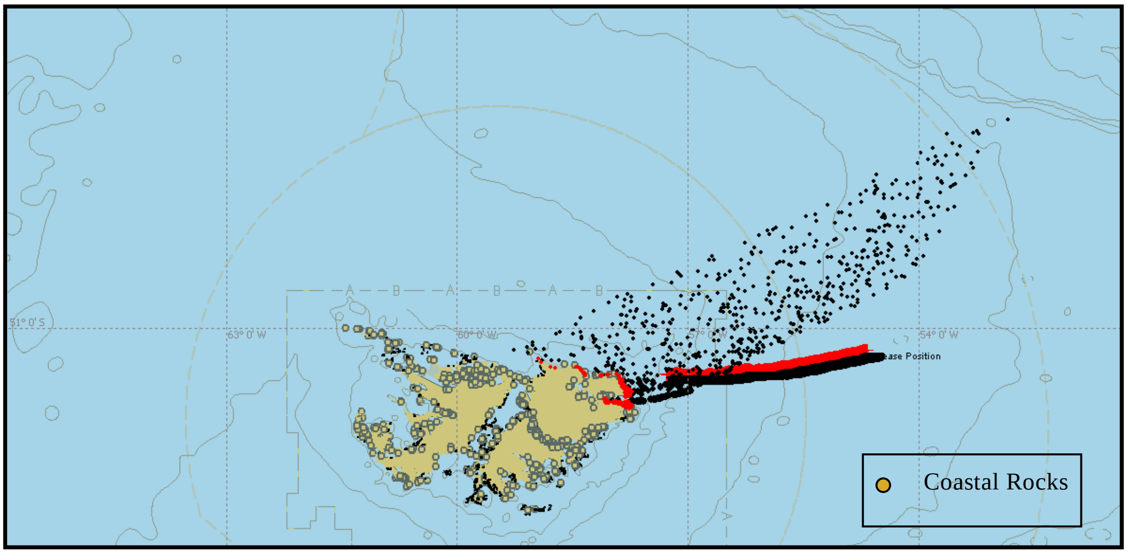


Figure 4.2. Nimrod-1: Trajectory model run of the largest possible rate of spillage from a blow-out (311m^3 per hour, for 240 hours); 18 °API crude oil with a 30 knot onshore wind towards the Falkland Islands (black and red lines/points indicate oil movement offshore and beaching onshore).

