Noble Energy Falklands Limited

Environmental Impact Statement (EIS) for Exploration Drilling Offshore the Falkland Islands

APPENDICES

Date: *09th January 2015*

Revision: *07*

Noble Energy Falklands Limited

Environmental Impact Statement (EIS) for Exploration Drilling Offshore the Falkland Islands

APPENDICES

DATE	VERSION	DESCRIPTION	PREPARED	CHECKED	APPROVED
09.05.14	Rev 01	Draft for Client review	SJS	AGP	AGP
20.06.14	Rev 02	Final draft for client review	SJS	AGP	AGP
14.07.14	Rev 03	Final for review	SJS	AGP	AGP
21.07.14	Rev 04	For Issue	SJS	AGP	AGP
	Rev 05	For Client Review	SJS	AGP	AGP
30.09.14	Rev 06	For Issue	SJS	AGP	AGP
09.01.15	Rev 07	For Issue	SJS/SM/AGP	AGP	KS
File Reference: P:\RPS (RBA) USA\EHE9033 - RPS Noble Exploration ESHIA\03_Deliverables\01_ESHIA					

NOBLE ENERGY DOCUMENT CONTROL

DATE	VERSION	DOCUMENT OWNER	DOCUMENT APPROVER
09.05.14	Rev 01	EHSR Coordinator – International Frontier Ventures	EHSR Manager – International Frontier Ventures
20.06.14	Rev 02	EHSR Coordinator – International Frontier Ventures	EHSR Manager – International Frontier Ventures
14.07.14	Rev 03	EHSR Coordinator – International Frontier Ventures	EHSR Manager – International Frontier Ventures
21.07.14	Rev 04	EHSR Coordinator – International Frontier Ventures	EHSR Coordinator – International Frontier Ventures
	Rev 05	EHSR Coordinator – International Frontier Ventures	EHSR Coordinator – International Frontier Ventures
30.09.14	Rev 06	EHSR Coordinator – International Frontier Ventures	EHSR Coordinator – International Frontier Ventures
09.01.15	Rev 07	EHSR Coordinator – International Frontier Ventures	EHSR Coordinator – International Frontier Ventures
Document Number: 050-14-EHSR-ESH-PA-T4			

Prepared by: Steve Saunders

RPS Energy
HSE and Risk Management
1st Floor
14 Cornhill
London
EC3V 3ND

Tel +44 (0)207 280 3200
Fax +44 (0)207 283 9248
Email saunderss@rpsgroup.com

Table of Contents

Appendix A: Action Register

As part of the Environmental Impact Statement (EIS), the potential aspects for each key project activity have been considered and potential impacts on environmental sensitivities have been identified. These impacts have been risk assessed to determine their significance following the methodology outlined in Section 5 of the EIS. Appropriate mitigation measures have been put in place to lower the risk as far as possible.

KEY

Event Type: **P** = Planned, **U** = Unplanned
1-6 = Category of Consequence (refer to Table 5.3 - Definition of Consequence Categories in Section 5.6.2 of the EIS)
A-E = Likelihood (Frequency) of Occurrence (refer to Table 5.4 - Likelihood Categories in Section 5.6.3 of the EIS)

Negative LOW	**Negative MEDIUM**	**Negative HIGH**	**No Interaction**	**Positive**

This page is intentionally blank

1.0 Physical Presence

Reference	Event Type	Aspect	Description of Potential Impact	Mitigation Measures
1.1	P	Removal of small area of seabed for well construction.	The impacts include the permanent removal of a small area of seabed, sediment and any macrofauna associated with that sediment. There is also the potential for disturbance of sensitive species that may be present.	As this impact is an inevitable consequence of well construction, there are no mitigation measures that can be used to reduce the potential impact. However, the measures described below in item 3.1 in relation to pre-drilling, during drilling and post-drilling environmental surveys will allow close monitoring of the impacts in situ. During pre-drilling monitoring of the wellhead location the presence of habitats of conservation importance will be established. Should any important habitats be observed prior to commencement of drilling, the wellhead will be re-located in order to avoid these habitats.
1.2	P	Physical presence of the drilling rig and OSVs.	Potential for navigation hazard and interference with shipping activities. Potential emergency situation due to collision.	Industry Best Practices A 500 metre radial safety zone will be implemented around the drilling unit whilst on location which will be applicable to all third-party vessels, to reduce the potential for a collision with the drilling unit. The 500 metre safety zone will be patrolled and enforced by a Safety Standby Vessel (SSV), which will be in attendance in the vicinity of the drilling unit at all times.. Up to 3 OSVs will be used throughout the drilling programme. At all times, the role of SSV will be undertaken by one of these OSVs to patrol the safety zone and warn of the presence of the drilling unit and vessel safety zone. All OSVs will be equipped with modern radar and radio equipment. A set of procedures will be established so that vessel masters, who need to deviate from their planned route based on their current sea passage trajectory, will be asked by the SSV via VHF radio to confirm that they intend to follow the requirements of the drilling rig Automatic Identification System (AIS) warnings. The SSV will maintain close contact with the third-party vessel until they have changed their course away from entering the safety zone. Due regard will also be given by the officers on watch on board the OSVs to fellow sea users at all times, in line with the International Regulations for Preventing Collisions at Sea (COLREGs). Any fishing vessel encountered by the OSVs in transit to/from the drilling unit shall be given a wide berth in full cooperation with any flags, symbols or

Risk to Receptors (before mitigation)

Reference	Physical: Marine Water Quality	Physical: Air Quality	Physical: Soils / Sediments	Biological: Terrestrial Communities	Biological: Benthic Communities	Biological: Plankton	Biological: Fish/ Shellfish	Biological: Offshore Seabirds	Biological: Coastal Seabirds	Biological: Marine Mammals	Biological: Protected/ Sensitive Areas	Human: Shipping	Human: Fishing	Human: Oil and Gas Activity	Human: Pipelines/Cables	Human: Archaeology	Human: Tourism/Leisure	Human: Land Use	Human: Coastal Populations	Human: Infrastructure	Human: Housing
1.1			1 E		1 E																
1.2												4 C	4 C						1 C		

Risk to Receptors (after mitigation)

Reference	Physical: Marine Water Quality	Physical: Air Quality	Physical: Soils / Sediments	Biological: Terrestrial Communities	Biological: Benthic Communities	Biological: Plankton	Biological: Fish/ Shellfish	Biological: Offshore Seabirds	Biological: Coastal Seabirds	Biological: Marine Mammals	Biological: Protected/ Sensitive Areas	Human: Shipping	Human: Fishing	Human: Oil and Gas activity	Human: Pipeline/ Cables	Human: Archaeology	Human: Tourism/Leisure	Human: Land Use	Human: Coastal population	Human: Infrastructure	Human: Housing
1.1			1 E		1 E																
1.2												3 A	3 A						1 C		

Reference	Event Type	Aspect	Description of Potential Impact	Risk to Receptors (before mitigation)																					Mitigation Measures	Risk to Receptors (after mitigation)																				
				Physical			Biological								Human											Physical			Biological								Human									
				Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas Activity	Pipelines/Cables	Archaeology	Tourism/Leisure	Land Use	Coastal Populations	Infrastructure	Housing		Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas activity	Pipeline/ Cables	Archaeology	Tourism/Leisure	Land Use	Coastal populations	Infrastructure	Housing
																									other instructions that the fishing vessel may be displaying or may issue via VHF. The emergency response plans and procedures of the drilling unit and OSVs will be verified by Noble for adequacy to respond to a potential collision threat. This shall include the threat of collision from icebergs. The Falkland Islands Fishing Companies Association (FIFCA), Consolidated Fisheries Limited (CFL) and Falkland Islands Government (FIG) will be notified, in writing, a minimum of 30 calendar days before the start of drilling activities, so that fishing vessels can plot the drilling location on marine charts, avoid the safety zone and plan their sea passage to/from any favoured fishing grounds accordingly; A message will be attached to the drilling unit's AIS to provide an identical set of information to the Daily Shipping Forecast described above. The drilling rig will be fitted with navigational lighting and a radar transponder to show its position to third-party vessels visually, and also through the use of radar equipment. Standard Marking Schedule provisions or International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) recommendations and guidelines will be adhered to during operations and transit to and from Stanley Harbour and the rig location by OSVs. Details of the as-built well locations will be provided to FIG and to hydrographic organisations to enable the location of the wells to be plotted onto navigational charts. Noble Project Specific Commitments Noble will liaise with the Fisheries Department and CFL with regard to the issue of navigation warnings advertising the presence of the drilling rig through the existing Fisheries Department Daily Shipping Forecast system. The information provided will include details on the current position of the drilling rig, presence of the OSVs, description of the 500 metre radial safety zone and the need for vessels to stay outside of this zone at all times. Any complaints associated with the temporary loss of access to the sea will be recorded and monitored, in accordance with the Noble Energy Community Feedback Mechanism.																					

Reference	Event Type	Aspect	Description of Potential Impact	Risk to Receptors (before mitigation)																					Mitigation Measures	Risk to Receptors (after mitigation)																				
				Physical			Biological								Human											Physical			Biological								Human									
				Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas Activity	Pipelines/Cables	Archaeology	Tourism/Leisure	Land Use	Coastal Populations	Infrastructure	Housing		Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas activity	Pipeline/ Cables	Archaeology	Tourism/Leisure	Land Use	Coastal populations	Infrastructure	Housing
1.3	P	Physical presence of the drilling rig and OSVs.	Potential for obstruction to fishing operations due to presence of the exclusion zone around the rig (loss of access to fishing ground). Potential economic costs to fisheries. Increased marine traffic to and from port facilities. Potential for congestion and interaction with coastal fishing activities.												3 C	3 C						1 C			Industry Best Practices Up to 3 OSVs will be used throughout the drilling programme. At all times, the role of SSV will be undertaken by one of these OSVs to patrol the safety zone and warn other users of the sea about the presence of the drilling unit and safety zone. All OSVs will be equipped with modern radar and radio equipment. A set of procedures will be established so that vessel masters, who need to deviate from their planned route based on their current sea passage trajectory, will be asked by the SSV via VHF radio to confirm that they intend to follow the requirements of the drilling rig AIS warnings. The SSV will maintain close contact with the third-party vessel until they have changed their course away from entering the safety zone. Noble will liaise with the Fisheries Department and CFL with regard to the issue of navigation warnings advertising the presence of the drilling rig through the existing Fisheries Department Daily Shipping Forecast system. The information provided will include details on the current position of the drilling rig, presence of the OSVs, description of the 500 metre radial safety zone and the need for vessels to stay outside of this zone at all times. A message will be attached to the drilling unit's AIS to provide an identical set of information to the Daily Shipping Forecast described above. The drilling rig will be fitted with navigational lighting and a radar transponder to show its position to third-party vessels visually, and also through the use of radar equipment. Details of the as built well locations will be provided to FIG and to hydrographic organisations to enable the location of the wells to be plotted onto navigational charts. Noble will comply with FIG regulatory requirements on the removal of the wellhead and near seabed casing to three metres below the seabed. . Noble Project Specific Commitments FIFCA, CFL and FIG will be notified, in writing, a minimum of 30 calendar days before the start of drilling activities, so that fishing vessels can plot the drilling location on marine charts, avoid the vessel exclusion zone and plan their sea												3 A	1 B						1 C		

Reference	Event Type	Aspect	Description of Potential Impact	Risk to Receptors (before mitigation)																					Mitigation Measures	Risk to Receptors (after mitigation)																				
				Physical			Biological								Human											Physical			Biological								Human									
				Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas Activity	Pipelines/Cables	Archaeology	Tourism/Leisure	Land Use	Coastal Populations	Infrastructure	Housing		Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas activity	Pipeline/ Cables	Archaeology	Tourism/Leisure	Land Use	Coastal populations	Infrastructure	Housing
																									passage to/from any favoured fishing grounds accordingly. Any complaints associated with the temporary loss of access to the sea will be recorded and monitored, in accordance with the Noble Energy Community Feedback Mechanism.																					
1.4	P	Physical presence of the drilling rig and OSVs.	Potential collision risk with marine mammals										2 C	2 C											<u>Noble Project Specific Commitments</u> Noble agrees to place a 10 kilometre avoidance area around both Beauchêne and Sea Lion Islands to avoid disturbance to sensitive species that may present within the vicinity of these islands. This will also reduce any potential collision risk (however small) with marine mammals within shallower areas. Whilst transiting near coastal areas (i.e. within the vicinity of the approaches to Port William, and whilst within Port William and Stanley Harbour), vessel speed should be reduced in order to minimise the chance of vessel strike with any species that may be present. All other applicable vessel speed limits shall also be observed when within the approaches to Port William and whilst within Port William and Stanley Harbour.										2 B	2 B										
1.5	P	Physical presence of the drilling rig.	Potential for impacts upon any wreck sites and associated archaeological remains in the immediate vicinity of the well locations.																3 C						<u>Industry Best Practices</u> Well locations will be chosen so that existing and reported wreck locations are avoided. Any subsequent changes to top-hole well locations will also actively avoid areas of existing wreck sites. Changes to the top-hole locations will be reported within subsequent addenda to this EIS (as required), and the impacts with respect to existing wrecks will be reassessed if necessary. <u>Noble Project Specific Commitments</u> No accurate positions of the shipwrecks within FISA12 are known. It is likely that the positions reported by Wrecksite.eu are inaccurate. The environmental survey of the FISA12 area put considerable effort into attempting to positively identify the un-charted wrecks during the survey; however, the wrecks were not identified. Noble will therefore avoid drilling within the immediate vicinity of the reported wreck locations by placing a 10 kilometre safety zone around the current reported Wrecksite.eu locations. The absence of wrecks in the vicinity of the well locations will also be confirmed through the pre-drilling site specific																3 A					

Reference	Event Type	Aspect	Description of Potential Impact	Mitigation Measures
				environmental seabed surveys with a remotely operated vehicle (ROV). Should the wreck sites be identified during the pre-drilling survey their location will be noted and reported to FIG and the well location relocated to avoid the wreck sites. A reporting protocol will be instigated for the accidental discovery of archaeological material during drilling activity and all appropriate notifications will be completed.
1.6	P	Workforce required by drilling operations on rig.	Potential for conflict between workers requiring temporary accommodation in Stanley and local residents.	<u>Noble Project Specific Commitments</u> Noble will use the locally available work force where possible. This will minimise the need for contractors to bring in workers from outside the Falkland Islands into Stanley. All Noble contractors, including the drilling contractor, will monitor individuals that are part of their work force and ensure they are made fully aware of the standards of behaviour expected, examples as to what constitutes a breach of their own Behavioural Code of Conduct, a description of the disciplinary and appeal processes and procedures to be followed for alleged misconduct. Contractors will ensure that these aspects are clearly outlined in the workers' contracts so that any termination of employment due to a breach is legally enforceable. In addition, the contractors and Noble will limit the amount of time offshore employees spend in Stanley during crew change periods. All complaints associated with the behaviour of workers will be recorded and monitored, in accordance with the Noble Energy Community Feedback Mechanism.

Risk to Receptors (before mitigation)

Reference	Physical: Marine Water Quality	Air Quality	Soils / Sediments	Biological: Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Human: Shipping	Fishing	Oil and Gas Activity	Pipelines/Cables	Archaeology	Tourism/Leisure	Land Use	Coastal Populations	Infrastructure	Housing
1.6																			2 C		2 C

Risk to Receptors (after mitigation)

Reference	Physical: Marine Water Quality	Air Quality	Soils / Sediments	Biological: Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Human: Shipping	Fishing	Oil and Gas activity	Pipeline/ Cables	Archaeology	Tourism/Leisure	Land Use	Coastal populations	Infrastructure	Housing
1.6																			2 B		2 B

Reference	Event Type	Aspect	Description of Potential Impact	Mitigation Measures
2.0 Atmospheric Emissions				
2.1	P	Power generation by rig, OSVs and helicopter(s).	Power generation for drilling operations by the drilling rig and fuel use by OSVs and helicopters, releasing combustion products to the atmosphere. These emissions have the potential to contribute to the pool of greenhouse gasses in the atmosphere (CH_4, CO_2), acid effects (SOx, NOx) and a short term localised impact on air quality.	<u>Industry Best Practices</u> Noble will undertake extensive pre-project planning in order to ensure that the project operations are conducted efficiently and to minimise the duration of project activities as far as possible. This will also assist in optimising the number of trips for OSVs and helicopters between the rig and onshore. Emissions generated from the proposed drilling programme will be controlled through the use of modern and well maintained power generation equipment. The equipment shall be well maintained in accordance with the written procedures based on manufacturer's guidelines, applicable industry code, or engineering standard to ensure efficient and reliable operation. <u>Noble Project Specific Commitments</u> Contracted vessels will be required to control fuel use, efficiently manage energy, and to plan voyages efficiently.
2.2	U	Fugitive emissions (e.g. volatile organic compounds - VOCs) associated with (for example), leaks, vents and fuel bunkering.	Emissions have the potential to contribute to global warming (CH_4, CO_2), acid effects (SOx, NOx) and a short term localised impact on air quality. If flammable gasses are involved, there will be a potential risk of fire and explosion.	<u>Industry Best Practices</u> To control fugitive emissions, operational and maintenance procedures will be implemented which include all environmentally critical valves, flanges, fittings and seals in use on the drilling rig to eliminate or reduce as far as possible their capacity for gas leaks and fugitive emissions. A gas/leak detection system and repair program will be in operation on the rig (requirement of rig Safety Case).
3.0 Discharges to Sea				
3.1	P	Discharge of drilling mud and associated chemicals	These discharges have the potential to cause smothering of the seabed in the vicinity of the well; increased localised turbidity; potential depletion of oxygen in surface sediments; potential loss of seafloor habitat. Potential cumulative impact with other wells drilled in the area.	<u>Industry Best Practices</u> It is proposed that water based mud (WBM) is used for drilling all sections of the exploration wells. The design of the drilling programme, to include the use of dedicated water based mud systems, negates the use of oil based mud (OBM), which, even after the required thermal cuttings cleaning treatment to FIG PON10 standards, would have a higher toxicity upon discharge to the marine

Risk to Receptors (before mitigation)

Reference	Physical: Marine Water Quality	Air Quality	Soils / Sediments	Biological: Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Human: Shipping	Fishing	Oil and Gas Activity	Pipelines/Cables	Archaeology	Tourism/Leisure	Land Use	Coastal Populations	Infrastructure	Housing
2.1		2 E																	1 B		
2.2		2 C																			
3.1	3 D		3 D		3 D	2 D	2 D						2 B			3 C					

Risk to Receptors (after mitigation)

Reference	Physical: Marine Water Quality	Air Quality	Soils / Sediments	Biological: Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Human: Shipping	Fishing	Oil and Gas activity	Pipeline/ Cables	Archaeology	Tourism/Leisure	Land Use	Coastal populations	Infrastructure	Housing
2.1		1 E																	1 B		
2.2		2 B																			
3.1	1 D		1 D		1 D	1 D	1 D						2 B			3 A					

Reference	Event Type	Aspect	Description of Potential Impact	Risk to Receptors (before mitigation)																					Mitigation Measures	Risk to Receptors (after mitigation)																				
				Physical			Biological								Human											Physical			Biological								Human									
				Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas Activity	Pipelines/Cables	Archaeology	Tourism/Leisure	Land Use	Coastal Populations	Infrastructure	Housing		Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas activity	Pipeline/ Cables	Archaeology	Tourism/Leisure	Land Use	Coastal populations	Infrastructure	Housing
																									environment than WBM. All drilling mud components will be selected on the basis of environmental performance as much as possible within the mud programme, so as to reduce any potential environmental impacts upon the release of the drilling mud. A Discharge Management Programme (DMPO) will be in place for the drilling operations. The purpose of the DMPO will be to provide a consistent set of discharge requirements for the exploration drilling programme. The prohibitions, limitations and monitoring requirements in the document will be based on recognized standards and regulations that have been developed to protect the environment. The DMPO will include provisions for the discharge of drilling mud. Chemical use and discharge will be closely monitored throughout the drilling program through the rig chemicals tracking system and minimised by the drill crew and mud engineers where practicable, without compromising well safety. All chemical use and discharge will be controlled through the DMPO through the detailing of the reporting procedures for chemical use and discharge. The DMPO will provide a consistent set of discharge requirements for the exploration drilling programme. Batch discharges of drilling mud will be minimised as far as possible. All drilling mud will be recycled and used on other well sections as much as possible, without compromising well safety. <u>Noble Project Specific Commitments</u> Seabed features and habitats at the well sites will be confirmed through site specific environmental seabed surveys, which will include pre-drilling, during drilling and post-drilling elements as follows: • The pre-drilling survey will include a 100 metre radius (centred on the well location) remotely operated vehicle (ROV) inspection of the seabed, using an environmental specialist to interpret for habitats and species. Additional features showing important species (e.g. rocks with epifaunal communities or the presence of corals) will be marked and re-visited after drilling is completed. Seabed sampling will be carried out upstream and downstream of the prevailing																					

Reference	Event Type	Aspect	Description of Potential Impact	Risk to Receptors (before mitigation)																					Mitigation Measures	Risk to Receptors (after mitigation)																				
				Physical			Biological								Human											Physical			Biological								Human									
				Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas Activity	Pipelines/Cables	Archaeology	Tourism/Leisure	Land Use	Coastal Populations	Infrastructure	Housing		Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas activity	Pipeline/ Cables	Archaeology	Tourism/Leisure	Land Use	Coastal populations	Infrastructure	Housing
																									currents at 50, 100 and 200 metre offset locations, using a specialist environmental ROV corer (89mm outside diameter). At each station, 2 x physico-chemical samples will be taken from the top 10 cm of sediment, and 5 x biological samples will be taken from the top 20 cm of sediment, and processed through a 500 µm mesh sieve. • During drilling, specially designed sediment traps will be deployed at each of the above environmental stations for the purposes of logging the settlement of any cuttings material deposited on the seabed. • The post-drilling survey will include a 100 metre radius (centred on the well location) ROV inspection of the seabed, using an environmental specialist to interpret for habitats and species. Any additional features showing important species marked during the pre-drilling survey will be re-visited. Seabed sampling will again be carried out at the same offset locations as the pre-drilling survey (i.e. at 50, 100 and 200 metre offset locations upstream and downstream of the prevailing currents), using a specialist environmental ROV corer (89mm OD). At each station, 2 x physico-chemical samples will be taken from the top 10 cm of sediment, and 5 x biological samples will be taken from the top 20 cm of sediment, and processed through a 500 µm mesh sieve. In addition, a 1.5 metre ROV corer will be used to assess the vertical profile of the sediments in the thickest part of the cuttings pile, expected to be approximately 10 metres from the wellhead. This will record the settlement regime of discharged material over the duration of the drilling, with discrete layers identified, measured and analysed for their physico-chemical properties.																					
3.2	P	Discharge of drill cuttings	These discharges have the potential to cause smothering of the seabed in the vicinity of the well by drill cuttings; increased localised turbidity; potential depletion of oxygen in surface sediments; potential loss of seafloor habitat. Potential cumulative impact with other wells drilled in the area.	3 D		3 D		3 D	2 D	2 D						3 B			3 C						Industry Best Practices All mitigation measures as described above for the release of drilling mud (3.1). The DMPO will be in place for the drilling operations, as described above in 3.1, and will include provisions for the discharge of drilling cuttings. Noble Project Specific Commitments Should any habitats of conservation importance be identified during pre-drilling surveys, Noble will look to	1 D		1 D		1 D	1 D	1 D						2 B			3 A					

Reference	Event Type	Aspect	Description of Potential Impact	Risk to Receptors (before mitigation)																					Mitigation Measures	Risk to Receptors (after mitigation)																				
				Physical			Biological								Human											Physical			Biological								Human									
				Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas Activity	Pipelines/Cables	Archaeology	Tourism/Leisure	Land Use	Coastal Populations	Infrastructure	Housing		Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas activity	Pipeline/ Cables	Archaeology	Tourism/Leisure	Land Use	Coastal populations	Infrastructure	Housing
																									relocate the well location to avoid these habitats. Should either the SMS Scharnhorst or SMS Gneisenau be identified during the pre-drilling surveys, Noble will look to relocate the well location to avoid these wrecks. The results of the post drilling surveys will be used to verify the accuracy of the cuttings dispersion modelling.																					
3.3	P	Potential discharge of cement and associated chemicals (including potentially large volumes of cement in the unlikely event of mixing and/or mechanical problems)	These discharges have the potential to cause smothering of the seabed in the vicinity of the well by cement; increased localised turbidity; potential depletion of oxygen in surface sediments; potential loss of seafloor habitat. Potential cumulative impact with other wells drilled in the area.	3 D		3 D		3 D	3 D	3 D															Industry Best Practices Cement volumes used will be minimised where practicable to limit any possible discharge of cement and associated chemicals, without compromise to well safety and integrity. Chemical use and discharge will be closely monitored throughout the drilling program through the rig chemical tracking system and minimised by the drill crew and cement engineers where practicable, without compromising well safety. All chemical use and discharge will be controlled through the DMPO. Batch discharges of cement will be minimised as far as possible. Great care will be taken when mixing cement on board the rig for use during cementing operations, ensuring that the potential need to discharge batches of cement due to technical and/or mixing problems is minimised. All cement discharge will be controlled through the DMPO. Noble Project Specific Commitments All cement components will be selected on the basis of environmental performance, so as to reduce any potential environmental impacts upon the potential release of the cement.	1 D		1 D		1 D	1 D	1 D														

Reference	Event Type	Aspect	Description of Potential Impact	Risk to Receptors (before mitigation)																					Mitigation Measures	Risk to Receptors (after mitigation)																				
				Physical			Biological								Human											Physical			Biological								Human									
				Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas Activity	Pipelines/Cables	Archaeology	Tourism/Leisure	Land Use	Coastal Populations	Infrastructure	Housing		Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas activity	Pipeline/ Cables	Archaeology	Tourism/Leisure	Land Use	Coastal population	Infrastructure	Housing
3.4	P	Discharge of domestic wastewater and food waste.	Discharges of domestic wastewater and food waste have the potential to cause a localised effect on water quality. The increased biological oxygen demand (BOD) in the water column could potentially disrupt biodiversity in the region, potentially giving rise to a temporary boom in opportunistic species.	2E					2E	2D	2C		2D												Industry Best Practices On board the drilling rig and OSVs, black (sewage) and grey water will be collected and treated in accordance with the requirements of the MARPOL Convention prior to being discharged to sea. Food waste will also be collected and treated (macerated) in accordance with the requirements of the MARPOL Convention. The discharge of sewage is only authorised if the ship/installation is equipped with authorised sewage treatment equipment, and the results of the tests of this equipment are documented and the effluent leaves no visible floating solids and does not discolour the surrounding water. The discharge of rubbish is prohibited, with the exception of food waste that is ground and passed through a sieve with a mesh size no greater than 25 millimetres for facilities that are more than 12 nautical miles from the coast. The DMPO will be in place for the drilling operations and will include provisions for the discharge of domestic wastewater and food waste; both from the drilling rig and OSVs.	1E					1E	1D	1C		1D											
3.5	P	Discharge of deck drainage water	Water quality has the potential to be reduced if chemicals and/or hydrocarbons contaminate drainage water. Fish may avoid any contaminated areas, which could potentially reduce their foraging areas. Contaminated effluents could potentially cause discomfort and/or disturbance to fish and benthic dwelling species.	2D					2D	2D	2D		2D												Industry Best Practice Deck areas will be kept clean of debris and any hydrocarbon materials. Any unintentional releases will be thoroughly cleaned up as soon as they occur before they have the chance to be washed overboard. Waste materials (absorbent pads, etc.) will be segregated. Hazardous waste will be disposed of according to established waste oil/chemical disposal procedures. The drilling rig and OSVs will be fitted with closed drainage containment and monitoring systems in all environmentally critical areas as part of their specification. An oily water bilge system in accordance with MARPOL regulations, and an oily water separator (OWS) in accordance with International Maritime Organisation (IMO) Marine Environment Protection Committee (MEPC) 107(49) (Guidelines and Specifications for Pollution Prevention Equipment for Machinery Space Bilges of Ships) will also be present. Procedures for drainage water will be addressed	2B					2B	2B	2B		1C											

noble energy

Reference	Event Type	Aspect	Description of Potential Impact	Risk to Receptors (before mitigation)																					Mitigation Measures	Risk to Receptors (after mitigation)																				
				Physical			Biological								Human											Physical			Biological								Human									
				Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas Activity	Pipelines/Cables	Archaeology	Tourism/Leisure	Land Use	Coastal Populations	Infrastructure	Housing		Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas activity	Pipeline/ Cables	Archaeology	Tourism/Leisure	Land Use	Coastal populations	Infrastructure	Housing
																									within both the drilling contractor's and OSV contractor's documentation. Oily water treatment systems on board the drilling rig and OSVs must have oil discharge monitoring and control equipment installed to ensure an oil concentration in water exiting the treatment systems of less than 15 parts per million (ppm) as required under MARPOL regulations and in accordance with IMO MEPC 107(49). Records of the oil content of water discharged and calibration of equipment must be maintained in accordance with the MARPOL Convention, in the form of an Oil Record Book. On the drilling rig, no direct overboard discharge of deck drainage water from environmentally critical areas (e.g. the drill floor) is to take place. All direct deck drainage on the drilling rig (e.g. walkway gratings) shall be used in clean, non-environmentally critical areas only. Noble Project Specific Commitments Spill kits will be readily available on deck for mopping up any minor unintentional releases. Personnel will be trained in the use of spill kits. Rainwater runoff from the drilling rig will be routinely monitored for any residual hydrocarbon content. The DMPO will include provisions for the discharge of drainage water.																					
4.0 Bio-security																																														
4.1	P	Discharge of ballast water	Potential introduction of invasive species leading to potential change in local ecosystem and possibly the wider ecosystem.	3 C				3 C	3 C	3 C			3 C									3 C			Industry Best Practices All vessels associated with the drilling operations (including the drilling rig itself), will undertake ballast exchange operations well clear of the Falkland Islands in offshore waters outside of the 12 nautical mile limit. The drilling rig and OSVs will all have procedures in place for ballast water management as part of both the drilling contractor's and OSV contractor's specification. These procedures will be subject to audit/assessment by Noble.	3 A				3 A	3 A	3 A			3 A									2 B		

Reference	Event Type	Aspect	Description of Potential Impact	Mitigation Measures
5.0 Noise and Vibration				
5.1	P	Underwater noise from drilling operations (rig and OSVs on site).	Potential disturbance to marine mammals, fish and seabirds. Potential behavioural changes in fish and marine mammals due to increase in background marine noise levels.	<u>Industry Best Practices</u> Drilling operations inevitably give rise to noise. The drilling rig will be on location for the minimum period of time required to conduct the drilling operations, thus minimising the duration of potential noise impacts as far as possible. The operational and maintenance procedures on the drilling rig will also aim to optimise the efficiency of the equipment and the schedule of operations.
5.2	P	Underwater noise from OSVs on sea passage.	Potential disturbance to marine mammals, fish and seabirds. Potential behavioural changes in fish and marine mammals due to increase in background marine noise levels.	<u>Noble Project Specific Commitments</u> Vessel movements will also avoid coastal areas (with the exception of the approaches to Port William and Stanley Harbour) where sensitive species, such as penguin colonies, may be present. Whilst transiting near beach areas (i.e. within the vicinity of the approaches to Port William, and whilst within Port William and Stanley Harbour), vessel speed should be reduced in order to minimise the chance of vessel strike with any species that may be present. Such a reduced speed would also limit noise impact from the vessels. All other applicable vessel speed limits shall also be observed when within the approaches to Port William and whilst within Port William and Stanley Harbour. Noble agrees to place a 10 kilometre avoidance area around both Beauchêne and Sea Lion Islands to avoid disturbance to sensitive species present within the vicinity of these islands.

Risk to Receptors (before mitigation)

Reference	Physical: Marine Water Quality	Air Quality	Soils / Sediments	Biological: Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Human: Shipping	Fishing	Oil and Gas Activity	Pipelines/Cables	Archaeology	Tourism/Leisure	Land Use	Coastal Populations	Infrastructure	Housing
5.1						1 D	1 C	1 A		1 C	1 A										
5.2						1 C	1 C	1 C	1 C	1 C	1 C										

Risk to Receptors (after mitigation)

Reference	Physical: Marine Water Quality	Air Quality	Soils / Sediments	Biological: Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Human: Shipping	Fishing	Oil and Gas activity	Pipeline/ Cables	Archaeology	Tourism/Leisure	Land Use	Coastal populations	Infrastructure	Housing
5.1						1 D	1 C	1 A		1 C	1 A										
5.2						1 C	1 C	1 C	1 C	1 C	1 C										

noble energy

Reference	Event Type	Aspect	Description of Potential Impact	Mitigation Measures
5.3	P	Underwater noise from helicopters in transit.	Potential disturbance to marine mammals, fish and seabirds on the helicopter route between Stanley Airport and the rig. Potential behavioural changes in marine mammals, fish, and offshore and coastal seabirds due to increase in background noise levels.	<u>Noble Project Specific Commitments</u> The aviation contractor will be prohibited from circling or hovering over marine mammals or sites identified as sensitive for seabird colonies in accordance with the Falkland Islands low flying avoidance maps and the Falkland Islands Low Flying Handbook. The aviation contractor will pay particular attention to paragraphs 37 to 40 and 54 to 60 of the Low Flying Handbook. Noble agrees to place a 10 kilometre avoidance area around both Beauchêne and Sea Lion Islands to avoid disturbance to sensitive species present within the vicinity of these islands.
5.4	P	Underwater noise from Vertical Seismic Profiling (VSP) operations.	Potential disturbance to marine mammals and fish; potential physical damage to plankton, fish eggs and larvae in immediate proximity to the VSP energy source. Potential behavioural changes in marine mammals and fish due to the sharp temporal increase in background marine noise levels.	<u>Noble Project Specific Commitments</u> VSP operations will be strictly controlled in line with the JNCC *Guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys* (2010). A qualified Marine Mammal Observer (MMO) will be on site during VSP operations. The MMO will monitor the 500 metre exclusion zone for 60 minutes prior to commencement of VSP operations to ensure that no marine mammals are present within the area. Soft-start ramp up of the seismic source during VSP operations, of no less than 20 minutes and no more than 40 minutes, will then be undertaken in line with the JNCC guidelines. This enables fish, marine mammals and squid in the area disturbed by the sound levels to move away from the noise source before being subject to the full force of the seismic array, thus minimising the potential for adverse impacts on these species. If marine mammals are observed within the 500 metre zone after the VSP has started, then they are deemed to be unaffected by the noise. A record of the sighting should be kept but no further action needs be taken. VSP operations will be started during daylight hours only.

Risk to Receptors (before mitigation)

Reference	Physical			Biological								Human									
	Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas Activity	Pipelines/Cables	Archaeology	Tourism/Leisure	Land Use	Coastal Populations	Infrastructure	Housing
5.3				1 E			1 B	1 B	1 B	1 B	1 B						1 E		1 E		
5.4						2 C	3 D	1 B		3 D			1 B								

Risk to Receptors (after mitigation)

Reference	Physical			Biological								Human									
	Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas activity	Pipeline/ Cables	Archaeology	Tourism/Leisure	Land Use	Coastal populations	Infrastructure	Housing
5.3				1 E			1 C	1 D	1 D	1 C	1 B						1 E		1 E		
5.4						2 B	2 C	1 B		2 C			1 B								

Reference	Event Type	Aspect	Description of Potential Impact
6.0 Airborne Noise			
6.1	P	Airborne noise from helicopters in transit.	Potential disturbance to coastal populations, terrestrial communities, birds, marine mammals and protected areas on the helicopter route between Stanley Airport and the rig.

Reference	Risk to Receptors (before mitigation)																				
	Physical			Biological								Human									
	Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas Activity	Pipelines/Cables	Archaeology	Tourism/Leisure	Land Use	Coastal Populations	Infrastructure	Housing
6.0 Airborne Noise																					
6.1				1 C				1 C	1 C	1 C	2 C						1 C		2 D		2 D

Reference	Mitigation Measures
6.0 Airborne Noise	
6.1	<u>Noble Project Specific Commitments</u> The aviation contractor will be prohibited from circling or hovering over marine mammals or sites identified as sensitive for seabird colonies unless essential for safety or operational purposes in accordance with the Falkland Islands low flying avoidance maps and the Falkland Islands Low Flying Handbook. The aviation contractor will pay particular attention to paragraphs 37 to 40 and 54 to 60 of the Low Flying Handbook. Routing over built up areas will be avoided, unless in an emergency and/or on the grounds of safety in accordance with paragraph 32 of the Falkland Islands Low Flying Handbook. Noble agrees to place a 10 kilometre avoidance area around both Beauchêne and Sea Lion Islands to avoid disturbance to sensitive species present within the vicinity of these islands. Helicopter flight planning will be undertaken in coordination with the appropriate Falkland Island authorities (Civil Aviation Department). Under normal operations, helicopter flights will only occur during daylight hours, in order to minimise potential disturbance to the local population.

Reference	Risk to Receptors (after mitigation)																				
	Physical			Biological								Human									
	Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas activity	Pipeline/ Cables	Archaeology	Tourism/Leisure	Land Use	Coastal populations	Infrastructure	Housing
6.0 Airborne Noise																					
6.1				1 B				1 B	1 B	1 B	1 B						1 C		1 C		1 C

Reference	Event Type	Aspect	Description of Potential Impact	Risk to Receptors (before mitigation)																				
				Physical			Biological								Human									
				Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas Activity	Pipelines/Cables	Archaeology	Tourism/Leisure	Land Use	Coastal Populations	Infrastructure	Housing
6.2	P	Airborne noise from OSVs on sea passage.	Potential disturbance to terrestrial communities, birds, marine mammals and protected areas				2 C				2 C	2 C	2 C	2 C										
7.0 Waste Management																								
7.1	P	Treatment and disposal of non-hazardous waste generated from drilling operations.	The effects of disposal of controlled wastes associated with onshore disposal are dependent on the nature of the site or process. This has the potential to produce limitations on future land use and the potential to cause small scale land and air contamination.		2 E	2 E	2 E					2 E									2 E	2 E		

Reference	Mitigation Measures
6.2	Noble Project Specific Commitments Vessel movements will avoid coastal areas (with the exception of the approaches to Port William and Stanley Harbour) where sensitive species, such as penguin colonies, may be present. Whilst transiting near beach areas (i.e. within the vicinity of the approaches to Port William, and whilst within Port William and Stanley Harbour), vessel speed will be reduced in order to minimise the chance of vessel strike with any species that may be present. Such a reduced speed would also limit noise impact from the vessels. All other applicable vessel speed limits shall also be observed when within the approaches to Port William and whilst within Port William and Stanley Harbour. In addition, Noble agrees to place a 10 kilometre avoidance area around both Beauchêne and Sea Lion Islands to avoid disturbance to sensitive species present within the vicinity of these islands.
7.1	Noble Project Specific Commitments Noble will develop and implement a Waste Management Plan (WMPA) for the proposed drilling programme that encompasses the drilling rig, OSVs and onshore support. The WMPA will cover the storage, transport and treatment of waste generated as part of the drilling programme. The WMPA will cover both offshore and onshore aspects of the exploration drilling operations (i.e. will cover both offshore and onshore elements of the waste streams). The WMPA will identify measures to reduce waste generated during drilling and how waste will be handled and disposed of safely and responsibly. The WMPA will: • Promote minimisation of the amounts of waste generated at source; • Require segregation of waste by type; • Require appropriate storage to prevent emissions and leaks; • Promote recycling or re-use where possible, in particular for scrap metal, waste oil and surplus chemicals;

Reference	Risk to Receptors (after mitigation)																				
	Physical			Biological								Human									
	Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas activity	Pipeline/ Cables	Archaeology	Tourism/Leisure	Land Use	Coastal populations	Infrastructure	Housing
6.2				1 B				1 B	1 B	1 B	1 B										
7.1		1 E	1 E	1 E					1 E									1 E	1 E		

Reference	Event Type	Aspect	Description of Potential Impact	Risk to Receptors (before mitigation)																					Mitigation Measures	Risk to Receptors (after mitigation)																				
				Physical			Biological								Human											Physical			Biological								Human									
				Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas Activity	Pipelines/Cables	Archaeology	Tourism/Leisure	Land Use	Coastal Populations	Infrastructure	Housing		Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas activity	Pipeline/ Cables	Archaeology	Tourism/Leisure	Land Use	Coastal populations	Infrastructure	Housing
																									• Require that waste be sent to authorised landfills or incineration facilities, depending on its precise nature, when no other option is possible; • Minimise and manage cumulative waste generation from the drilling campaign; and • Ensure a clear chain of ownership for all waste through the use of waste transfer manifests until final disposal, particularly relating to trans-boundary matters. Noble will work closely with FIG prior to drilling operations to determine acceptable options for onshore non-hazardous waste disposal. The following measures will be included in the Waste Management Plan: • No un-combusted wastes arising from the drilling programme will be landfilled in the Falkland Islands; • Some non-hazardous combustible waste will be segregated and sent to a local incinerator for incineration in the Falkland Islands; and • The waste ash arising from this incineration will be landfilled in the Falkland Islands along with other incinerator waste at an existing landfill facility (Eliza Cove or Mary Hill Quarry). Noble will confirm all waste management and disposal routes within the WMPA to be approved by FIG prior to drilling operations commencing. All contractors will be required to adhere to the requirements outlined within the WMPA.																					
7.2	P	Treatment and disposal of hazardous waste generated from drilling operations.	Potential trans-boundary impacts due to the trans-boundary movement of hazardous waste.		3 E	3 E	3 E					2 E									3 E	3 E			<u>Noble Project Specific Commitments</u> Special arrangements will be in place for hazardous wastes and will be detailed within the WMPA. As no suitable onshore facilities exist in the Falkland Islands for the treatment and disposal of hazardous waste, the waste will be exported in accordance with the Basel Convention. Under the Basel Convention, a trans-boundary movement (TBM) means any movement of hazardous wastes or other wastes: • From an area under the national jurisdiction of one State; and		1 E	1 E	1 E					1 E									1 E	1 E		

noble energy

Reference	Event Type	Aspect	Description of Potential Impact	Risk to Receptors (before mitigation)																					Mitigation Measures	Risk to Receptors (after mitigation)																				
				Physical			Biological								Human											Physical			Biological								Human									
				Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas Activity	Pipelines/Cables	Archaeology	Tourism/Leisure	Land Use	Coastal Populations	Infrastructure	Housing		Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas activity	Pipeline/ Cables	Archaeology	Tourism/Leisure	Land Use	Coastal populations	Infrastructure	Housing
																									• To or through an area under the national jurisdiction of another State, or to or though an area not under the national jurisdiction of any State. The Basel Convention requires that the standard of "environmentally sound management" (ESM) of hazardous wastes or other wastes is met. ESM means taking all practicable steps to ensure hazardous wastes or other wastes are managed in a manner which will protect human health and the environment against the adverse effects which may result from such wastes. The final stage in the TBM procedure is for the generator and country of export to receive confirmation that the wastes moved across borders have been disposed of by the disposer as planned and in an environmentally sound manner. Noble will ensure that a dedicated waste specialist is appointed to: • Receive and handle waste (including hazardous waste) at the TDF; • Arrange for local recycling or disposal of non-hazardous waste; • Safely store any hazardous waste; • Arrange appropriate export of hazardous waste in accordance with the Basel Convention; and • Ensure confirmation from the disposer that the wastes moved have been disposed of as planned and in an environmentally sound manner in accordance with the Basel Convention. Noble will conduct an audit/assessment of any selected waste specialist and processing facilities to ensure their compliance with local and international best practice and the WMPA.																					
8.0 Light																																														
8.1	P	Use of artificial lighting on board the rig and OSVs.	Potential disturbance to offshore seabirds during hours of darkness.								2 D														Industry Best Practices Heli-deck landing lights will be switched off when not in use (if not required to be left on for safety reasons, such as during an emergency incident) to reduce potential impacts of these skyward facing lights on any bird species that may be present. Night time helicopter flights will only be								1 C													

Reference	Event Type	Aspect	Description of Potential Impact	Risk to Receptors (before mitigation): Physical: Marine Water Quality	Air Quality	Soils / Sediments	Biological: Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Human: Shipping	Fishing	Oil and Gas Activity	Pipelines/Cables	Archaeology	Tourism/Leisure	Land Use	Coastal Populations	Infrastructure	Housing	Mitigation Measures	Risk to Receptors (after mitigation): Physical: Marine Water Quality	Air Quality	Soils / Sediments	Biological: Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Human: Shipping	Fishing	Oil and Gas activity	Pipeline/ Cables	Archaeology	Tourism/Leisure	Land Use	Coastal populations	Infrastructure	Housing
																									conducted during emergency situations and are not planned to be part of normal operations during drilling activities Under normal operations, Helicopter flights will only occur during daylight hours so requirements for heli-deck lighting will be minimal if at all. In addition, the OSV and SSV deck lighting will be switched off when not in use (if not required to be left on for safety reasons, such as during resupplying of the rig at night). Noble Project Specific Commitments The precise details of the bird monitoring on the rig are yet to be finalised. Noble will monitor the number of birds found on the rig throughout the exploration drilling programme and will report monthly to an advisory group the findings of this monitoring. In the event that it is considered that significant and unacceptable numbers of seabirds have been attracted to the rig at night this will immediately be reported to FIG. Noble will then investigate whether further measures can be implemented and will work with FIG and their advisors to develop suitable measures. However, based on the experience of a previous study offshore the Falklands (albeit in northern waters) it should be noted that an event such as this is considered highly unlikely to occur. As part of the monitoring programme, a protocol will be established for the identification and recording of species involved in the event of mortality. Species present on the rig, involved in collisions or observed attracted to the rig will be recorded, including species name, numbers observed, behaviour and location on the rig. Photographs of species observed will be taken as part of the recording procedure. However, based on the experience of a previous study offshore the Falklands (albeit in northern waters) it should be noted that mortality due to association is expected to be highly unlikely to occur. The finalised protocol for recording species observed will be developed prior to drilling operations occurring and will be agreed with FIG.																					

Reference	Event Type	Aspect	Description of Potential Impact	Risk to Receptors (before mitigation)																					Mitigation Measures	Risk to Receptors (after mitigation)																				
				Physical			Biological								Human											Physical			Biological								Human									
				Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas Activity	Pipelines/Cables	Archaeology	Tourism/Leisure	Land Use	Coastal Populations	Infrastructure	Housing		Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas activity	Pipeline/ Cables	Archaeology	Tourism/Leisure	Land Use	Coastal populations	Infrastructure	Housing
9.0 Seascape, Landscape and Visual Impact																																														
9.1	P	Physical presence of the drilling rig, OSVs, helicopter flights and shore base.	A temporary change in seascape, landscape and visual setting due to the presence of the drilling rig, OSVs, helicopter flights and shore base.									2 E	2 E	2 E	2 E	2 E									<u>Industry Best Practices</u> The duration of OSVs at the TDF and within Stanley Harbour will be minimised to the extent possible through project planning activities. The number of helicopter flights and the time spent in the air near Stanley Airport will be minimised to the extent possible through appropriate planning measures. <u>Noble Project Specific Commitments</u> Any land-based equipment and materials not in active use will be stored at Noble's shore base, whenever possible. All onshore working areas will be maintained in a tidy condition with the aim of minimising the potential visual impact. All complaints associated with the effects on the seascape, landscape and visual setting of Stanley will be recorded and monitored, in accordance with the Noble Energy Community Feedback Mechanism.									1 E	1 E	1 E	1 E	1 E								
10.0 Utilities, Transport Networks, Communications & Local Resources																																														
10.1	P	Presence of drilling operations workers during peak tourist season.	Additional demand placed on local guest house and hotel accommodation during drilling operations.																	3 E		3 E	3 E	3 E	<u>Noble Project Specific Commitments</u> Noble will adhere to the FIG "Procurement Code of Practice by Oil and Gas Companies and their Subcontractors Operating in the Falkland Islands" (Code) which is currently under development (available as a draft only and not yet approved). This Code aims to maximise the use of businesses registered on the Falklands Islands by the oil and gas industry and minimise the need for contractors to bring in workers who will subsequently require temporary accommodation. Noble will utilise the local work force where possible in order to reduce the need for additional accommodation. Noble continues to work with FIG on the progress of this code of practice; Disturbance to local accommodation facilities will be minimised through advanced consultation with local hotels being used for overnight accommodation. Noble intends to have a permanent arrangement for housing and leasing rooms in local hotels in place in advance of drilling operations commencing and well in advance of the rooms being required.																	1 C		1 C	1 C	1 C

Reference	Event Type	Aspect	Description of Potential Impact	Risk to Receptors (before mitigation)																					Mitigation Measures	Risk to Receptors (after mitigation)																				
				Physical			Biological								Human											Physical			Biological								Human									
				Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas Activity	Pipelines/Cables	Archaeology	Tourism/Leisure	Land Use	Coastal Populations	Infrastructure	Housing		Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas activity	Pipeline/ Cables	Archaeology	Tourism/Leisure	Land Use	Coastal populations	Infrastructure	Housing
																									In addition to the above accommodation arrangements, Noble, in conjunction with other operators, has initial plans to build temporary accommodation in the Stanley area. This accommodation will have a capacity of 80 rooms. Plans for this temporary accommodation have yet to be finalised. Expressions of interest for the provision of this accommodation have been released. Noble will minimise, where possible, the number of their own management staff in the Falkland Islands needed to manage the exploration drilling programme (without compromising safety and quality). The Emergency Response Plan (ERP) developed by Noble will include arrangements for the provision of emergency accommodation in Stanley. Each of the 80 rooms within the temporary accommodation described above will have an extra bunk to assist in emergency evacuation situations. It is also noted that the Falkland Islands Defence Force (FIDF) based in Stanley could accommodate up to 200 persons in the event of an emergency, although no guarantees of available space can be made. However, the use of this facility for emergency situations will be discussed in advance with FIG and FIDF prior to any inclusion in the ERP.																					
10.2	P	Use of water from the municipal water supply in Stanley	Potential to place pressure on the available water resources within Stanley.																	3 E		3 E	3 E	3 E	Noble Project Specific Commitments The storage tanks on the TDF, which will be utilised for the storage of drill water, will be trickle filled from the municipal water supply, which will mitigate against the potential for sudden, high-volume 'shock' demands being placed on the local water supply network. During the exploration drilling programme, Noble will provide written notification to the FIG Public Works Department (PWD) a minimum of 10 calendar days before drill water is required to be taken from the municipal water supply. The written communiqué shall confirm the expected quantity of water to be taken from the regional supply network, the expected date and start/end time and the telephone contact details of the relevant Noble supervisor.																	1 E		1 E	1 E	1 E
10.3	P	Use of local road network to transport rig workers	Increased traffic and potential increased risk to community health & safety and other road users.																	2 E		2 E	2 E		Noble Project Specific Commitments Local transport companies will be used for all road transfers of offshore personnel. This will reduce health																	1 E		1 E	1 E	

noble energy

Reference	Event Type	Aspect	Description of Potential Impact	Risk to Receptors (before mitigation)																					Mitigation Measures	Risk to Receptors (after mitigation)																				
				Physical			Biological							Human												Physical			Biological							Human										
				Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas Activity	Pipelines/Cables	Archaeology	Tourism/Leisure	Land Use	Coastal Populations	Infrastructure	Housing		Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas activity	Pipeline/ Cables	Archaeology	Tourism/Leisure	Land Use	Coastal populations	Infrastructure	Housing
		to/from Stanley, Stanley Airport and MPA during drilling.																							and safety risks, as local drivers will be familiar with local roads and local conditions. Careful planning of transportation will be undertaken to ensure efficient use of vehicles and to reduce the number of trips required. Onshore personnel will be given driving training appropriate to the local roads. Complaints associated with the transport of work force and increased traffic will be monitored and dealt with through the Noble Community Feedback Mechanism. Should any major issues be identified that are causing community concern they will be raised with FIG and alternative solutions proposed and discussed.																					
11.0 Accidental Events																																														
11.1	U	Uncontrolled gas release during drilling	Emissions have the potential to contribute to global warming (CH_4, CO_2), acid effects (SOx, NOx) and a short term localised impact on air quality. If flammable gasses are involved, there will be a potential risk of fire and explosion.		3 B																				Industry Best Practices Well control mitigations as below for uncontrolled release of reservoir hydrocarbons (11.4). To control fugitive emissions, operational and maintenance procedures will be implemented which include all environmentally critical valves, flanges, fittings and seals in use on the drilling rig to eliminate or reduce as far as possible their capacity for gas leaks and fugitive emissions. A gas/leak detection system and repair program will be in operation on the rig (requirement of rig Safety Case).		1 A																			
11.2	U	Potential unintentional releases of fuel or other fluids (e.g. diesel, drilling mud, hydraulic oil or lubricants) during day-to-day operations (including re-fuelling)	During general operations associated with drilling, there is the potential for unintentional releases. These releases have the potential to cause localised toxic effects on marine fauna and flora and localised pollution, which may impact local marine wildlife and rafting seabirds on the sea surface.	4 C				2 B	4 C	4 C	4 C	2 B	4 C			4 C				4 C					Industry Best Practices The drilling rig will be fitted with closed drainage containment, treatment and monitoring systems in all environmentally critical areas as part of the rig specification. Procedures for drainage water management will be addressed within the drilling contractor's documentation and the Noble DMPO. Noble will ensure that the drilling and OSV contractors have procedures for fuel bunkering. These procedures will be subject to audit/assessment prior to drilling operations commencing. Offshore bulk materials and fluid transfers will be minimised where possible, making efficient use of OSV loads and voyages.	2 B				2 B	2 B	2 B	2 B	2 B	2 B			2 B				2 B				

Reference	Event Type	Aspect	Description of Potential Impact	Mitigation Measures
				Where practicable, re-fuelling and transfer of bulk fluids will be undertaken during daylight hours only. Fluid transfer and crane operations will take place only in suitable weather conditions. Transfer operations will be supervised at all times both from the OSVs and drilling rig. Non-return valves will be installed on bulk fluid transfer hoses. Hoses will be tested and inspected as a part of the drilling contractor's planned maintenance system / procedure. To prevent losses of drilling mud, the marine riser system will be operated and maintained in good order as per Noble and drilling contractor policies, including: • Lower Marine Riser Package (LMRP) to have integrated Remotely Operated Vehicle (ROV) remote interfaces for emergency use; • Use of low pressure alarms in the riser system; • Rig Emergency Disconnect System (EDS) locked-out in normal operation; • Regular LMRP inspection with rig ROV; • Regular riser-tensioner system inspection. All contracted vessels will have an onboard SOPEP in place to define their response procedures in the event of a pollution incident. Drilling chemicals will be selected on the basis of environmental performance as much as possible within the mud programme, so as to reduce any potential environmental impacts. Noble Project Specific Commitments Spill kits will be readily available on deck for mopping up any minor unintentional releases. Personnel will be trained in unintentional release prevention and the use of spill kits. Regular drills will be held to contain and clean up deck spills. Noble will have Tier 1 response packages available in order to provide a timely and efficient Tier 1 spill response effort. An Oil Spill Response Plan (OSRP) will be developed and implemented prior to drilling operations commencing. All instances of unintentional release will be handled in

Risk to Receptors (before mitigation)

Physical			Biological								Human									
Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas Activity	Pipelines/Cables	Archaeology	Tourism/Leisure	Land Use	Coastal Populations	Infrastructure	Housing

Risk to Receptors (after mitigation)

Physical			Biological								Human									
Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas activity	Pipeline/ Cables	Archaeology	Tourism/Leisure	Land Use	Coastal populations	Infrastructure	Housing

Reference	Event Type	Aspect	Description of Potential Impact	Risk to Receptors (before mitigation)																					Mitigation Measures	Risk to Receptors (after mitigation)																				
				Physical			Biological								Human											Physical			Biological								Human									
				Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas Activity	Pipelines/Cables	Archaeology	Tourism/Leisure	Land Use	Coastal Populations	Infrastructure	Housing		Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas activity	Pipeline/ Cables	Archaeology	Tourism/Leisure	Land Use	Coastal populations	Infrastructure	Housing
																									accordance with Falkland Islands Government Petroleum Operations Notice 8, May 2012 Revision (hereafter referred to as PON 8). In particular, the use of dispersants will be coordinated with Incident Command as defined in the National Oil Spill Contingency Plan (NOSCP) as noted in Section 3 of PON 8 for approval and usage conditions.																					
11.3	U	An emergency incident (e.g. vessel collision), leading to potential unintentional releases.	Potential total loss of containment of entire inventories of diesel, utility fuels and chemicals from either the rig or OSVs potentially causing significant hydrocarbon and chemical pollution. Potential impacts on water quality and marine wildlife in the affected area.	5 C				3 B	4 B	5 C	5 C	4 B	5 C			5 C				5 C					<u>Industry Best Practices</u> All mitigation measures as defined above in Physical Presence (1.2) <u>Noble Project Specific Commitments</u> Pre-mobilisation audits/assessments will be undertaken on all vessels. Vessels will be selected which comply with IMO codes for pollution prevention. All contracted vessels will have a SOPEP in place to enable fast and effective response to any potential pollution incident. An Emergency Response Plan (ERP) and Oil Spill Response Plan (OSRP) will be developed and implemented prior to drilling operations commencing. All instances of unintentional release will be handled in accordance with Falkland Islands Government Petroleum Operations Notice 8, May 2012 Revision (hereafter referred to as PON 8). In particular, the use of dispersants will be coordinated with Incident Command as defined in the National Oil Spill Contingency Plan (NOSCP) as noted in Section 3 of PON 8 for approval and usage conditions.	4 A				3 A	3 A	4 A	4 A	3 A	4 A			4 A				4 A				
11.4	U	Uncontrolled release of reservoir hydrocarbons (blow-out).	Potential for a significant unintentional release of hydrocarbons due to uncontrolled well flow. Potential for physical oiling and toxicity impacts to marine wildlife and flora, potential contamination of coastal habitats. Indirect impacts could potentially include: habitat loss, impact on tourism and fisheries, issues associated with waste disposal, trans-boundary issues, accumulation of oil and chemicals in ecosystem food chain and in sediments, loss of biodiversity and loss of revenue to local businesses and fisheries.	6 B	4 B	4 B		3 B	6 B	6 B	6 B	6 B	6 B	6 B	5 B	6 B	5 B			6 B	3 B	6 B			<u>Industry Best Practices</u> The drilling operations will follow established drilling safety standards to minimise the risk of loss of well control. Well control systems and procedures will be in place as per all Noble and drilling contractor well control guidelines. The drilling crews will be adequately experienced, trained in well control techniques and supervised at all times. Emergency drills will be held regularly. Well designs will be reviewed by an independent well examiner. A Blow-out Preventer (BOP) will be in place and will be subject to regular maintenance and testing. BOP equipment/controls and emergency/contingency controls	5 A	4 A	4 A		3 A	5 A	5 A	5 A	5 A	5 A	5 A	3 A	5 A	3 A			5 A	2 A	5 A		

Reference	Event Type	Aspect	Description of Potential Impact	Risk to Receptors (before mitigation)																					Mitigation Measures	Risk to Receptors (after mitigation)																				
				Physical			Biological								Human											Physical			Biological								Human									
				Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas Activity	Pipelines/Cables	Archaeology	Tourism/Leisure	Land Use	Coastal Populations	Infrastructure	Housing		Marine Water Quality	Air Quality	Soils / Sediments	Terrestrial Communities	Benthic Communities	Plankton	Fish/ Shellfish	Offshore Seabirds	Coastal Seabirds	Marine Mammals	Protected/ Sensitive Areas	Shipping	Fishing	Oil and Gas activity	Pipeline/ Cables	Archaeology	Tourism/Leisure	Land Use	Coastal populations	Infrastructure	Housing
																									will be tested both prior to and immediately after deployment onto the wellhead. Noble Project Specific Commitments The BOP will be subject to a third party verification and audit prior to drilling operations commencing. The BOP specification will include one (1) shear ram, one (1) casing shear ram and a ROV remote interface to key BOP functions for emergency use. All key offshore personnel will have International Well Control Forum (IWCF) well control certification. Noble is a FULL member of Oil Spill Response Limited, providing an enhanced Tier 2/3 oil spill response capability. Noble is a member of the Global Dispersant Stockpile provided by OSRL for the purpose of responding to unintentional releases. An Emergency Response Plan (ERP) and Oil Spill Response Plan (OSRP) will be developed and implemented prior to drilling operations commencing. All instances of unintentional release will be handled in accordance with Falkland Islands Government Petroleum Operations Notice 8, May 2012 Revision (hereafter referred to as PON 8). In particular, the use of dispersants will be coordinated with Incident Command as defined in the National Oil Spill Contingency Plan (NOSCP) as noted in Section 3 of PON 8 for approval and usage conditions.																					

Appendix B: Drilling Operations Supporting Information

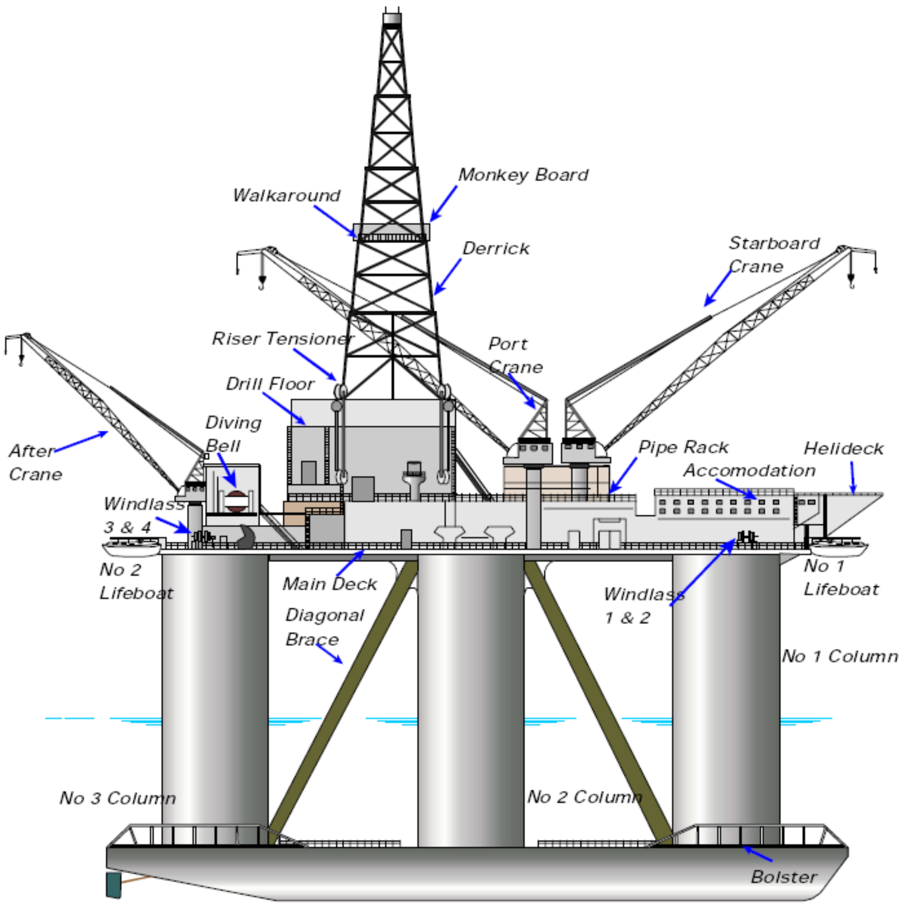
B.1 The Drilling Rig

The exploitation of hydrocarbons requires the construction of a conduit between the surface and the reservoir. This is achieved by the drilling process. Offshore wells are typically drilled by mobile offshore drilling units (MODUs) of which there are three broad designs currently in use: Drill ship;

- Semi-submersible drilling rig, and;
- Jack-up drilling rig.
- The proposed wells will be drilled using a semi-submersible drilling rig.

A semi-submersible rig is a floating unit that is supported primarily on large pontoon structures submerged below the sea surface. The operating decks are typically elevated 30 metres above the pontoons on large steel columns. Semi-submersible rigs are usually anchored to the seabed with six to twelve anchor chains or kept in place by a dynamic positioning (DP) system, which is a computer controlled thruster system used to maintain the rig position. Semi-submersible rigs can be used for drilling, work-over operations or as production platforms, depending on their equipment. Modern semi-submersible rigs - with DP systems - have the capacity to operate in deep water in excess of 1,500 metres. In addition, semi-submersible rigs have great flexibility concerning operating water depth and have the capacity to work in medium water and some shallow water fields. A schematic diagram of a typical semi-submersible drilling rig is given in Figure B.1 below.

Figure B.1: Typical semi-submersible drilling rig layout



To support the drilling operations, the following systems and services are usually located on a semi-submersible rig:

- Bulk Storage – Provided for fuel oil, bulk mud and cement, liquid mud, drill water and potable water;
- Pipe and Materials Storage – Covered storage is provided for sacked material, drilling equipment, spares, etc. and deck storage for drill pipe and casing;
- Helideck – Normally rated for a Sikorsky S-61 helicopter or equivalent;
- Craneage – Two deck cranes provided for loading/off loading equipment/supplies from Offshore Supply Vessels (OSVs);
- Emergency Systems – this includes life saving appliances, fire detection and protection equipment, combustible gas detection systems and life vessels; and
- Environmental Protection – Sewage treatment unit, blow-out preventer (BOP) system, cuttings cleaning equipment, hazardous and non-hazardous drainage systems (which collect rainwater and/or any minor spills and transport them to a drains tank for treatment prior to discharge to sea, or allow transfer to tote tanks for shipment to shore and appropriate disposal).

B.2 Well Construction

Once the rig is on location and secured, drilling operations to reach the potential hydrocarbon reservoir can commence. Well lengths can vary greatly from the order of a few hundred metres to in excess of 10,000 metres.

All rigs have a drilling derrick; a steel tower located over the drill floor which is the area of the rig where the majority of drilling activity is concentrated.

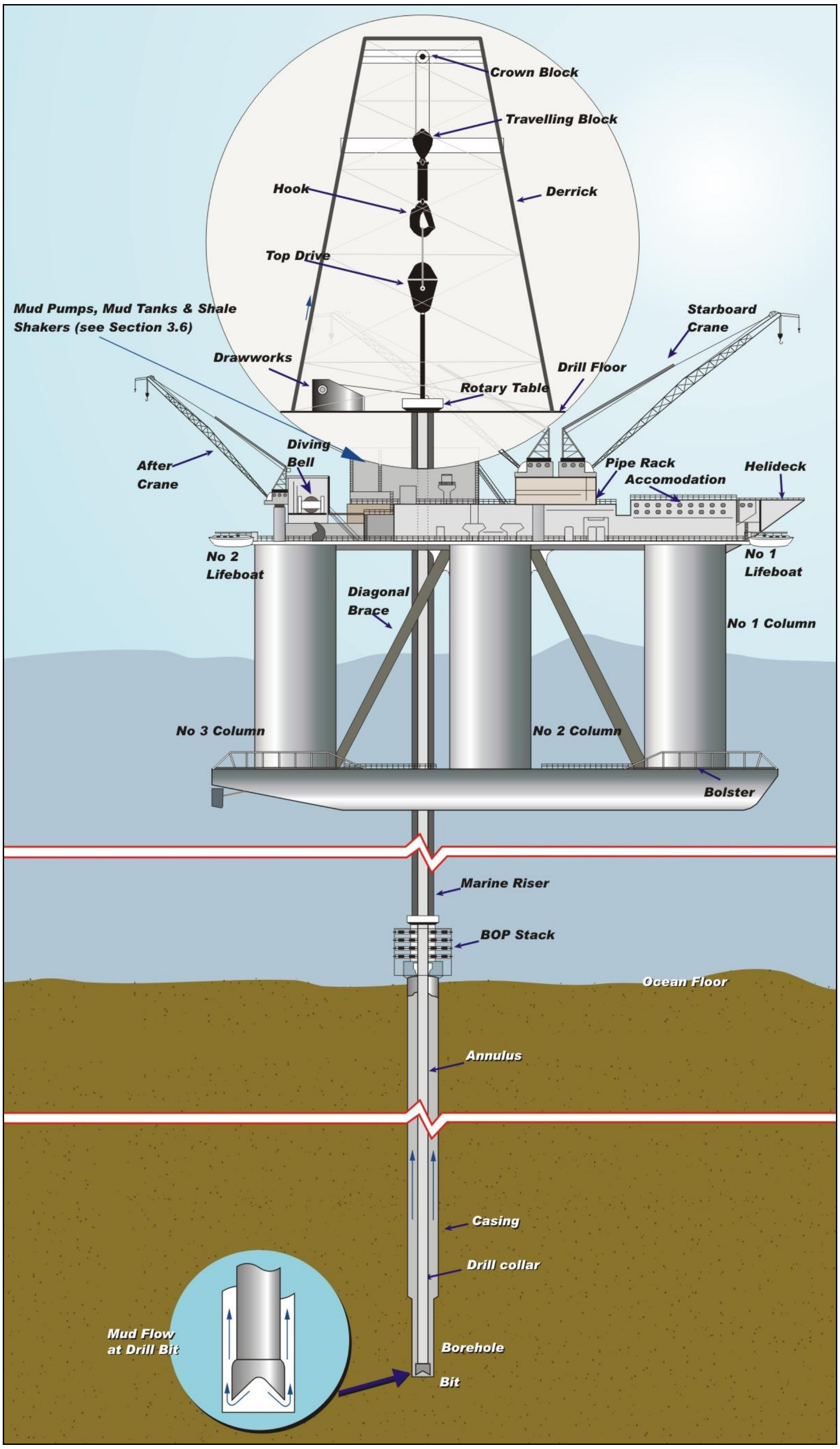
The derrick supports the weight of the drillstring which is screwed together from lengths of hollow drill pipe. Hoisting equipment in the derrick can raise or lower the drillstring. At the bottom of the drillstring is a drill bit, which can vary in size and type (Figure B.2). It is attached to the drill collars, which are heavy pipe-sections that put weight on the bit.

Figure B.2: A range of types of drill bit

On semi-submersible rigs, a compensator keeps the drillstring stationary while the rig and derrick move as a result of wave motion. The drill bit is rotated either by turning the whole drillstring ("rotary drilling") or by using a downhole turbine which rotates as drilling fluid is pumped through it. In rotary drilling, the rotary motion is imparted to the drillstring by a “rotary table” on the drill floor or more commonly these days a "top drive". This is an electro-hydraulic motor suspended in the top of the derrick. It is attached to the top of the drillstring and imparts torque to it, causing it to rotate.

To add a new section of drill pipe the drillstring is clamped in the drill floor with wedges (slips) and the top drive disconnected. The new joint is screwed into the drillstring suspended in the drill floor, the top drive connected to the top of the new joint and drilling restarted. The raising and lowering of the top drive and the maintenance of correct tension on the drillstring is controlled by the driller operating the drawworks lever in a control cabin on the drill floor (called the "doghouse"). A schematic of the main components of the conventional rotary drilling process are given in Figure B.3.

Figure B.3: Conventional rotary drilling system



The process of drilling grinds up the rock into small cuttings which are brought to the surface by the drilling fluid (also called "mud"), which is mainly water-based. The mud is pumped continuously down the hollow drillstring while drilling is ongoing. It is forced out of holes at the front of the drill bit (refer to Figure B.2), lubricates and cools the drilling tools, washes up the drill cuttings (small rock chippings) away from the bit and most importantly, balances the pressure of fluids in the rock formations below to prevent blowouts. The drilling mud is continuously circulated down the drill pipe and then pumped back up to the surface via the well annulus (the gap between drillstring and the side of the well bore) with the drilling cuttings. At the surface, the cuttings are removed from the mud, the drilling mud cleaned and then returned to the circulation system. Drilling muds and their use are described in further detail in Section B.4.

In offshore drilling, the first step is to install a wide-diameter conductor pipe (called a Marine Riser) into the seabed to guide the drilling and contain the drilling fluid. On mobile rigs this is drilled into the seabed. The conductor pipe represents the largest diameter of the well profile. As drilling operations continue, completed sections of the well are cased (lined) with steel pipe called 'casing' which is cemented into place. Casing the hole is essential as it not only facilitates drilling mud and cuttings to be re-circulated to the rig, but also seals off the pressure zones and weaker formations thus preventing hole collapse, as well as preventing contamination of potential aquifers by hydrocarbons and drilling materials.

B.3 Well Logging

The well is drilled in sections, each decreasing in diameter. As each well section is drilled, sensors that are integrated into the drill string take measurements whilst the well is being drilled. This process is called Logging Whilst Drilling (LWD). LWD measures and transmits geological parameters (such as rock density, formation pressure and resistivity at the drill bit) while the well is being drilled. Measured data is transmitted to the surface in real time via pressure pulses in the well's mud fluid column. At the end of the section, the drill string is removed from the well and wireline logs deployed into the well to obtain more data on the well characteristics.

B.4 Drilling Mud

During drilling operations, a fluid known as drilling mud is pumped through the drill string down to the drilling bit and once a conductor tube or riser is set in place, is returned to the rig via the space (or annulus) between the drill string and the casing (Figure B.4).

The selection of a type of ‘mud’ depends primarily on the geology of well to be drilled and the characteristics of the oil and/or gas reservoir in which drilling will take place. Drilling fluid is essential to the drilling operation and five basic properties are usually defined by the well program and monitored during drilling:

- Rheology - A high viscosity fluid is desirable to carry cuttings to surface and suspend weighting agents in the mud (such as barite). However, if viscosity is too high, friction may impede the circulation of the mud causing excessive pump pressure.
- Density - Sufficient hydrostatic pressure is required to prevent the borehole wall from caving in and to keep formation fluid from entering the wellbore. The higher the density of the mud compared to the density of the cuttings, the easier it is to clean the hole and the cuttings will be less inclined to fall through the mud.
- Fluid loss - The aim is to create a low-permeability filter cake to seal between the wellbore and the formation. Control of fluid loss restricts the invasion of the formation by filtrate and minimizes the thickness of filter cake that builds up on the borehole wall, reducing formation damage.
- Solids content - Solids are usually classified as high gravity (HGS) (barite and other weighting agents) or low gravity (LGS) (clays, polymers and bridging materials) deliberately put in the mud, plus drilled solids from dispersed cuttings and ground rock. The amount and type of solids in the mud affect a number of mud properties. A high solids content, particularly LGS, will increase plastic viscosity and gel strength. High-

solids muds have much thicker filter cakes and slower drilling rates. Large particles of sand in the mud cause abrasion on pump parts, tubulars and down-hole motors.

- Chemical properties - The chemical properties of the drilling fluid are central to performance and hole stability. Properties that must be anticipated include the dispersion of formation clays or dissolution of salt formations, the performance of other mud products (for example, polymers are affected by pH and calcium) and corrosion in the well.

The drilling mud also has to function as a lubricant and coolant for the drill bit and string. The ingredients of most drilling muds can be categorised into the following groupings:

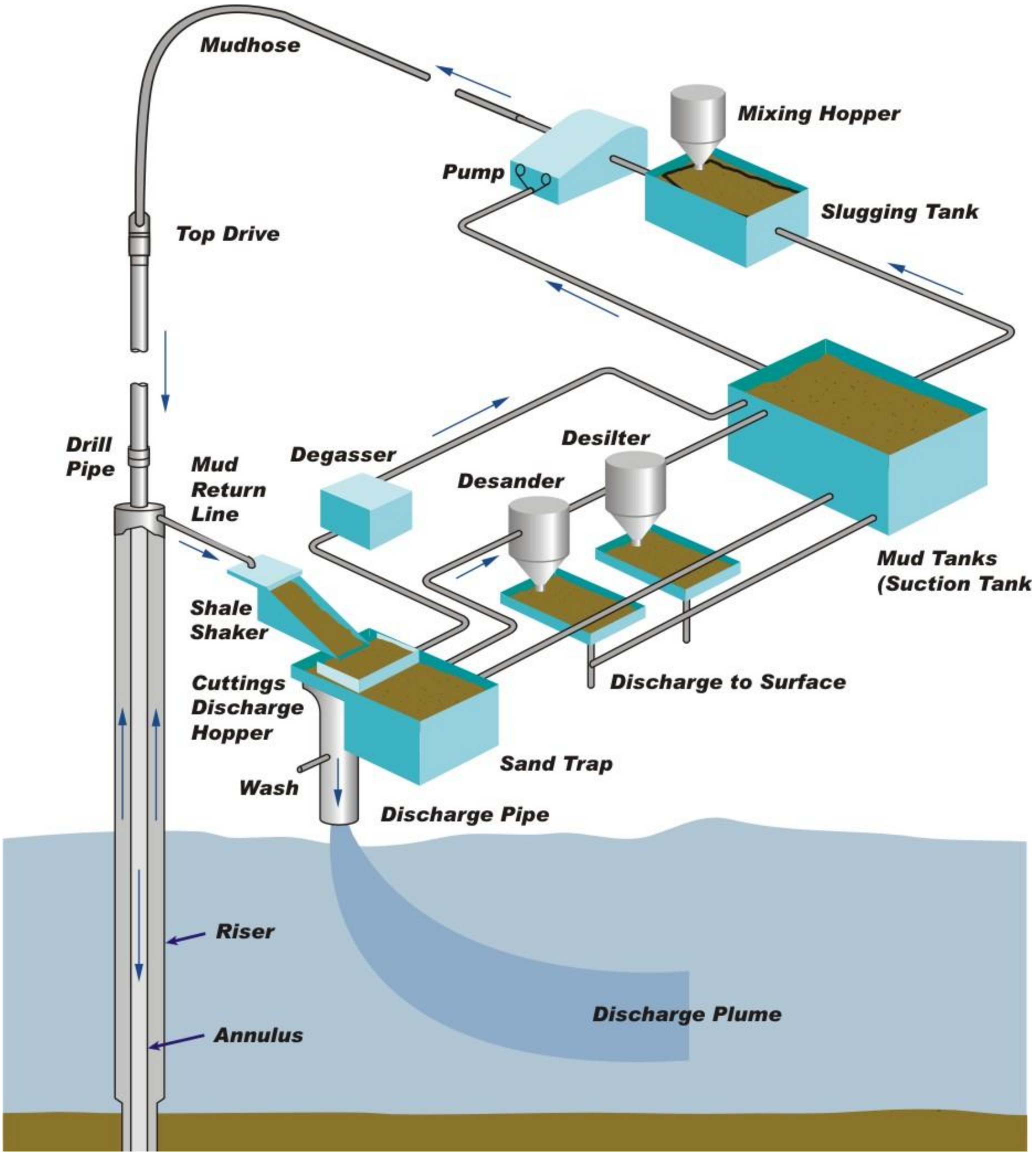
- Water - In water-based mud (WBM) this is the largest component. It may be used in its natural state, or salts may be added to change filtrate reactivity with the formation. Water hardness is usually eliminated through treatment and alkalinity is often controlled.
- Weighting agents - These are added to control formation fluid pressure. The most common is barite.
- Clay - Most commonly, bentonite is used to provide viscosity and create a filter cake on the borehole wall to control fluid loss. Clay is frequently replaced by organic colloids such as biopolymers, cellulose polymers or starch.
- Polymers - These are used to reduce filtration, stabilize clays, flocculate drilled solids and increase cuttings-carrying capacity. Cellulosic, poly-acrylic and natural gum polymers are used in low-solids mud to help maintain hole stability and minimize dispersion of the drill cuttings. Long-chain polymers are adsorbed onto the cuttings, thereby preventing disintegration and dispersion.
- Thinners - These are added to the mud to reduce its resistance to flow and to stifle gel development. They are typically plant tannins, polyphosphates, lignitic materials, lignosulfonates or synthetic polymers.
- Surfactants - These agents serve as emulsifiers, foamers and defoamers, wetting agents, detergents, lubricators and corrosion inhibitors.
- Inorganic chemicals - A wide variety of inorganic chemicals are added to mud to carry out various functions. For example, calcium hydroxide is used in lime mud and calcium chloride in oil based mud (OBM); sodium hydroxide and potassium hydroxide (caustic soda and caustic potash) are used to increase mud pH and solubilize lignite; sodium carbonate (soda ash) to remove hardness, sodium chloride to increase salinity, increase density, prevent hydrate formation and provide inhibition.
- Bridging materials - Calcium carbonate, cellulose fibres, asphalts and gilsonites are added to build up a filter cake on the fractured borehole and help prevent filtrate loss.
- Lost circulation materials - These are used to block large openings in the wellbore. These include walnut shells, mica and mud pills containing high concentrations of xanthum and modified cellulose.
- Specialized chemicals - Scavengers of oxygen, carbon dioxide or hydrogen sulphide are sometimes required, as are biocides and corrosion inhibitors.

Drilling mud is recycled and maintained in good condition throughout the drilling operation. The mud and suspended cuttings are processed on the rig through screens called “shale shakers” to maximise recovery of the mud. The recovered mud is then passed through a desander to remove sand particles and, if necessary, subsequent treatment may be provided by a centrifuge or desilter. This additional equipment removes the fine colloidal solids - the particles too small to be removed by the conventional equipment - which if allowed to build up can make the mud too viscous.

Three major types of mud are typically used in offshore drilling:

- Water based mud (WBM) – water forms the continuous phase of the mud (up to 90 percent by volume);
- Low toxicity oil based mud (LTOBM) – base oils, refined from crude oil, form the continuous phase of the mud, and;
- Synthetic based mud (SBM) – the continuous phase is refined from a number of organic compounds chosen because they act like base oil but are selected to be more biodegradable.

Figure B.4: Typical mud recycling system, once marine riser is in place



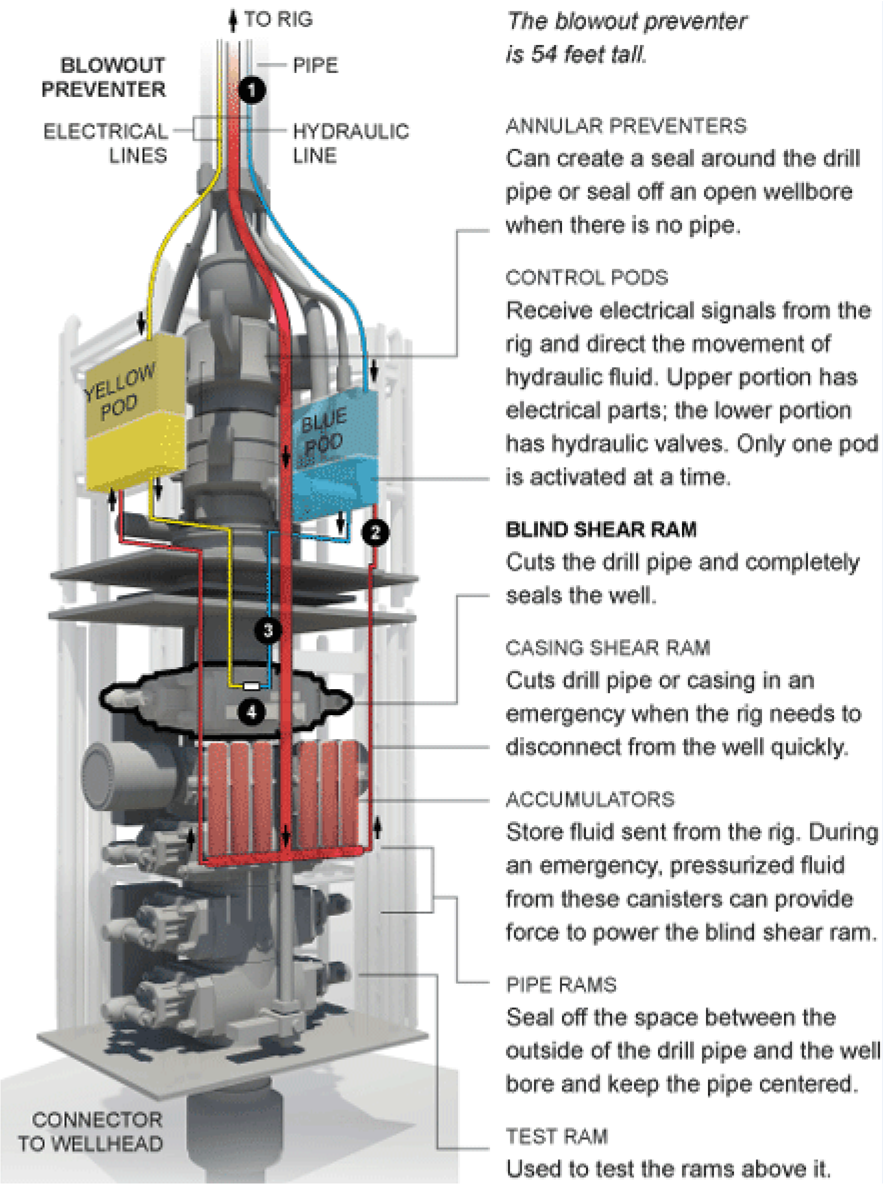
B.5 Well Control & Blow out Prevention

In addition to careful monitoring and control of the fluid system and the installation of casing in each section of the well, a blow-out preventer (BOP) stack, consisting of a series of individual valves (called preventers), is installed on the wellhead at the seafloor after the surface casing has been installed (Figure B.5).

The function of the BOP is to prevent uncontrolled flow from the well by positively closing in the well-bore if non routine flow from the well-bore is detected. The BOP is made up of a series of hydraulically (or electro-hydraulically) operated gate valves which contain rams (mechanical devices that are used to seal the bore which come in a range of different designs, depending on their intended purpose) which can be functioned in the event of an emergency on the drill rig or down-hole to seal off the wellbore.

The exploration wells are not anticipated to encounter any zones of abnormal pressure during Noble's exploration drilling programme. The BOP will be rated for pressures well in excess of those expected to be encountered in the well.

Figure B.5: A typical Subsea Blow-Out Preventer (BOP) stack



Appendix C: Offshore Chemical Notification Scheme (OCNS) & Harmonised Mandatory Control Scheme (HMCS) Information

Previously the control of offshore chemical discharges was controlled under the Offshore Chemical Notification Scheme (OCNS). Within the UK, the OCNS has been succeeded by The Offshore Chemicals Regulations 2002, which introduced a new approach to the consideration of chemical use and their discharge; the Harmonised Mandatory Control Scheme (HMCS). The Falkland Islands Government (FIG) aims to follow the example of the UK with regard to offshore chemical use. Both the OCNS and the HMCS are discussed below.

C.1 Offshore Chemical Notification Scheme (OCNS)

The Offshore Chemical Notification Scheme (OCNS) requires that all chemicals used in offshore exploration and production be tested using standard test protocols. Chemicals are then classified based on their biological properties e.g. toxicity and biodegradability. The OCNS scheme was adopted in the UK in 1979 and formed the basis of the Oslo and Paris Commissions (OSPARCOM) Harmonised Offshore Chemical Notification Format (HOCNF) which was established under cover of the Paris Commission Decision 96/3. The objectives of the OCNS and HOCNF are to regulate and manage chemical use by the oil and gas industry and consequently to prevent unacceptable damage to the marine environment through the operational or accidental discharge of chemicals.

The scheme was originally voluntary in the UK and all chemicals were given an OCNS Category ranging from 0 to 4. The system was later altered to harmonise the system with those operated by other countries bordering the North Sea. The HOCNS classifies all chemicals into five groups, A to E, with Category A chemicals being the most toxic and least biodegradable and Category E chemicals considered to be the least harmful to the offshore environment.

In addition to being placed into one of the five HOCNS categories, substances known or expected to cause tainting of fish tissue or substances known or expected to cause endocrine disruption, if lost or discharged, will be identified with a special taint or endocrine disrupter (ED) warning.

Chemicals are categorised on the basis of a series of laboratory tests with particular reference to their ecotoxicological effect, the biodegradability of the chemical and the potential for bioaccumulation in marine species. The ecotoxicological data used to classify the toxicity of chemicals are the results of laboratory tests on aquatic indicator organisms. Acute toxicity is assessed and expressed as either:

- An LC_{50} – the concentration of the test substance in sea water that causes mortality 50 percent of the test batch; and
- An EC_{50} – the concentration with a specified sub-lethal effect on 50 percent of the test batch.

The HOCNS grouping for a chemical is determined by comparing the results of toxicity tests for that chemical with the toxicity data given in Table C.1.

Table C.1: HOCNS Grouping Toxicity values (ppm) (Source: CEFAS, 2007)

HOCNS Grouping	A	B	C	D	E
Results for aquatic toxicity data (ppm)	<1	>1-10	>10-100	>100-1,000	>1,000
Results for sediment toxicity data (ppm)	<10	>10-100	>100-1,000	>1,000-10,000	>10,000

Aquatic toxicity - refers to the Skeletonema costatum EC_{50}, Acartia tonsa LC_{50}, and Scophthalmus maximus (juvenile turbot) LC_{50} test

Sediment toxicity - refers to the Corophium volutator LC_{50} test.

The categorisation also takes into account the chemicals' potential to bio-accumulate and biodegrade and other aspects such as potential endocrine disruption. The bioaccumulation potential and biodegradation rate relates to the fate of a chemical within the marine environment. Bioaccumulation potential describes the net result of uptake, distribution, biodegradation and elimination of a substance within an organism, subsequent to exposure but within the environment. The partition coefficient between octanol and water (expressed as Log Pow) is used as an indication of the potential for a substance to be bioaccumulated. A high value indicates a tendency to accumulate in lipophilic ("oil liking") phases such as the fatty tissues of organisms, suspended particles or sediments. However, because of biodegradation and elimination processes, a high Log P_{ow} does not necessarily imply bioaccumulation will occur. The classification outlined in Table C.2 is generally used to describe bioaccumulation potential.

Table C.2: Classification of Bioaccumulation Potential

Bioaccumulation Potential	Log P_{OW}
Low	<2
Medium	2-4
High	>4

C.2 Harmonised Mandatory Control Scheme (HMCS)

The OSPAR Decision introducing an HMCS for the use and discharge of chemicals offshore came into force through the Offshore Chemicals Regulations 2002. The regulatory regime requires operators to obtain a permit to use and discharge chemicals in the course of oil and gas exploration and production operations offshore.

The OSPAR Decision and its supporting Recommendations entered into force on 16 January 2001. The Decision requires offshore chemicals to be ranked according to their calculated Hazard Quotients relating to each chemical discharge under standardised platform conditions (HQ = ratio of Predicted Environmental Concentration (PEC) to Predicted No Effect Concentration (PNEC)). It also obliges authorities to use the CHARM "hazard assessment" module as the primary tool for ranking. In the UK this is carried out by a multidisciplinary team at the CEFAS Burnham Laboratory. From this information, operators assess and select their chemical need, calculating PEC:PNECs for actual conditions of use (utilising the CHARM module as appropriate) and bearing in mind the objective of the HMCS to identify substances of concern for substitution and ranking of others to support moves towards the use of less harmful substances. Inorganic chemicals and organic chemicals with functions for which the CHARM model has no algorithms will continue to be ranked using the existing HOCNS hazard groups defined above.

A series of ranked lists are maintained on the CEFAS web site which use a banding system to rank organic chemicals of similar function according to PEC:PNEC "Hazard Quotients" calculated using the CHARM model. The band definitions are given in Table C.3.

Table C.3: Classification of Bioaccumulation Potential

HQ Band	HQ Value
Gold	0>X<1
Silver	1=<X<30
White	30=<X<100
Blue	100=<X<300
Orange	300=<X<1000
Purple	1000=<X

The minimum data set of actual values and the parameters used by CEFAS to calculate them are disclosed to chemical suppliers on "templates". The suppliers then pass these on to operators to enable the calculation of site-specific risk assessments (RQs) for any chemicals they may want to use. Some chemicals are generated and used in-situ on offshore installations (e.g. Sodium Hypochlorite) and don't fall under the remit of any one supplier.

The properties of substances on the OSPAR List of Substances/Preparations Used and Discharged Offshore, Which Pose Little Or No Risk to the Marine Environment (PLONOR) are sufficiently well known that the UK Regulatory Authorities do not require them to be tested. This list is reviewed annually and the notification requirements for these chemicals are given in the PLONOR document.

C.3 Chemicals not Covered by OCNS

The OCNS does not apply to chemicals that might otherwise be used on a ship, helicopter or other offshore structure. Products used solely within domestic accommodation areas - such as additives to potable water systems, paints and other coatings, fuels, lubricants, fire-fighting foams, hydraulic fluids used in cranes and other machinery - are also exempt.

C.4 Substitution Warnings

The substitution of harmful chemicals is an important part of the HMCS. The UK is obliged to implement the policy to replace chemical substances identified as candidates for substitution. Any chemical that contains one or more components that have been recommended for substitution is assigned the chemical label code 'SUB'.

A chemical may carry a substitution warning for a variety of reasons, which include if the chemical:

- is on the OSPAR List of chemicals for priority action;
- is on the list of chemicals of possible concern;
- is considered by the authorising authority to be of equivalent concern for the marine environment;

Or:

- is inorganic and has a LC_{50} or EC_{50} of less than 1 mg/l

Or:

- has a biodegradation of:

- <20% in OECD 306, marine BODIS or any other accepted marine protocols, or
- <20% in 28 days in freshwater (OECD 301 and 310), or
- if half-life values >60 and 180 days from simulation tests in marine water and sediment, respectively (e.g. OECD 308, 309);

Or meets two of the following three criteria:

- **Biodegradation**:
    - <60% in 28 days in OECD 306, marine BODIS or any other acceptable marine protocol, or in the absence of valid results for such tests (<60% in 28 days (OECD 301B, 301C, 301D, 301F, 310, freshwater BODIS), or
    - <70% in 28 days (OECD 301A, 301E), or
- **Bioaccumulation**:
    - BCF >100 or Log Pow ≥3 and molecular weight <700, or
    - if the conclusion of a weight-of-evidence expert judgement under Appendix 3 of OSPAR Agreement 2008-5 is negative, or
- **Toxicity**:
    - LC50 <10mg/l or EC50 <10mg/l.

A reliable value of Log P_{ow} cannot be calculated for surfactants and therefore cannot be used to indicate whether a surfactant might bio-accumulate. OSPAR requires regulatory authorities to take a precautionary approach where data are ambiguous or missing. Therefore, substitution warnings are applied to those surfactants that have a molecular weight of <700 and are either:

- Less than 60% or 70% biodegradable in 28 days (according to the test protocol), or
- Have an EC50/LC50 <10 mg/l

unless Cefas is satisfied that other evidence submitted by the product supplier indicates that the substance should not bio-accumulate.

During the risk-assessment process, operators are required to consider the selection of products both in terms of the magnitude of their Risk Quotient (RQ) and the presence of hazardous substances, including candidates for substitution. Operators are required to provide a robust defence for the continued use of products that have a high RQ or contain candidates for substitution.

Chemical suppliers must consider the advice they provide to operators that justifies continued use of any product containing candidates for substitution. In addition, suppliers should consider a managed approach to the replacement of any undesirable components, leading to the reformulation and re-certification of products.

Operators are encouraged to select products without a substitution warning. Therefore, a supplier may wish to seek alternatives at the product-development stage. However, there may be good technical reasons why a particular substance cannot immediately be substituted. The supplier should highlight these to operators so that they can include this information in their justification for the continued use of the product.

Appendix D: Noble Energy Inc. Global Environmental, Health & Safety Management System Elements

GMS

Global Environmental, Health and Safety Management System

A consistent framework for the management of EHS issues is necessary to protect the environment and the health and safety of our employees and communities. Our GMS incorporates legal requirements and best practices under an umbrella framework consisting of 14 elements:

Prepare

1. Management Commitment and Employee Participation
2. Legal Aspects and Document Control
3. Safe Work and Operating Practices
4. Process Safety and Environmental Information
5. Emergency Preparedness and Community Awareness

Execute

6. Safety and Environmental Training
7. Contractor Safety Management
8. Pre-startup Review
9. Management of Change
10. Risk Assessment and Management

Verify

11. Performance Monitoring and Measuring
12. Incident Reporting, Analysis and Corrective Action
13. Management System Compliance Audit

Perform

14. Operational Integrity and Continual Improvement

Appendix E: Fisheries Statistics Maps

Fisheries statistics for the period 2008 to 2013 have been provided by the Falkland Islands Government (FIG) Department of Natural Resources – Fisheries Department to Noble for the purposes of this ESHIA document. In addition, Vessel Monitoring System (VMS) data have also been provided for the period 2008 to 2012.

Maps for the following species have been produced:

- Southern Blue Whiting (*Micromesistius australis*) (Figure E.1);
- Grenadiers (*Macrouridae*) (Figure E.2);
- Hake (*Merluccius sp.*) (Figure E.3);
- Hoki (*Macruronus magellanicus*) (Figure E.4);
- Rays (*Rajidae*) (Figure E.5);
- Red Cod (*Salilota australis*) (Figure E.6);
- Rock Cod (*Patagonotothen ramsayi*) (Figure E.7);
- Patagonian Toothfish (*Dissostichus eleginoides*) (Figure E.8);
- Kingclip (*Genypterus blacodes*) (Figure E.9);
- Argentine shortfin squid (*Illex argentinus*) (Figure E.10);
- Patagonian Squid (*Doryteuthis gahi*) (Figure E.11);
- Other species (Figure E.12).

Maps for the following VMS positions have been produced:

- VMS Positions for 2008 (Figure E.13);
- VMS Positions for 2009 (Figure E.14);
- VMS Positions for 2010 (Figure E.15);
- VMS Positions for 2011 (Figure E.16);
- VMS Positions for 2012 (Figure E.17);
- VMS Positions – All years and all months (Figure E.18).

The data have been plotted quarterly for each year for both species and VMS position.

Maps of fisheries effort have also been produced:

- Fishing Effort, 2008 (Figure E.19);
- Fishing Effort, 2009 (Figure E.20);
- Fishing Effort, 2010 (Figure E.21);
- Fishing Effort, 2011 (Figure E.22);
- Fishing Effort, 2012 (Figure E.23).

The fisheries catch statistics maps should be used with caution. As the catch maps do not take into account the level of fishing effort, it is important to remember that patterns between areas could be due to differential fishing effort, as levels of fishing effort are highly likely to vary seasonally.

Figure E.1a: Fisheries catch mass (tonnes) for Southern Blue Whiting (Micromesistius australis) for the year 2008 (FIG Department of Natural Resources – Fisheries Department, 2014)

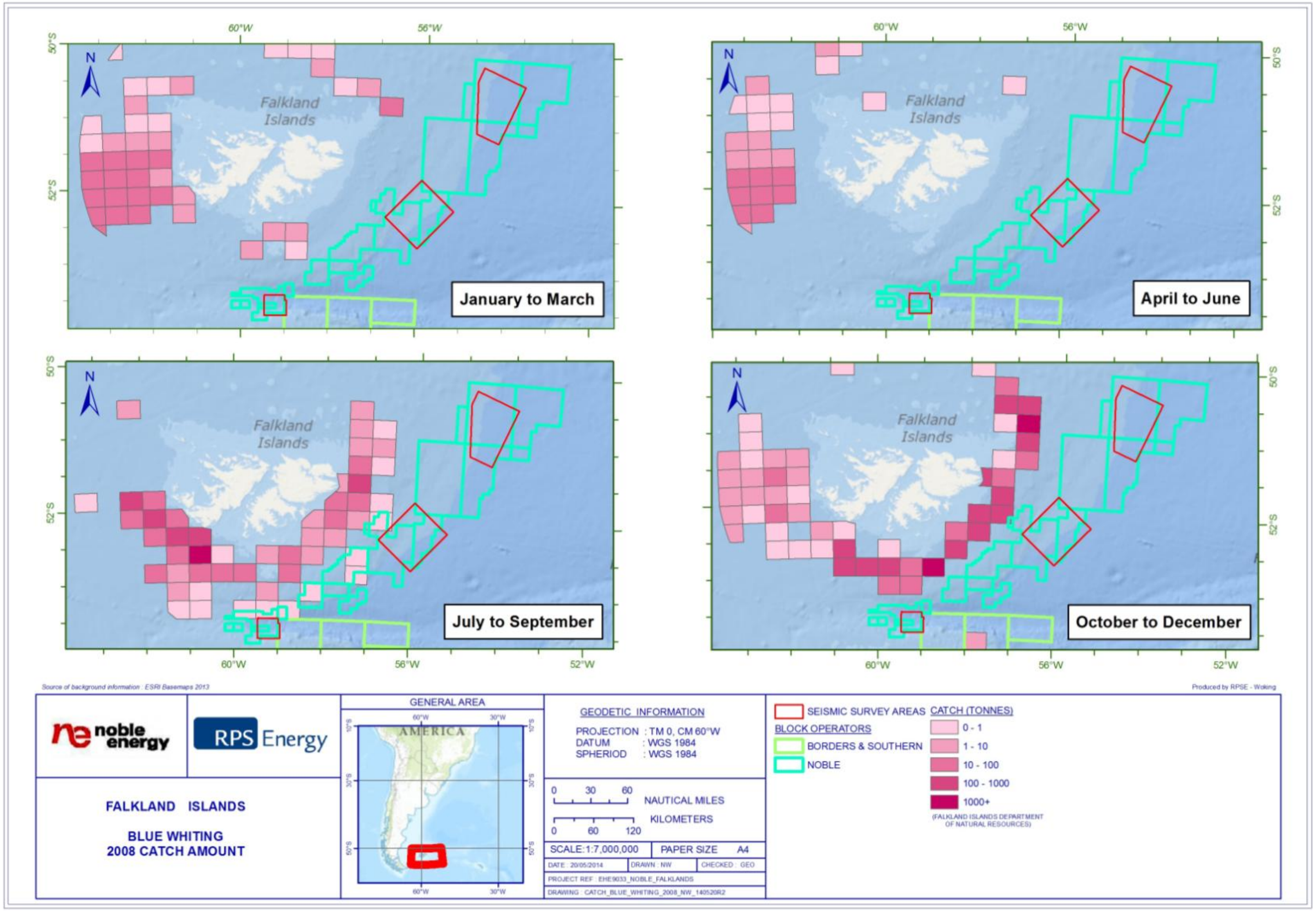


Figure E.1b: Fisheries catch mass (tonnes) for Southern Blue Whiting (Micromesistius australis) for the year 2009 (FIG Department of Natural Resources – Fisheries Department, 2014)

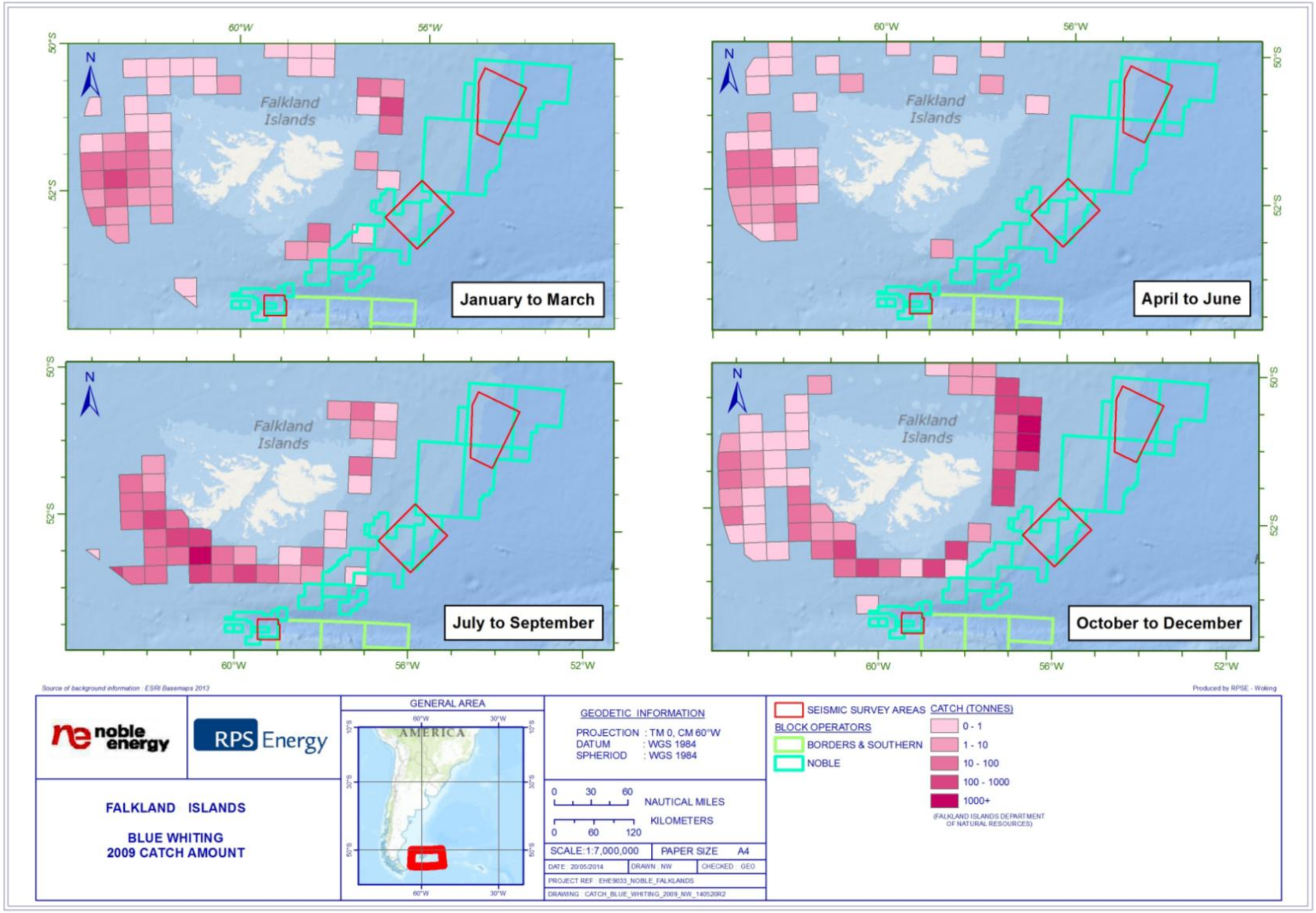


Figure E.1c: Fisheries catch mass (tonnes) for Southern Blue Whiting (Micromesistius australis) for the year 2010 (FIG Department of Natural Resources – Fisheries Department, 2014)

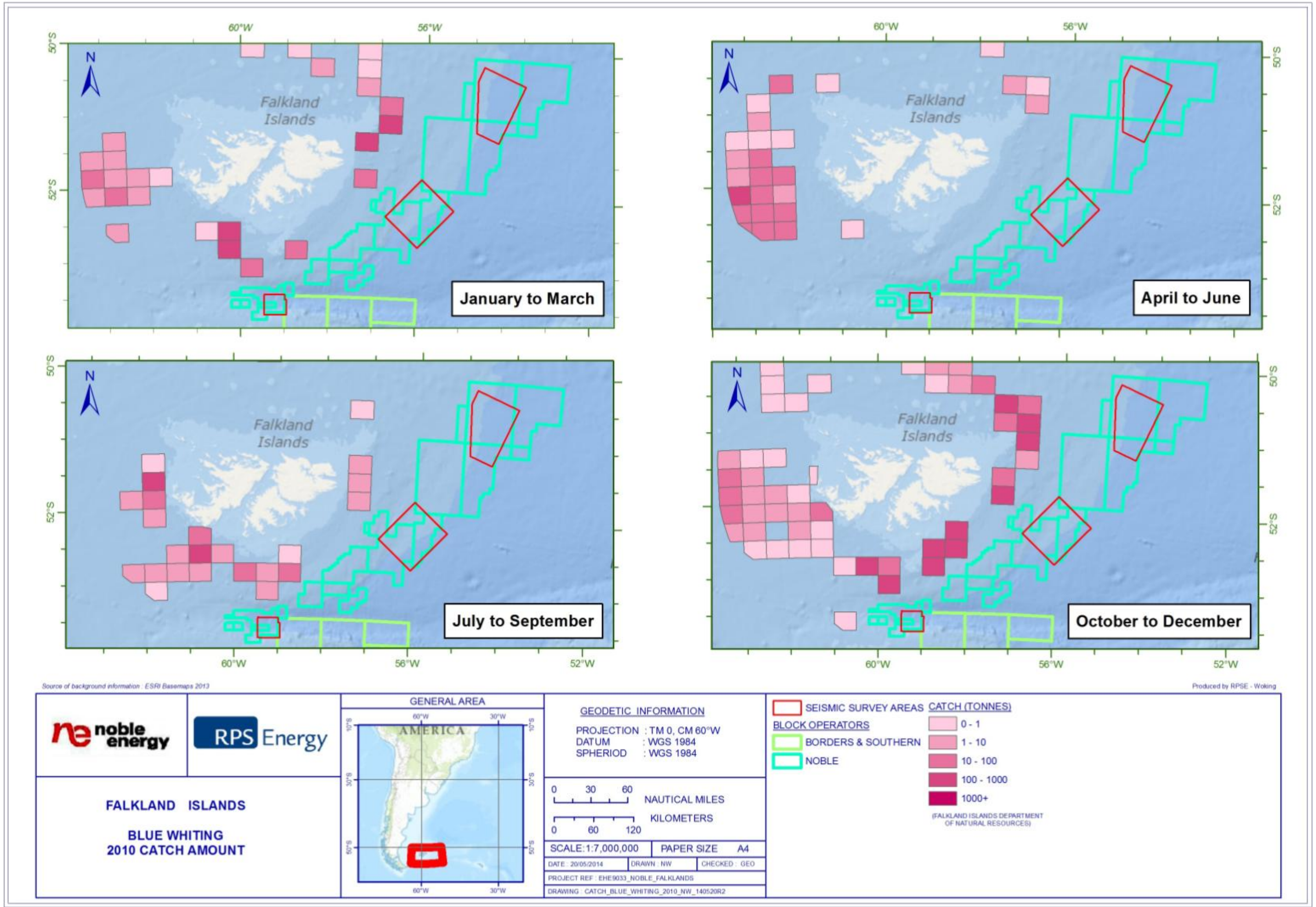


Figure E.1d: Fisheries catch mass (tonnes) for Southern Blue Whiting (Micromesistius australis) for the year 2011 (FIG Department of Natural Resources – Fisheries Department, 2014)

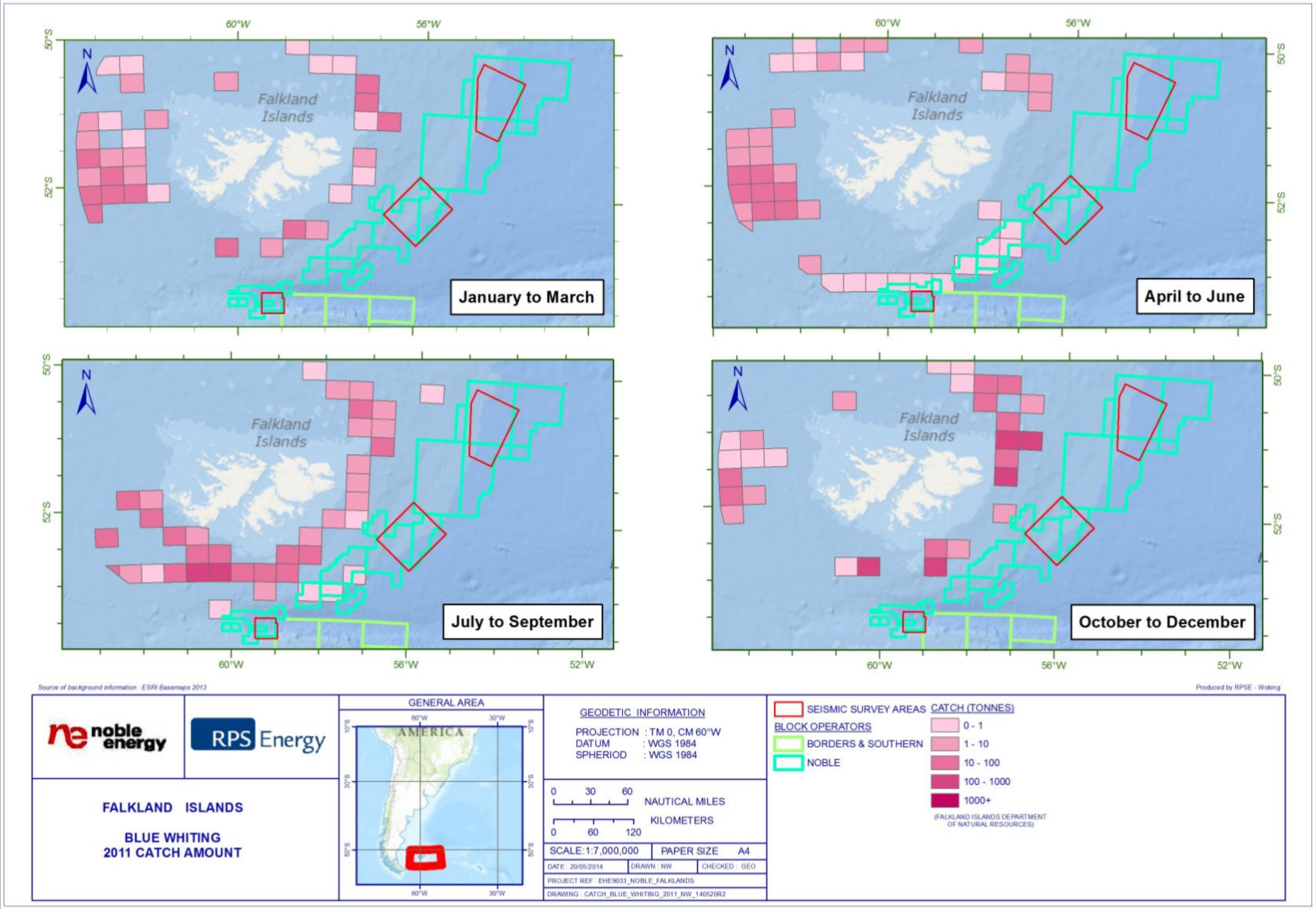


Figure E.1e: Fisheries catch mass (tonnes) for Southern Blue Whiting (Micromesistius australis) for the year 2012 (FIG Department of Natural Resources – Fisheries Department, 2014)