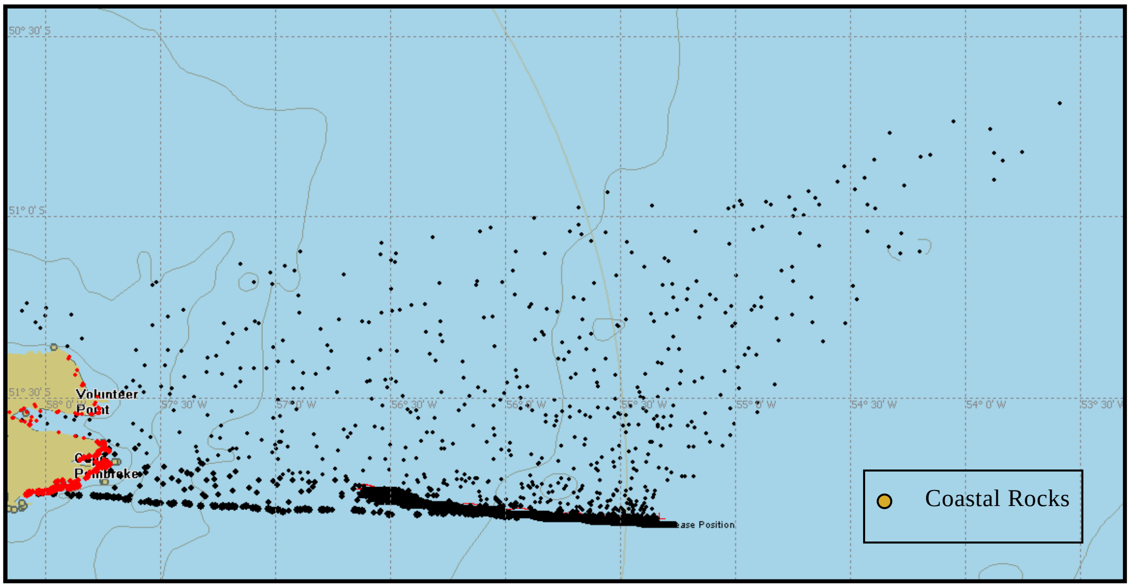


Figure 4.3. Scotia East D: Trajectory model run of the largest possible rate of spillage from a blow-out (311m^3 per hour, for 240 hours) ; 30^{o}API crude oil with a 30 knot onshore wind towards the Falkland Islands (black and red lines/points indicate oil movement offshore).

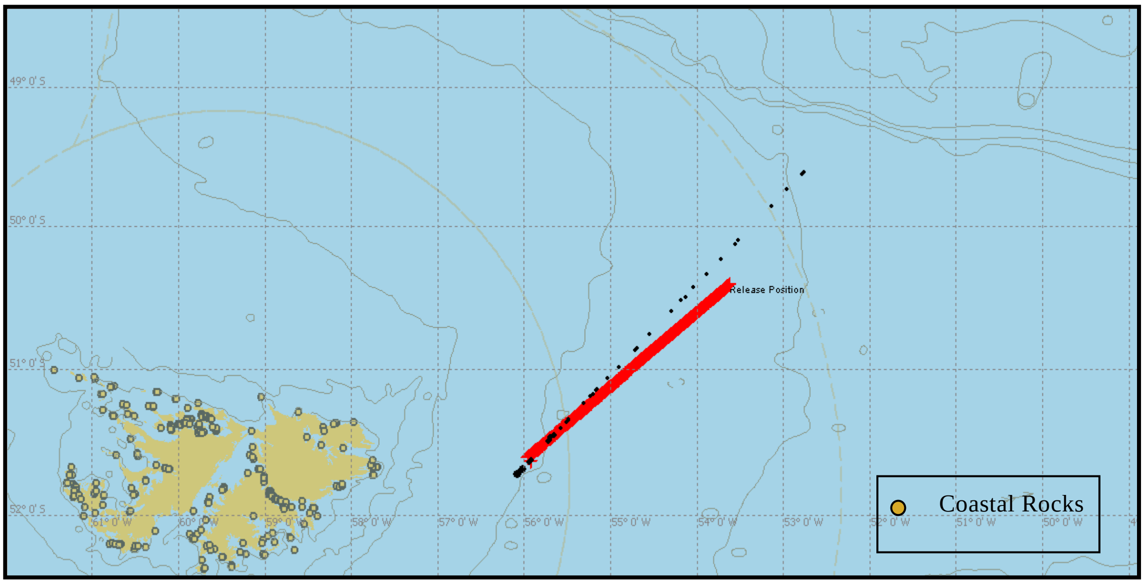


Figure 4.4. Loligo A: Stochastic model run of uncontrolled flow (blowout: 470m^3 per hour for 240 hours) of 18 °API crude oil under typical wind conditions; Expressed as percentage probability of oiling (blue points indicate oil beaching locations)

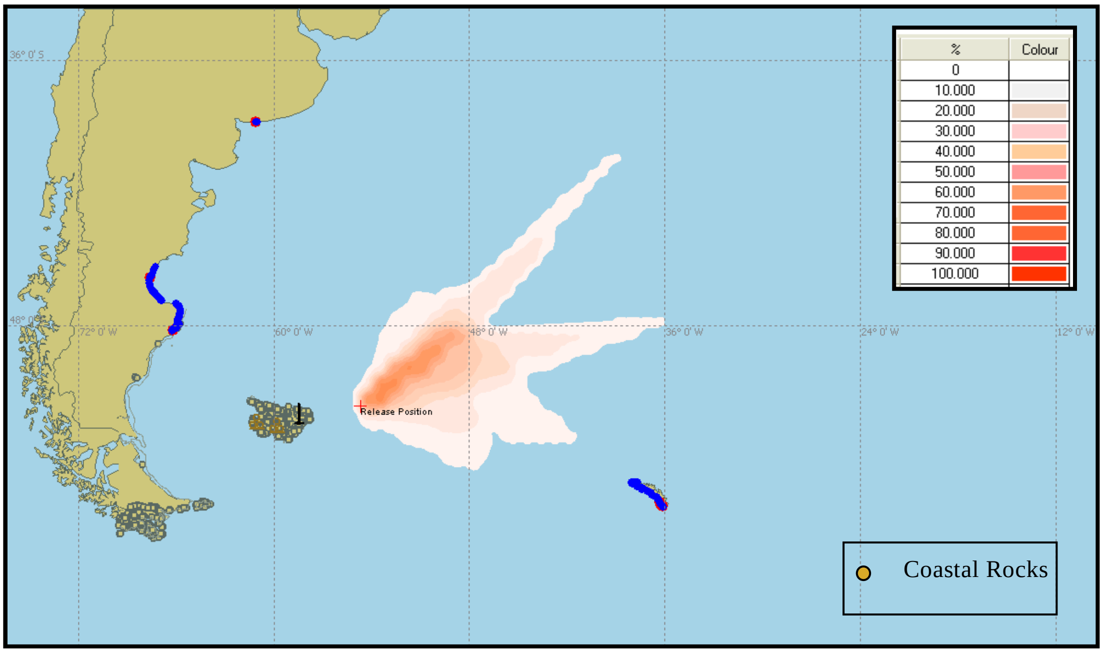


Figure 4.5. Nimrod-1: Stochastic model run of uncontrolled flow (blowout: 311m³ per hour for 240 hours) of 18 °API crude oil under typical wind conditions; Expressed as percentage probability of oiling (blue points indicate oil beaching locations)