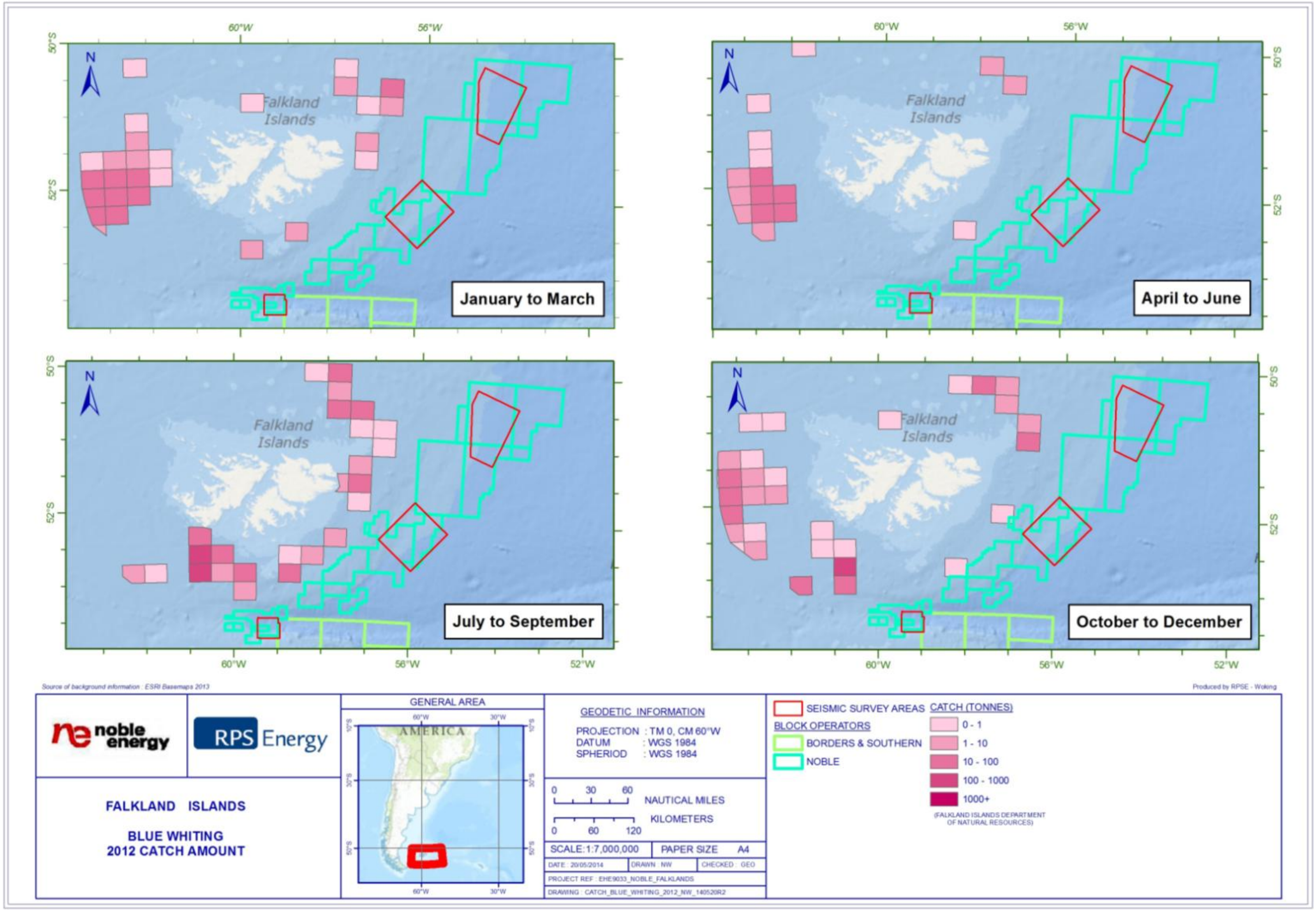


Figure E.1f: Fisheries catch mass (tonnes) for Southern Blue Whiting (Micromesistius australis) for the year 2013 (FIG Department of Natural Resources – Fisheries Department, 2014)

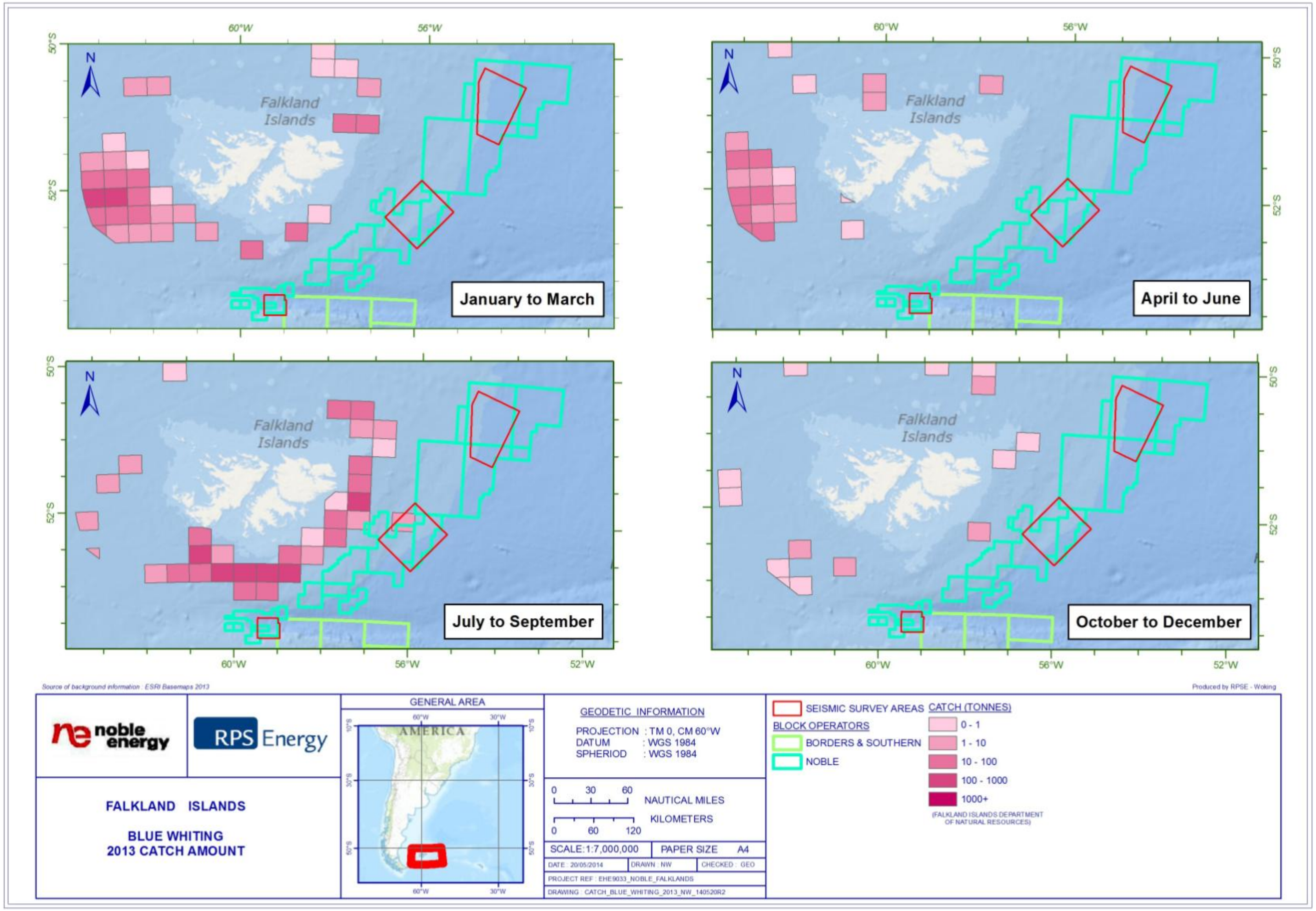


Figure E.2a: Fisheries catch mass (tonnes) for Grenadiers (Macrouridae) for the year 2008 (FIG Department of Natural Resources – Fisheries Department, 2014)

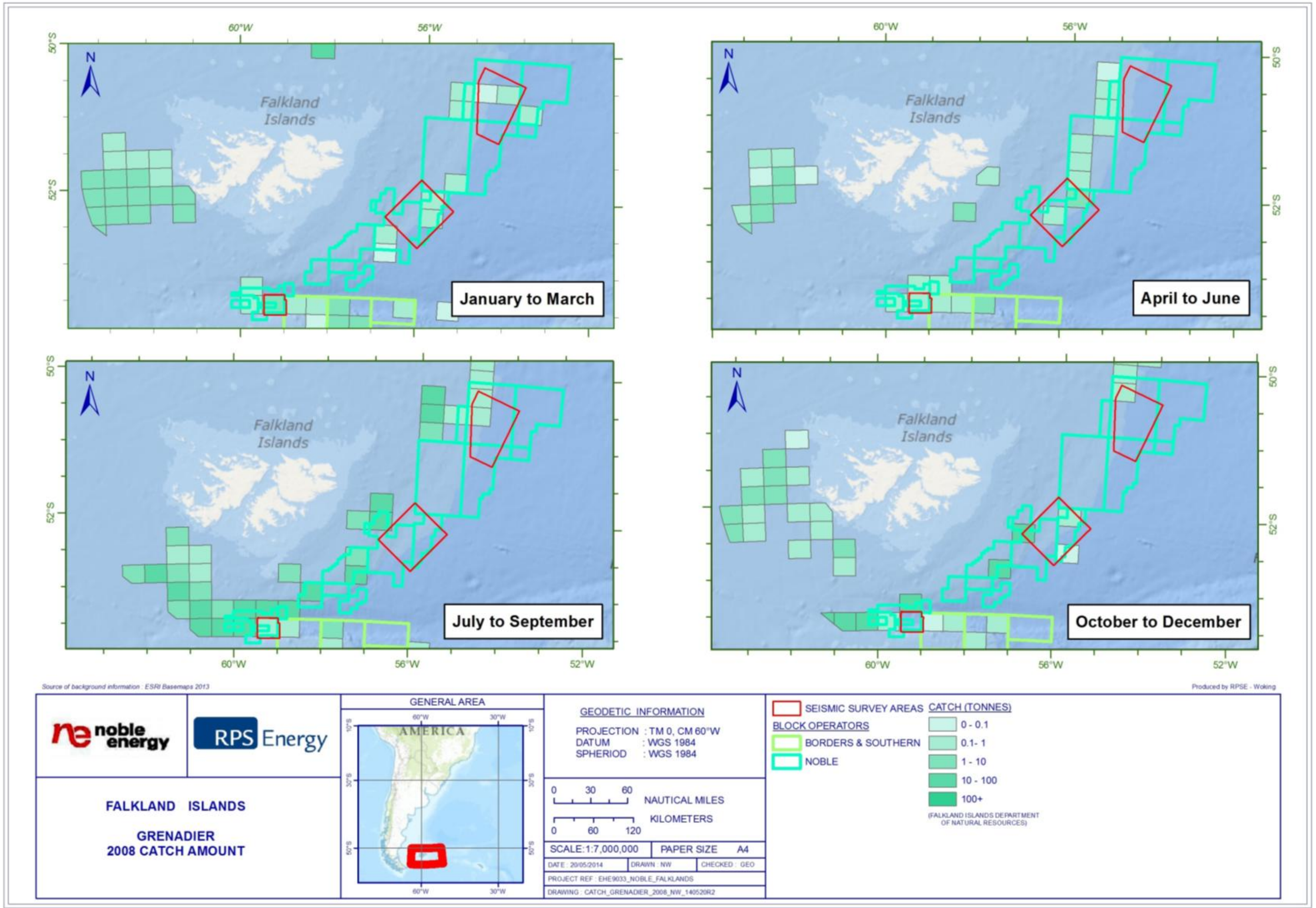


Figure E.2b: Fisheries catch mass (tonnes) for Grenadiers (Macrouridae) for the year 2009 (FIG Department of Natural Resources – Fisheries Department, 2014)

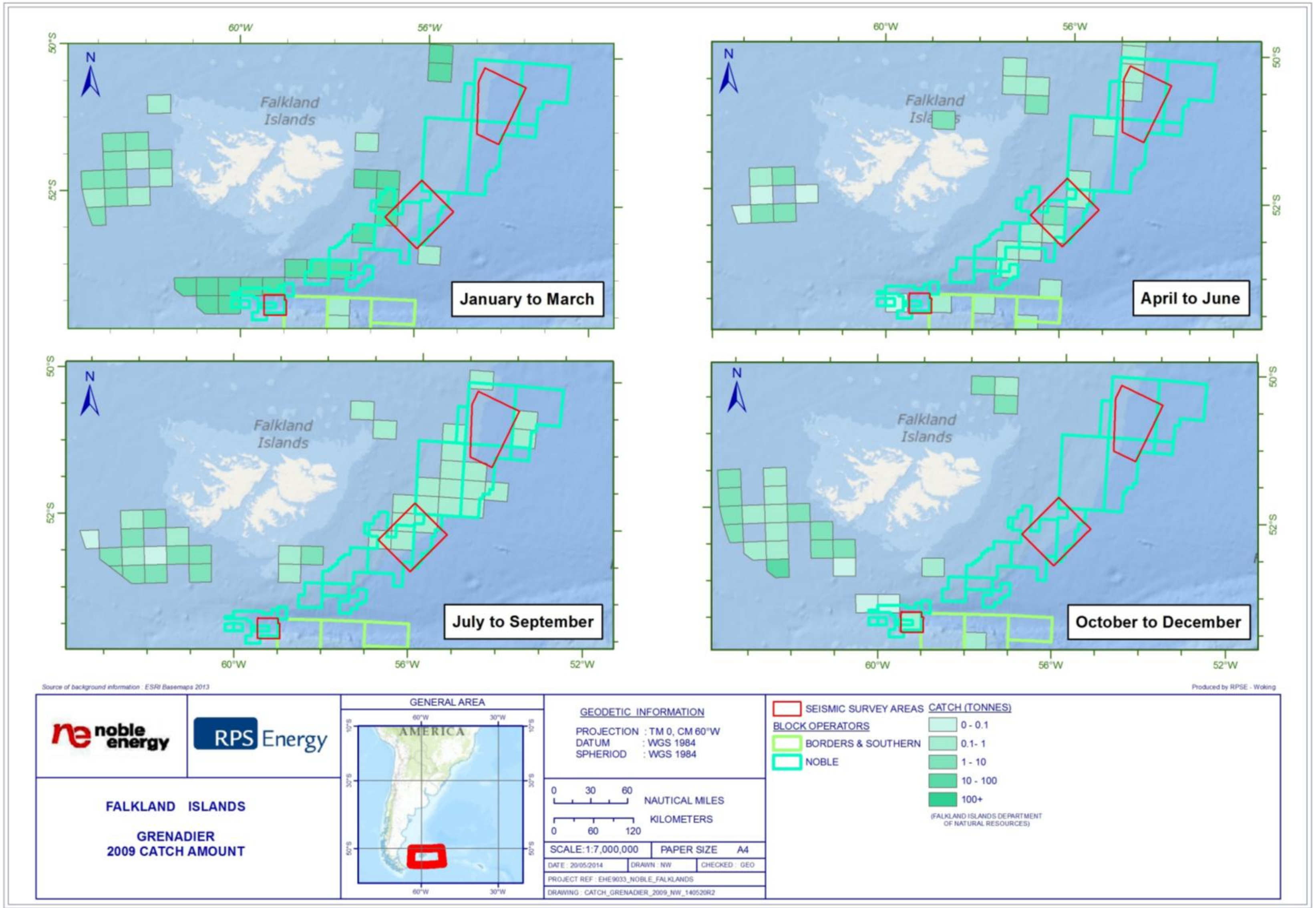


Figure E.2c: Fisheries catch mass (tonnes) for Grenadiers (Macrouridae) for the year 2010 (FIG Department of Natural Resources – Fisheries Department, 2014)

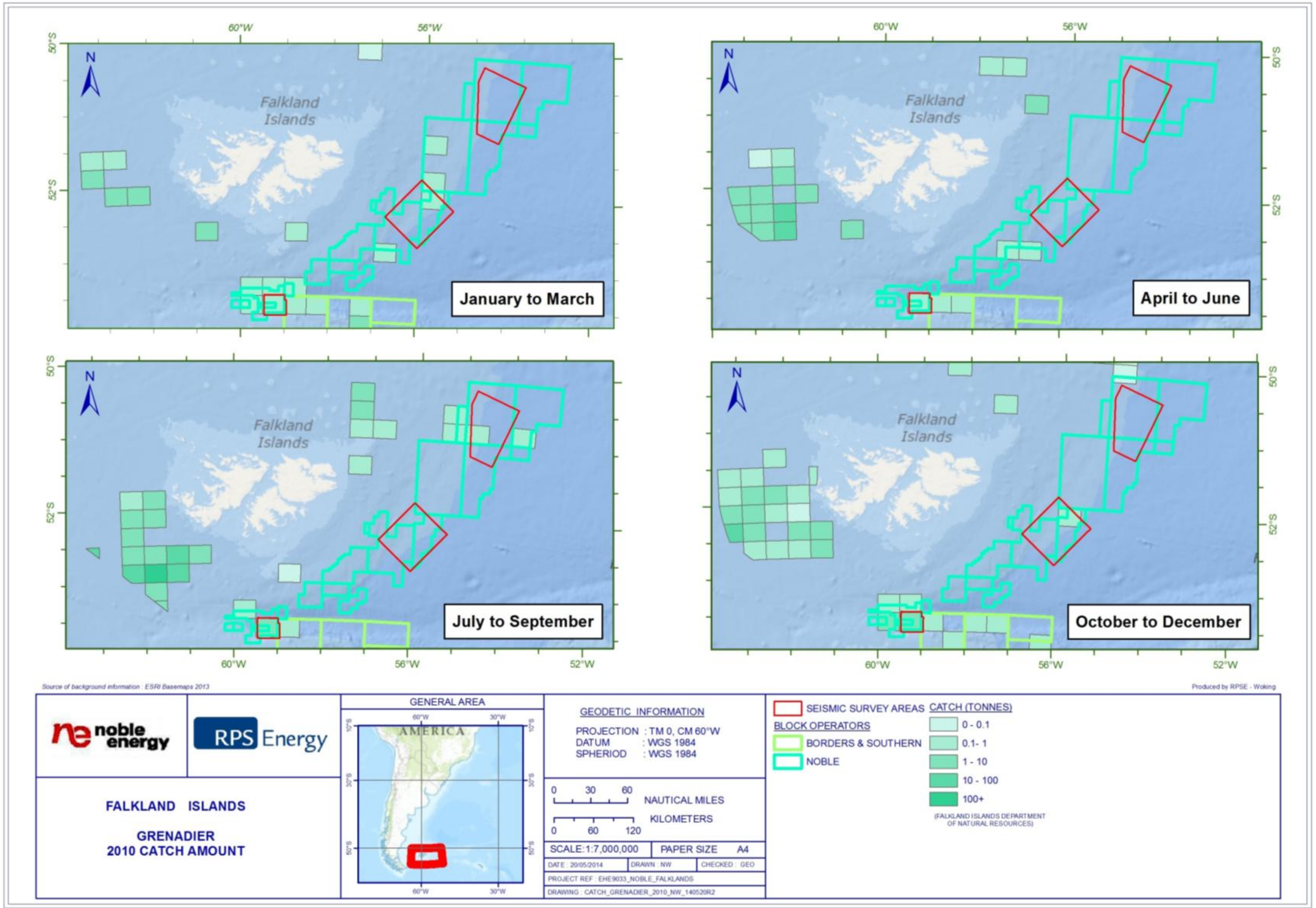


Figure E.2d: Fisheries catch mass (tonnes) for Grenadiers (Macrouridae) for the year 2011 (FIG Department of Natural Resources – Fisheries Department, 2014)

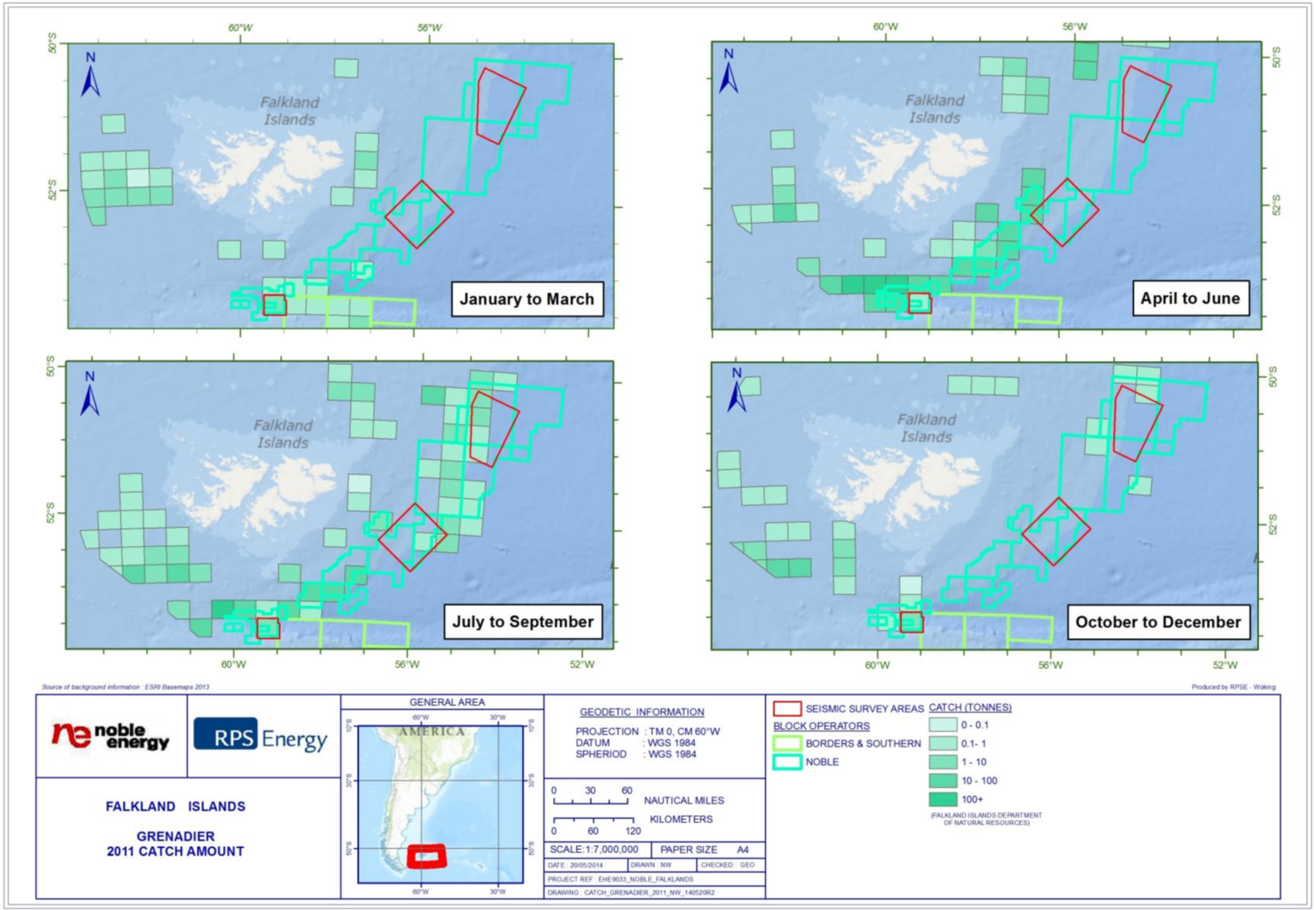


Figure E.2e: Fisheries catch mass (tonnes) for Grenadiers (Macrouridae) for the year 2012 (FIG Department of Natural Resources – Fisheries Department, 2014)

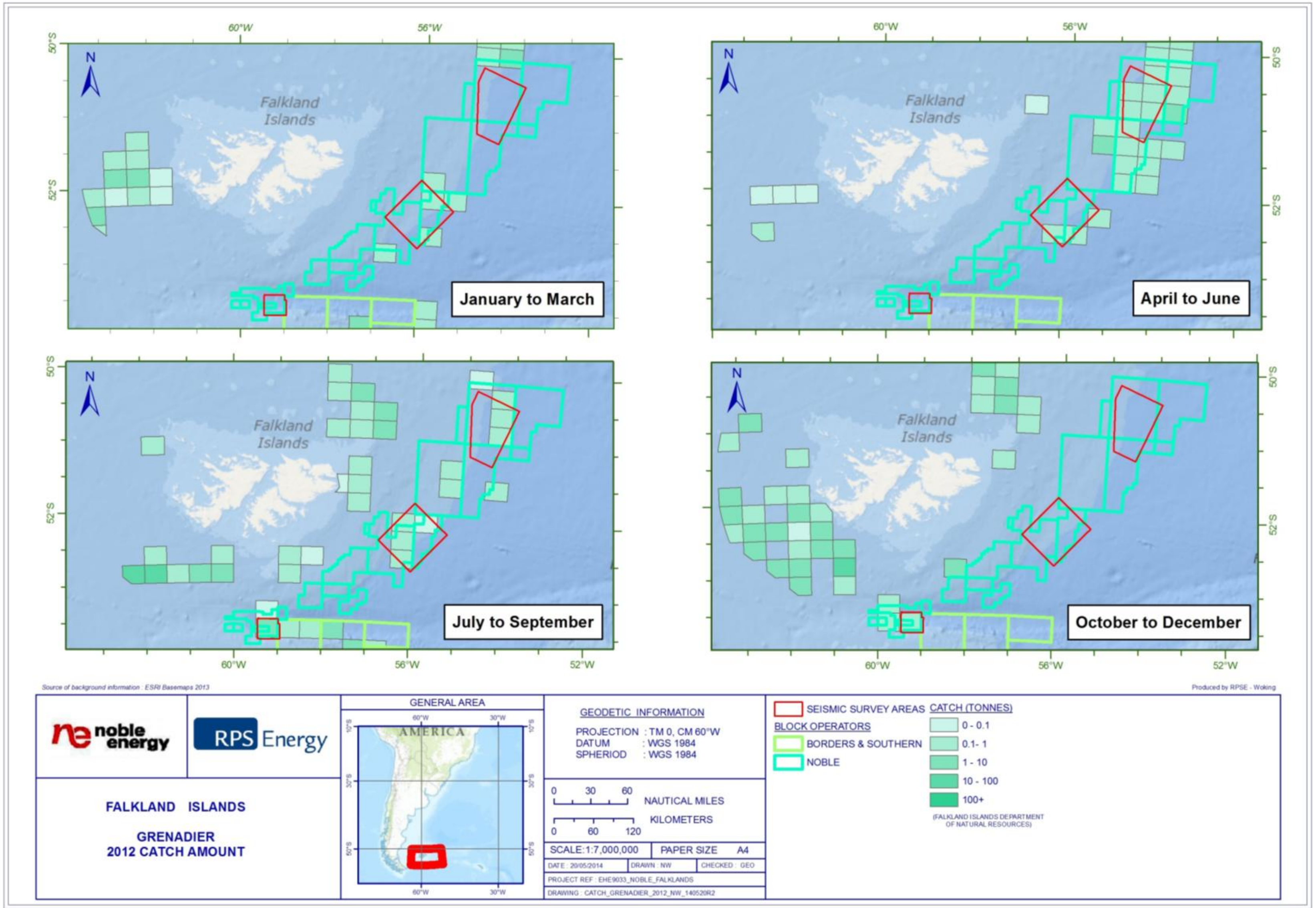


Figure E.2f: Fisheries catch mass (tonnes) for Grenadiers (Macrouridae) for the year 2013 (FIG Department of Natural Resources – Fisheries Department, 2014)

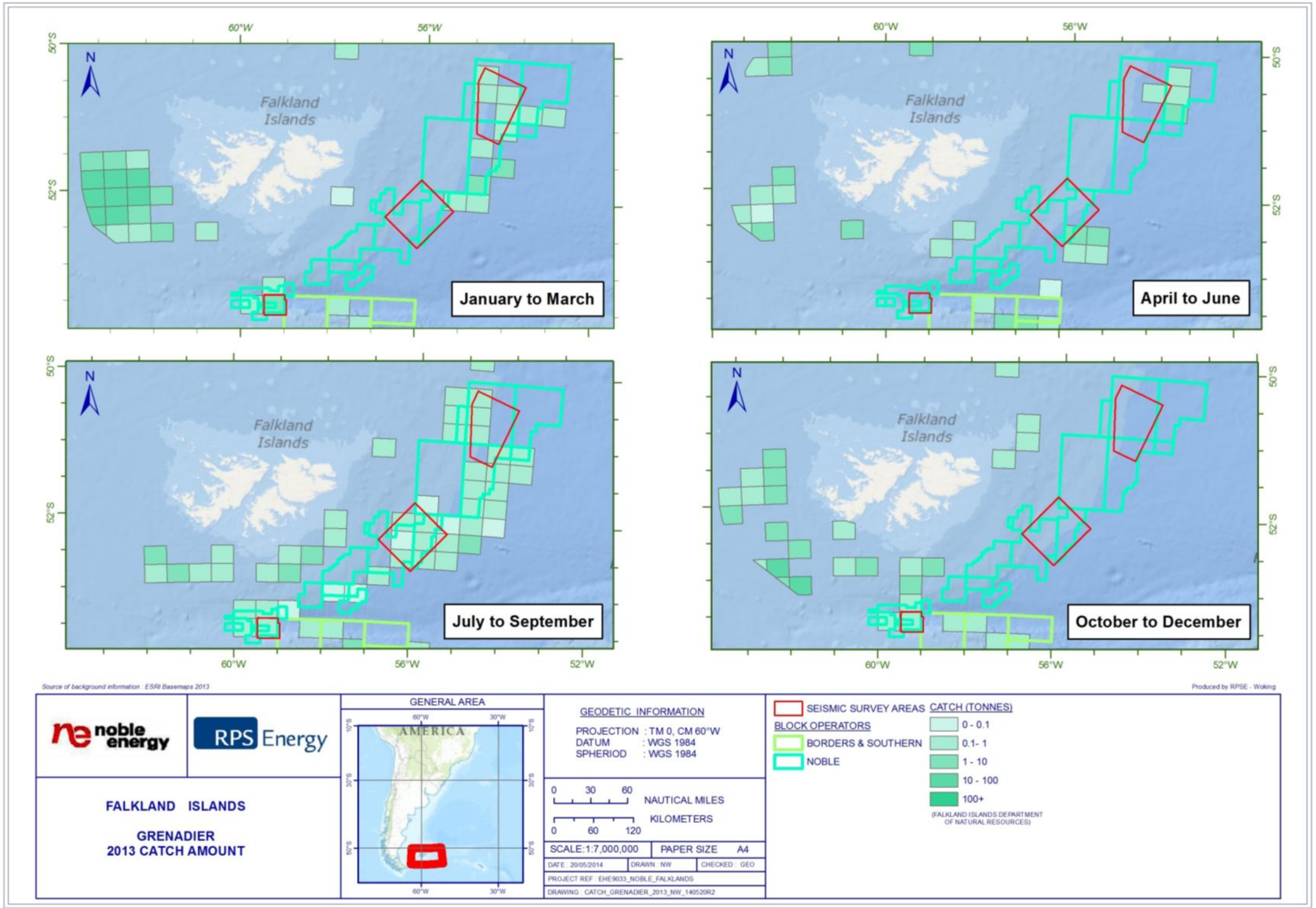


Figure E.3a: Fisheries catch mass (tonnes) for Hake (Merluccius sp.) for the year 2008 (FIG Department of Natural Resources – Fisheries Department, 2014)

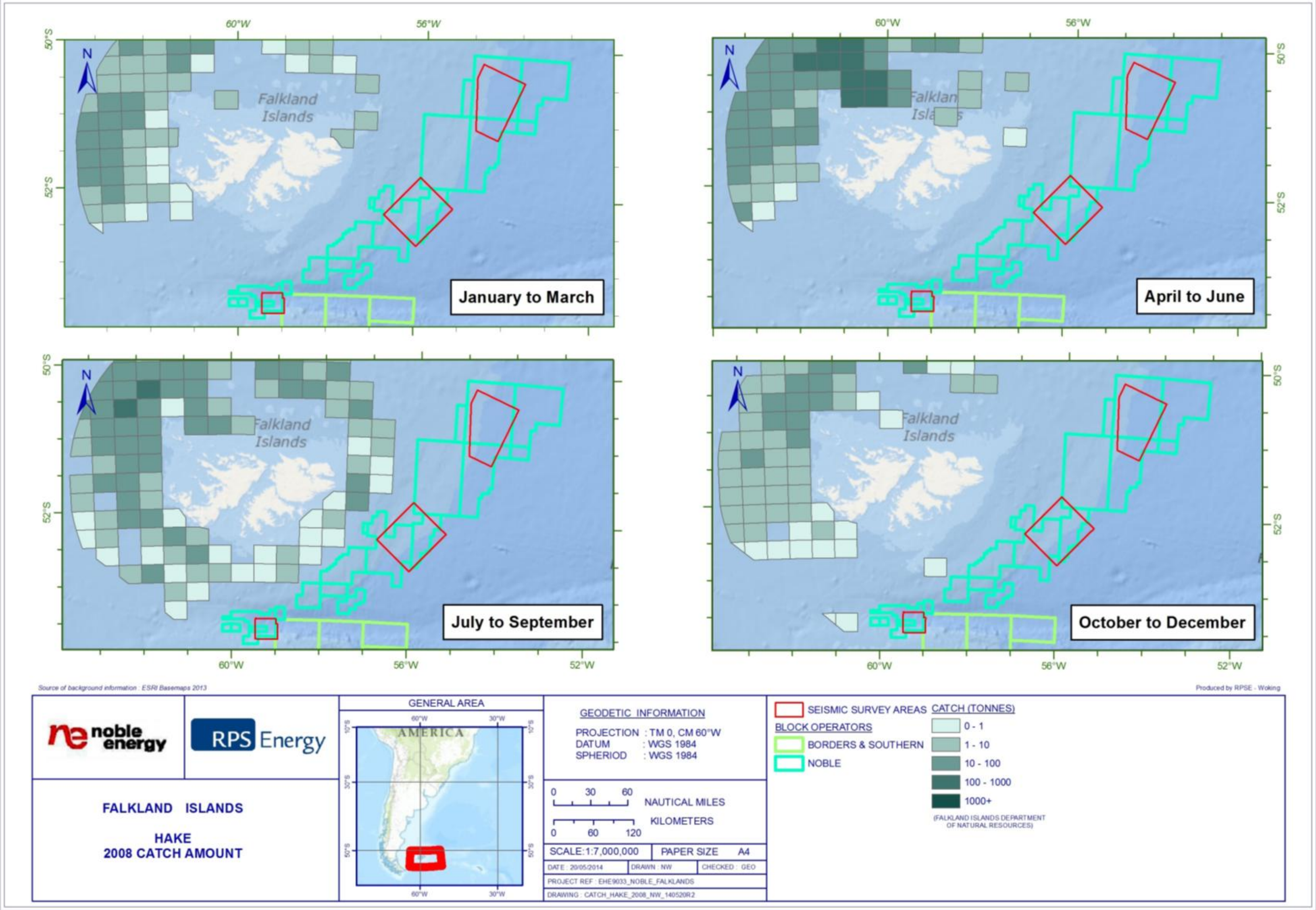


Figure E.3b: Fisheries catch mass (tonnes) for Hake (Merluccius sp.) for the year 2009 (FIG Department of Natural Resources – Fisheries Department, 2014)

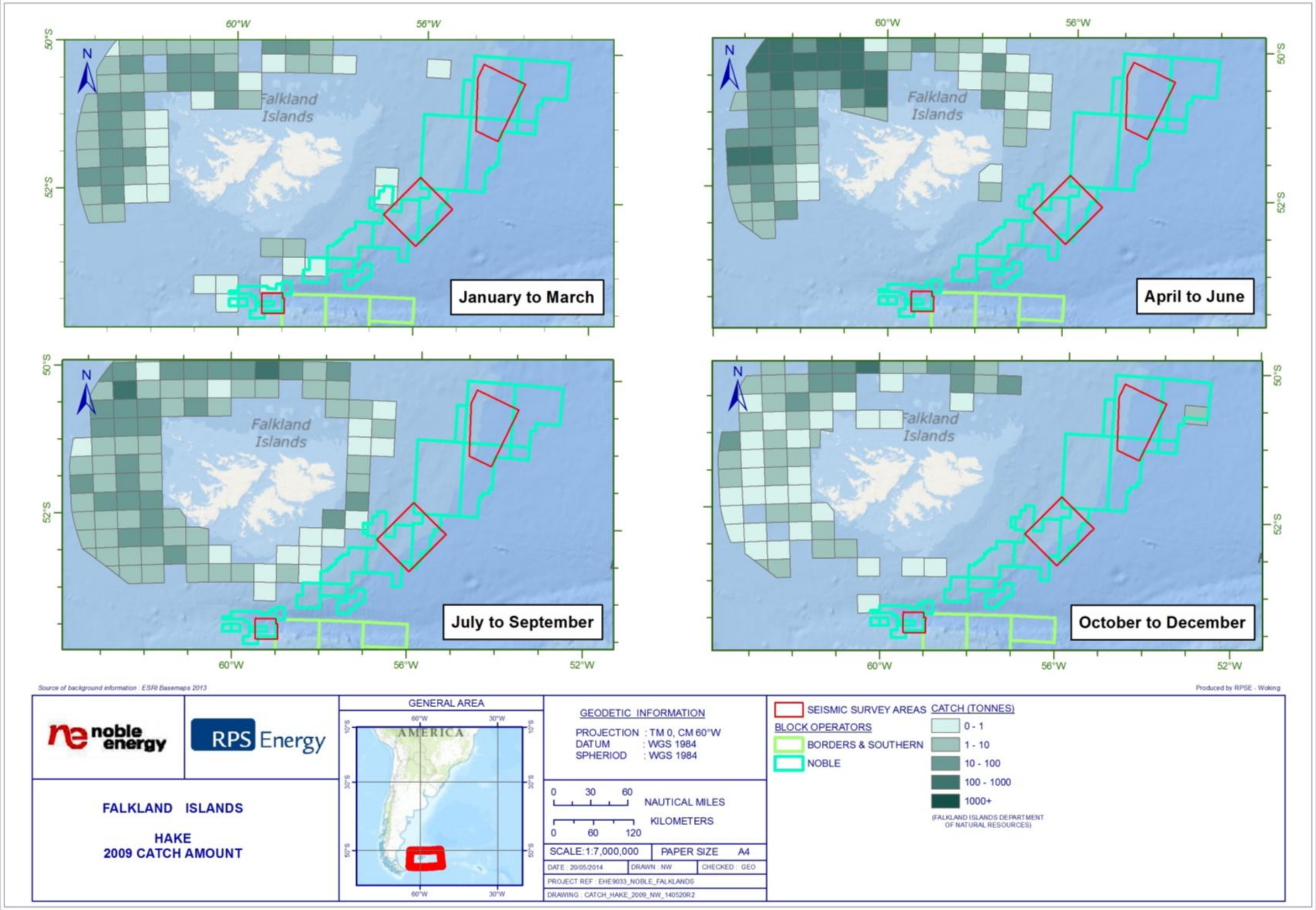


Figure E.3c: Fisheries catch mass (tonnes) for Hake (Merluccius sp.) for the year 2010 (FIG Department of Natural Resources – Fisheries Department, 2014)

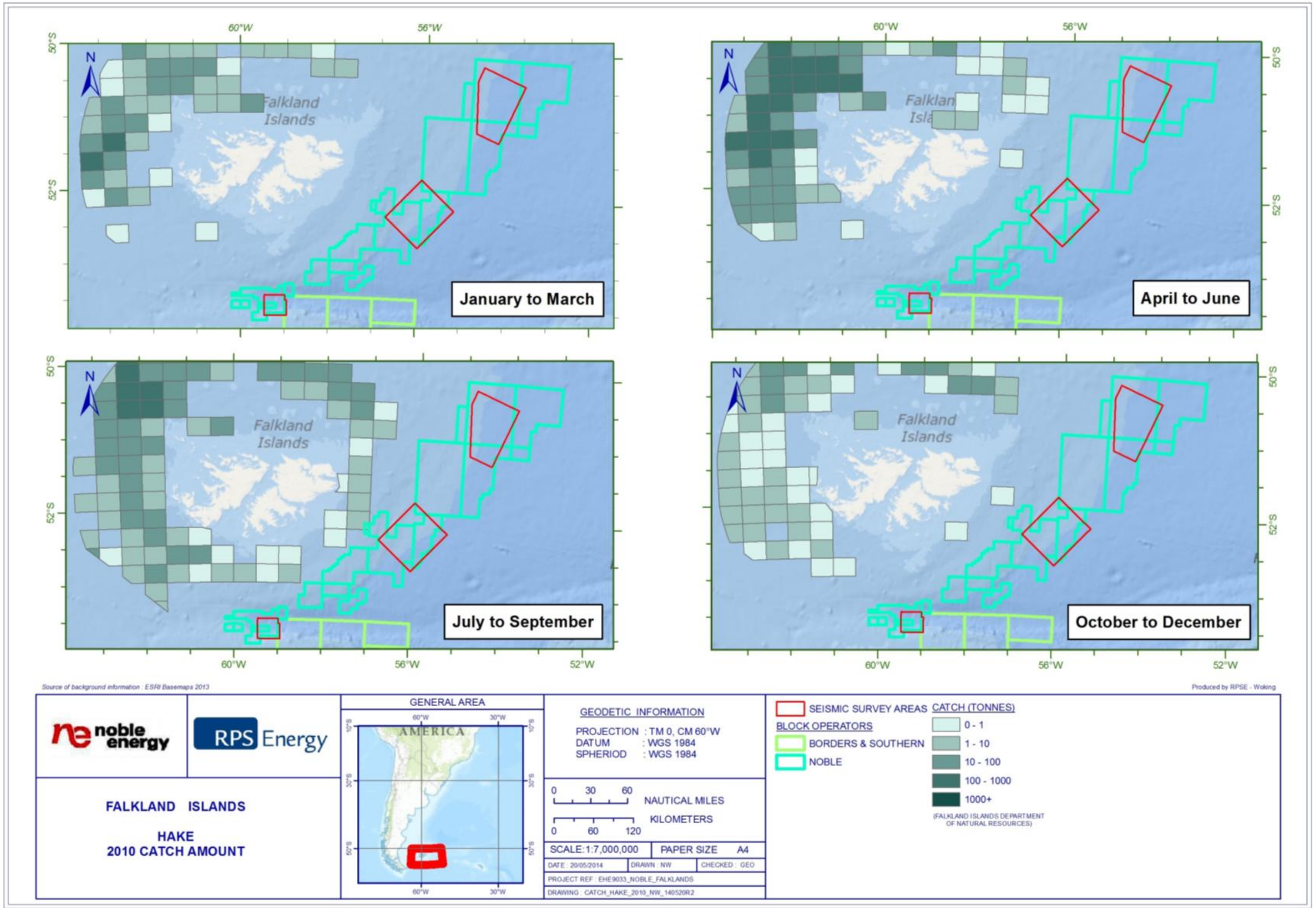


Figure E.3d: Fisheries catch mass (tonnes) for Hake (Merluccius sp.) for the year 2011 (FIG Department of Natural Resources – Fisheries Department, 2014)

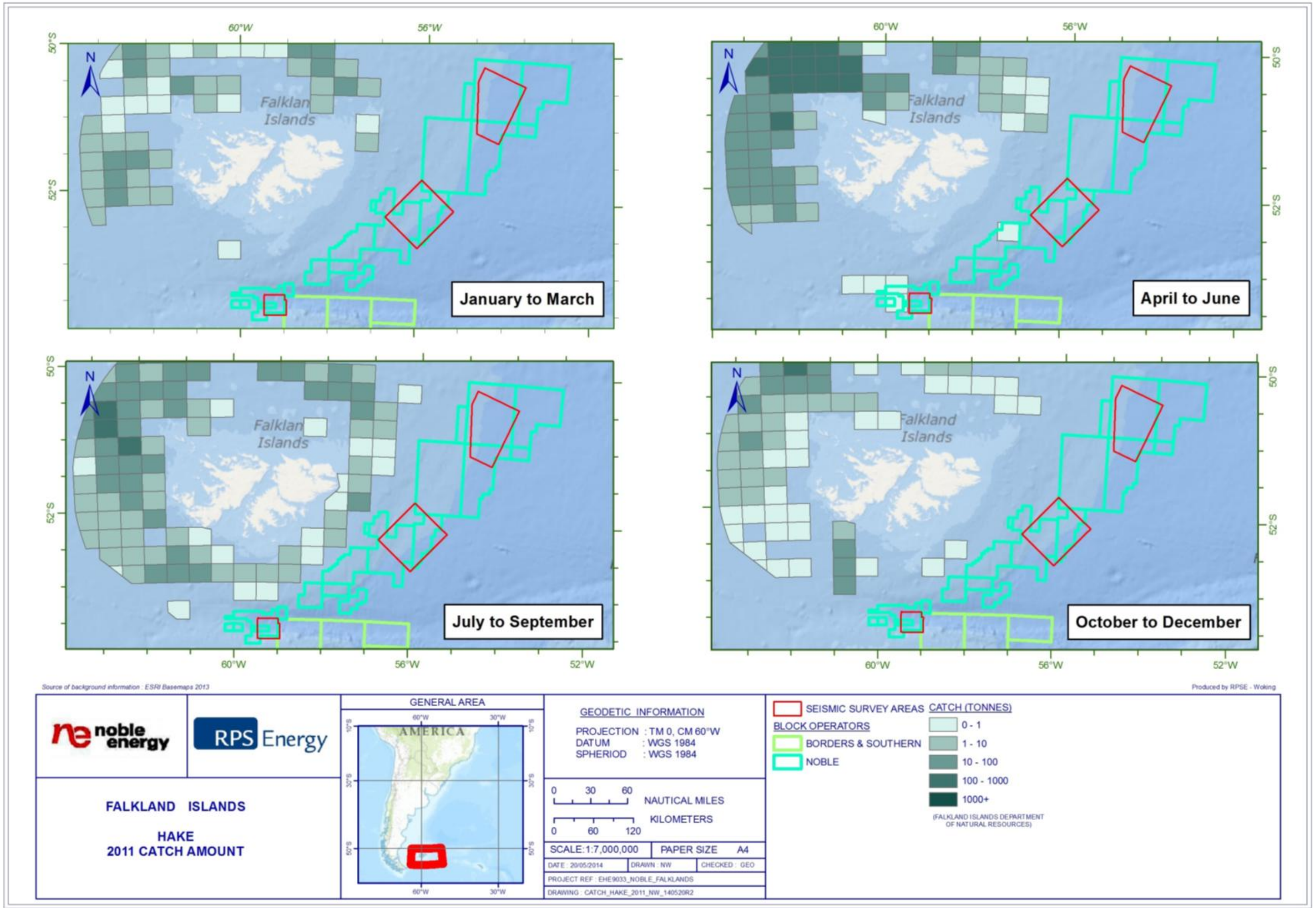


Figure E.3e: Fisheries catch mass (tonnes) for Hake (Merluccius sp.) for the year 2012 (FIG Department of Natural Resources – Fisheries Department, 2014)

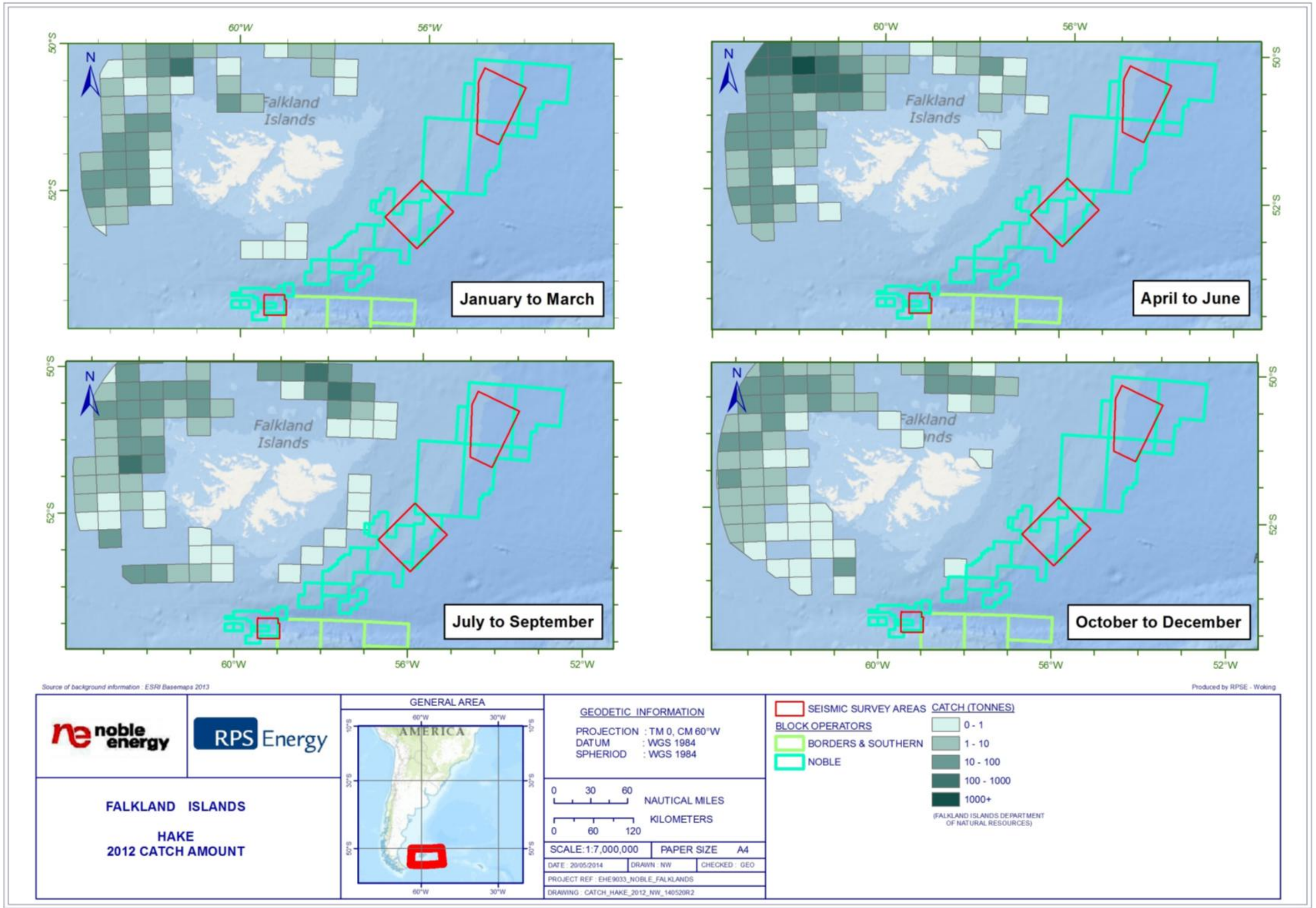


Figure E.3f: Fisheries catch mass (tonnes) for Hake (Merluccius sp.) for the year 2013 (FIG Department of Natural Resources – Fisheries Department, 2014)

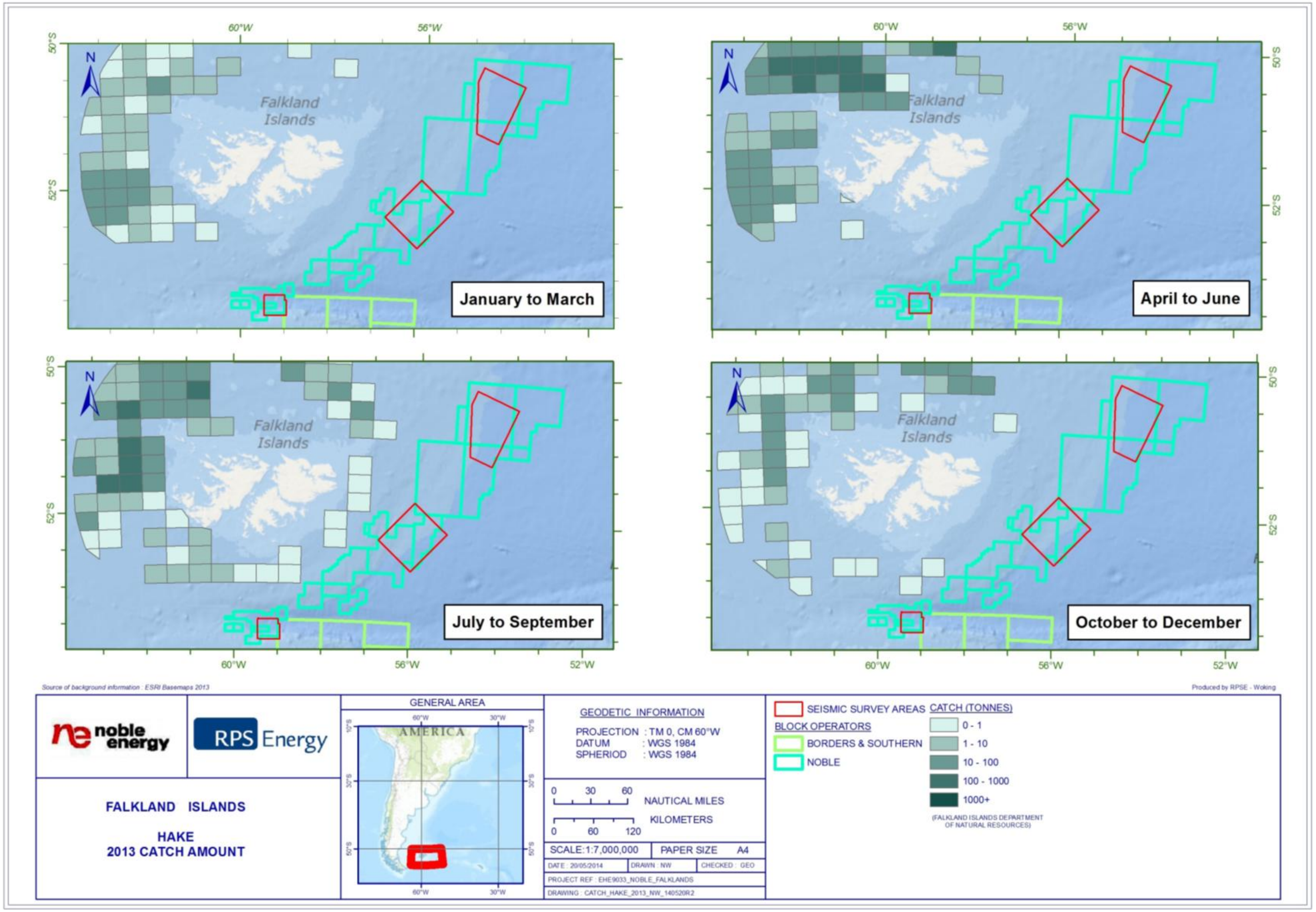


Figure E.4a: Fisheries catch mass (tonnes) for Hoki (Macruronus magellanicus) for the year 2008 (FIG Department of Natural Resources – Fisheries Department, 2014)

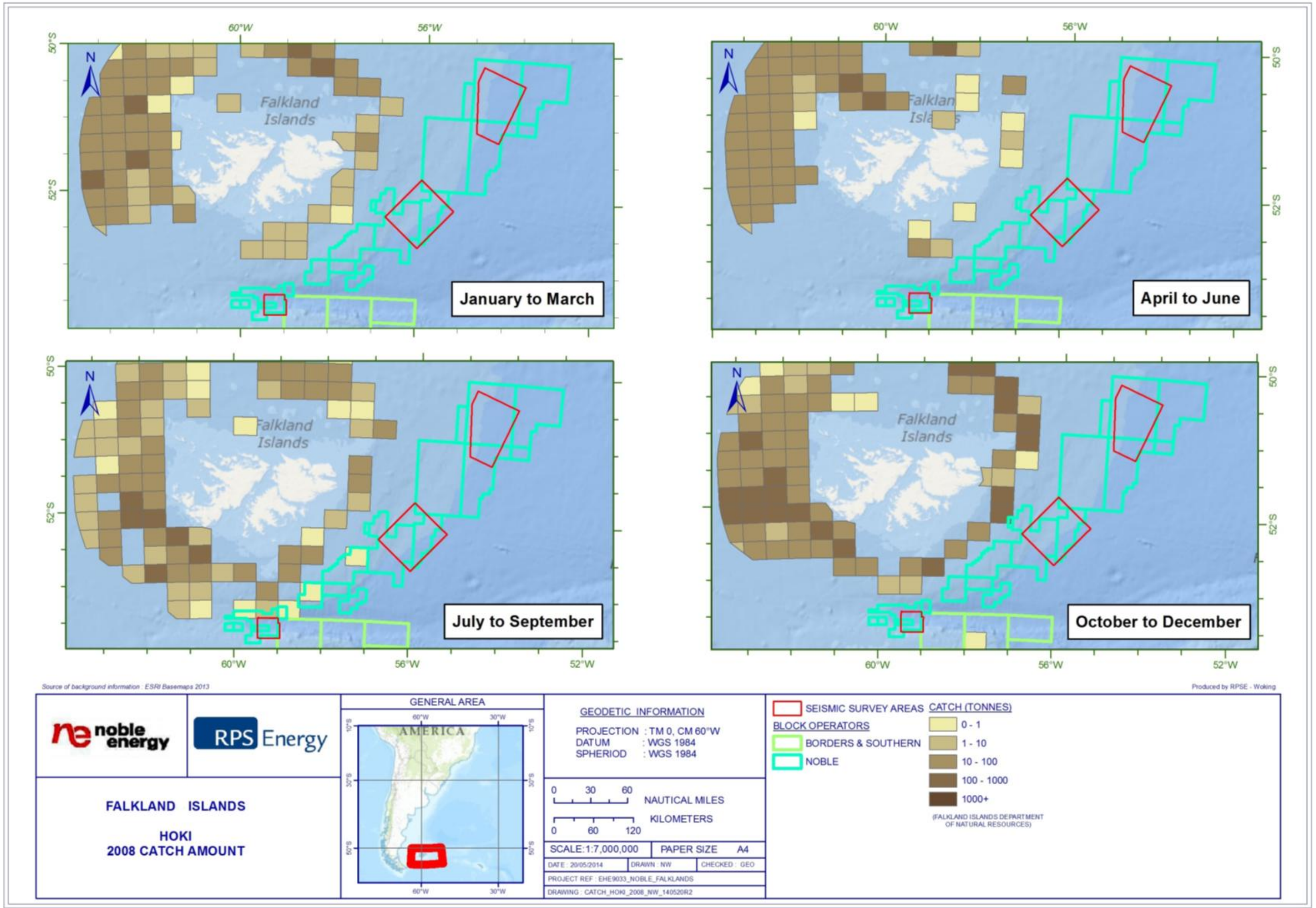


Figure E.4b: Fisheries catch mass (tonnes) for Hoki (Macruronus magellanicus) for the year 2009 (FIG Department of Natural Resources – Fisheries Department, 2014)

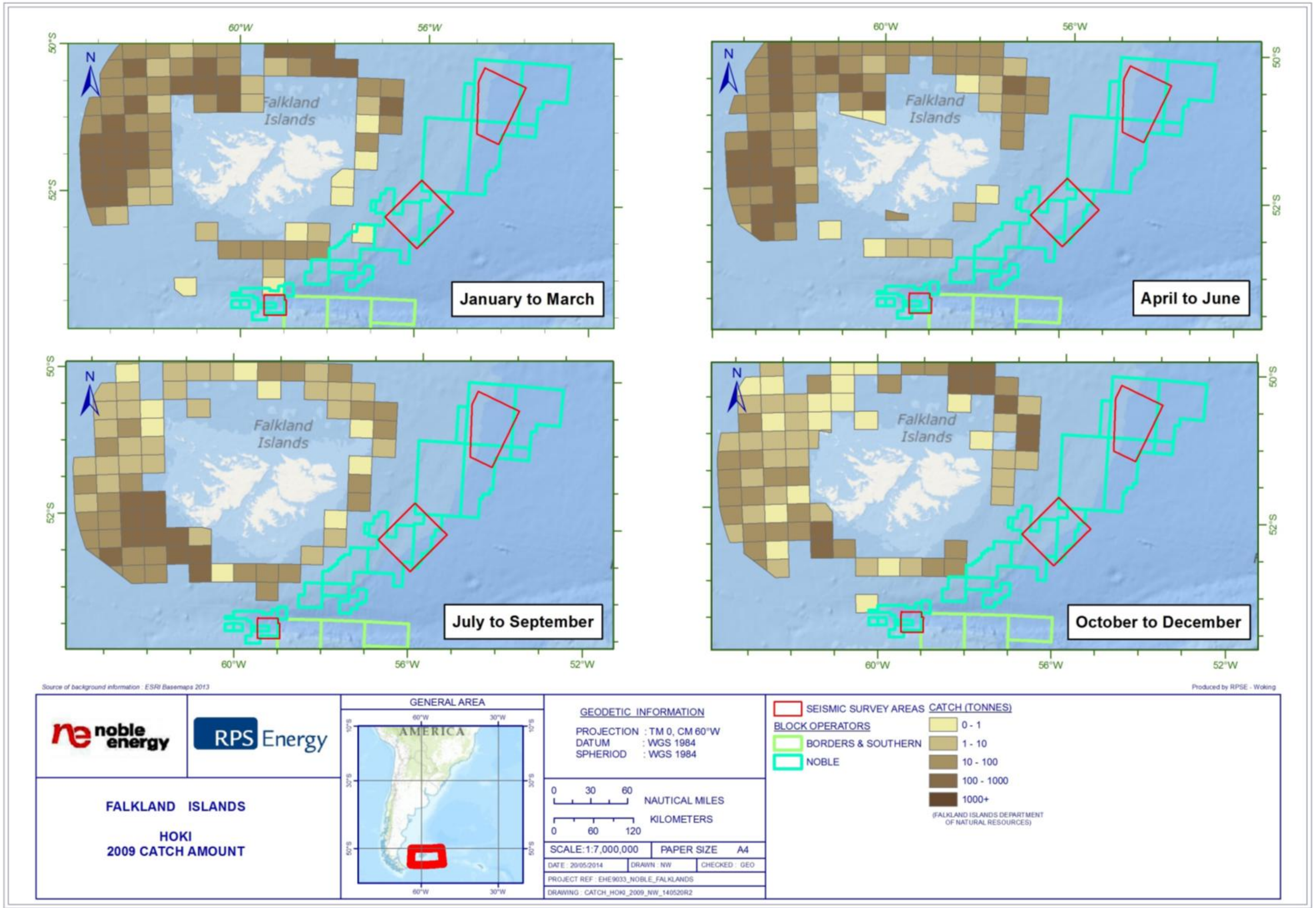


Figure E.4c: Fisheries catch mass (tonnes) for Hoki (Macruronus magellanicus) for the year 2010 (FIG Department of Natural Resources – Fisheries Department, 2014)

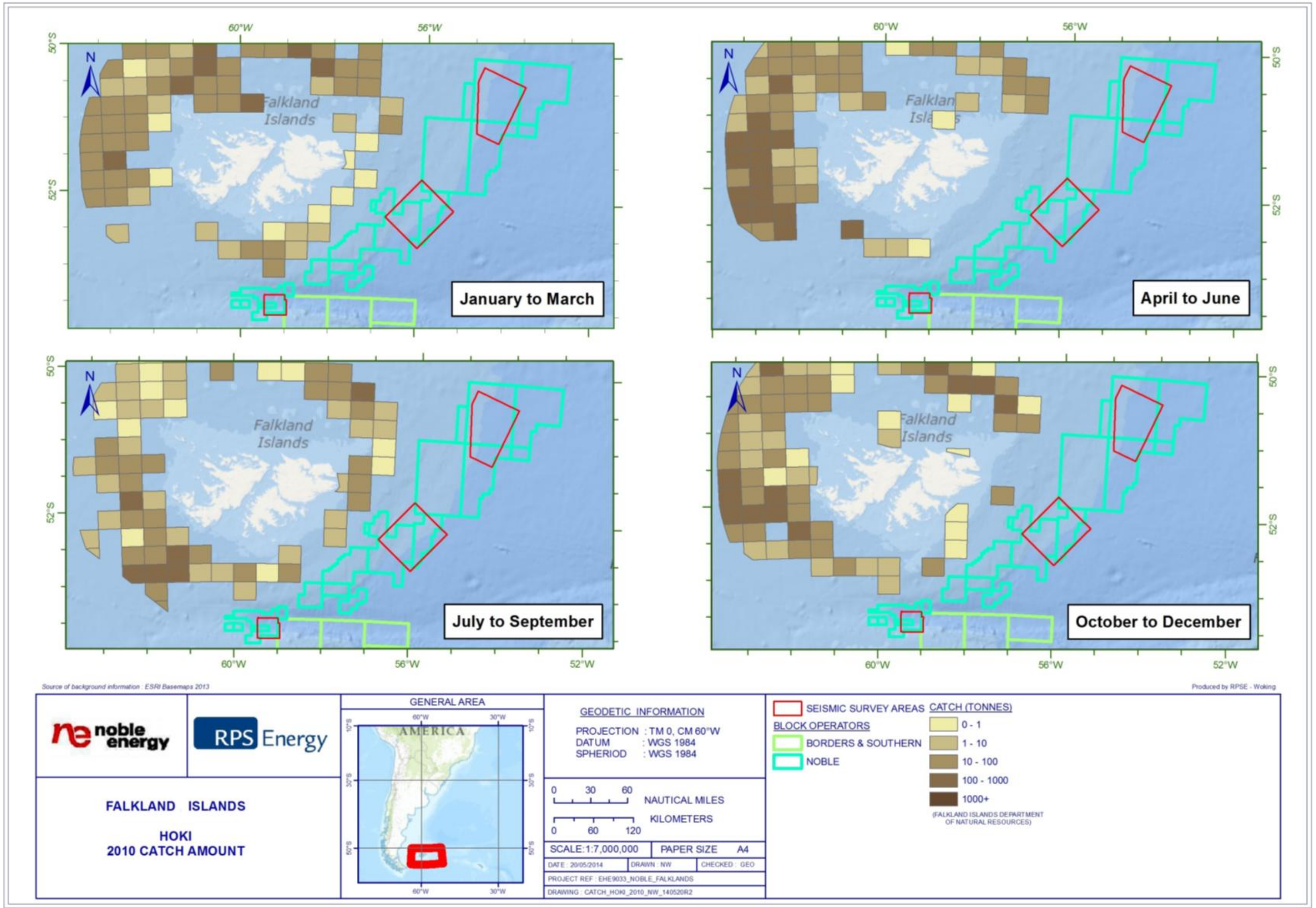


Figure E.4d: Fisheries catch mass (tonnes) for Hoki (Macruronus magellanicus) for the year 2011 (FIG Department of Natural Resources – Fisheries Department, 2014)

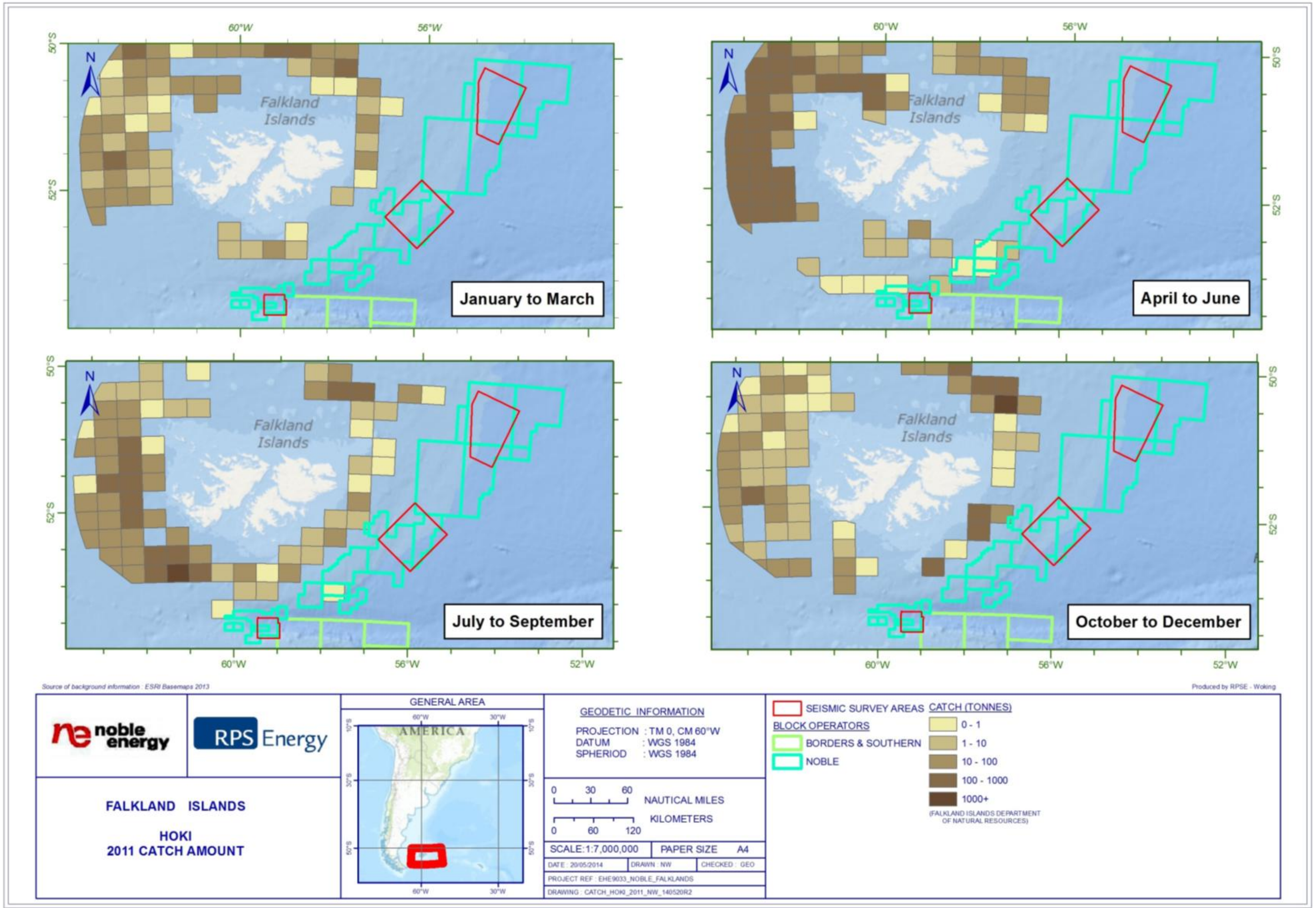


Figure E.4e: Fisheries catch mass (tonnes) for Hoki (Macruronus magellanicus) for the year 2012 (FIG Department of Natural Resources – Fisheries Department, 2014)

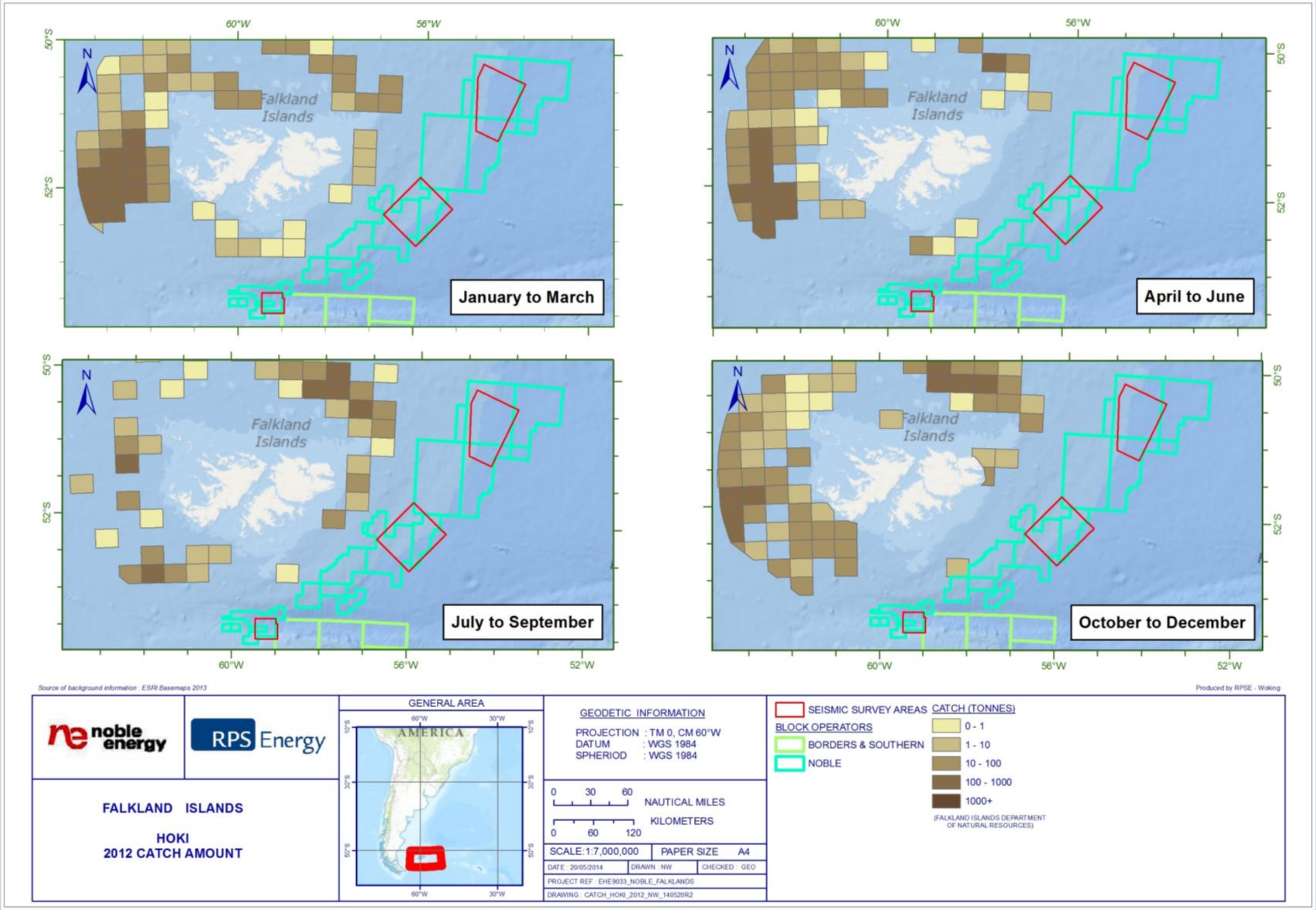


Figure E.4f: Fisheries catch mass (tonnes) for Hoki (Macruronus magellanicus) for the year 2013 (FIG Department of Natural Resources – Fisheries Department, 2014)

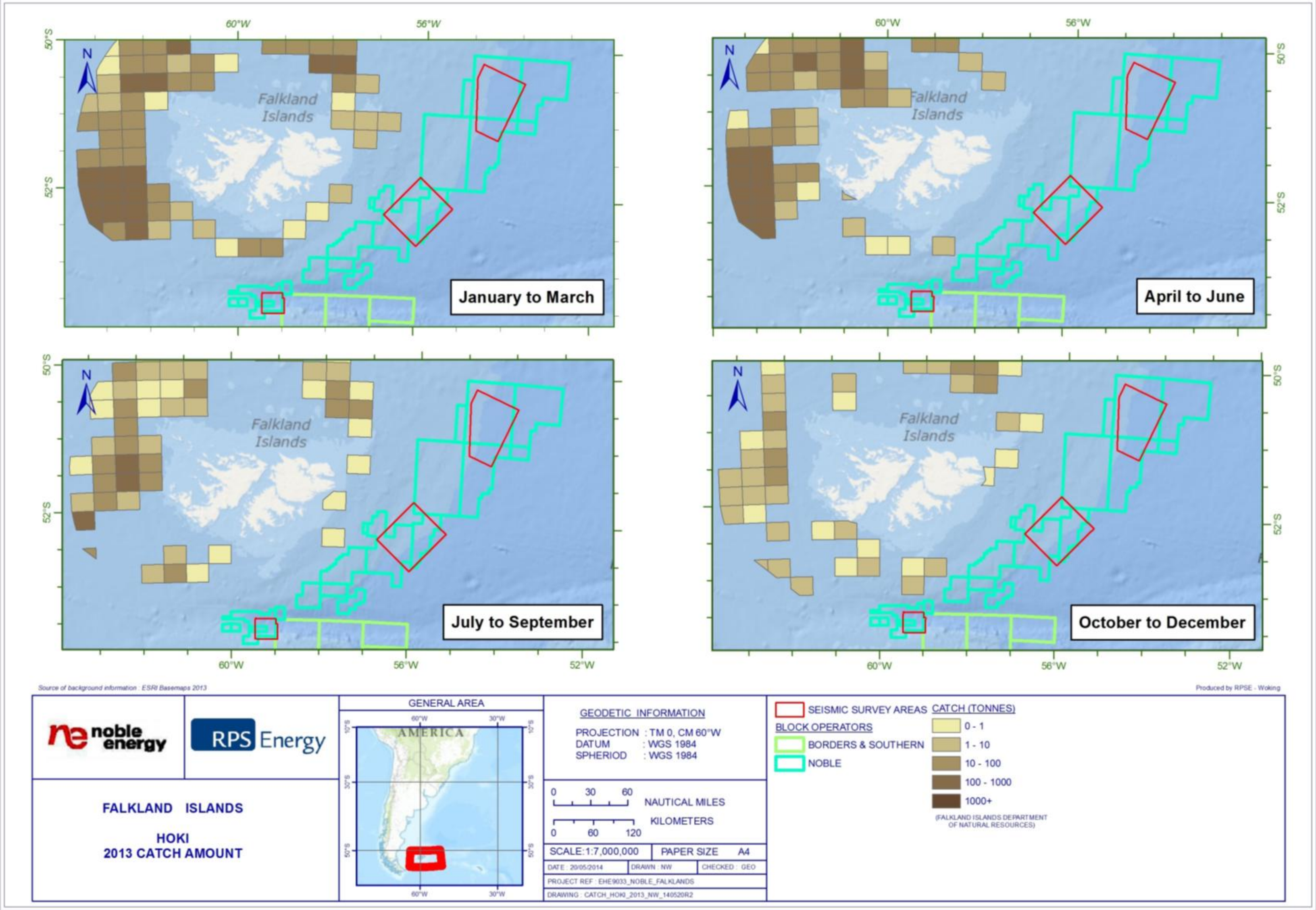


Figure E.5a: Fisheries catch mass (tonnes) for Rays (Rajidae) for the year 2008 (FIG Department of Natural Resources – Fisheries Department, 2014)

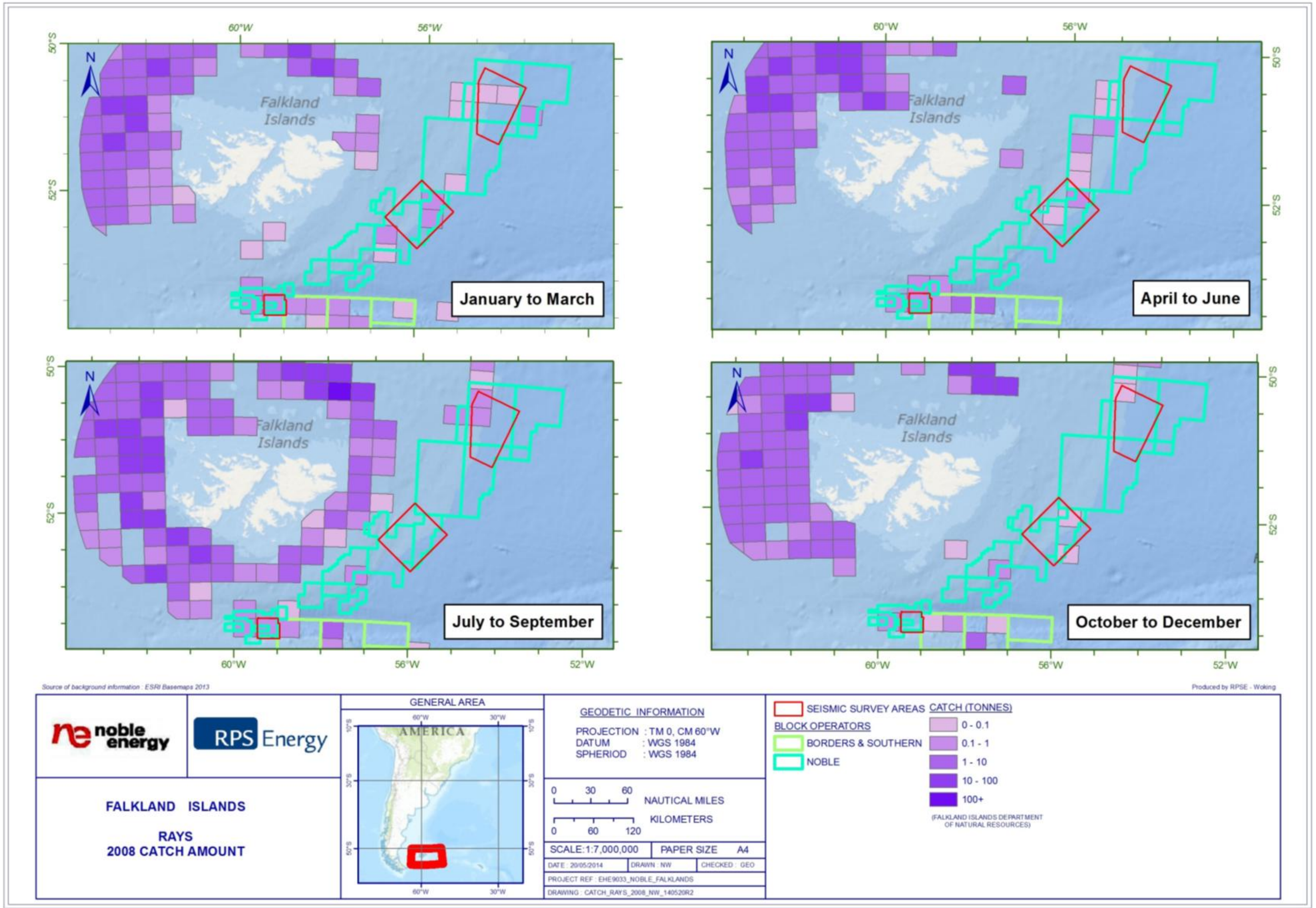


Figure E.5b: Fisheries catch mass (tonnes) for Rays (Rajidae) for the year 2009 (FIG Department of Natural Resources – Fisheries Department, 2014)

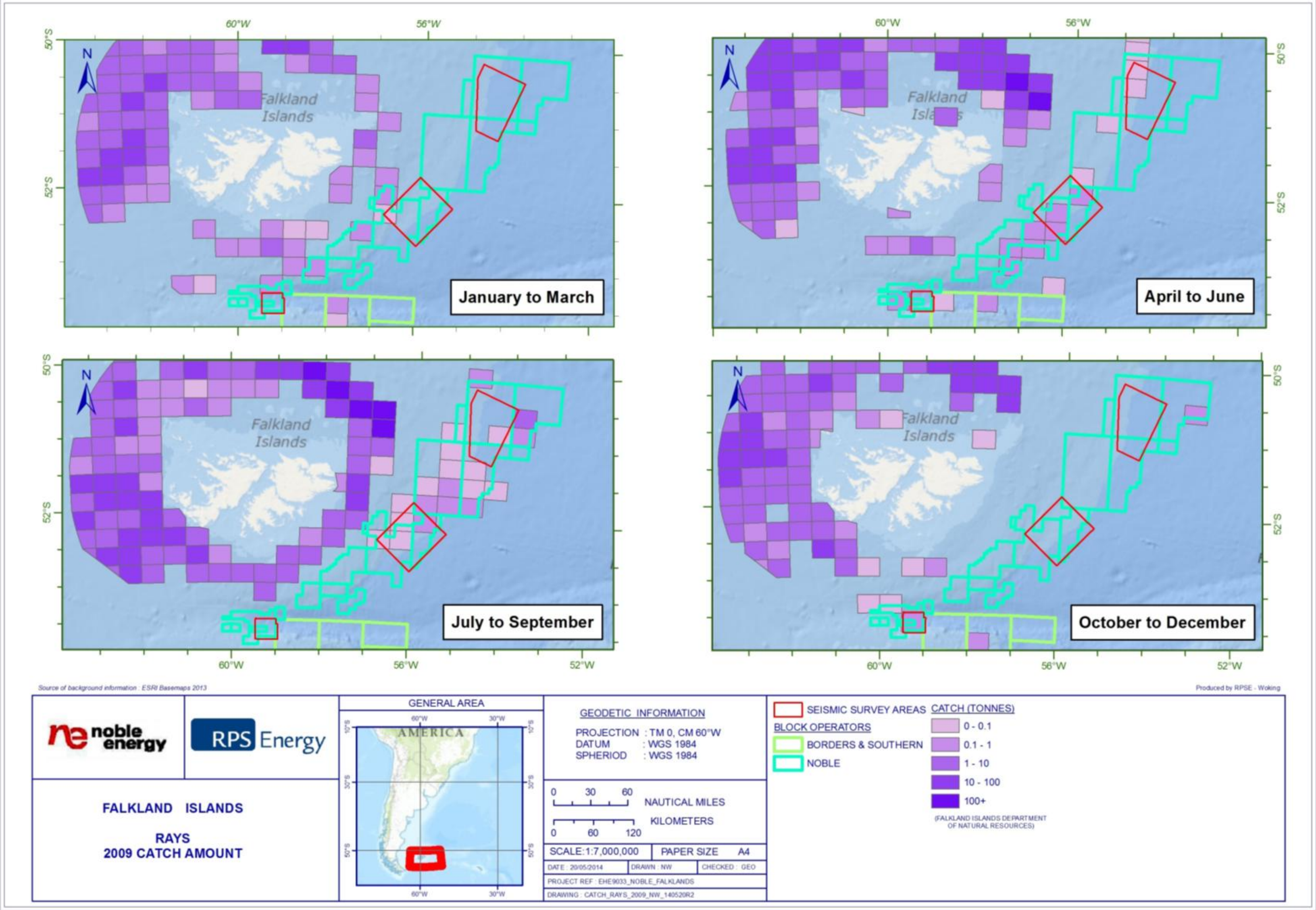


Figure E.5c: Fisheries catch mass (tonnes) for Rays (Rajidae) for the year 2010 (FIG Department of Natural Resources – Fisheries Department, 2014)

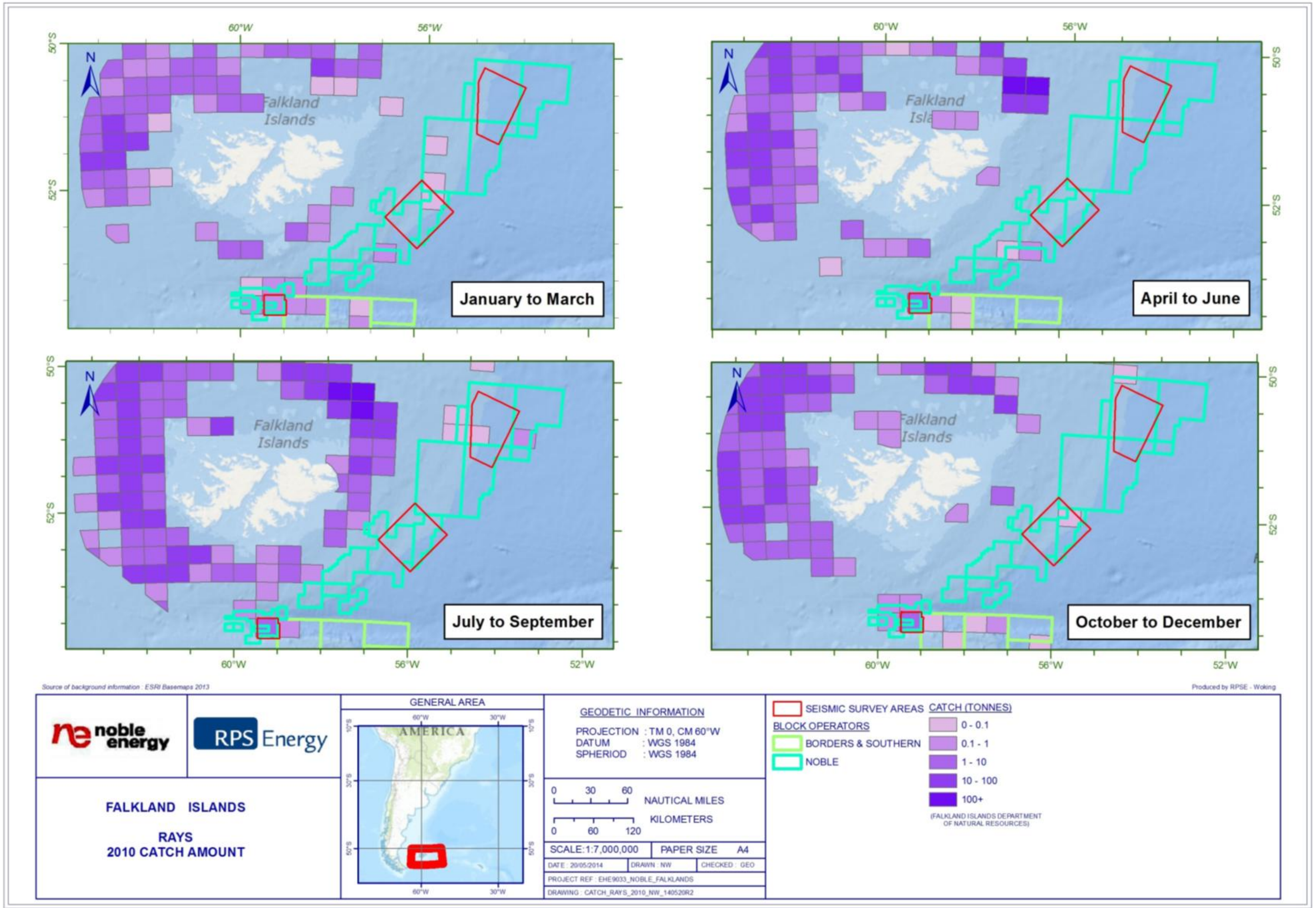


Figure E.5d: Fisheries catch mass (tonnes) for Rays (Rajidae) for the year 2011 (FIG Department of Natural Resources – Fisheries Department, 2014)

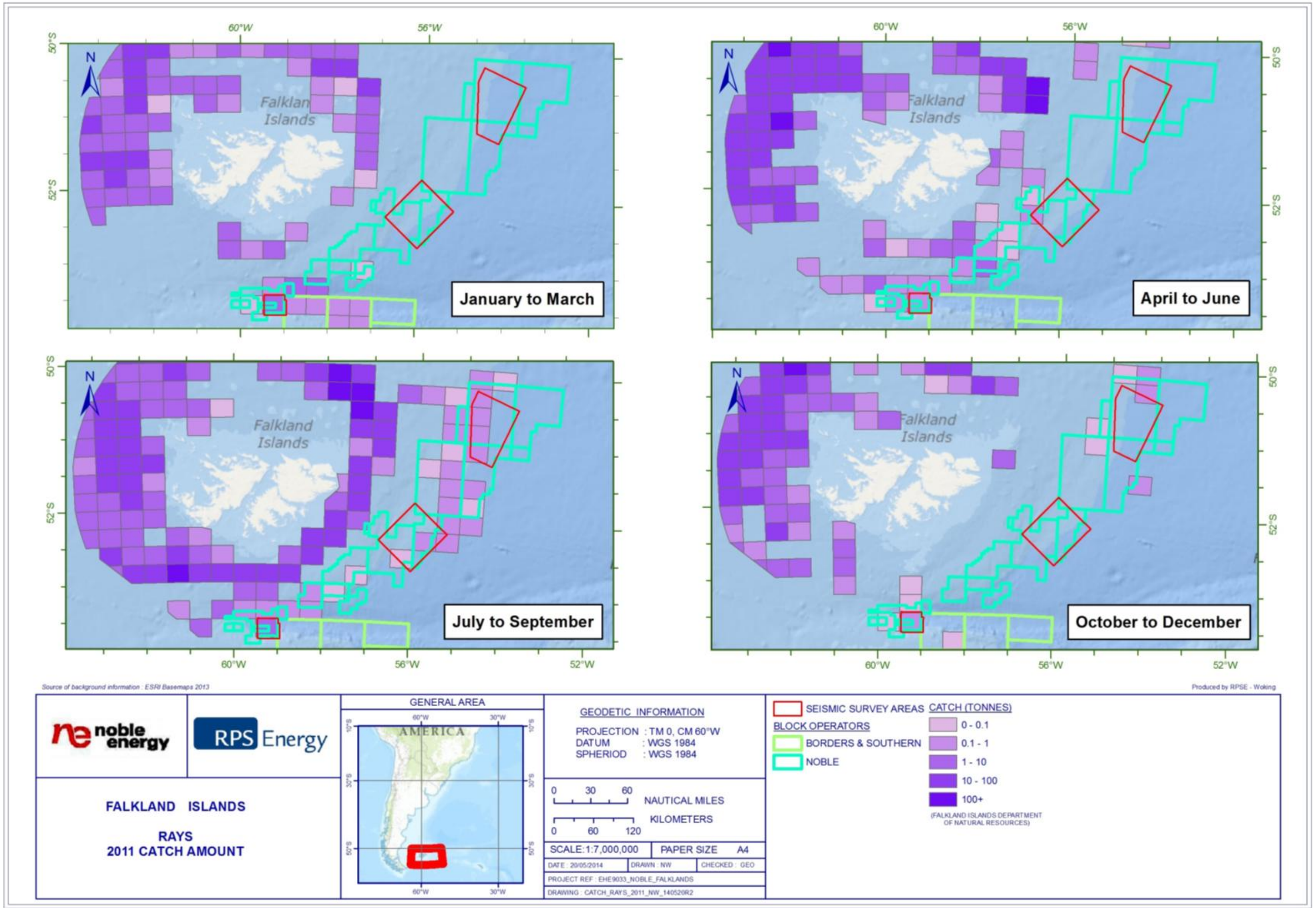


Figure E.5e: Fisheries catch mass (tonnes) for Rays (Rajidae) for the year 2012 (FIG Department of Natural Resources – Fisheries Department, 2014)

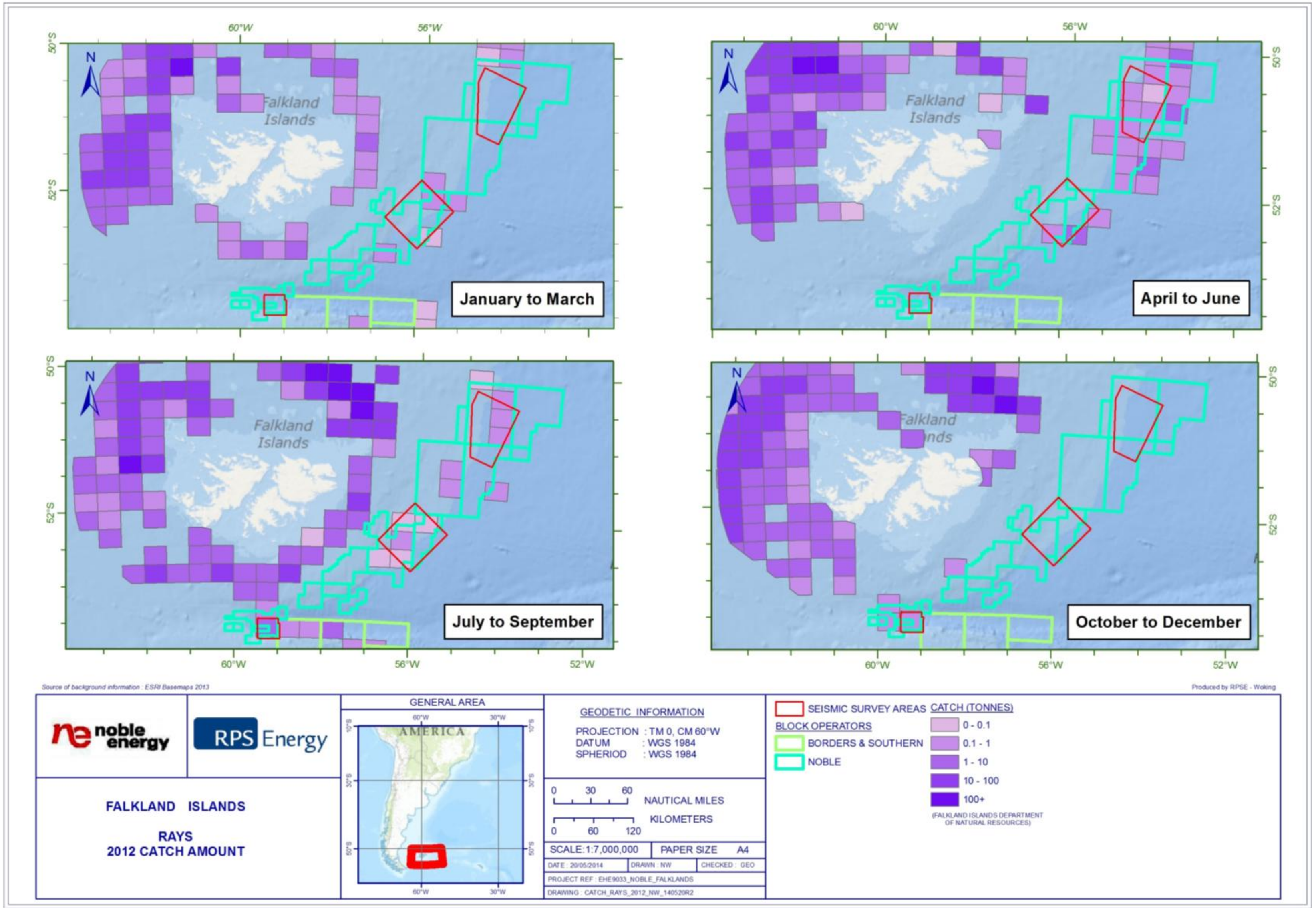


Figure E.5f: Fisheries catch mass (tonnes) for Rays (Rajidae) for the year 2013 (FIG Department of Natural Resources – Fisheries Department, 2014)

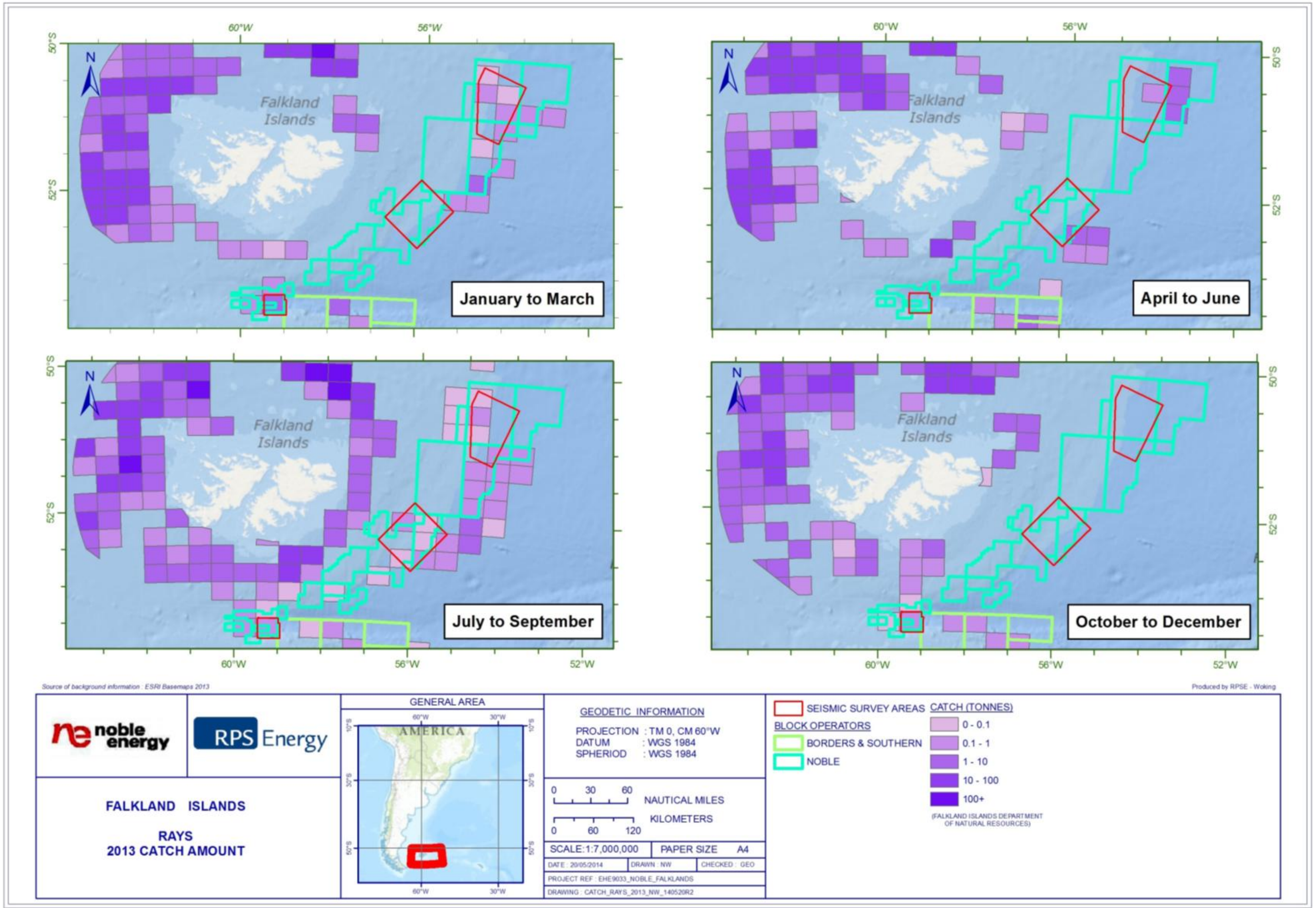


Figure E.6a: Fisheries catch mass (tonnes) for Red Cod (Salilota australis) for the year 2008 (FIG Department of Natural Resources – Fisheries Department, 2014)

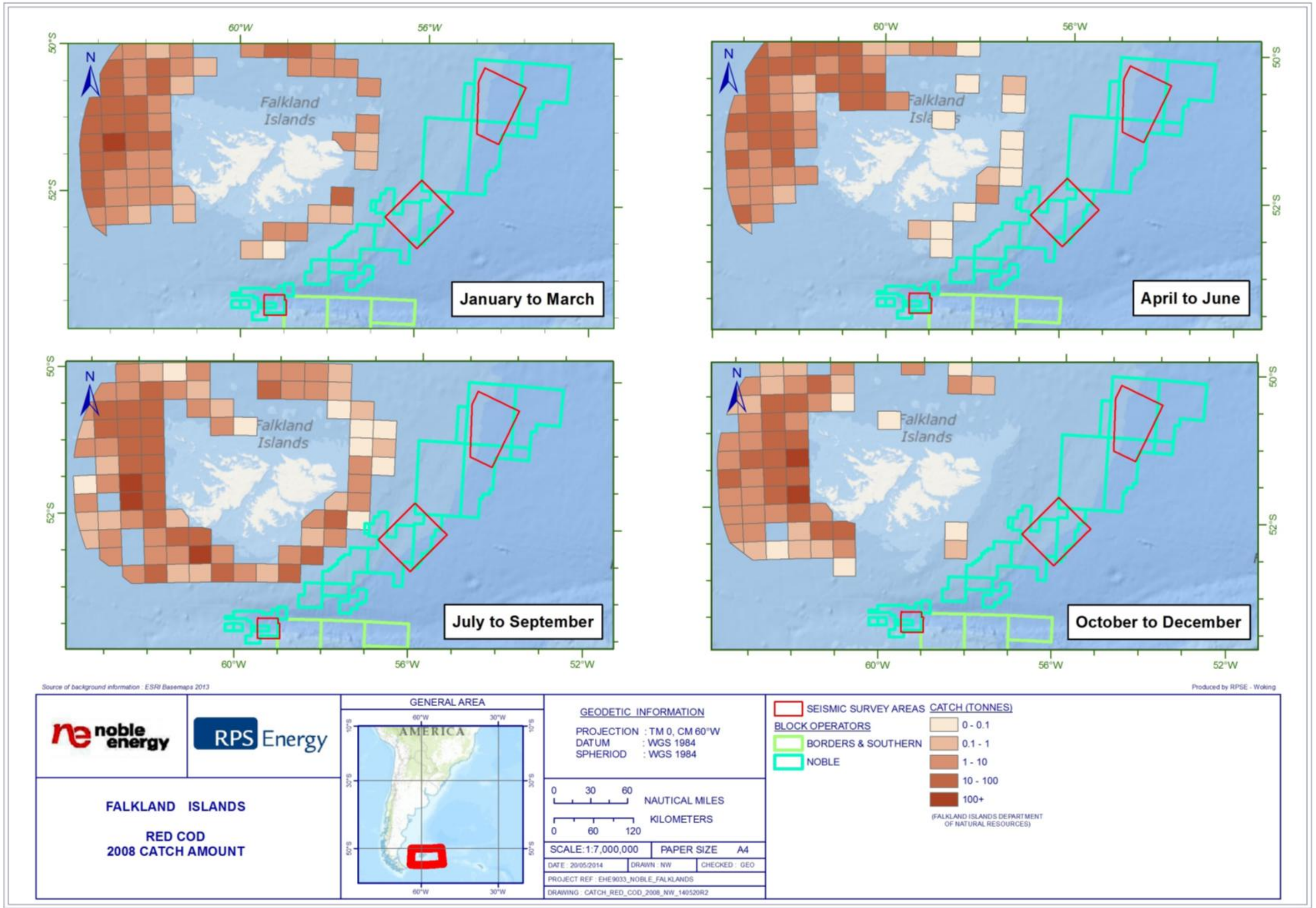


Figure E.6b: Fisheries catch mass (tonnes) for Red Cod (Salilota australis) for the year 2009 (FIG Department of Natural Resources – Fisheries Department, 2014)

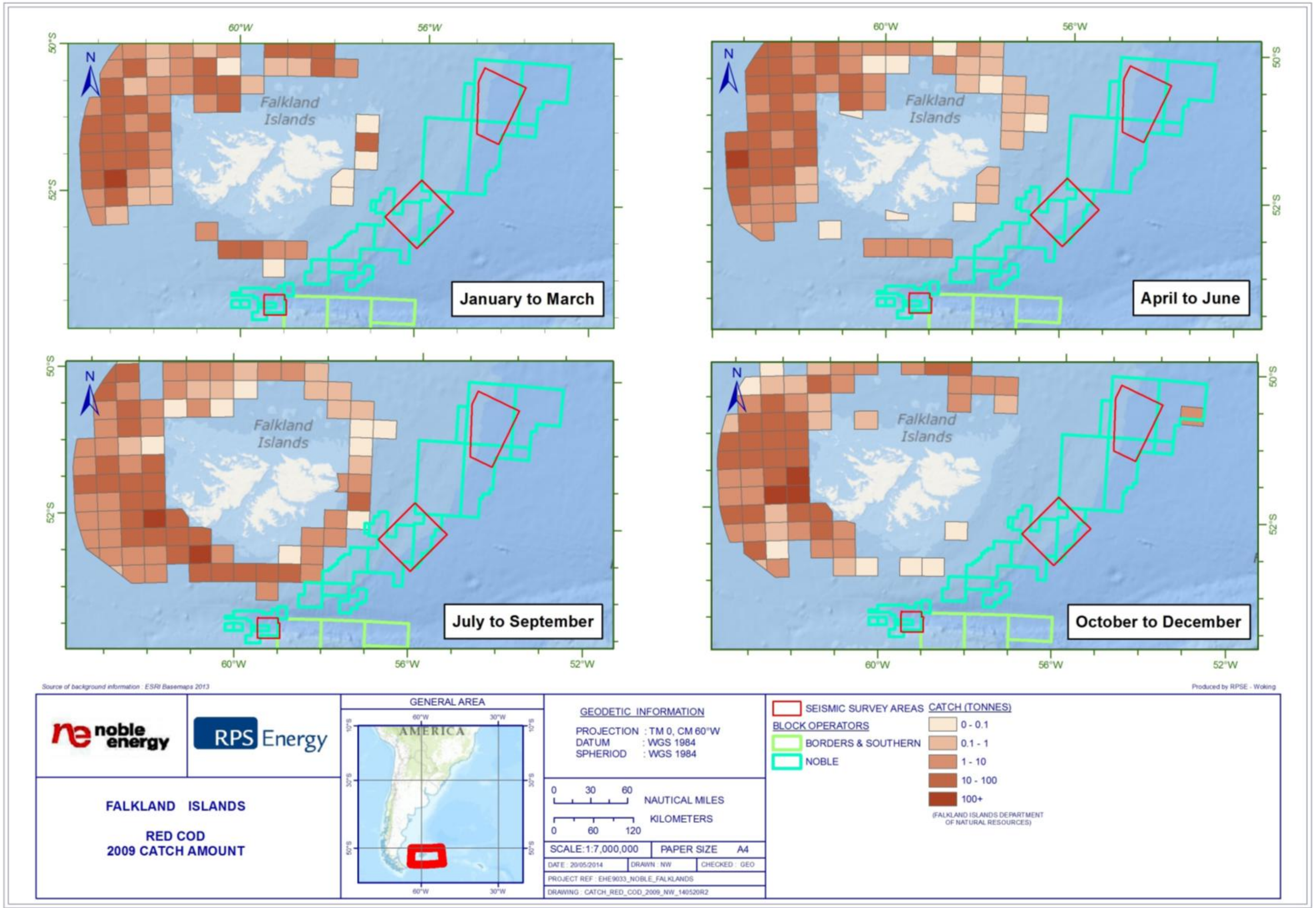


Figure E.6c: Fisheries catch mass (tonnes) for Red Cod (Salilota australis) for the year 2010 (FIG Department of Natural Resources – Fisheries Department, 2014)

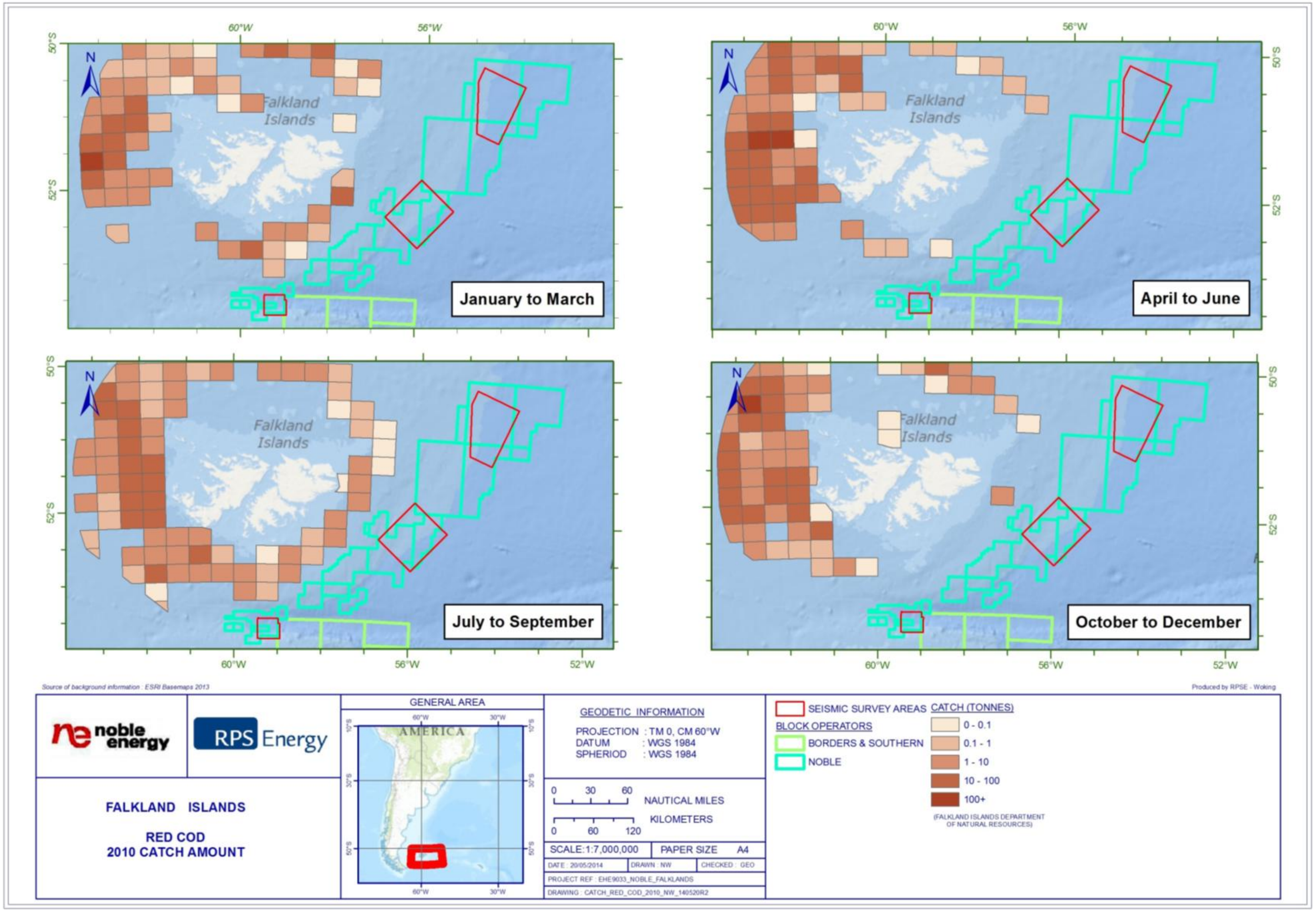


Figure E.6d: Fisheries catch mass (tonnes) for Red Cod (Salilota australis) for the year 2011 (FIG Department of Natural Resources – Fisheries Department, 2014)