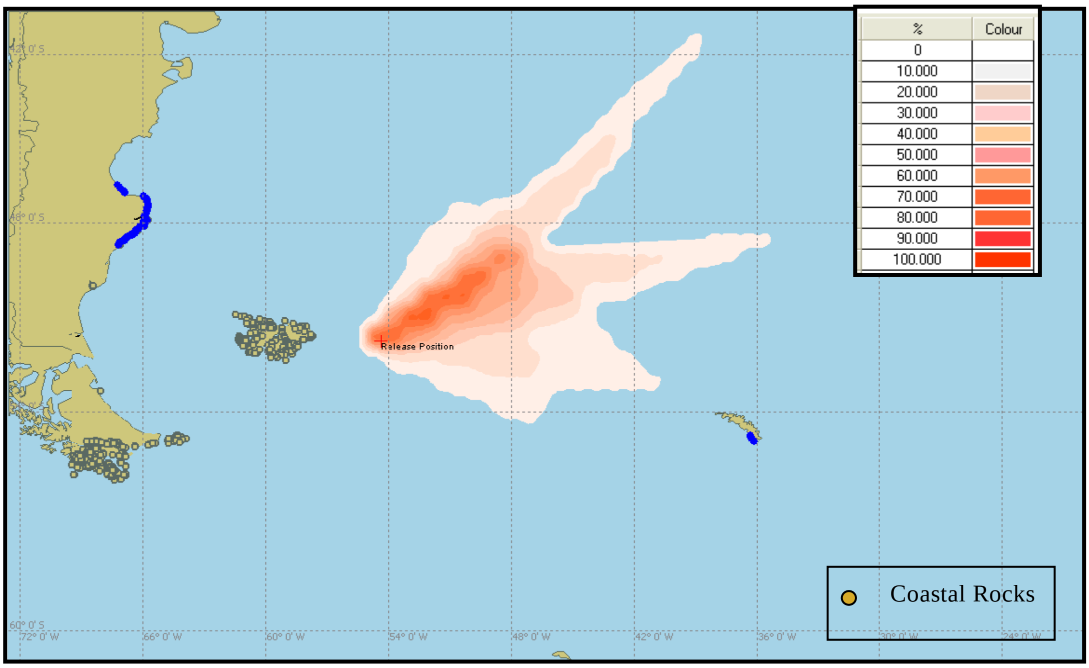


Figure 4.6. Scotia East D: Stochastic model run of uncontrolled flow (blowout: 311m³ per hour for 240 hours) of 30 °API crude oil under typical wind conditions; Expressed as percentage probability of oiling.

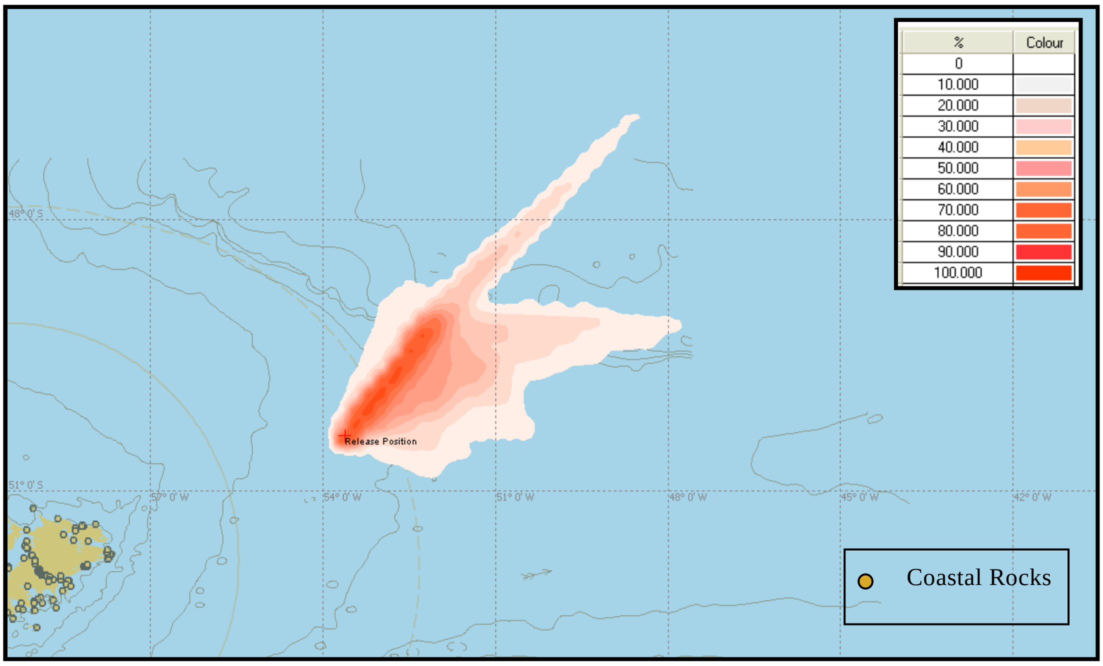
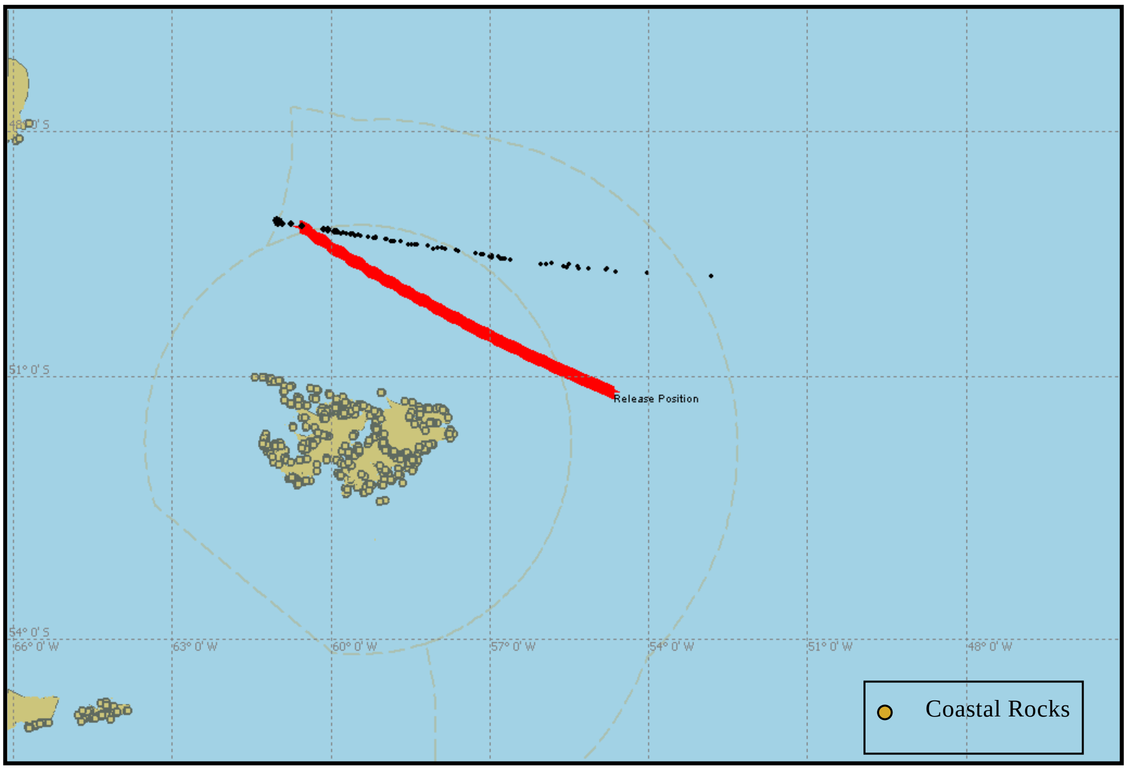