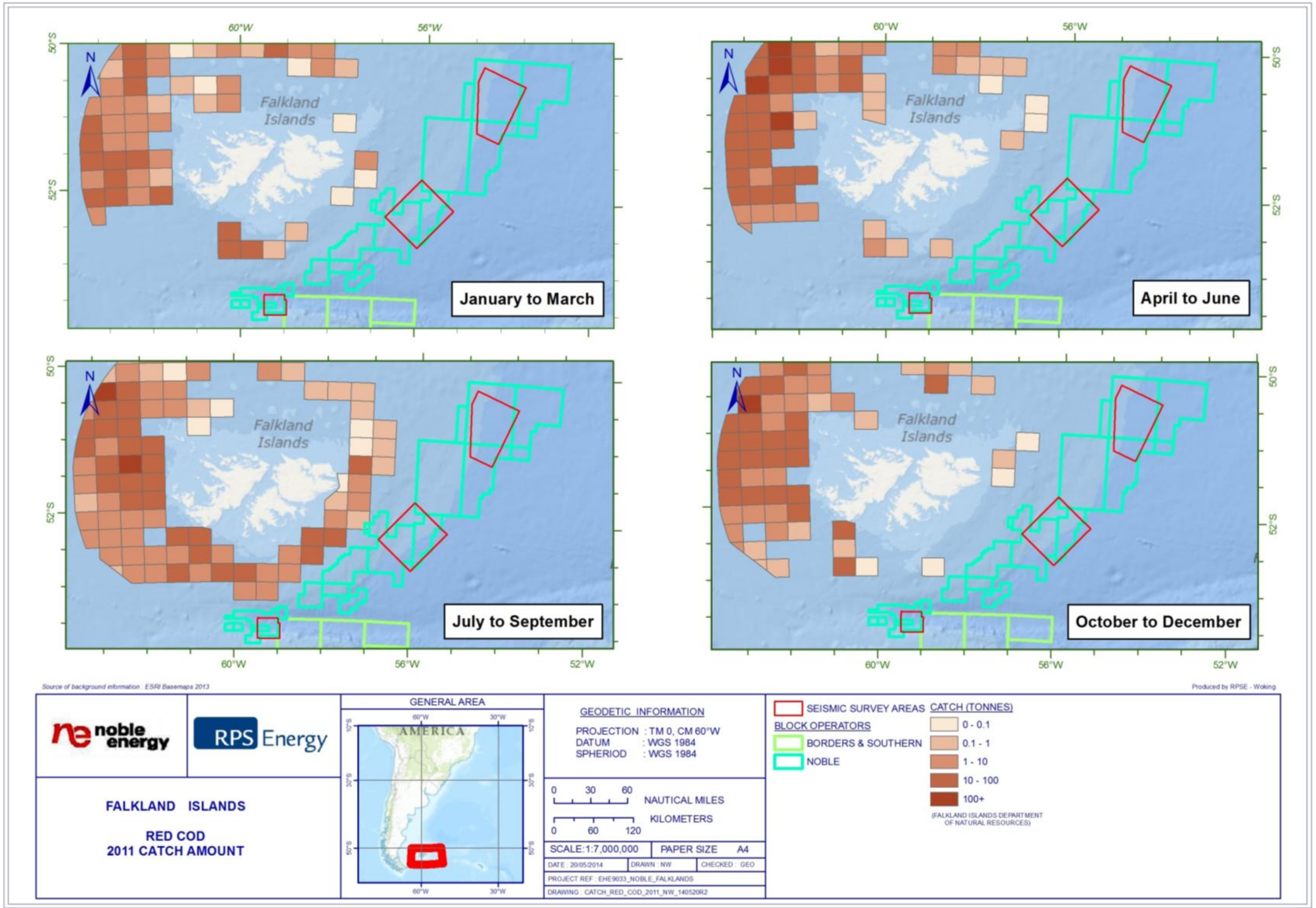


Figure E.6e: Fisheries catch mass (tonnes) for Red Cod (Salilota australis) for the year 2012 (FIG Department of Natural Resources – Fisheries Department, 2014)

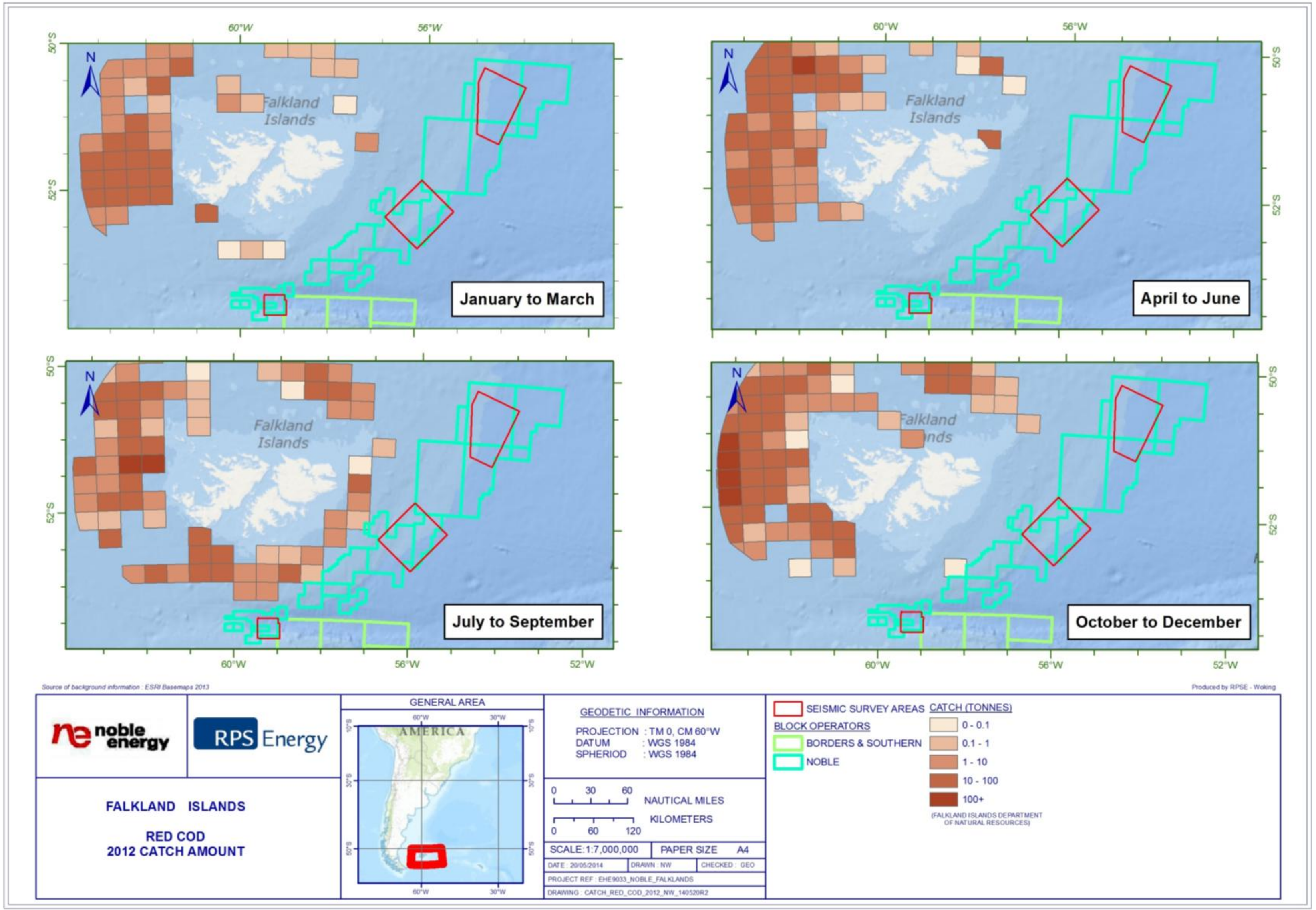


Figure E.6f: Fisheries catch mass (tonnes) for Red Cod (Salilota australis) for the year 2013 (FIG Department of Natural Resources – Fisheries Department, 2014)

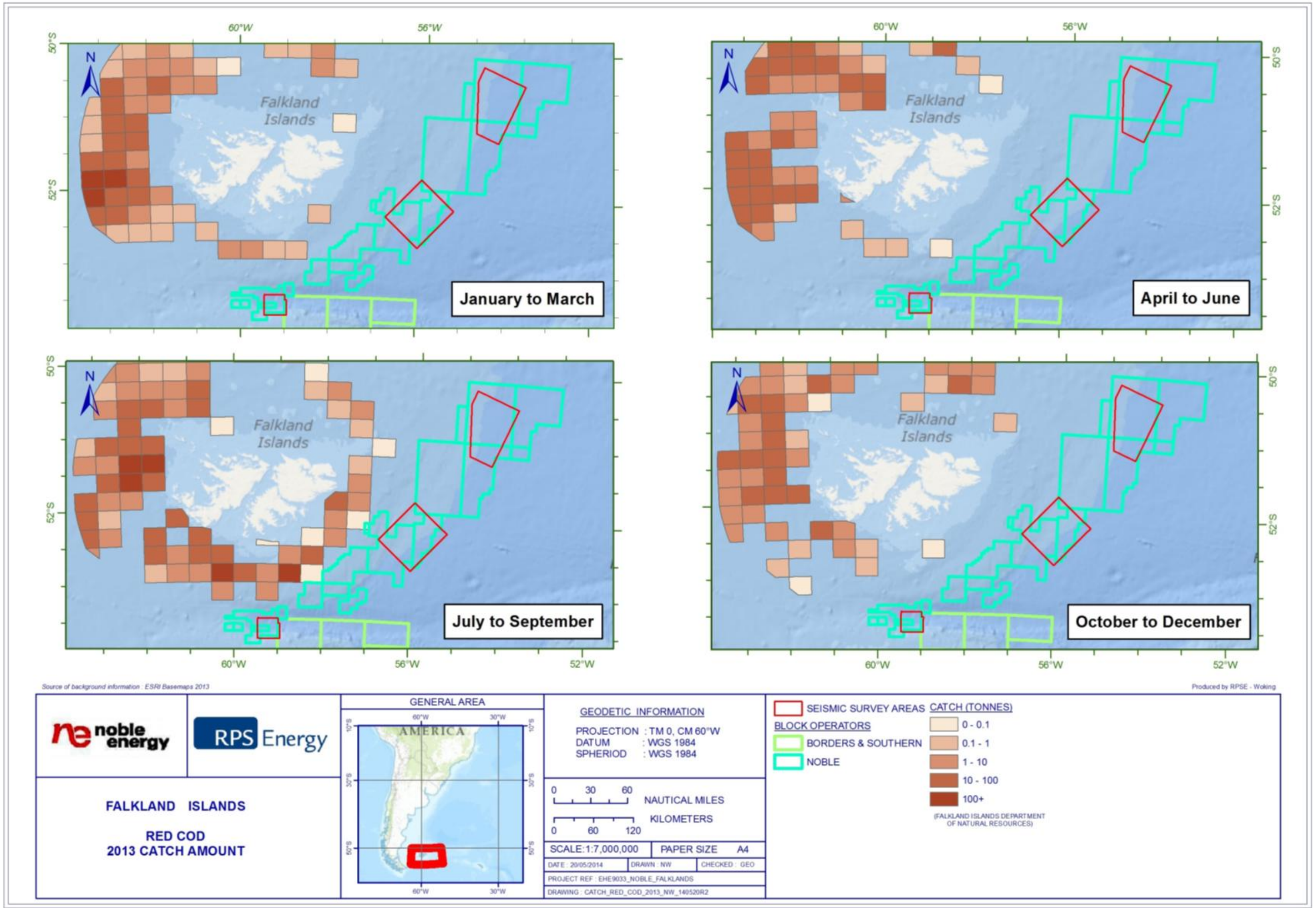


Figure E.7a: Fisheries catch mass (tonnes) for Rock Cod (Patagonotothen ramsayi) for the year 2008 (FIG Department of Natural Resources – Fisheries Department, 2014)

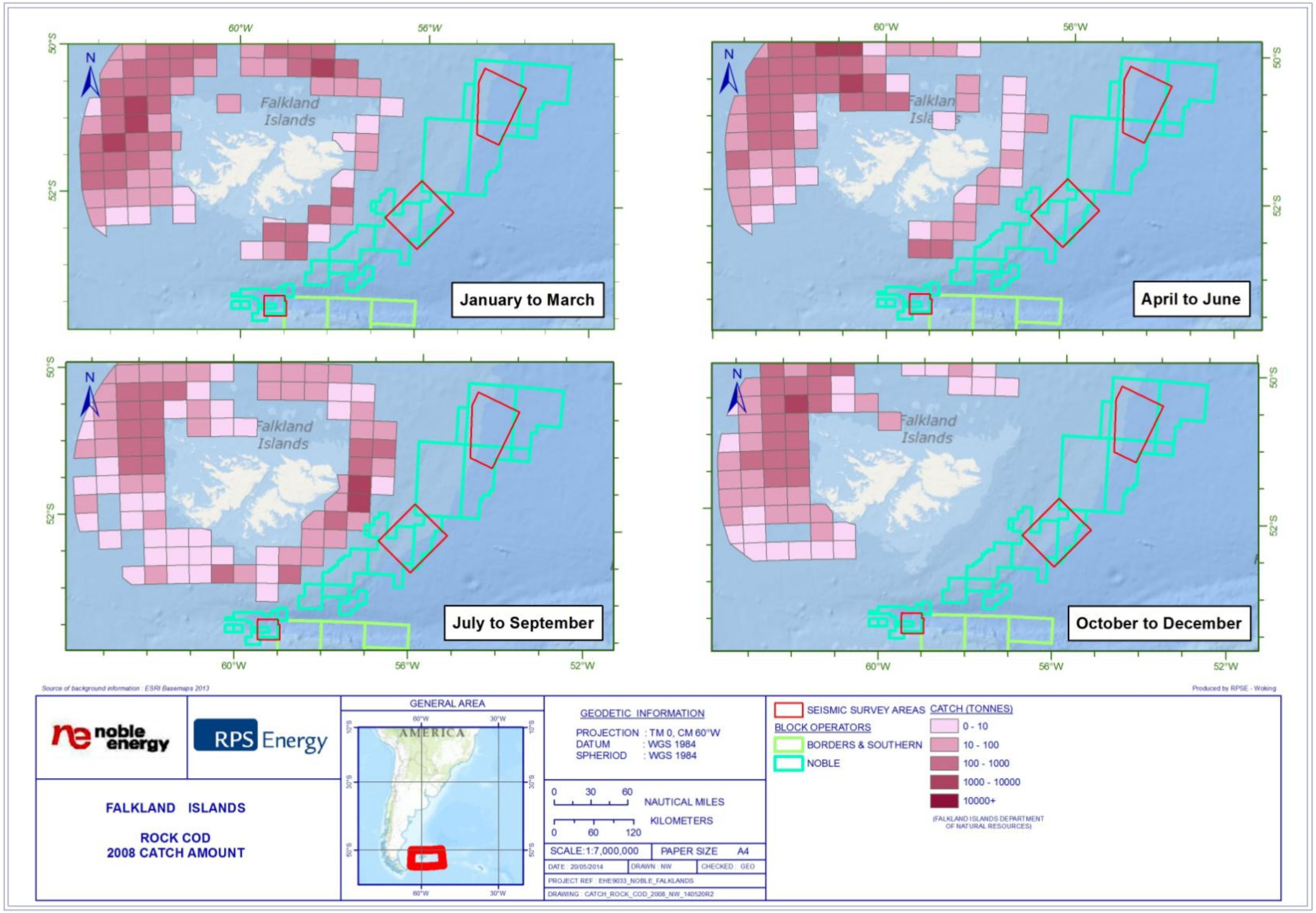


Figure E.7b: Fisheries catch mass (tonnes) for Rock Cod (Patagonotothen ramsayi) for the year 2009 (FIG Department of Natural Resources – Fisheries Department, 2014)

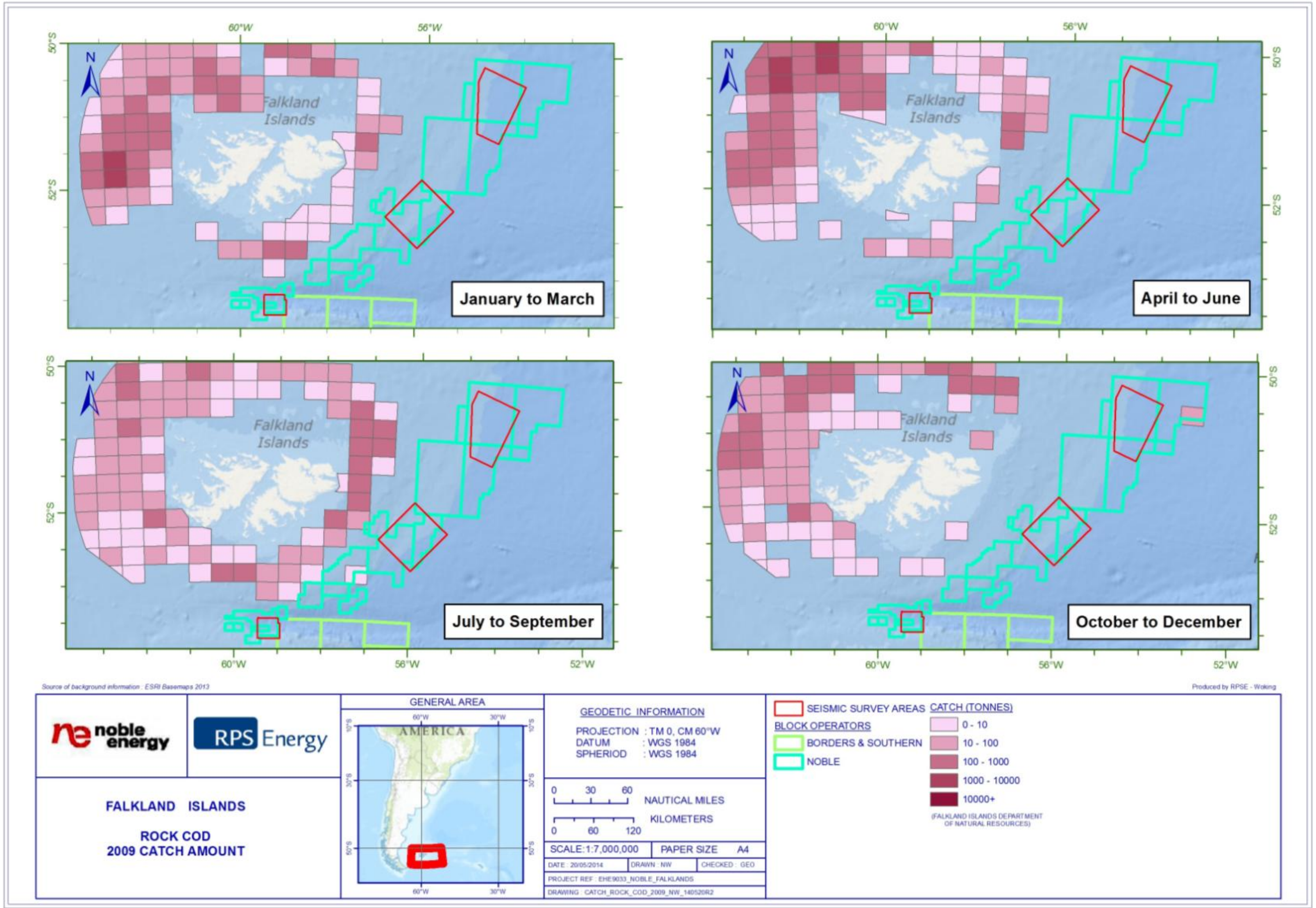


Figure E.7c: Fisheries catch mass (tonnes) for Rock Cod (Patagonotothen ramsayi) for the year 2010 (FIG Department of Natural Resources – Fisheries Department, 2014)

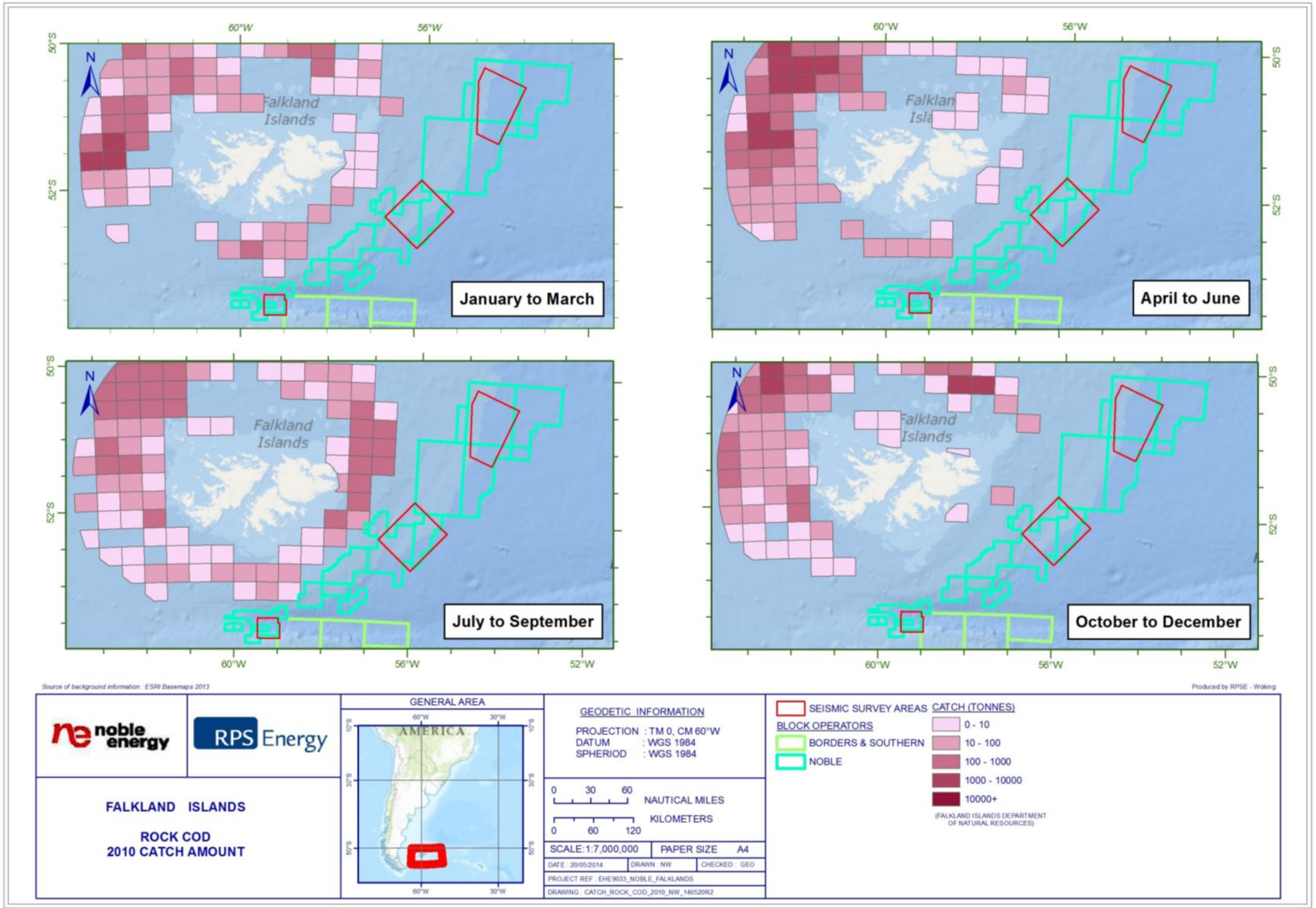


Figure E.7d: Fisheries catch mass (tonnes) for Rock Cod (Patagonotothen ramsayi) for the year 2011 (FIG Department of Natural Resources – Fisheries Department, 2014)

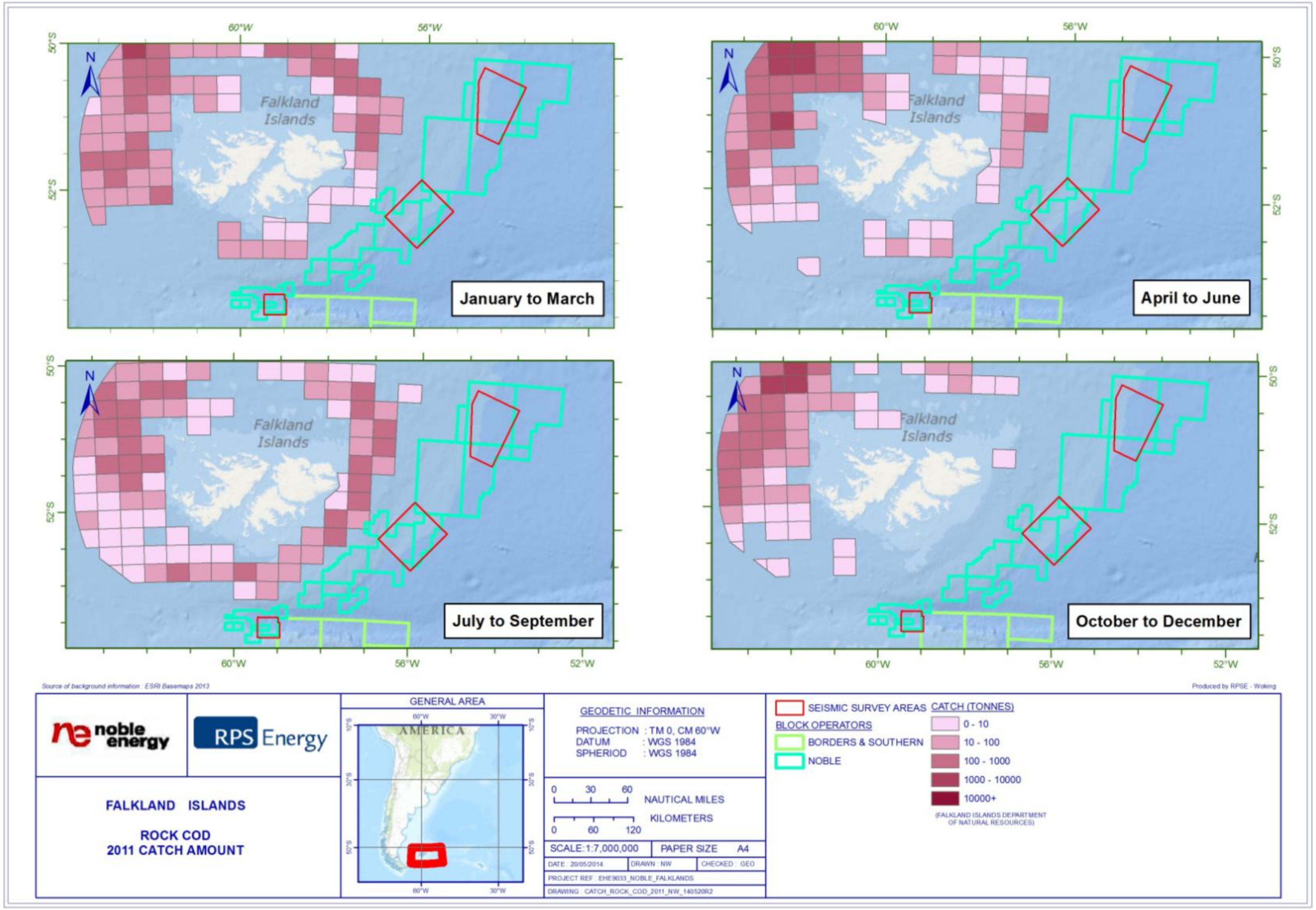


Figure E.7e: Fisheries catch mass (tonnes) for Rock Cod (Patagonotothen ramsayi) for the year 2012 (FIG Department of Natural Resources – Fisheries Department, 2014)

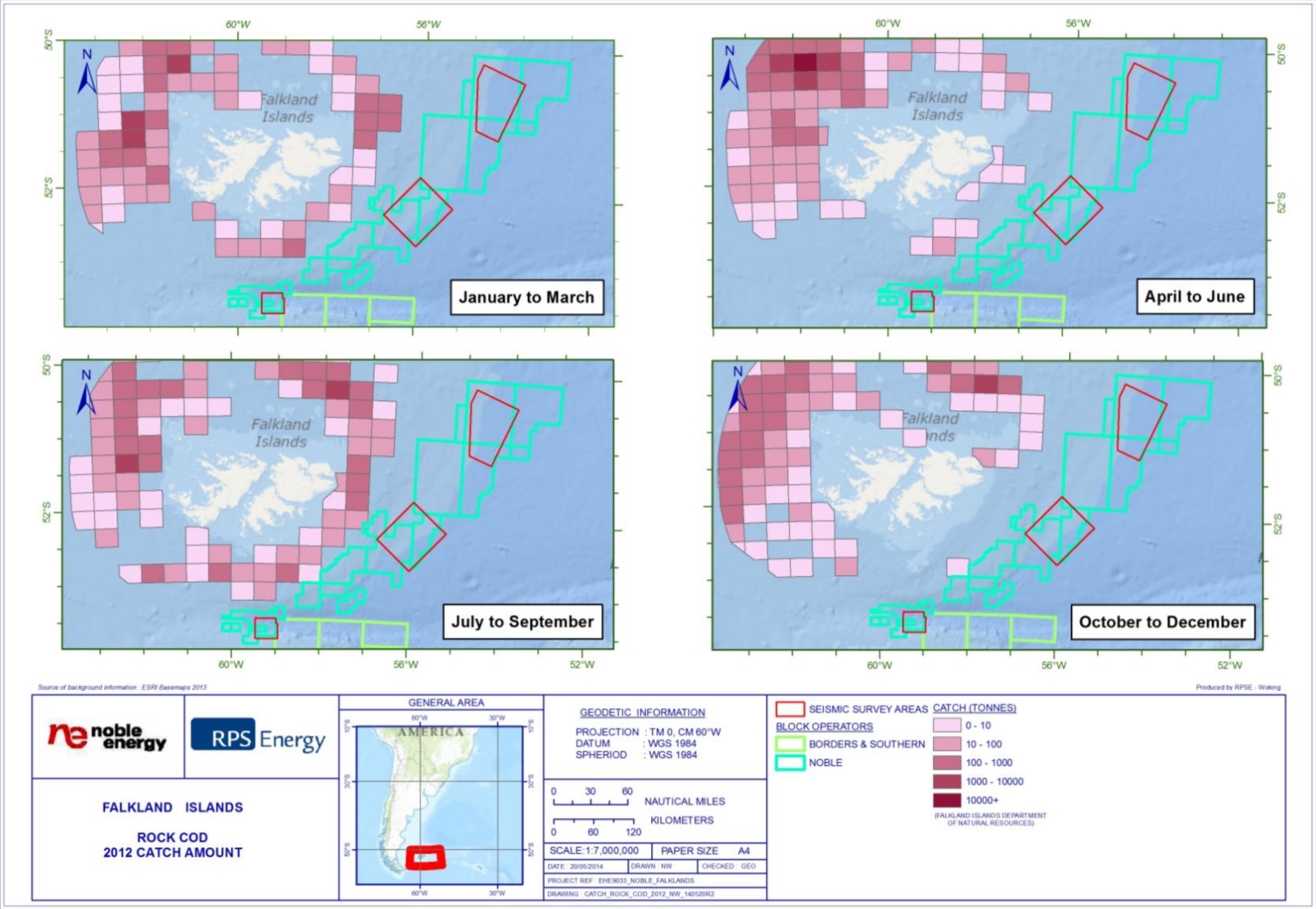


Figure E.7f: Fisheries catch mass (tonnes) for Rock Cod (Patagonotothen ramsayi) for the year 2013 (FIG Department of Natural Resources – Fisheries Department, 2014)

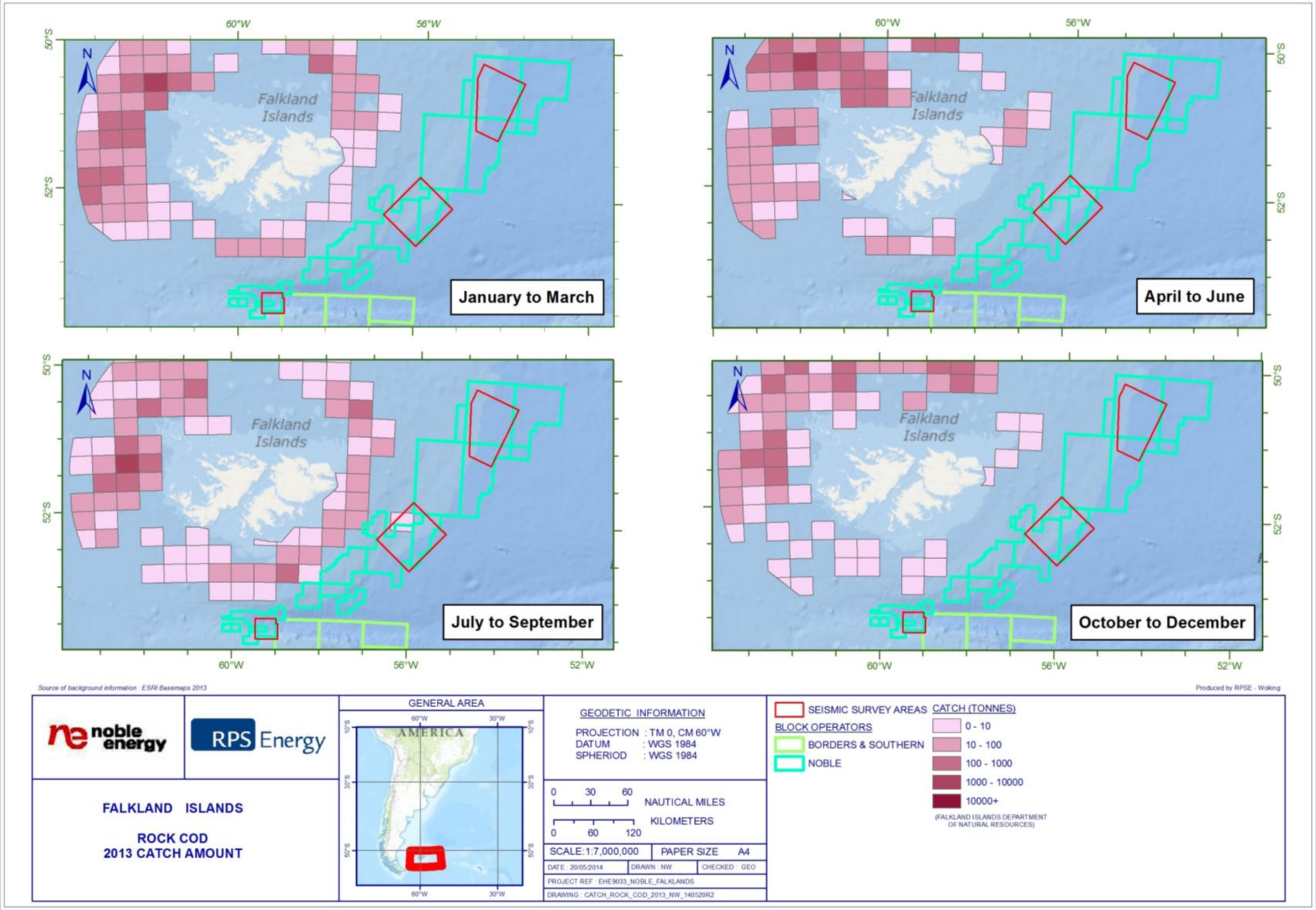


Figure E.8a: Fisheries catch mass (tonnes) for Patagonian Toothfish (Dissostichus eleginoides) for the year 2008 (FIG Department of Natural Resources – Fisheries Department, 2014)

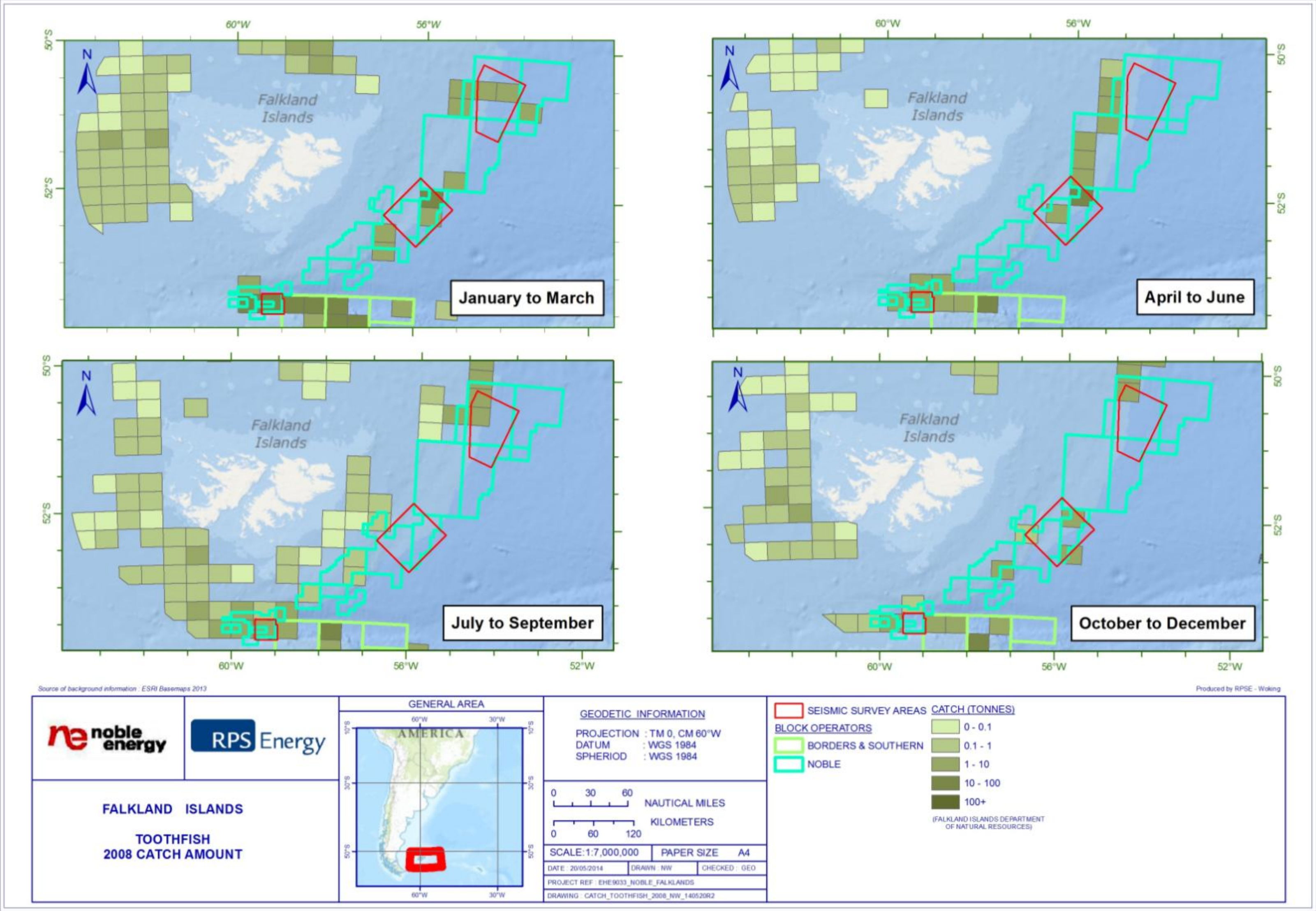


Figure E.8b: Fisheries catch mass (tonnes) for Patagonian Toothfish (Dissostichus eleginoides) for the year 2009 (FIG Department of Natural Resources – Fisheries Department, 2014)

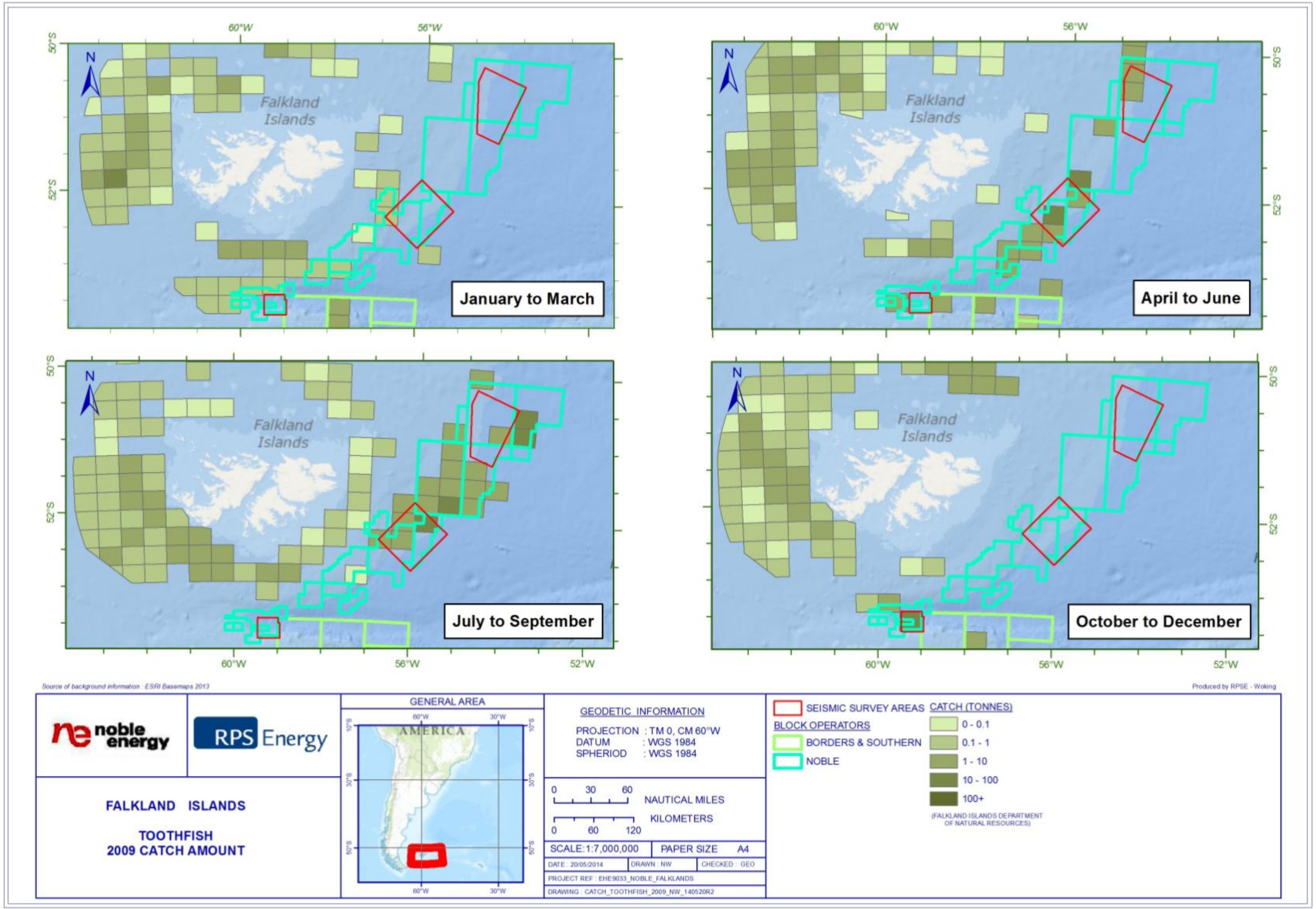


Figure E.8c: Fisheries catch mass (tonnes) for Patagonian Toothfish (Dissostichus eleginoides) for the year 2010 (FIG Department of Natural Resources – Fisheries Department, 2014)

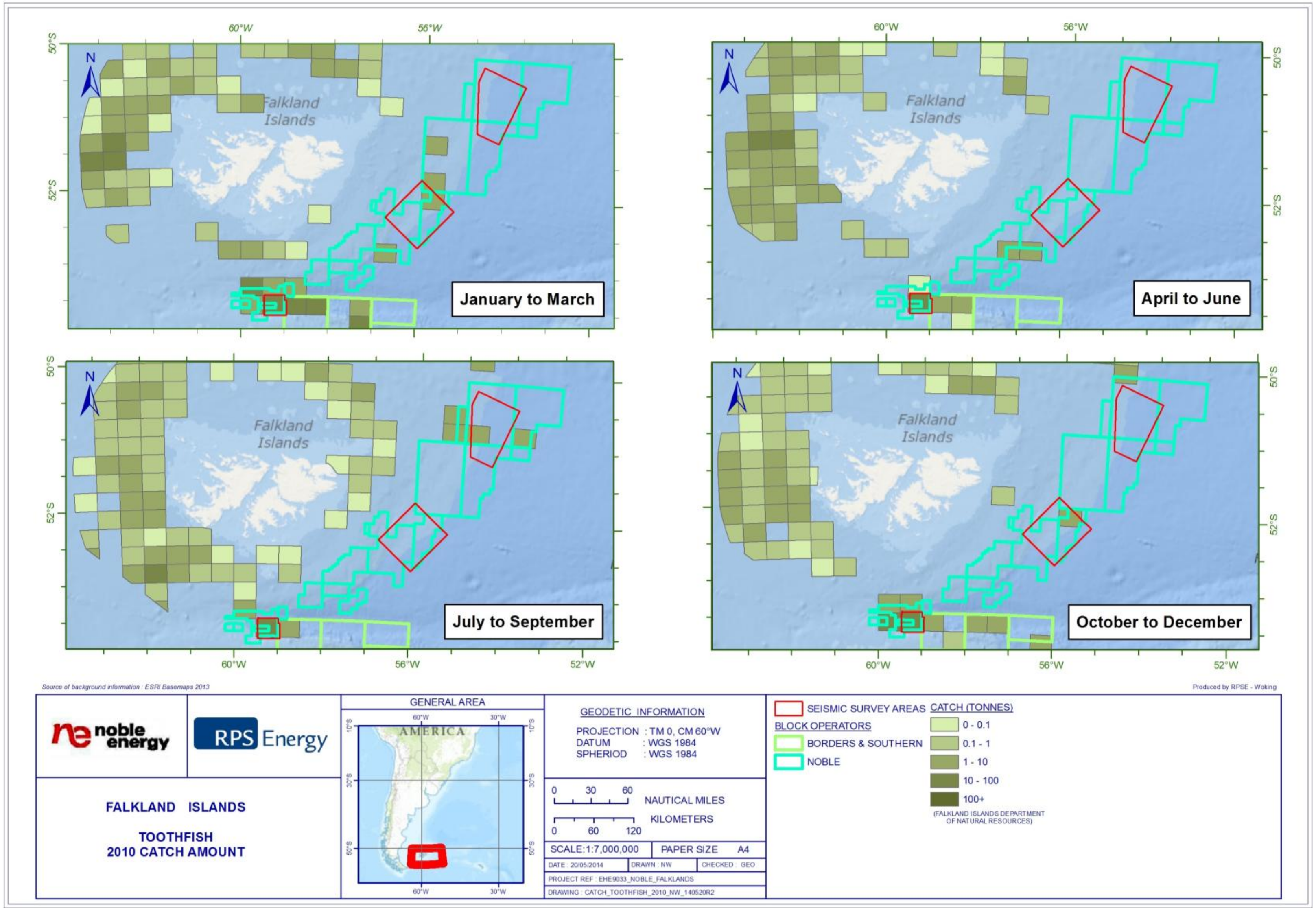


Figure E.8d: Fisheries catch mass (tonnes) for Patagonian Toothfish (Dissostichus eleginoides) for the year 2011 (FIG Department of Natural Resources – Fisheries Department, 2014)

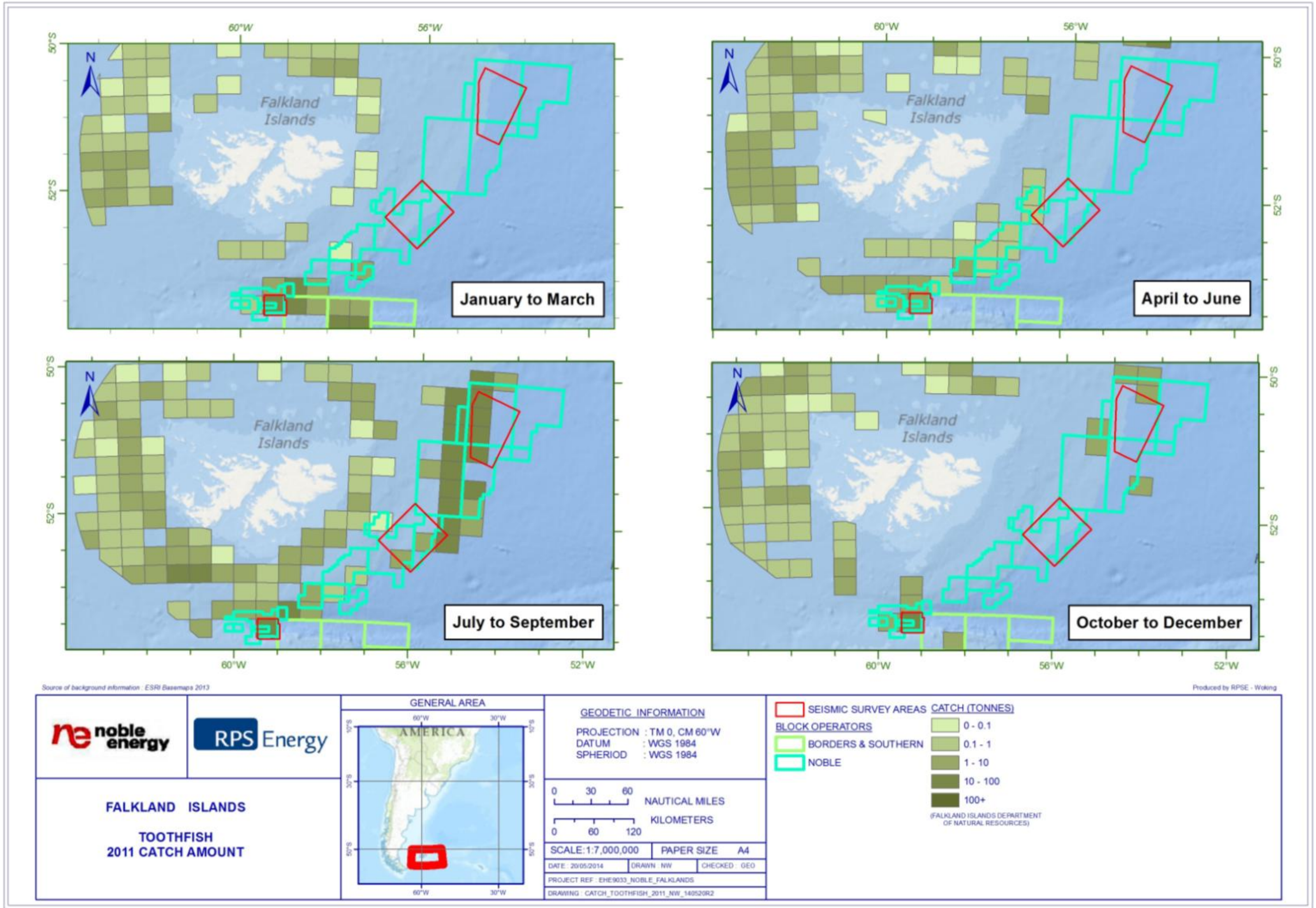


Figure E.8e: Fisheries catch mass (tonnes) for Patagonian Toothfish (Dissostichus eleginoides) for the year 2012 (FIG Department of Natural Resources – Fisheries Department, 2014)

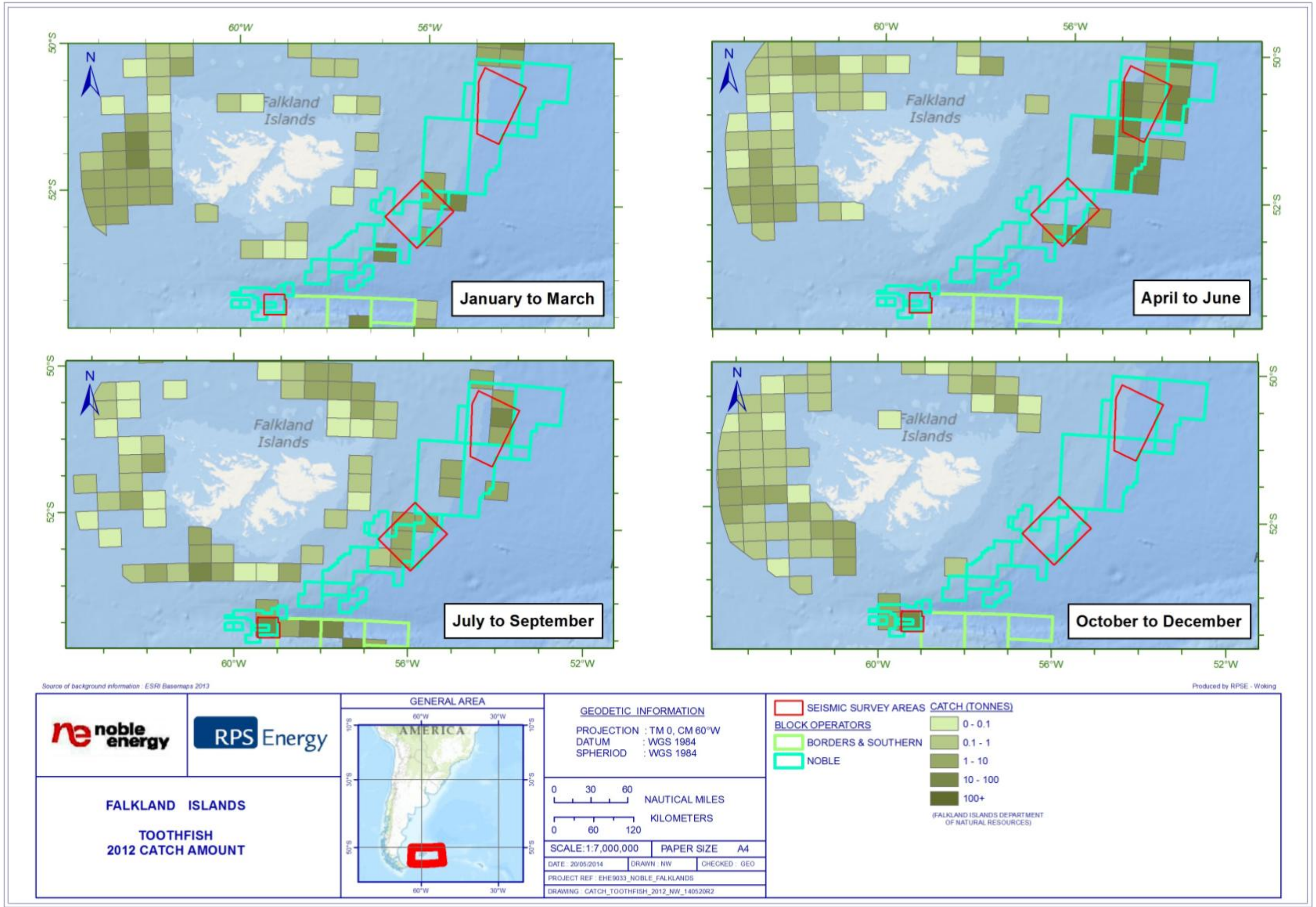


Figure E.8f: Fisheries catch mass (tonnes) for Patagonian Toothfish (Dissostichus eleginoides) for the year 2013 (FIG Department of Natural Resources – Fisheries Department, 2014)

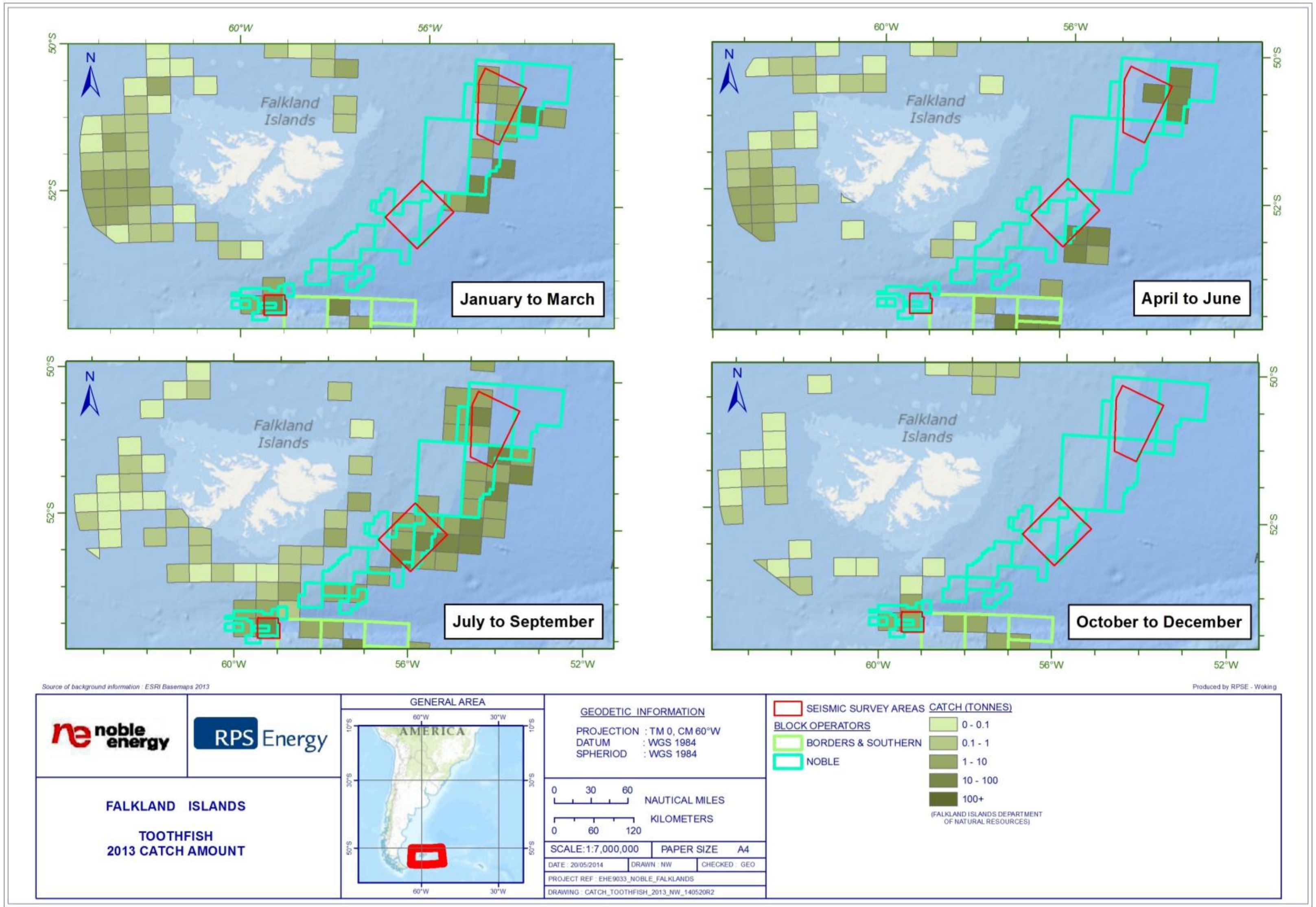


Figure E.9a: Fisheries catch mass (tonnes) for Kingclip (Genypterus blacodes) for the year 2008 (FIG Department of Natural Resources – Fisheries Department, 2014)

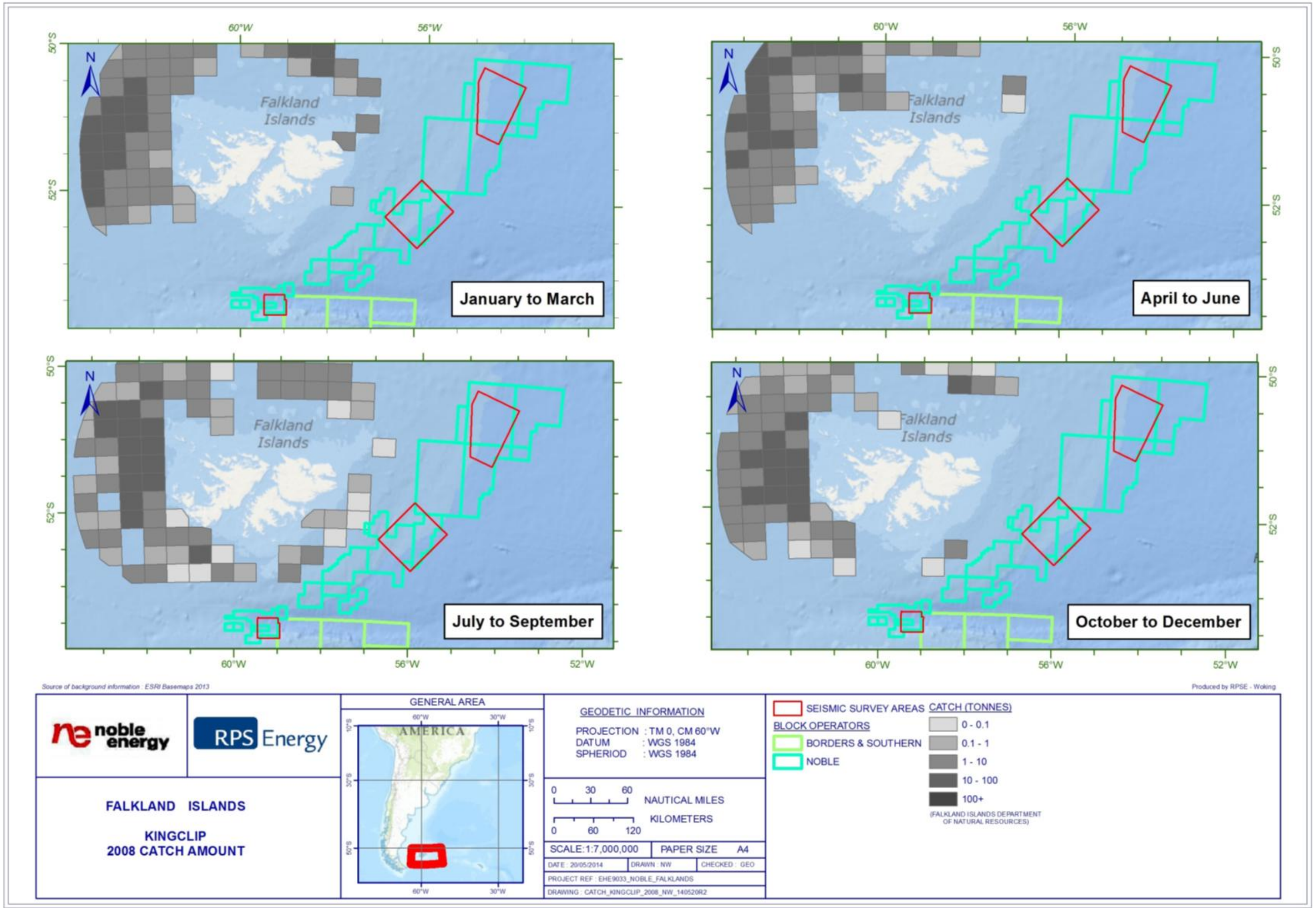


Figure E.9b: Fisheries catch mass (tonnes) for Kingclip (Genypterus blacodes) for the year 2009 (FIG Department of Natural Resources – Fisheries Department, 2014)

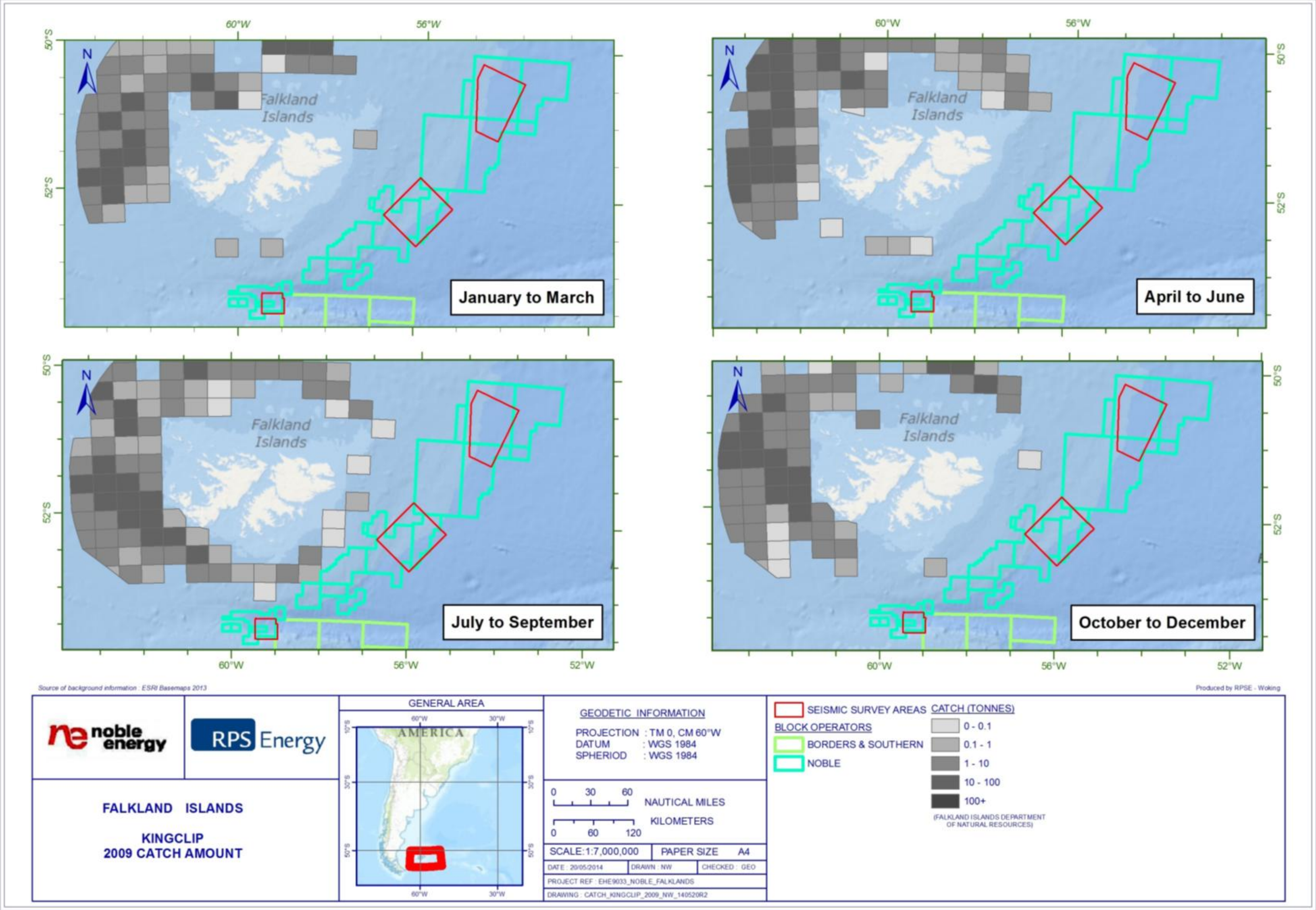


Figure E.9c: Fisheries catch mass (tonnes) for Kingclip (Genypterus blacodes) for the year 2010 (FIG Department of Natural Resources – Fisheries Department, 2014)

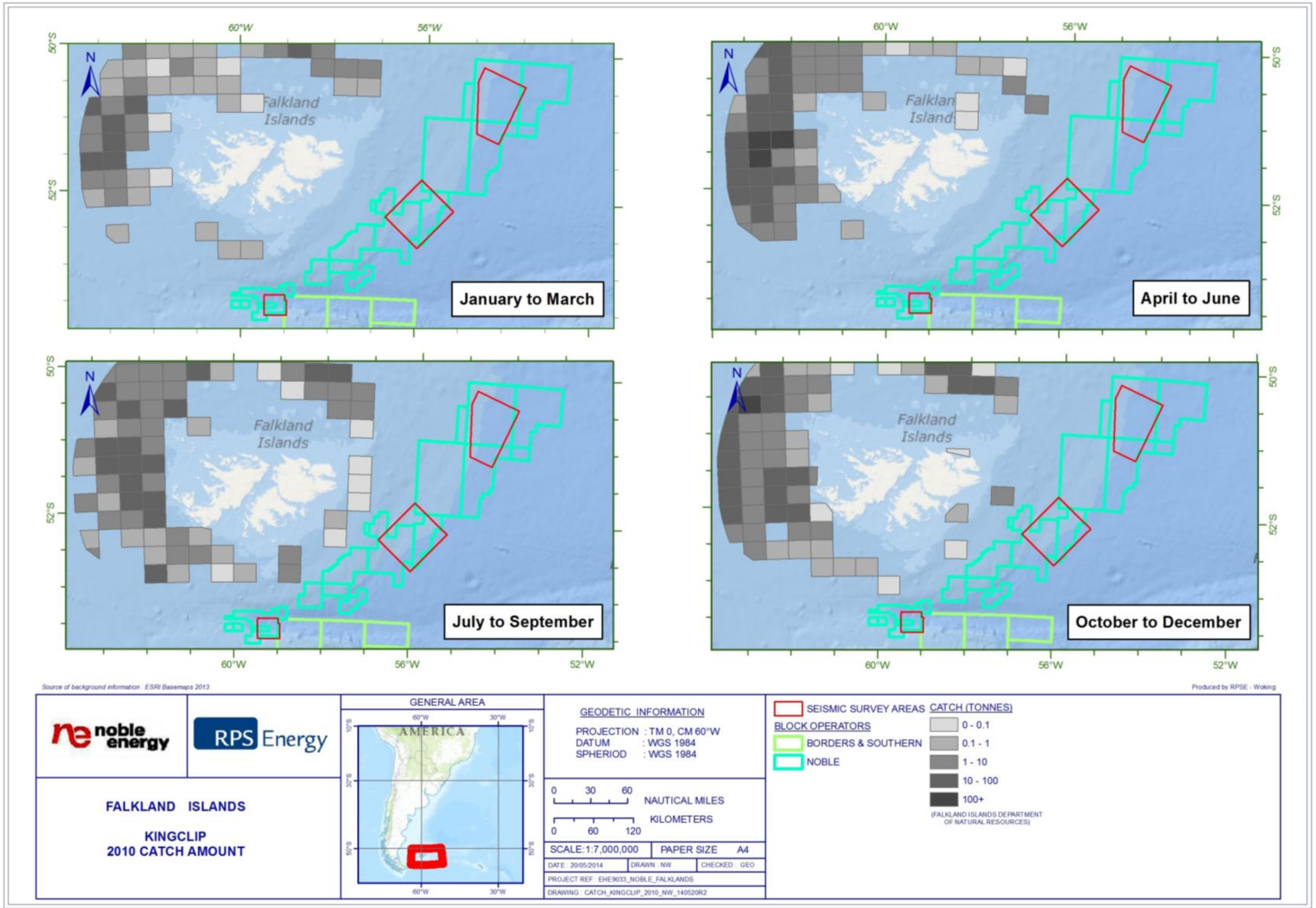


Figure E.9d: Fisheries catch mass (tonnes) for Kingclip (Genypterus blacodes) for the year 2011 (FIG Department of Natural Resources – Fisheries Department, 2014)

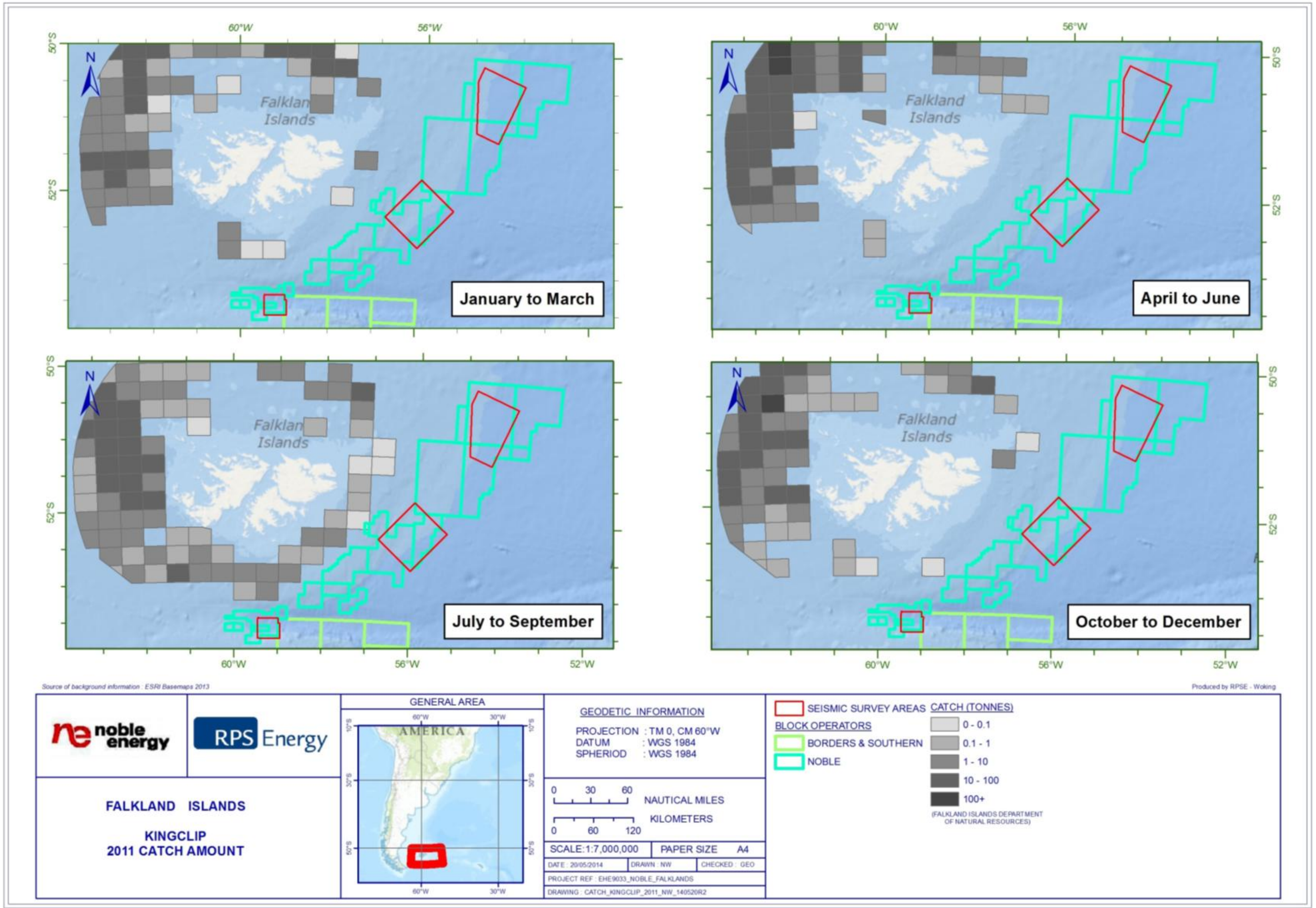


Figure E.9e: Fisheries catch mass (tonnes) for Kingclip (Genypterus blacodes) for the year 2012 (FIG Department of Natural Resources – Fisheries Department, 2014)

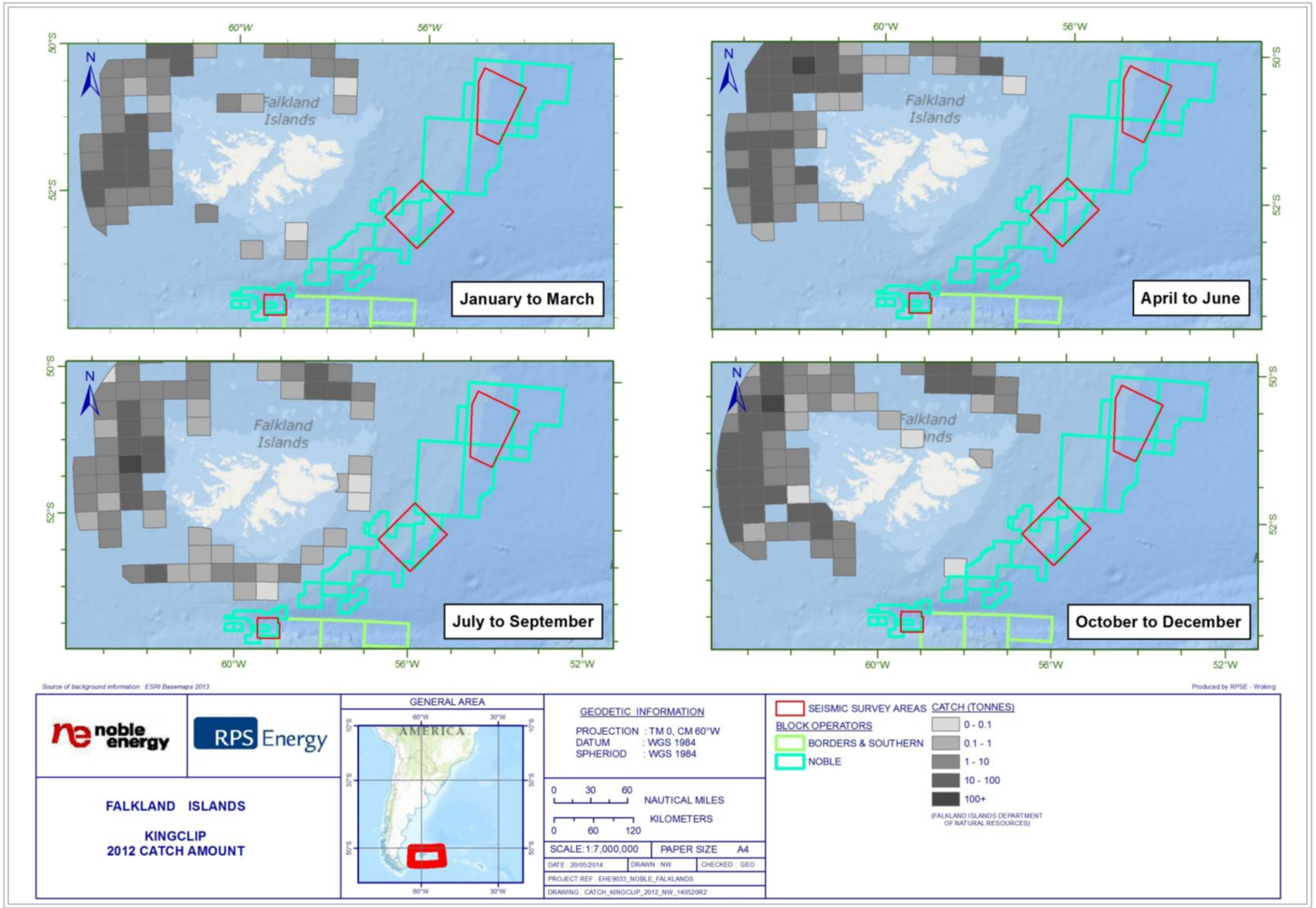


Figure E.9f: Fisheries catch mass (tonnes) for Kingclip (Genypterus blacodes) for the year 2013 (FIG Department of Natural Resources – Fisheries Department, 2014)

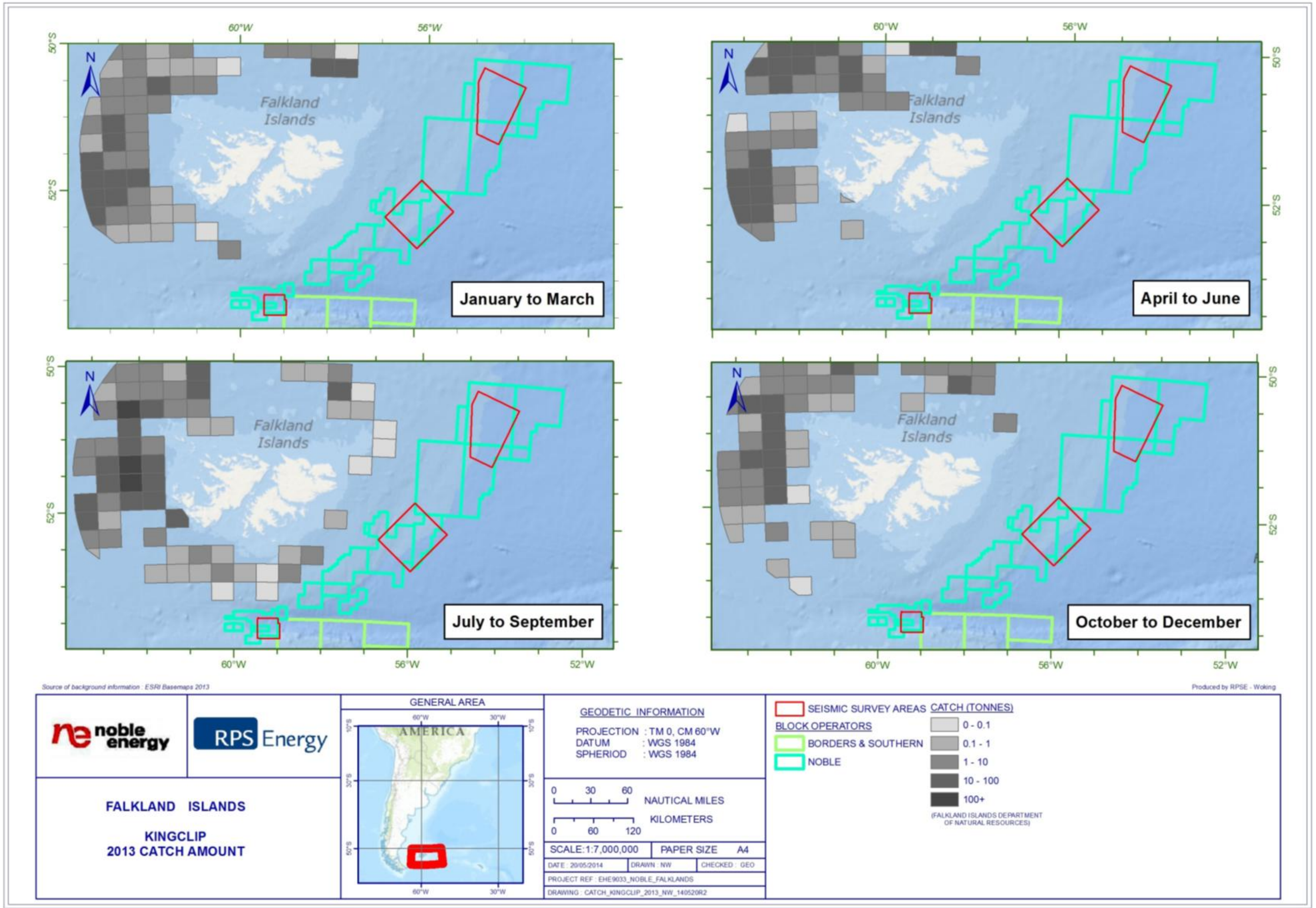


Figure E.10a: Fisheries catch mass (tonnes) for Argentine shortfin squid (Illex argentinus) for the year 2008 (FIG Department of Natural Resources – Fisheries Department, 2014)

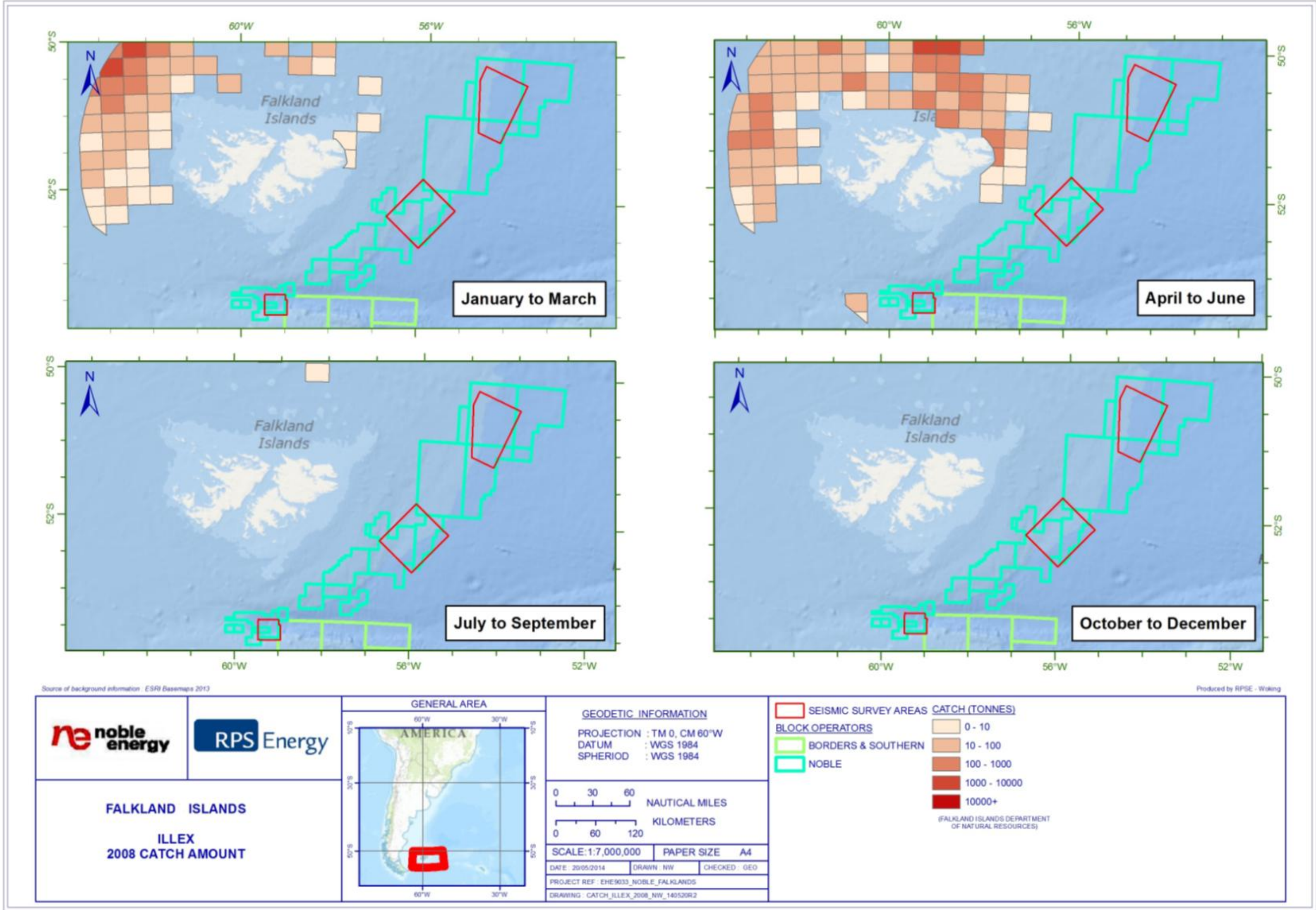


Figure E.10b: Fisheries catch mass (tonnes) for Argentine shortfin squid (Illex argentinus) for the year 2009 (FIG Department of Natural Resources – Fisheries Department, 2014)

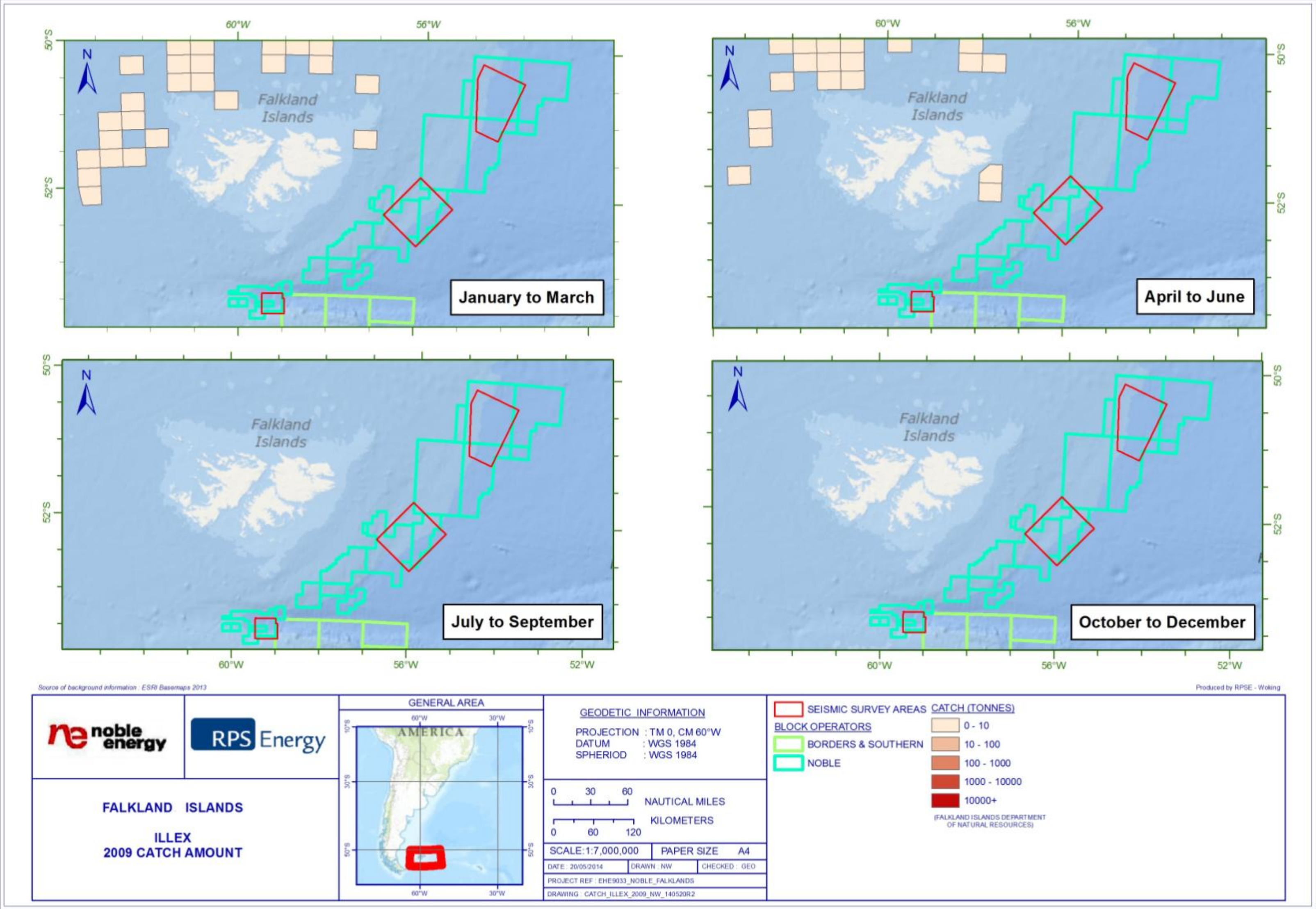


Figure E.10c: Fisheries catch mass (tonnes) for Argentine shortfin squid (Illex argentinus) for the year 2010 (FIG Department of Natural Resources – Fisheries Department, 2014)

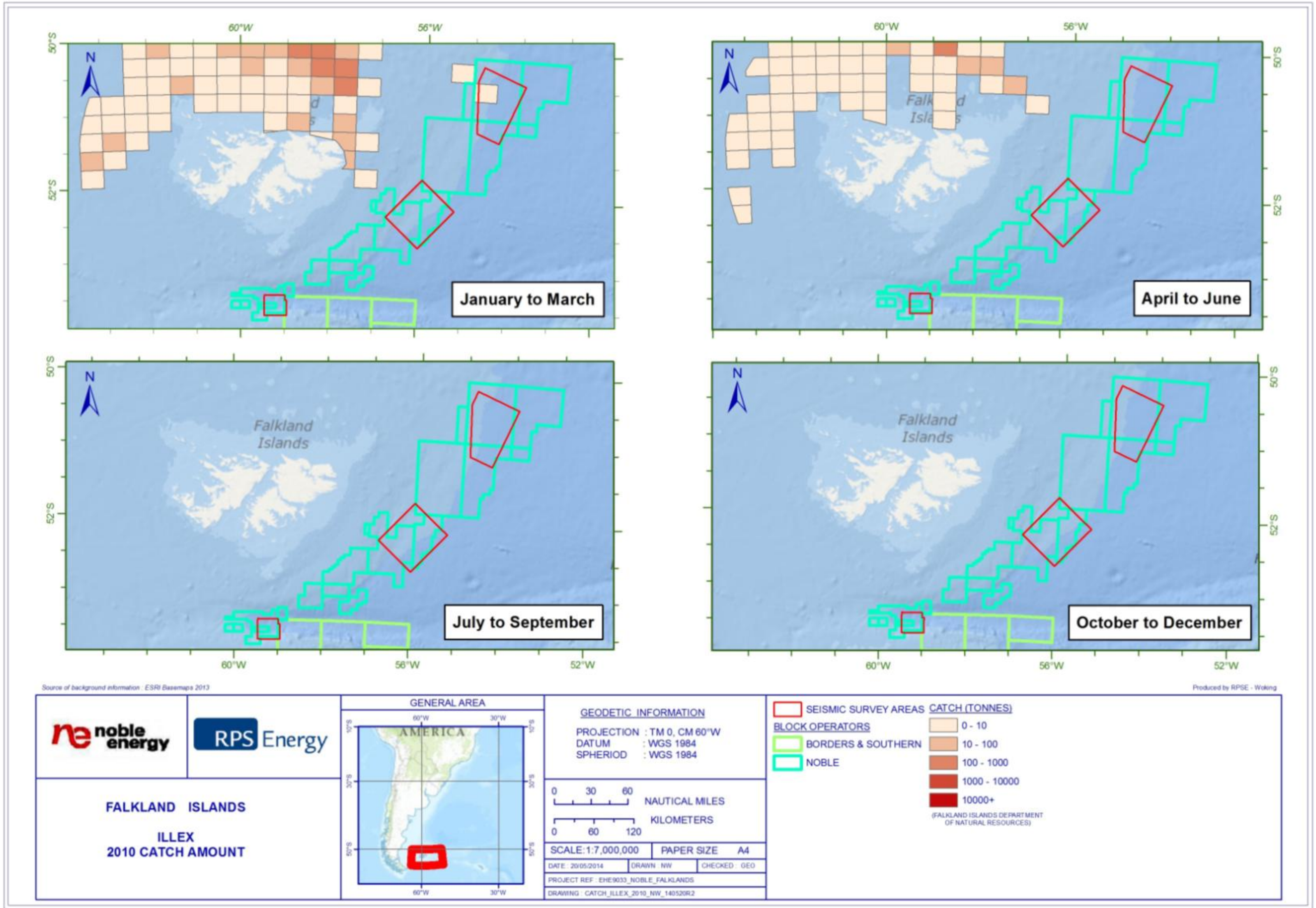


Figure E.10d: Fisheries catch mass (tonnes) for Argentine shortfin squid (Illex argentinus) for the year 2011 (FIG Department of Natural Resources – Fisheries Department, 2014)

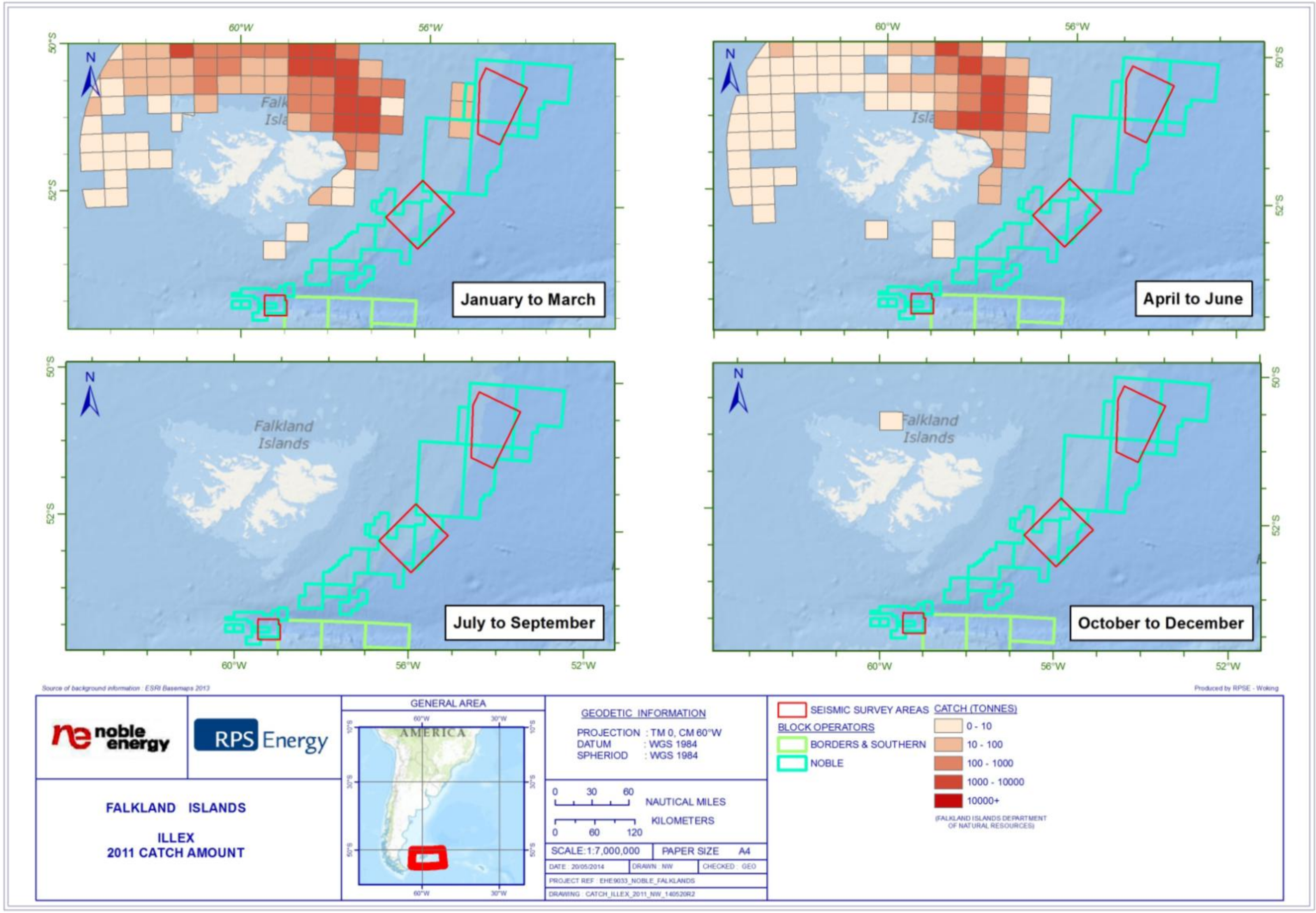


Figure E.10e: Fisheries catch mass (tonnes) for Argentine shortfin squid (Illex argentinus) for the year 2012 (FIG Department of Natural Resources – Fisheries Department, 2014)

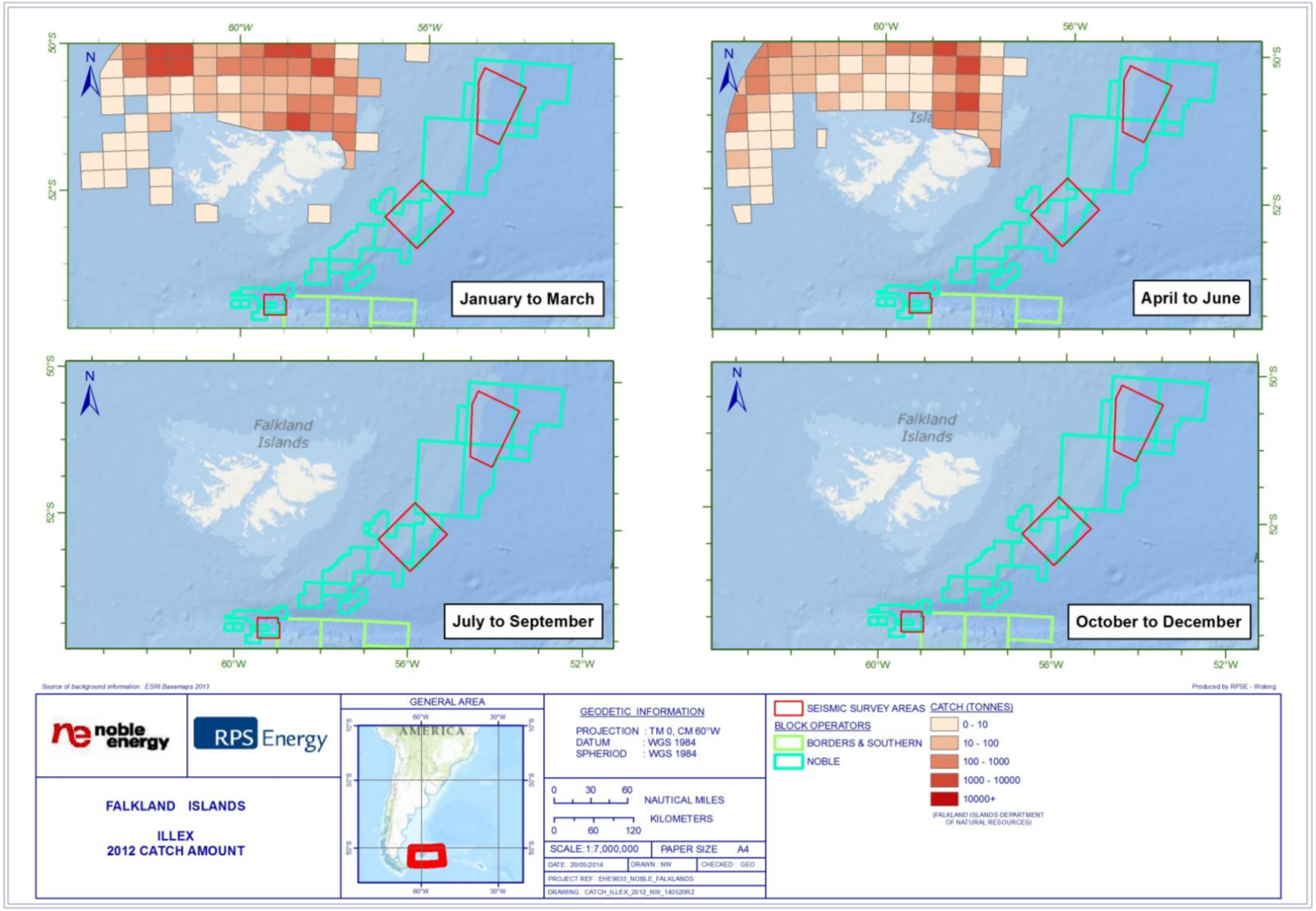


Figure E.10f: Fisheries catch mass (tonnes) for Argentine shortfin squid (Illex argentinus) for the year 2013 (FIG Department of Natural Resources – Fisheries Department, 2014)

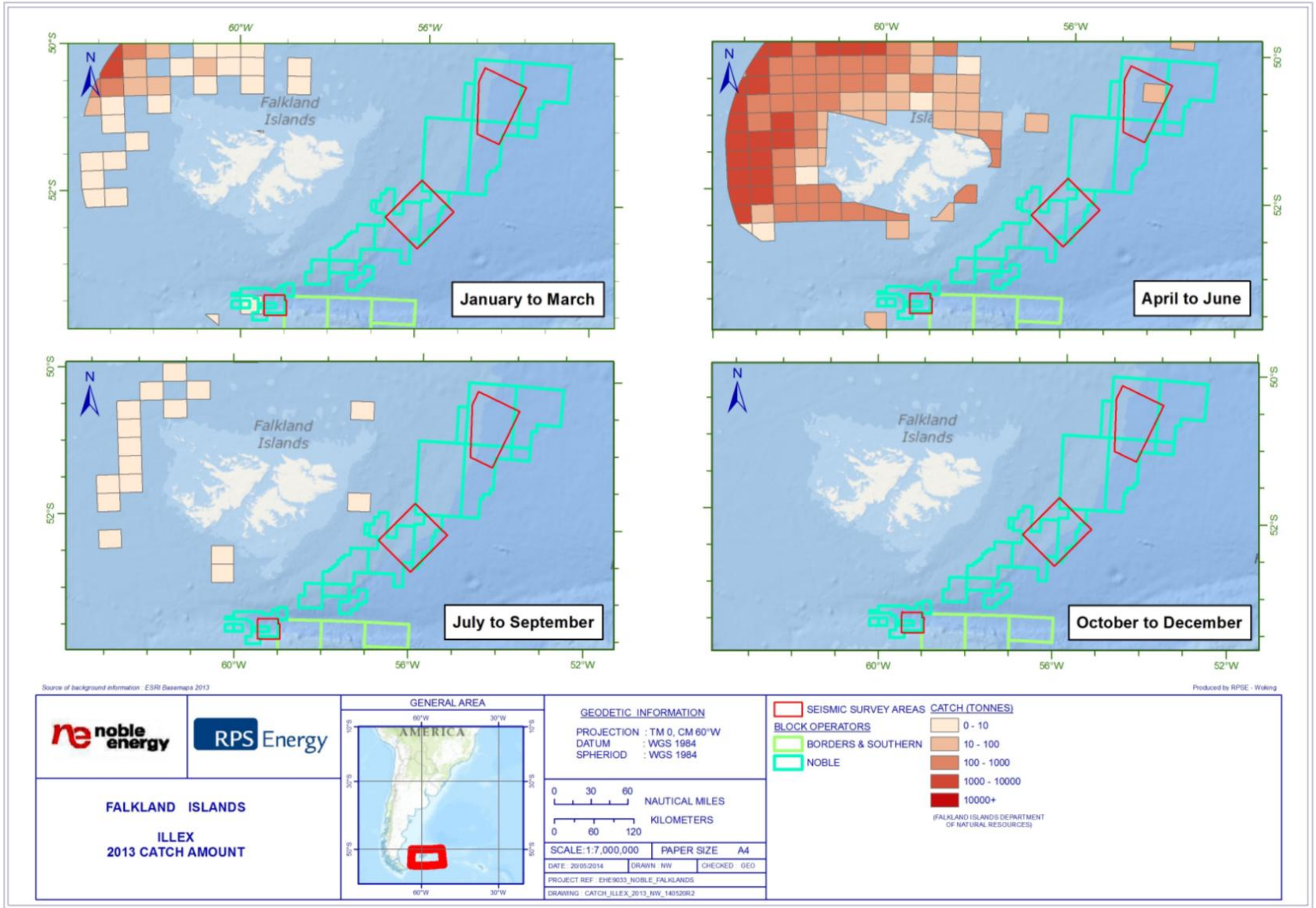


Figure E.11a: Fisheries catch mass (tonnes) for Patagonian Squid (Doryteuthis gahi) for the year 2008 (FIG Department of Natural Resources – Fisheries Department, 2014)

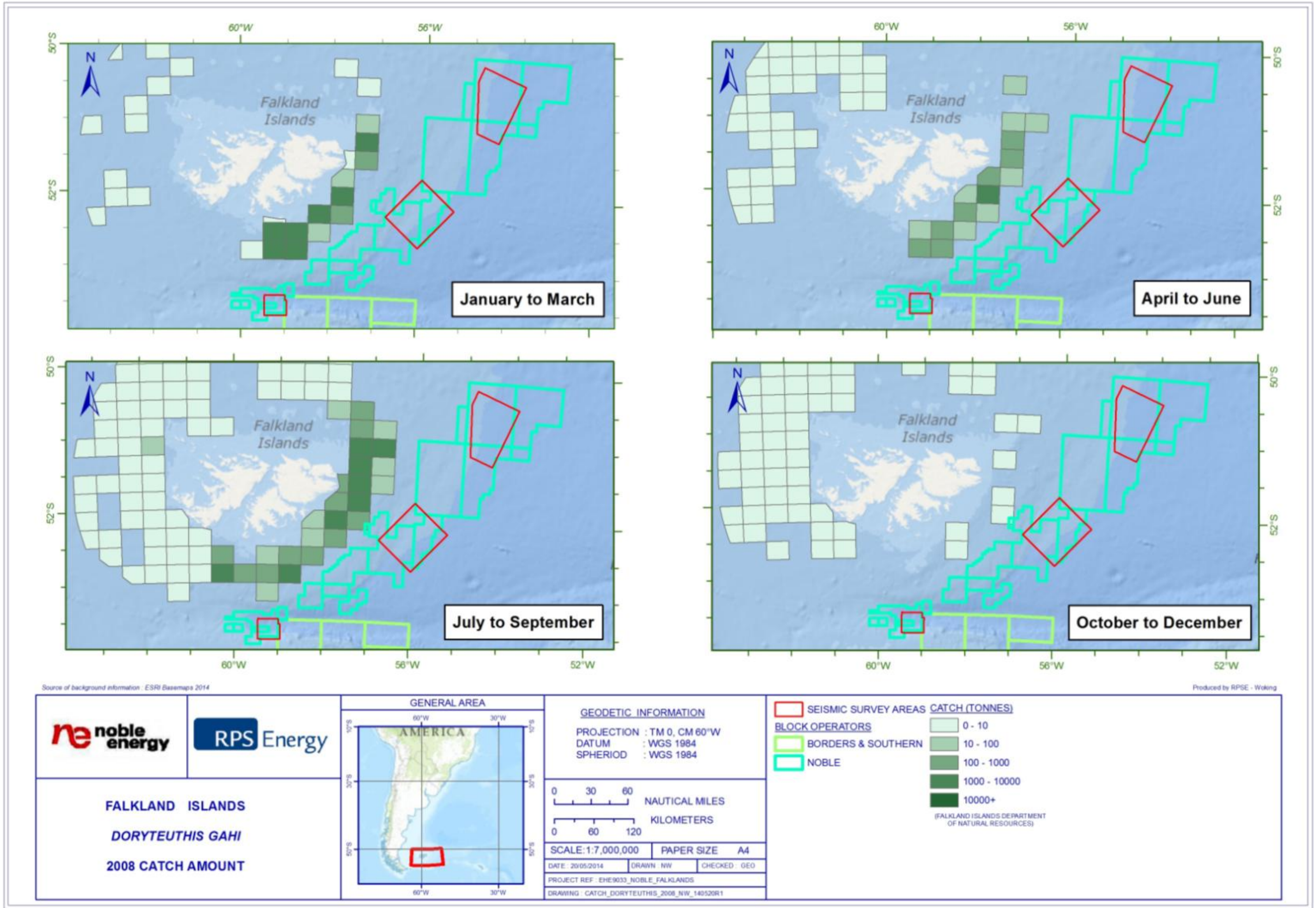


Figure E.11b: Fisheries catch mass (tonnes) for Patagonian Squid (Doryteuthis gahi) for the year 2009 (FIG Department of Natural Resources – Fisheries Department, 2014)

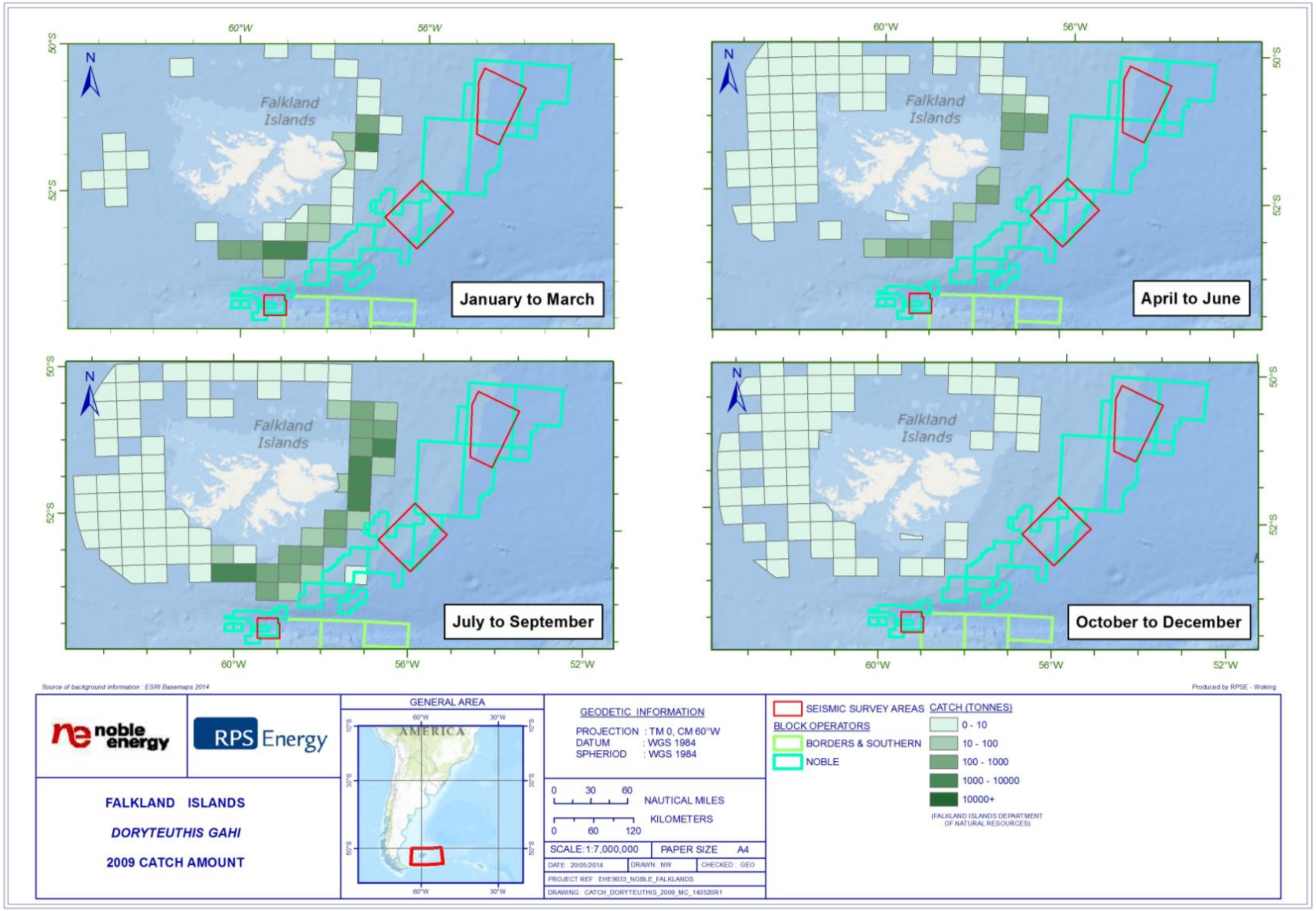


Figure E.11c: Fisheries catch mass (tonnes) for Patagonian Squid (Doryteuthis gahi) for the year 2010 (FIG Department of Natural Resources – Fisheries Department, 2014)