Figure 4.7. Trajectory model run of a blow-out at the Loligo A well site (470 m^3 per hour, for 240 hours); 18 °API crude oil with a 30 knot wind blowing towards the median line with Argentina (black and red lines/points indicate oil movement offshore).



5 Conclusions

In light of the supplementary information presented in this Addendum, it has been concluded that the significance of project impacts would remain at the levels of the initial evaluation presented in the EIS.

Given FOGL's current operational commitments and proposed mitigation measures (refer to Sections 6 and 7 of the EIS), it is considered that the routine drilling activities can be undertaken without significant impacts to the Falkland Islands' environment. However, in the event of a potential blowout under worst case scenario conditions (i.e. loss of control of the well due to failure of numerous redundant safety systems e.g. blow-out preventer and long term release of liquid hydrocarbons), the impact is likely to be of major significance. In this case, an effective response strategy can reduce potentially severe consequences. The Oil Spill Contingency Plan developed by FOGL is aimed to address this issue.

Additional oil spill modelling reinforced the fact that any oil spill is a highly undesirable event in the logistically challenging and sensitive environment of the Falkland Islands. Prevention of such events through best industry health and safety practices should be of high priority in protecting vulnerable local and regional ecosystems.

Transboundary impacts from the proposed project have a low probability of occurring. The probability of beaching on the Argentinean coast is estimated at maximum 0.3% and on the South Georgia coast at 5.5%, without taking into consideration any response mitigation measures being implemented during the modelled 10 day blow out release. The significance of transboundary impacts is considered minor, provided oil spill mitigation measures are successfully implemented within a few days following uncontrolled release.