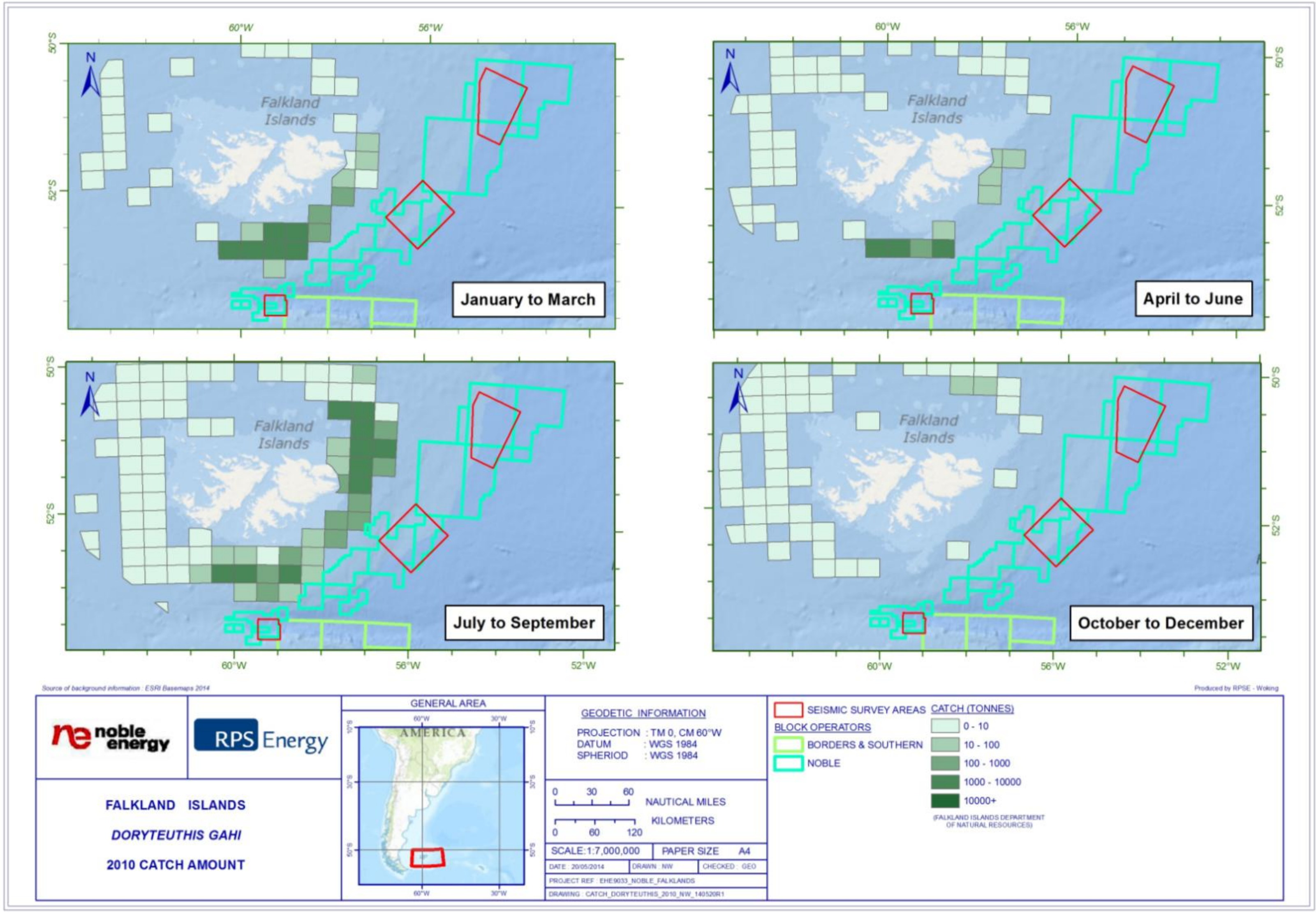


Figure E.11d: Fisheries catch mass (tonnes) for Patagonian Squid (Doryteuthis gahi) for the year 2011 (FIG Department of Natural Resources – Fisheries Department, 2014)

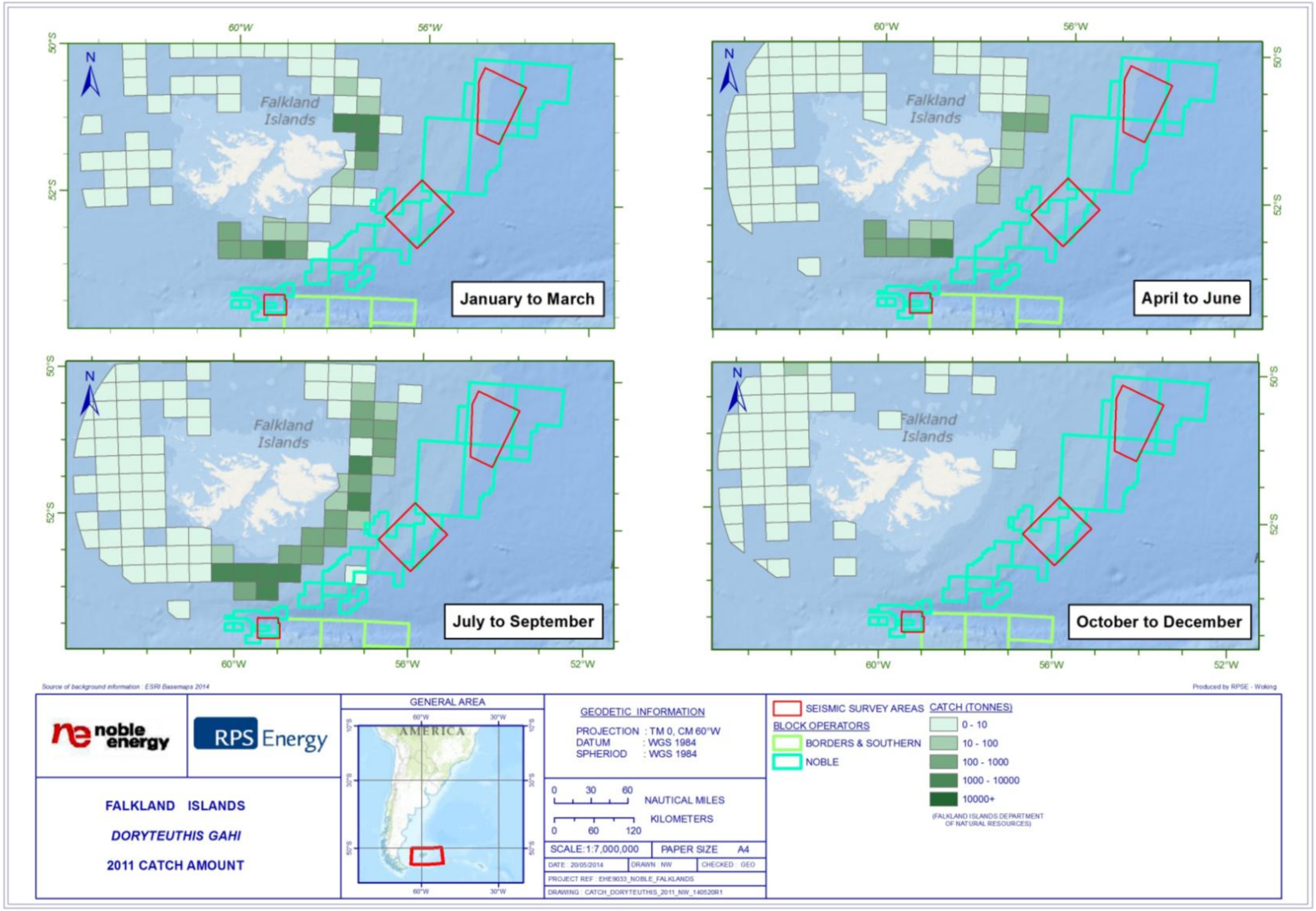


Figure E.11e: Fisheries catch mass (tonnes) for Patagonian Squid (Doryteuthis gahi) for the year 2012 (FIG Department of Natural Resources – Fisheries Department, 2014)

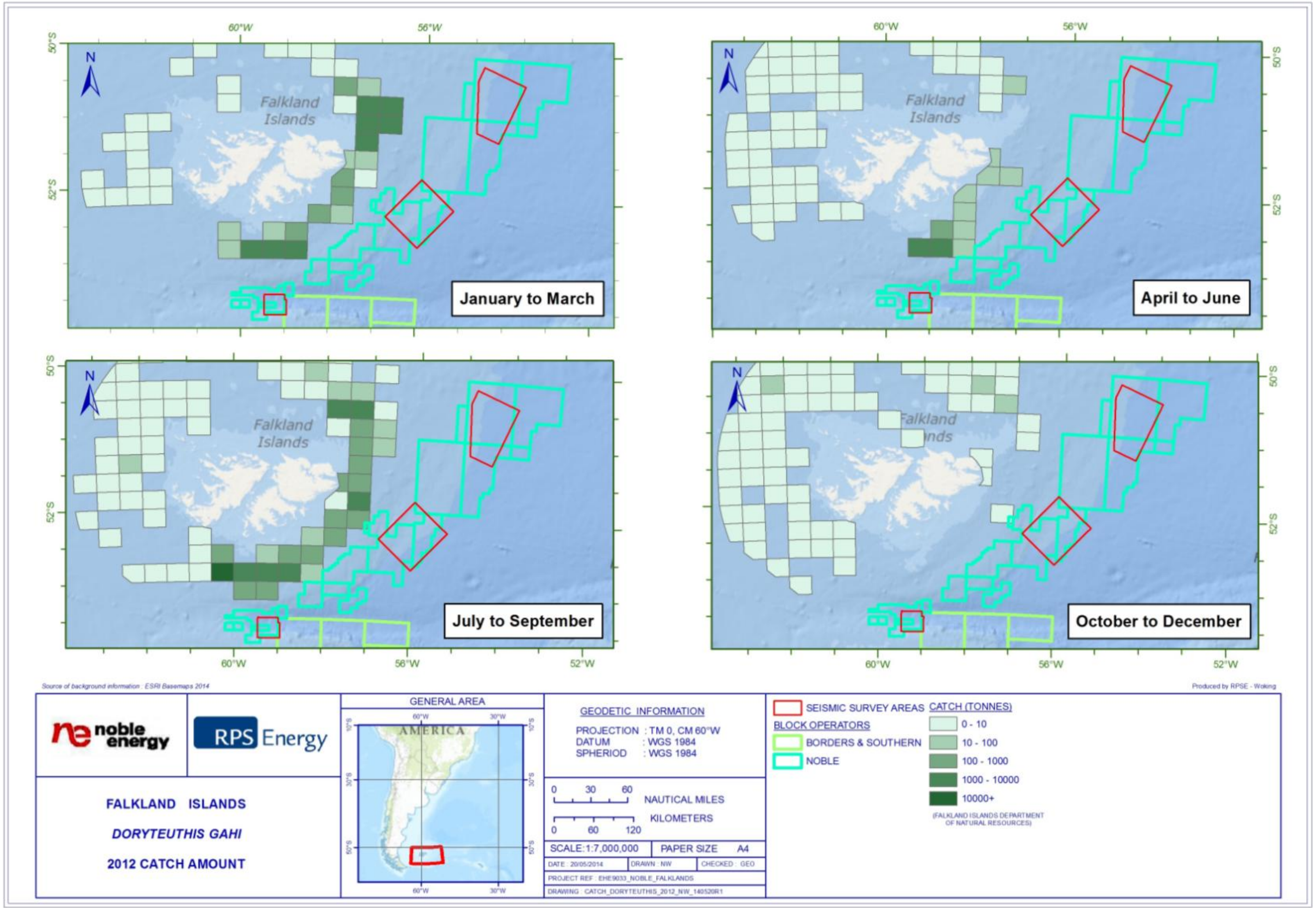


Figure E.11f: Fisheries catch mass (tonnes) for Patagonian Squid (Doryteuthis gahi) for the year 2013 (FIG Department of Natural Resources – Fisheries Department, 2014)

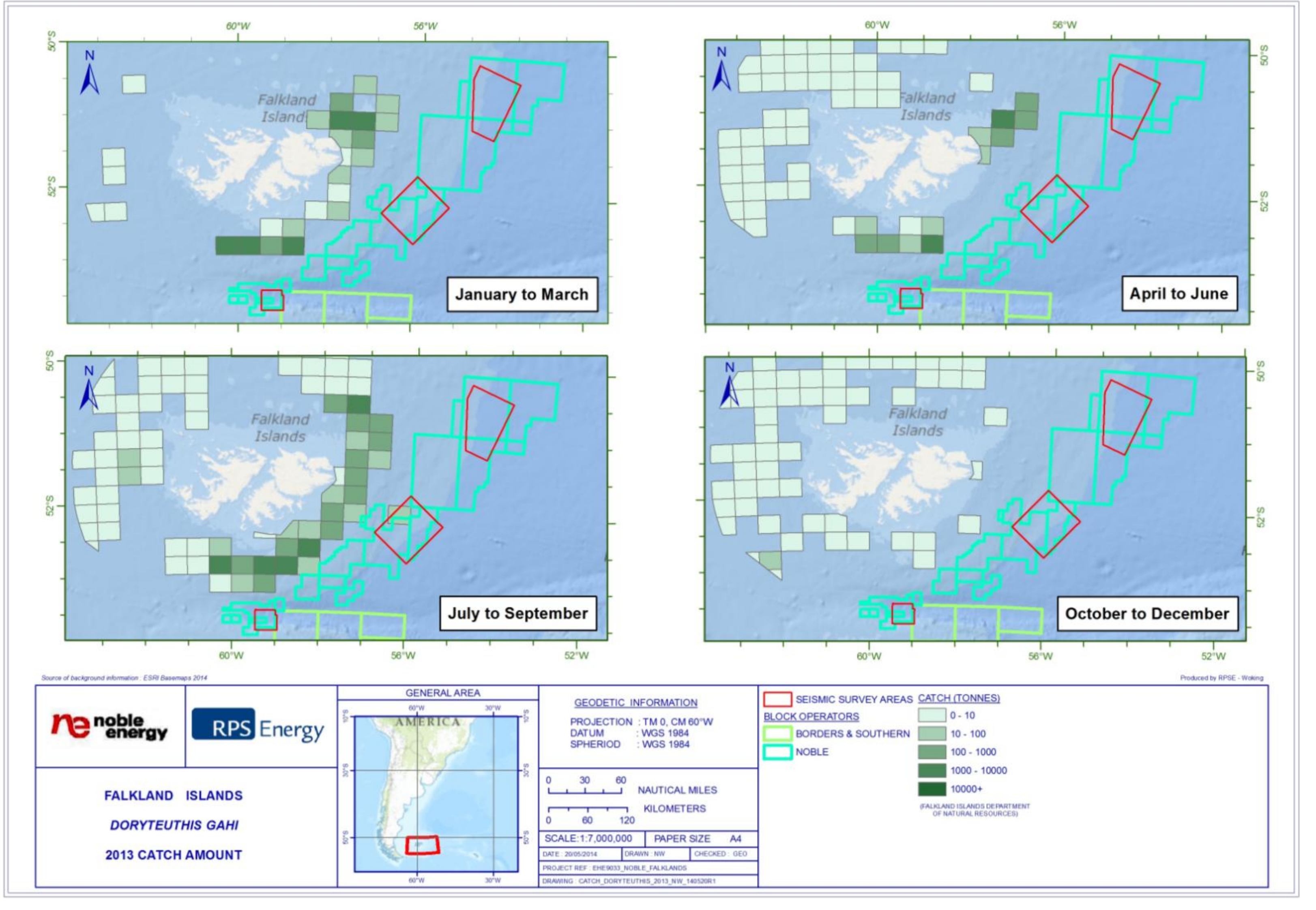


Figure E.12a: Fisheries catch mass (tonnes) for other species for the year 2008 (FIG Department of Natural Resources – Fisheries Department, 2014)

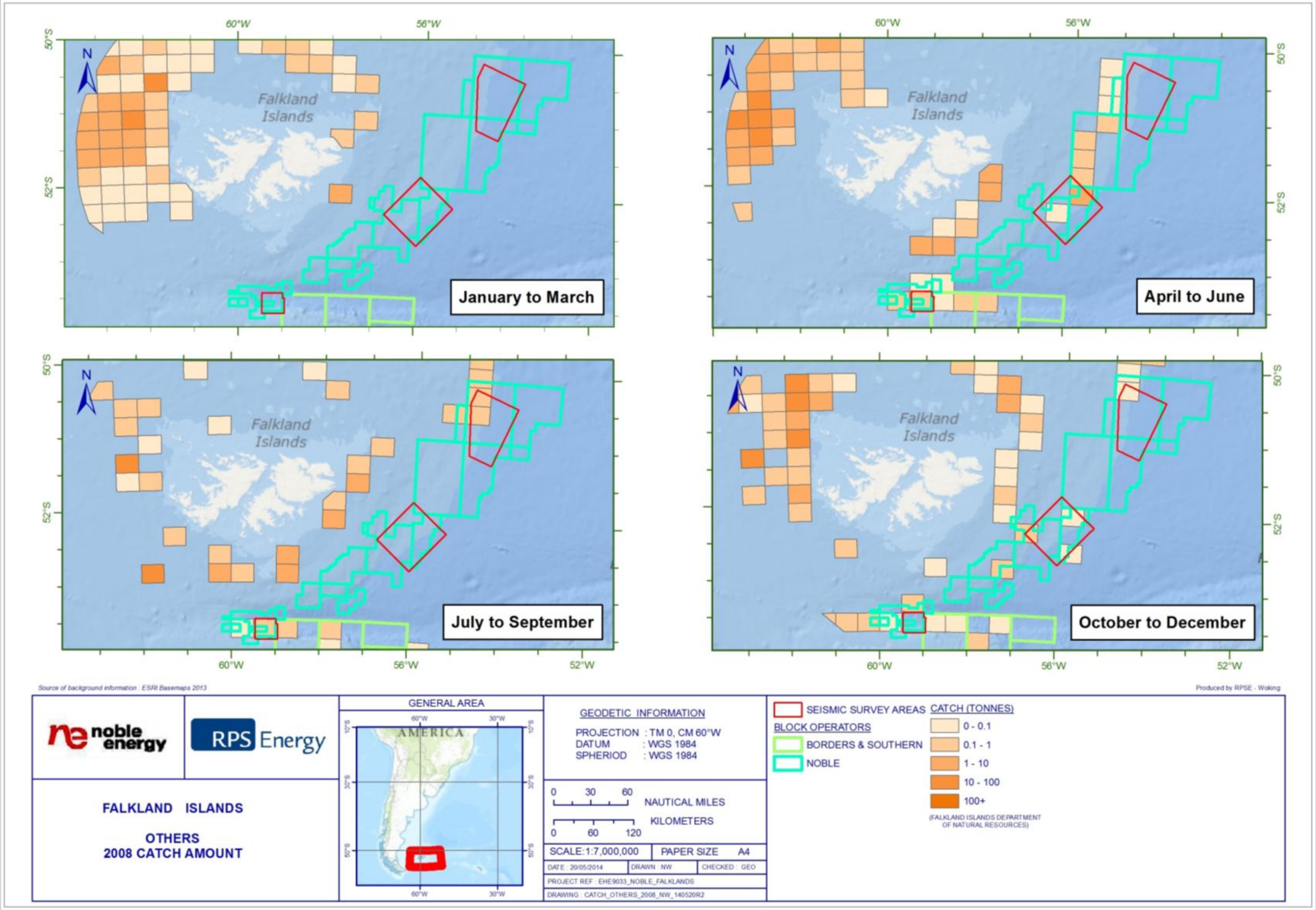


Figure E.12b: Fisheries catch mass (tonnes) for other species for the year 2009 (FIG Department of Natural Resources – Fisheries Department, 2014)

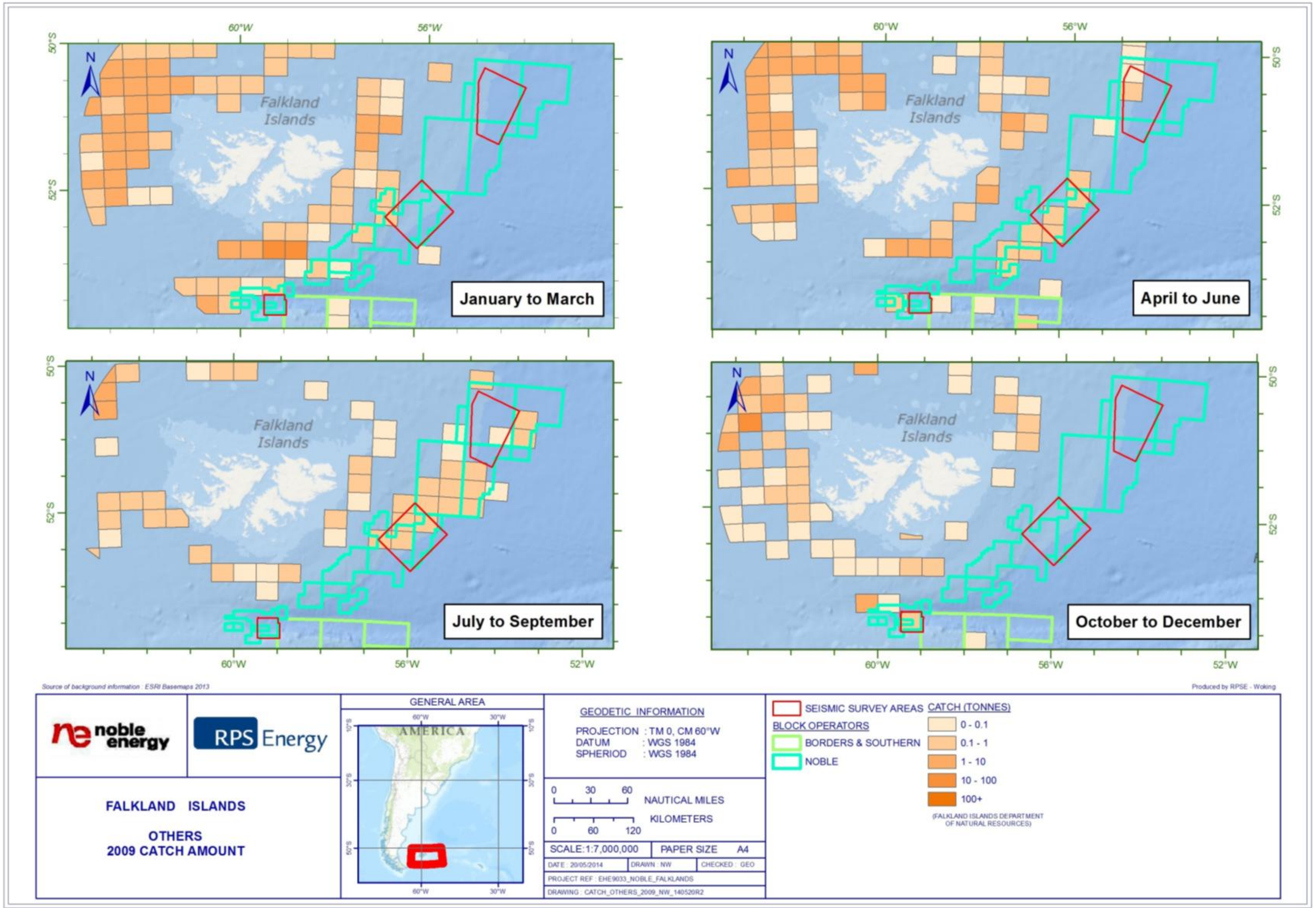


Figure E.12c: Fisheries catch mass (tonnes) for other species for the year 2010 (FIG Department of Natural Resources – Fisheries Department, 2014)

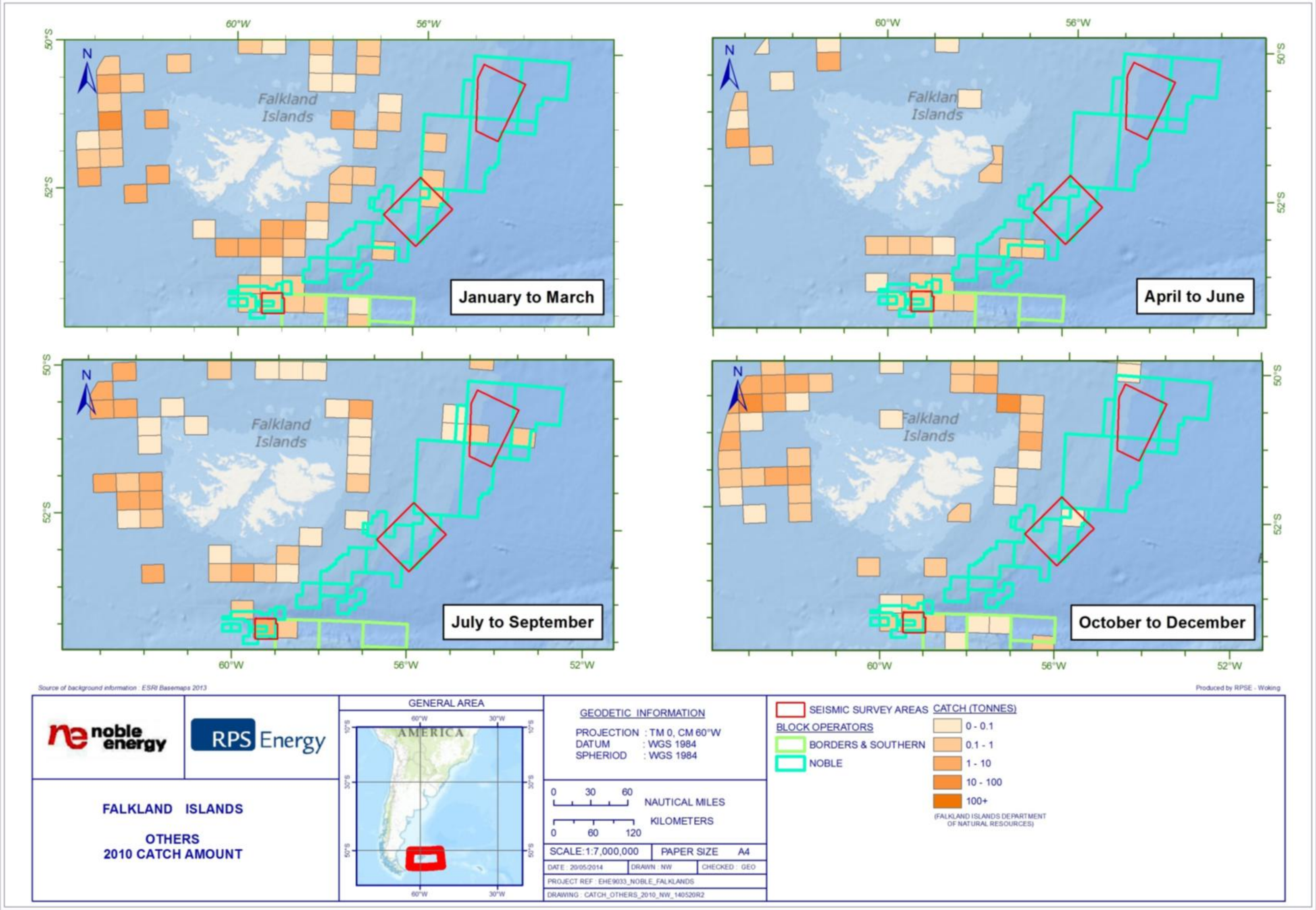


Figure E.12d: Fisheries catch mass (tonnes) for other species for the year 2011 (FIG Department of Natural Resources – Fisheries Department, 2014)

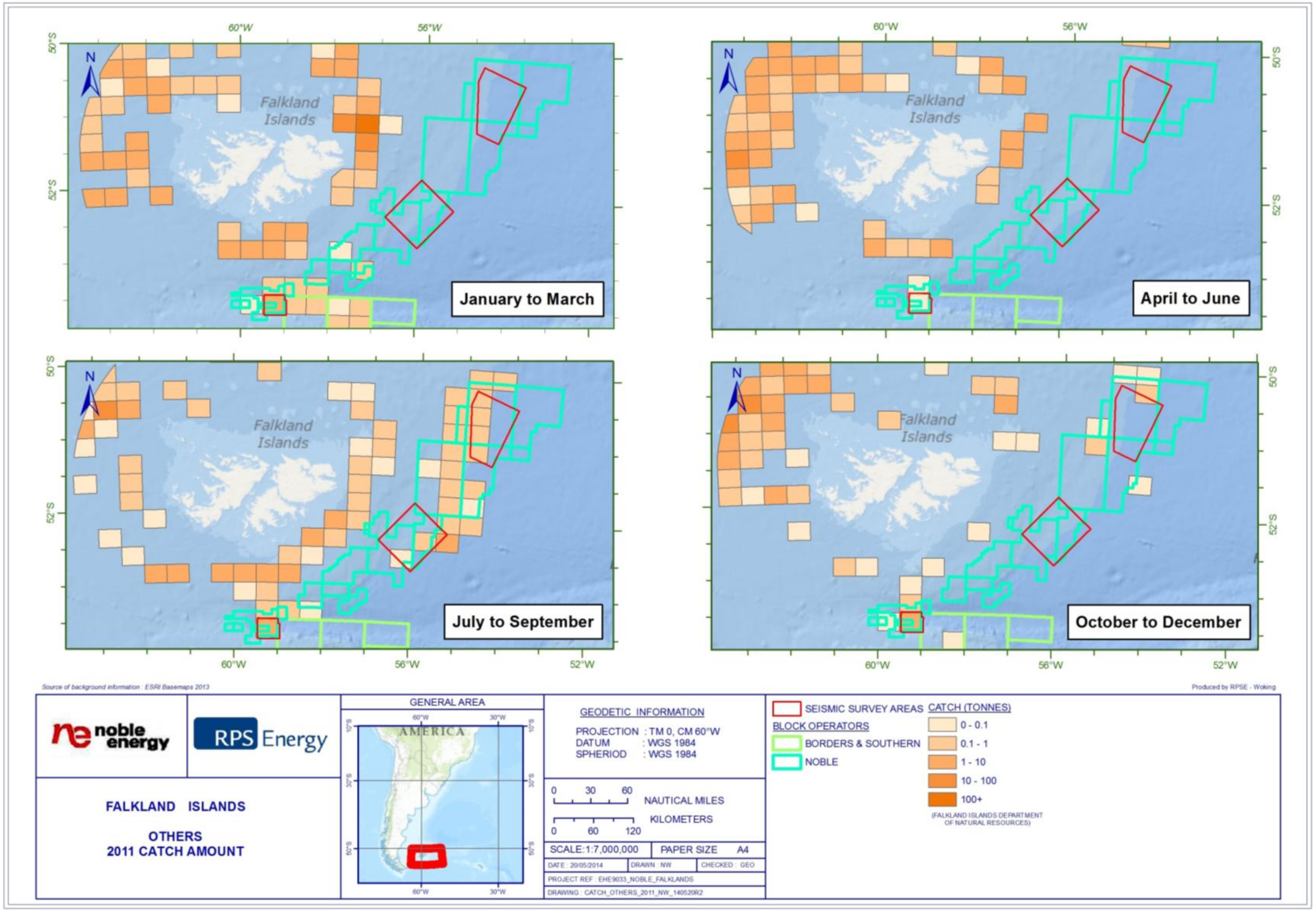


Figure E.12e: Fisheries catch mass (tonnes) for other species for the year 2012 (FIG Department of Natural Resources – Fisheries Department, 2014)

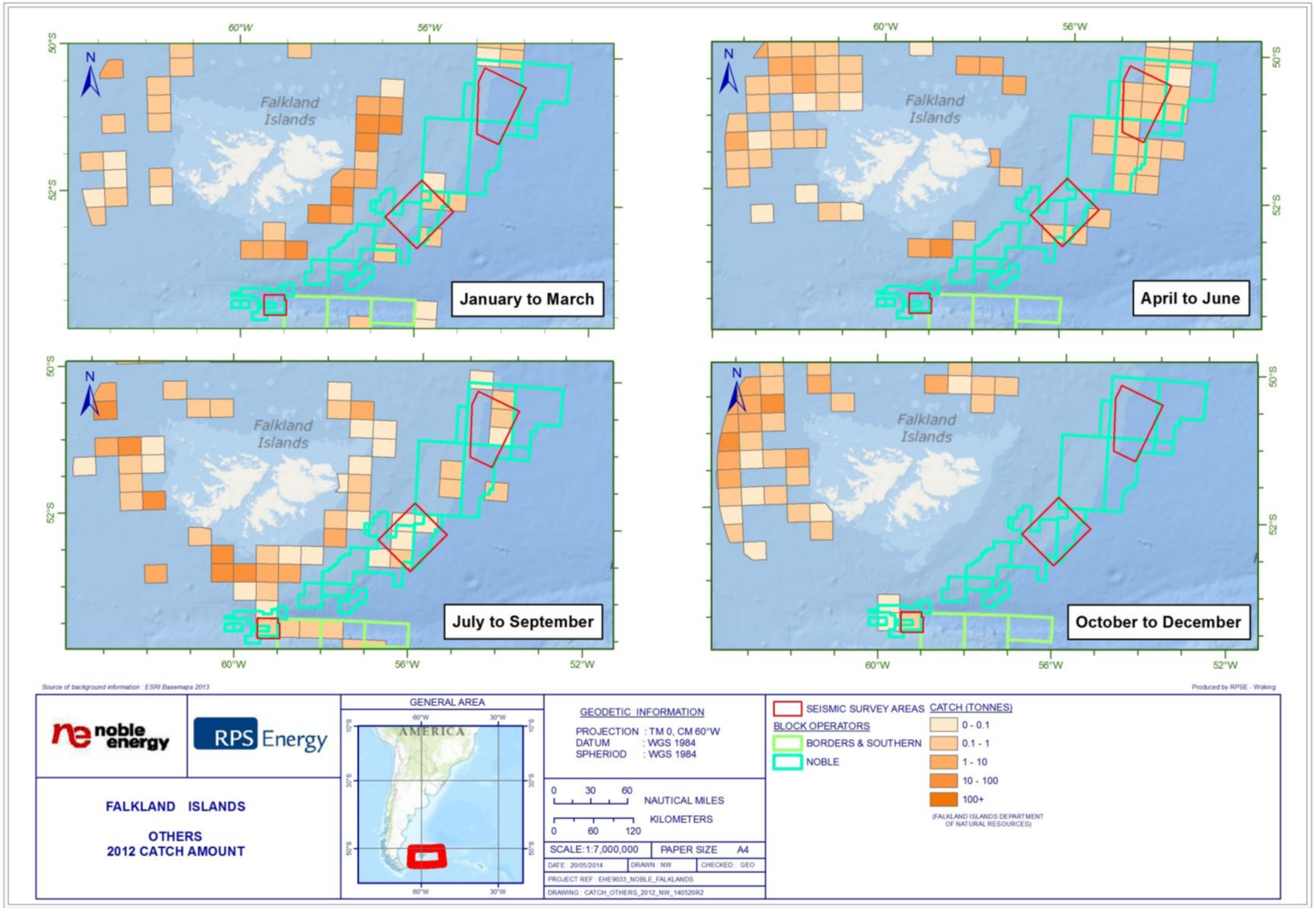


Figure E.12f: Fisheries catch mass (tonnes) for other species for the year 2013 (FIG Department of Natural Resources – Fisheries Department, 2014)

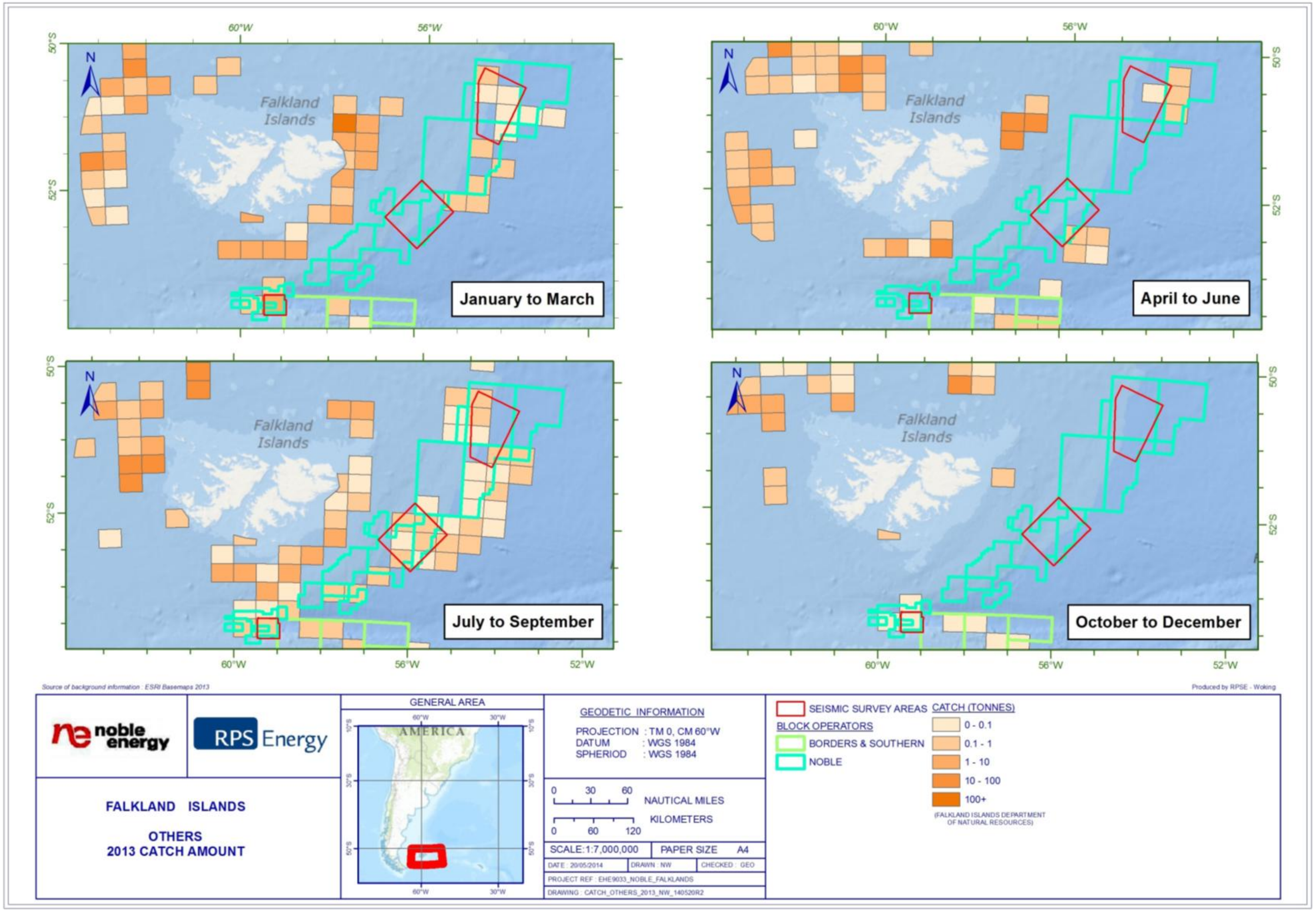


Figure E.13a: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2008 for the months January to March (FIG Department of Natural Resources – Fisheries Department, 2013)

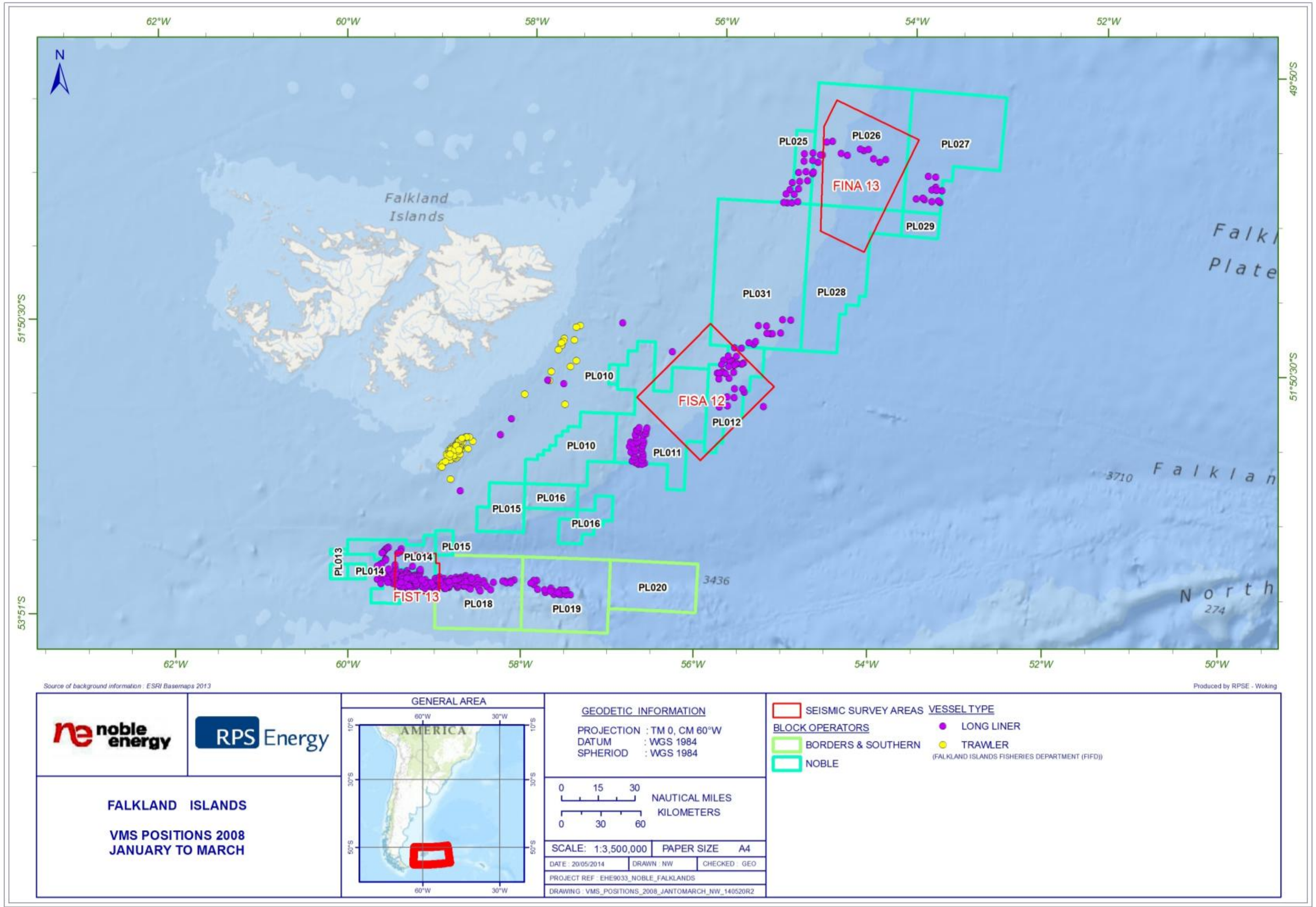


Figure E.13b: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2008 for the months April to June (FIG Department of Natural Resources – Fisheries Department, 2013)

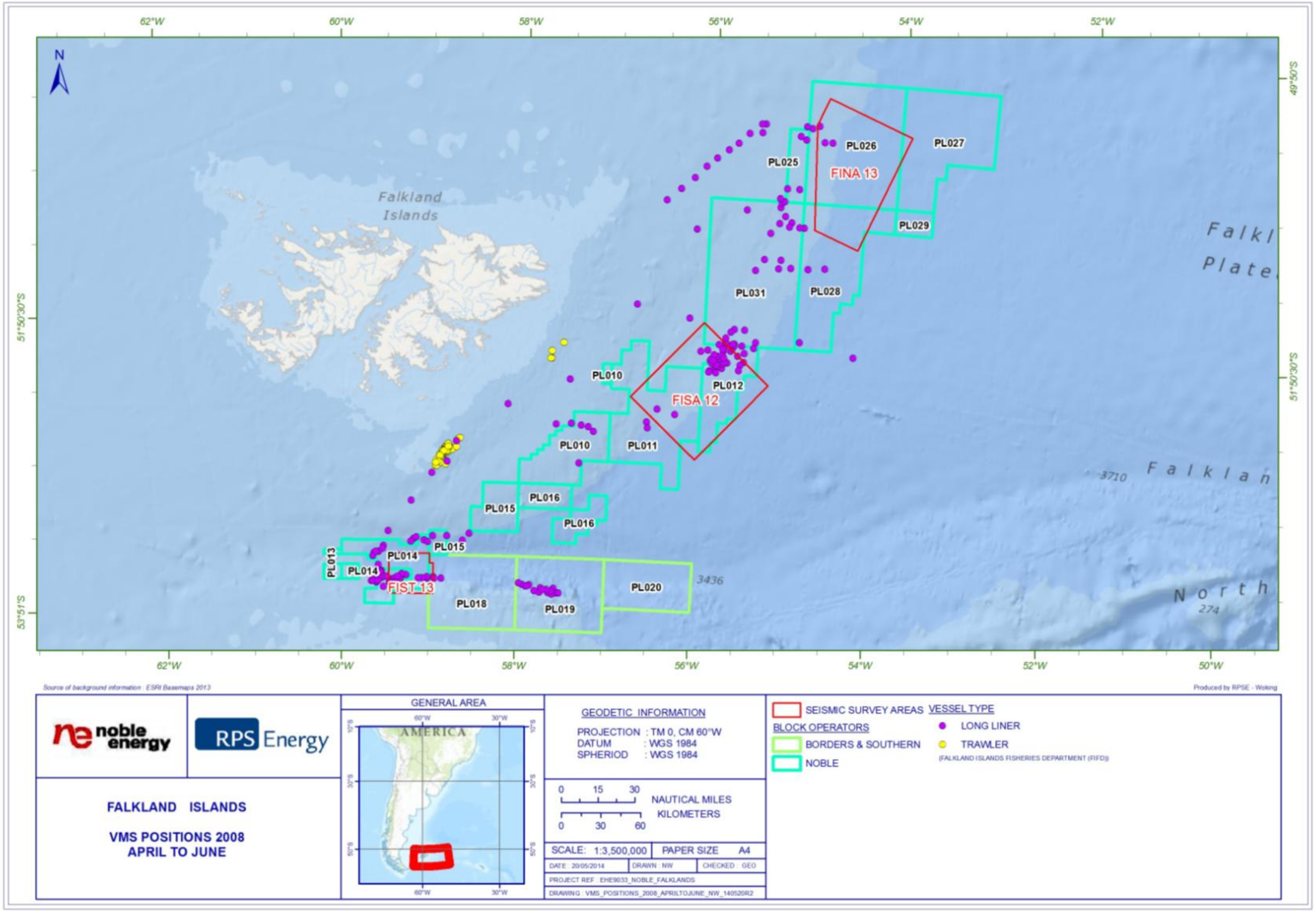


Figure E.13c: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2008 for the months July to September (FIG Department of Natural Resources – Fisheries Department, 2013)

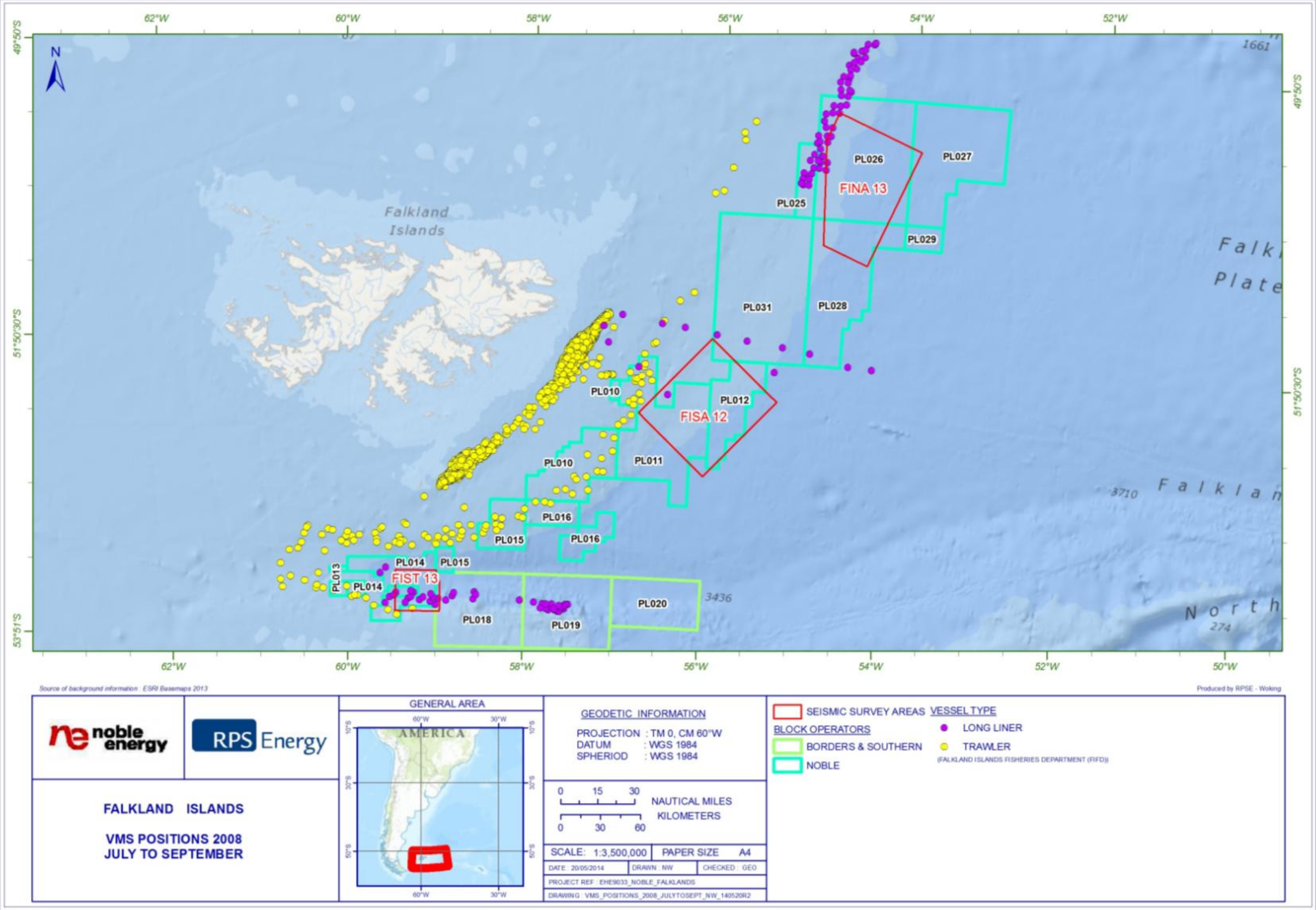


Figure E.13d: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2008 for the months October to December (FIG Department of Natural Resources – Fisheries Department, 2013)

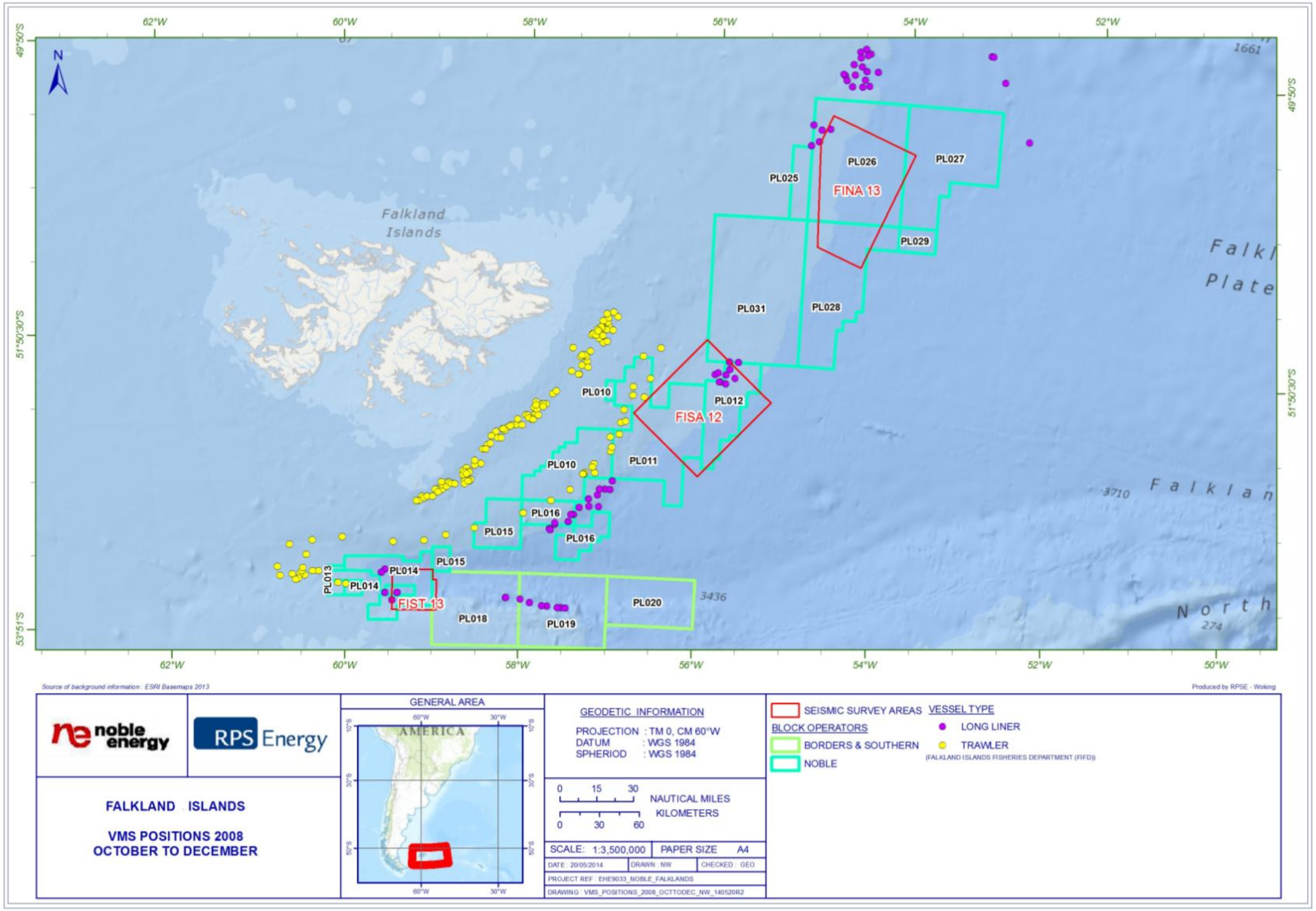


Figure E.13e: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2008, all months (FIG Department of Natural Resources – Fisheries Department, 2013)

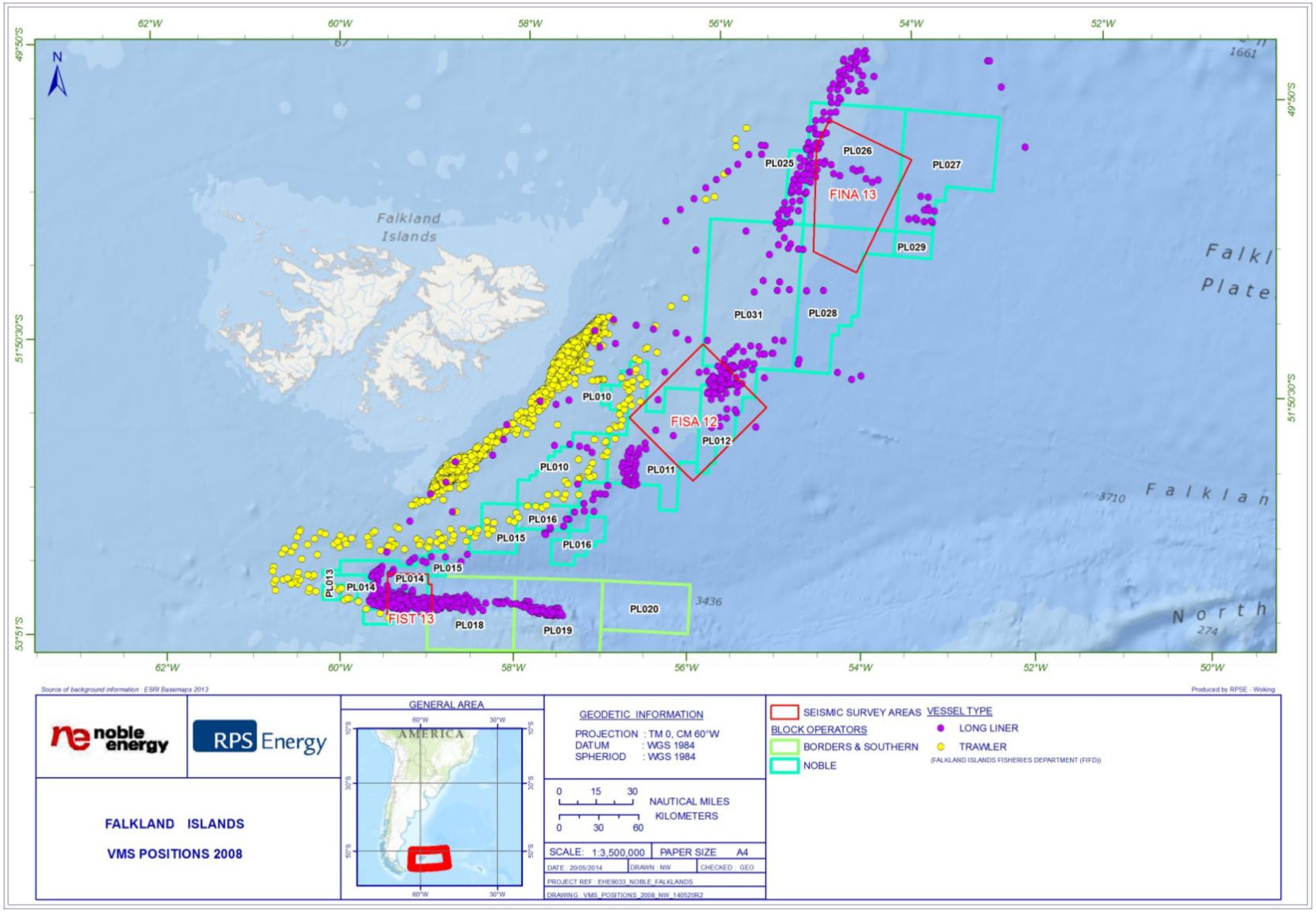


Figure E.14a: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2009 for the months January to March (FIG Department of Natural Resources – Fisheries Department, 2013)

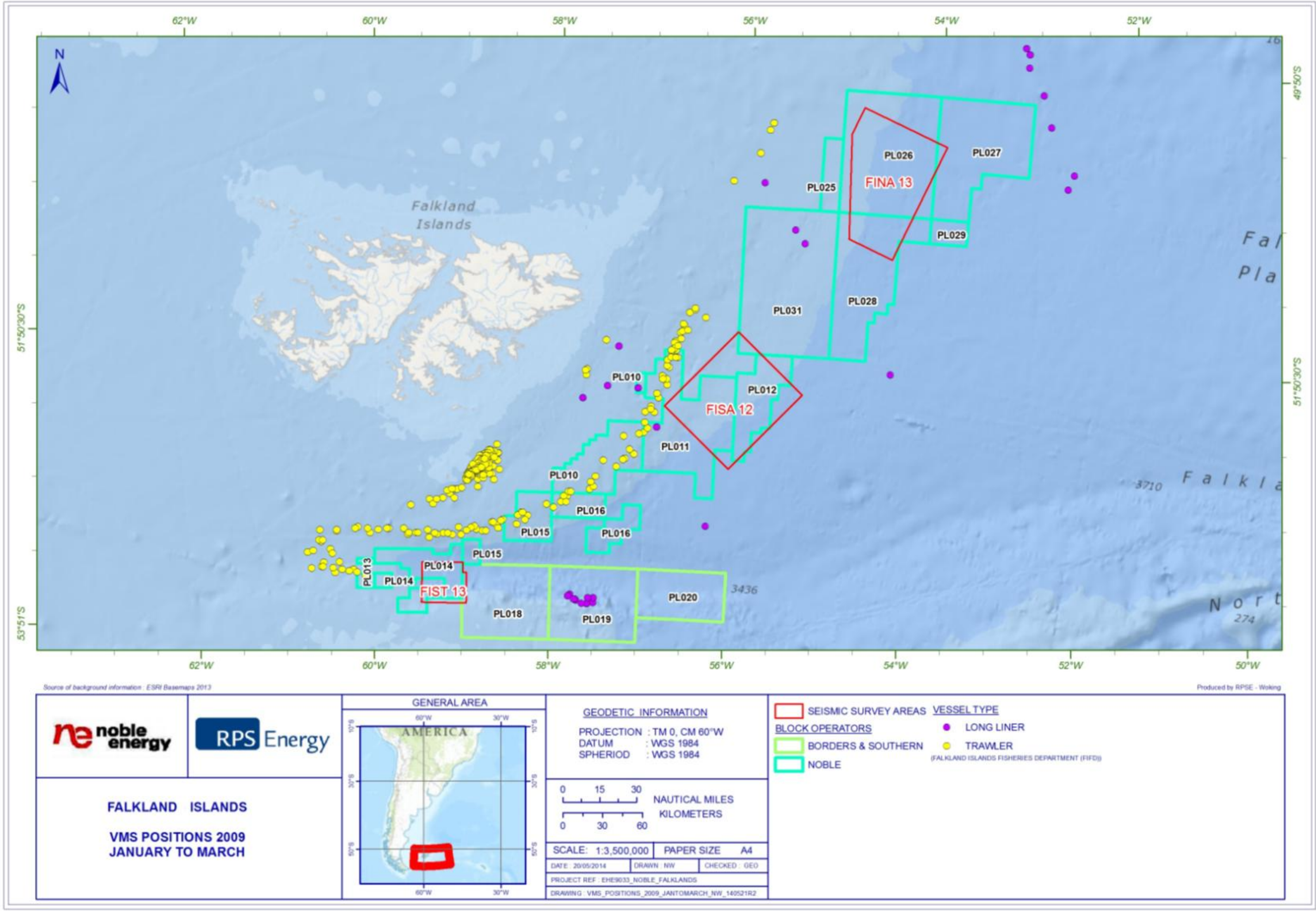


Figure E.14b: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2009 for the months April to June (FIG Department of Natural Resources – Fisheries Department, 2013)

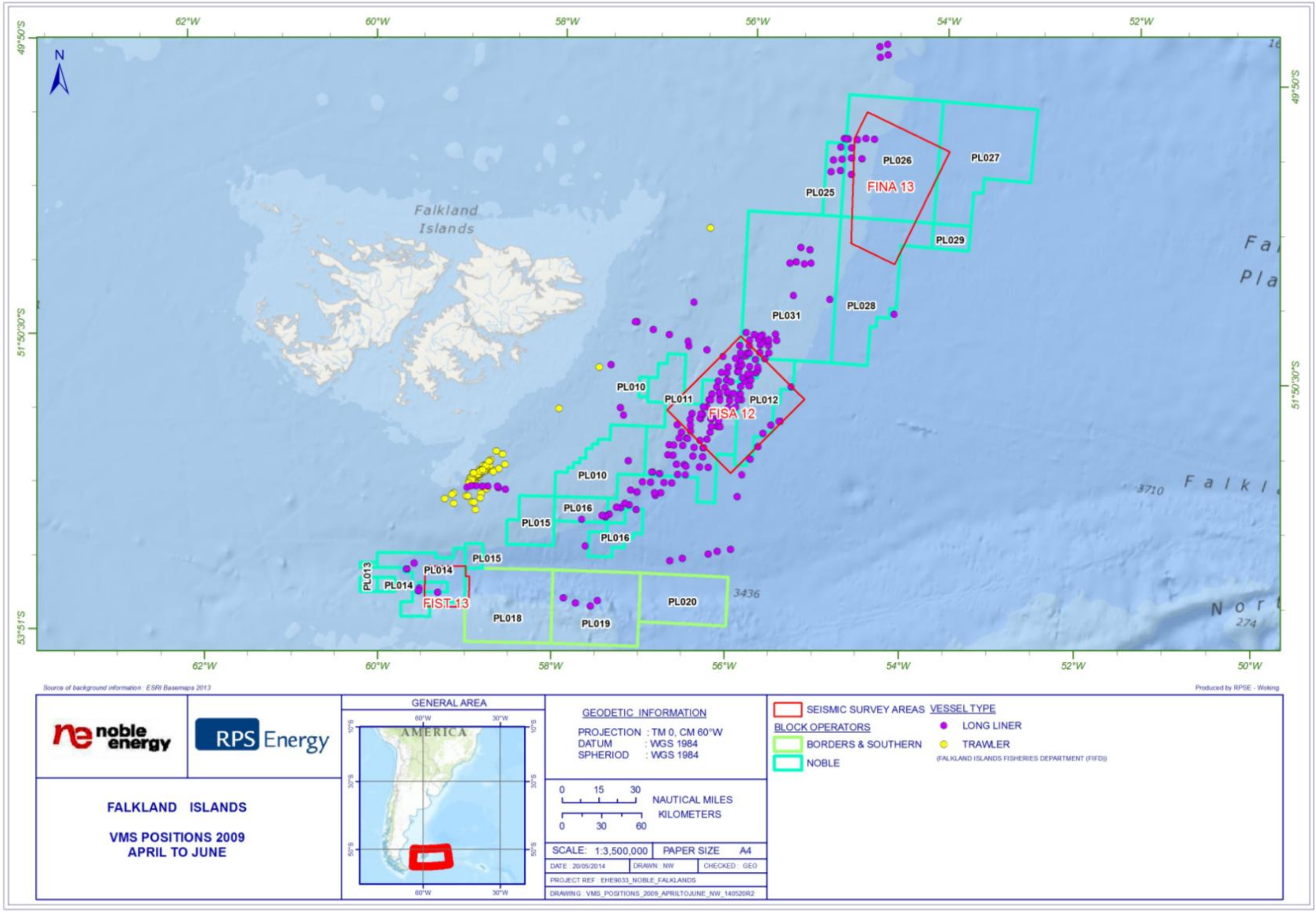


Figure E.14c: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2009 for the months July to September (FIG Department of Natural Resources – Fisheries Department, 2013)

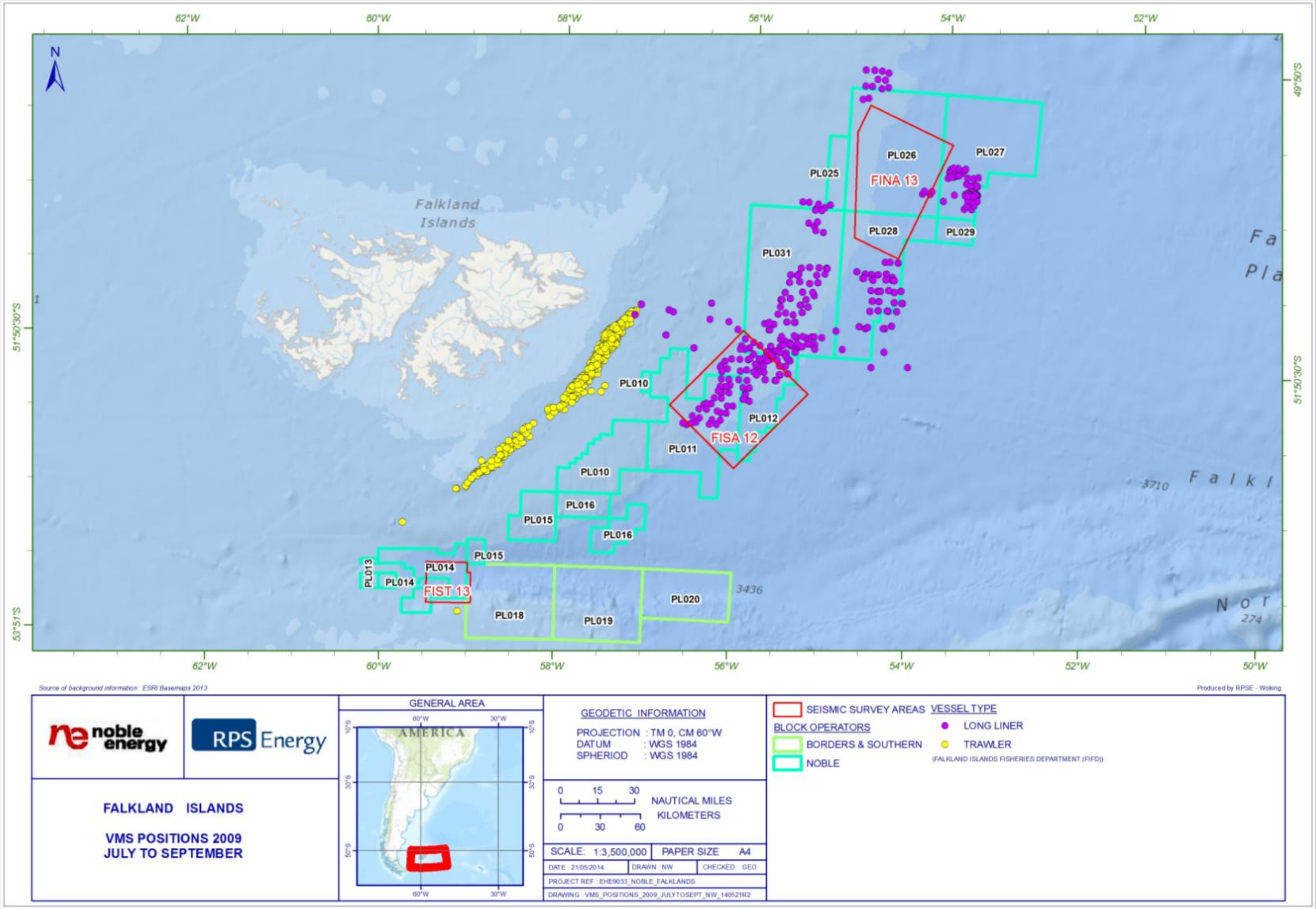


Figure E.14d: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2009 for the months October to December (FIG Department of Natural Resources – Fisheries Department, 2013)

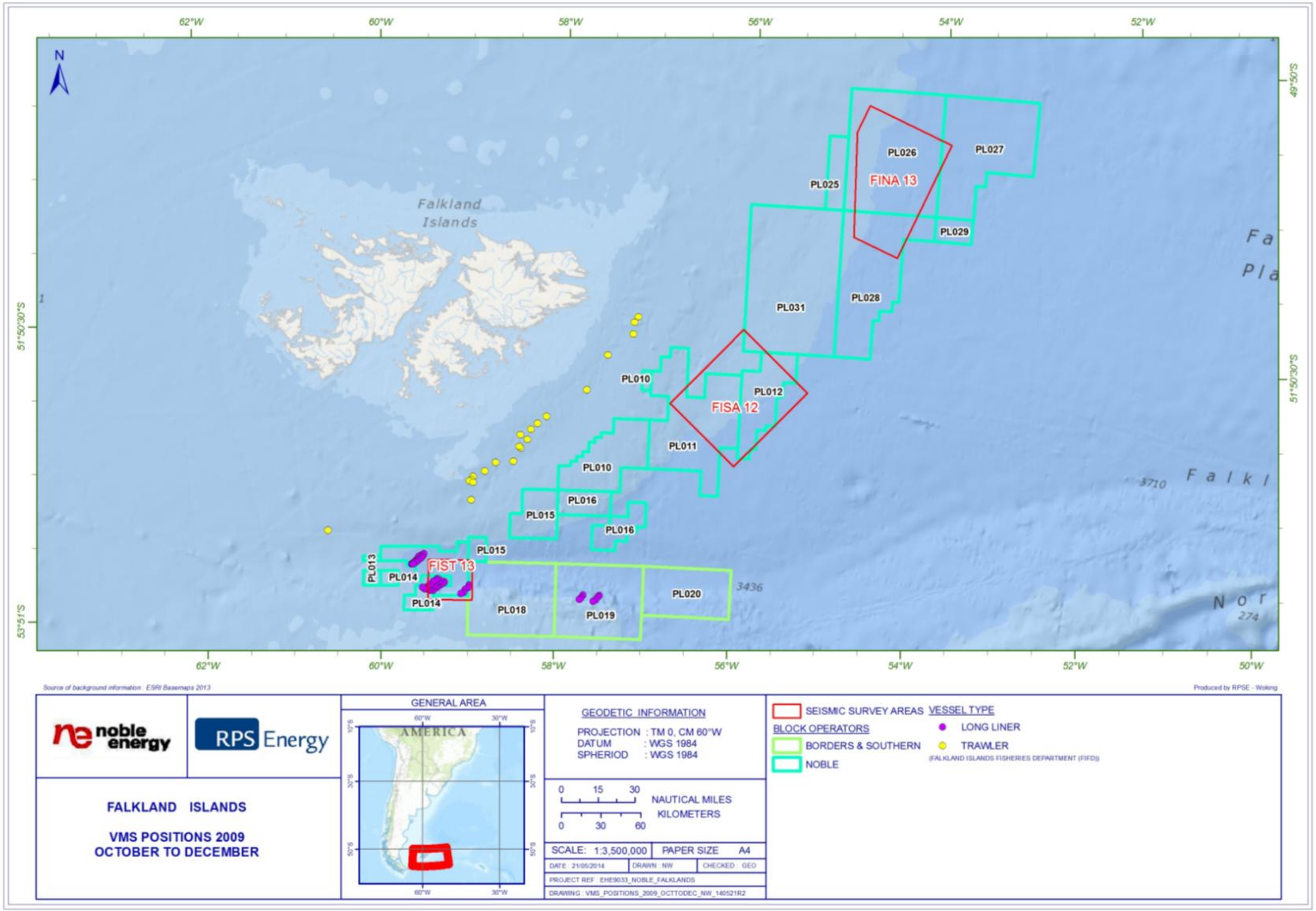


Figure E.14e: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2009, all months (FIG Department of Natural Resources – Fisheries Department, 2013)

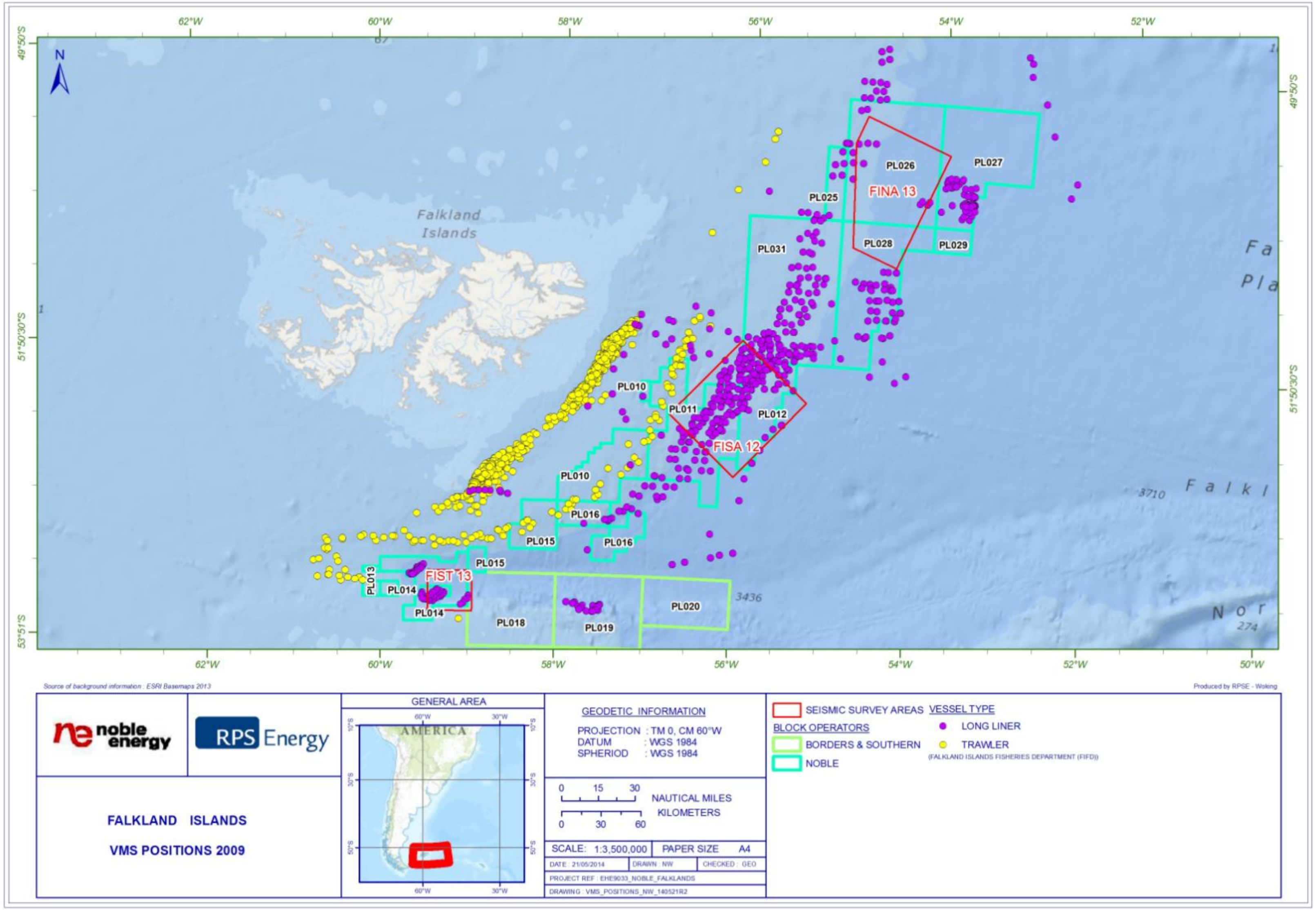


Figure E.15a: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2010 for the months January to March (FIG Department of Natural Resources – Fisheries Department, 2013)

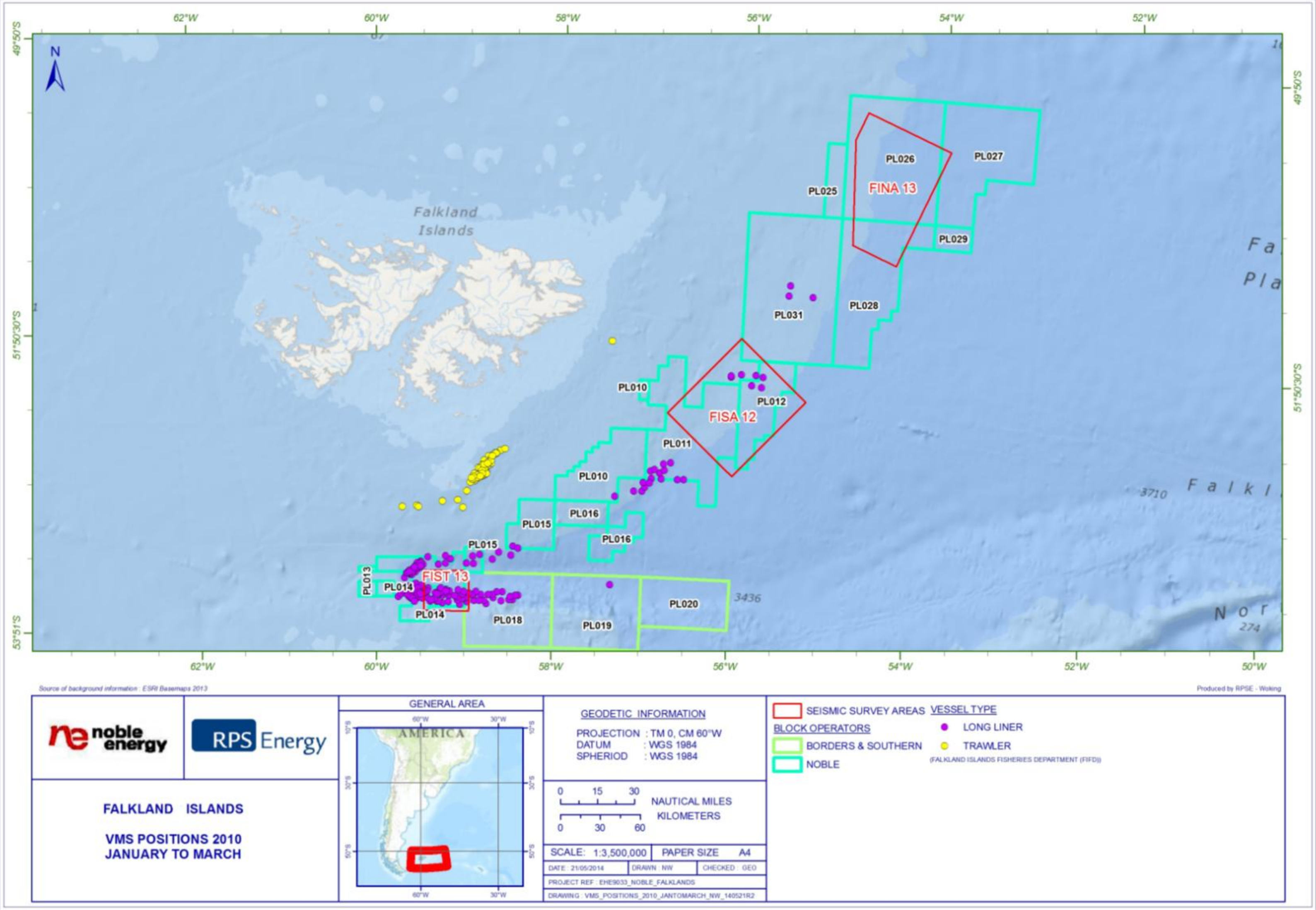


Figure E.15b: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2010 for the months April to June (FIG Department of Natural Resources – Fisheries Department, 2013)

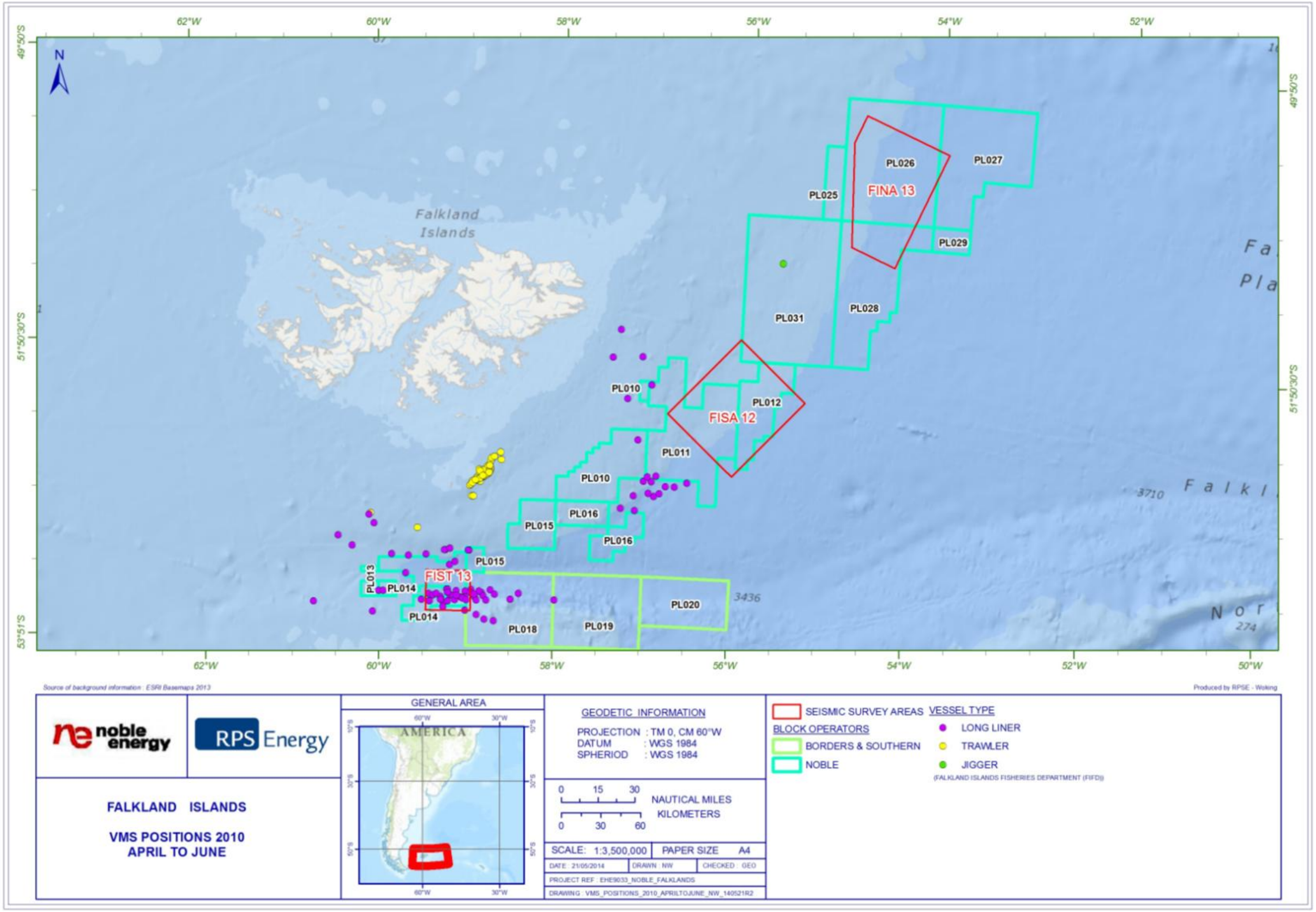


Figure E.15c: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2010 for the months July to September (FIG Department of Natural Resources – Fisheries Department, 2013)

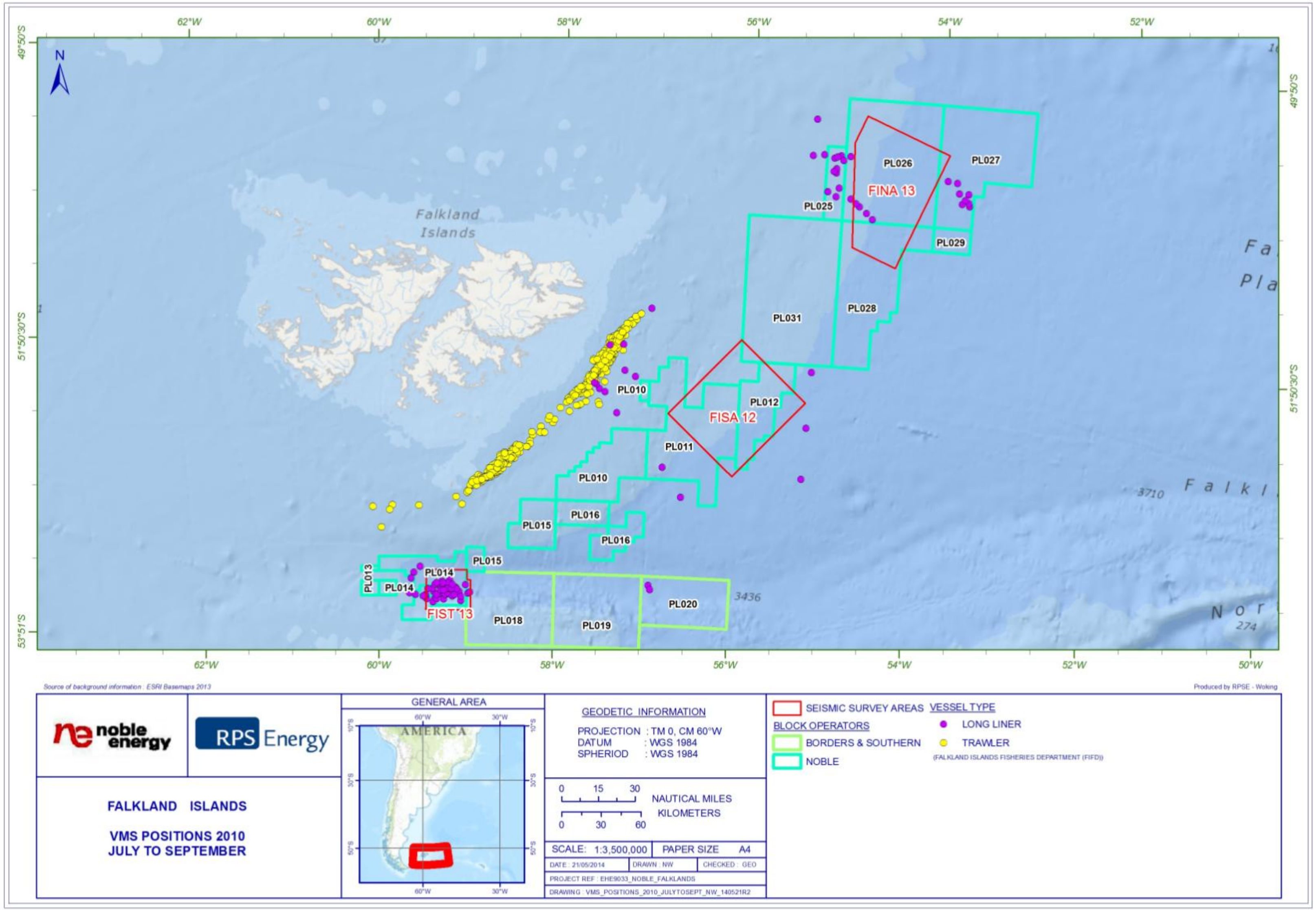


Figure E.15d: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2010 for the months October to December (FIG Department of Natural Resources – Fisheries Department, 2013)

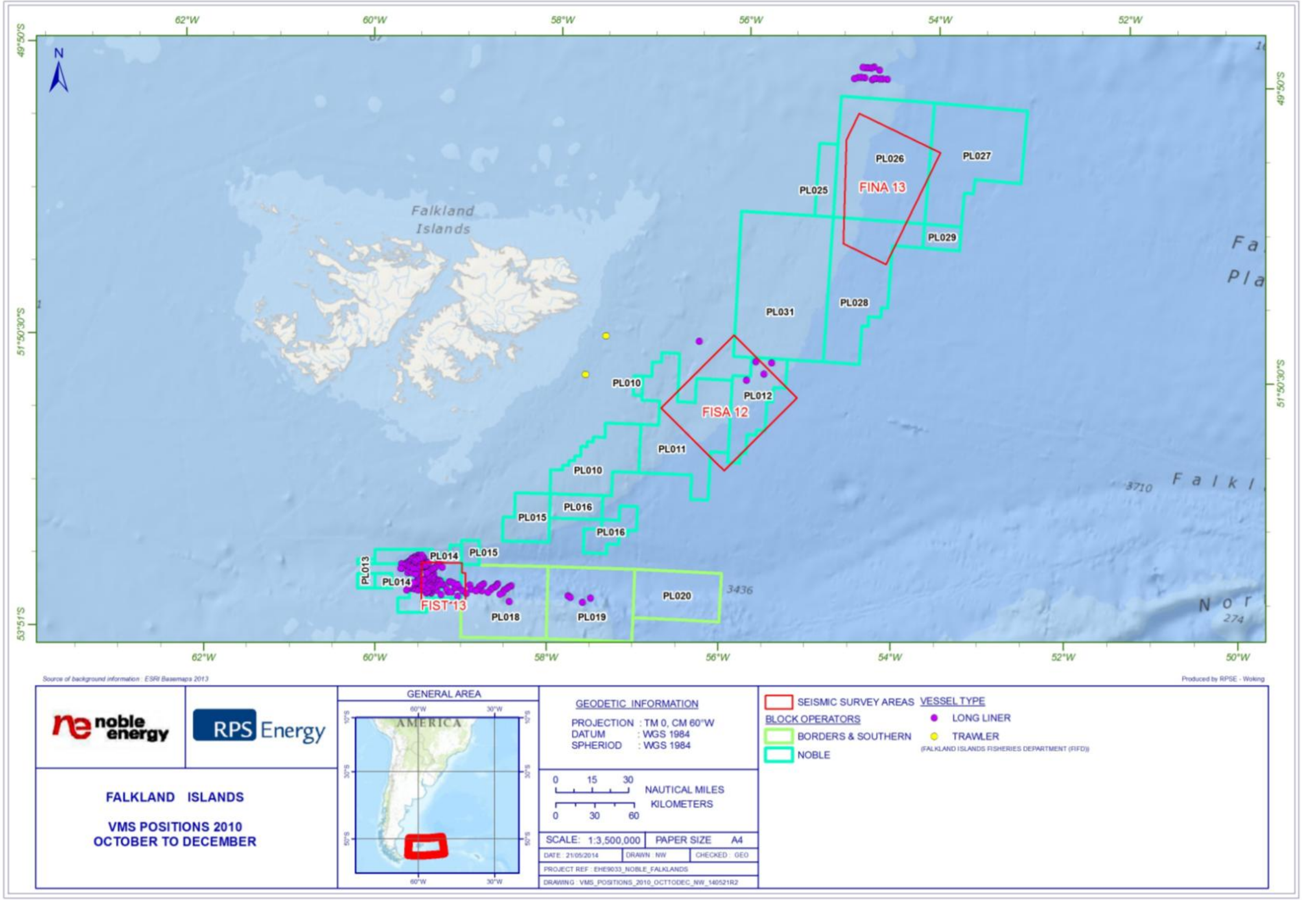


Figure E.15e: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2010, all months (FIG Department of Natural Resources – Fisheries Department, 2013)

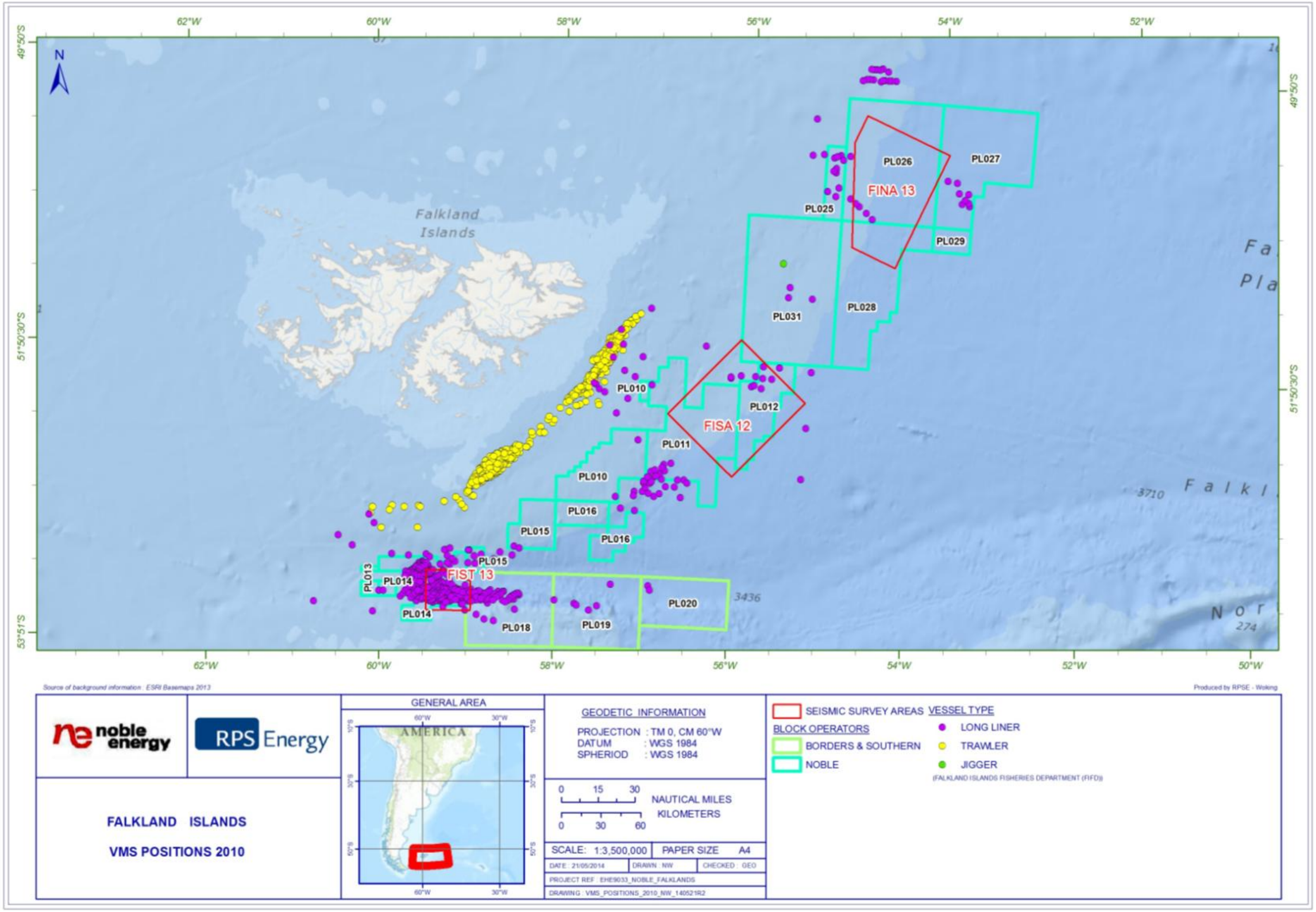


Figure E.16a: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2011 from January to March (FIG Department of Natural Resources – Fisheries Department, 2013)

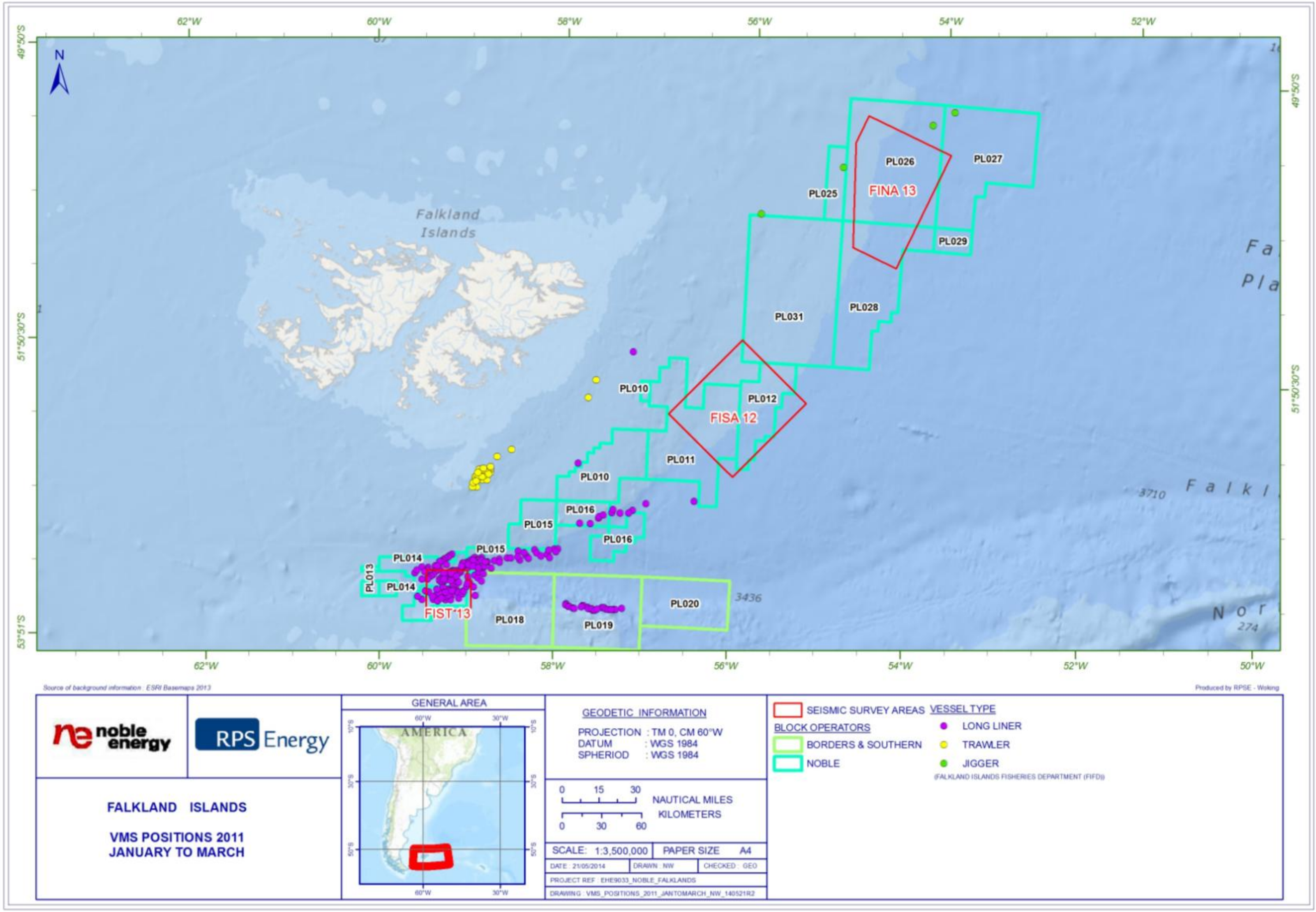


Figure E.16b: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2011 from April to June (FIG Department of Natural Resources – Fisheries Department, 2013)

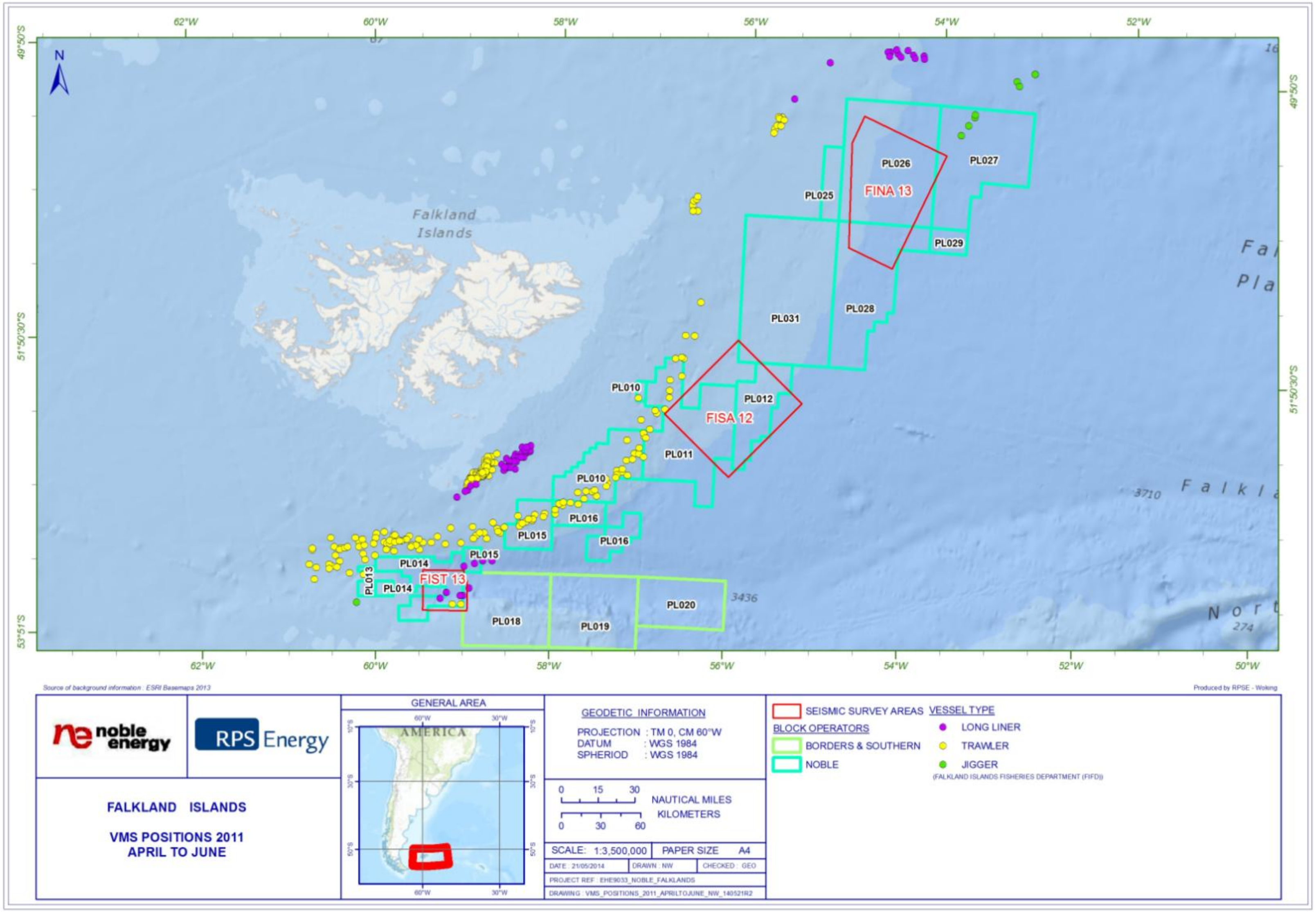


Figure E.16c: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2011 from July to September (FIG Department of Natural Resources – Fisheries Department, 2013)

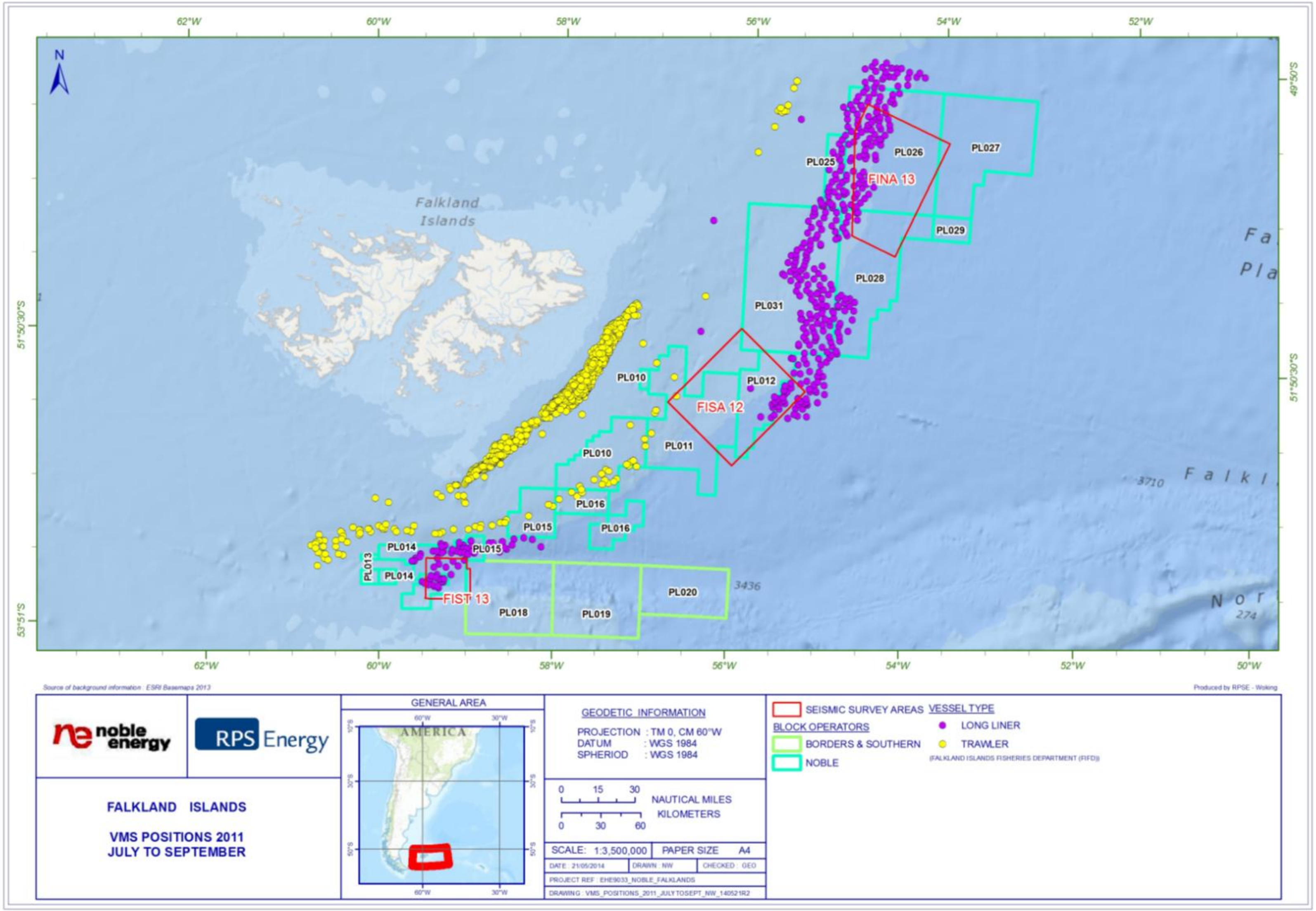


Figure E.16d: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2011 from October to December (FIG Department of Natural Resources – Fisheries Department, 2013)

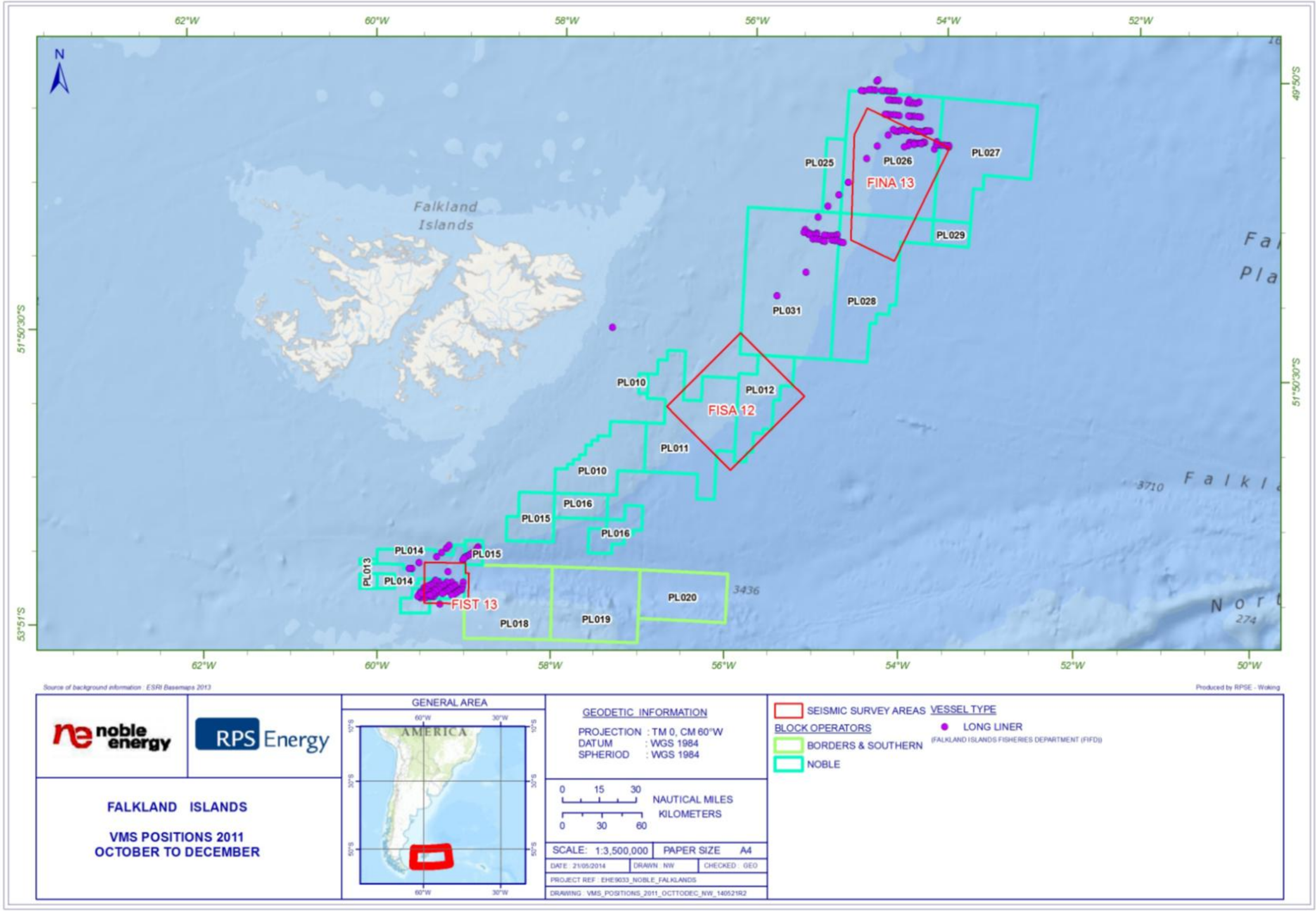


Figure E.16e: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2011, all months (FIG Department of Natural Resources – Fisheries Department, 2013)

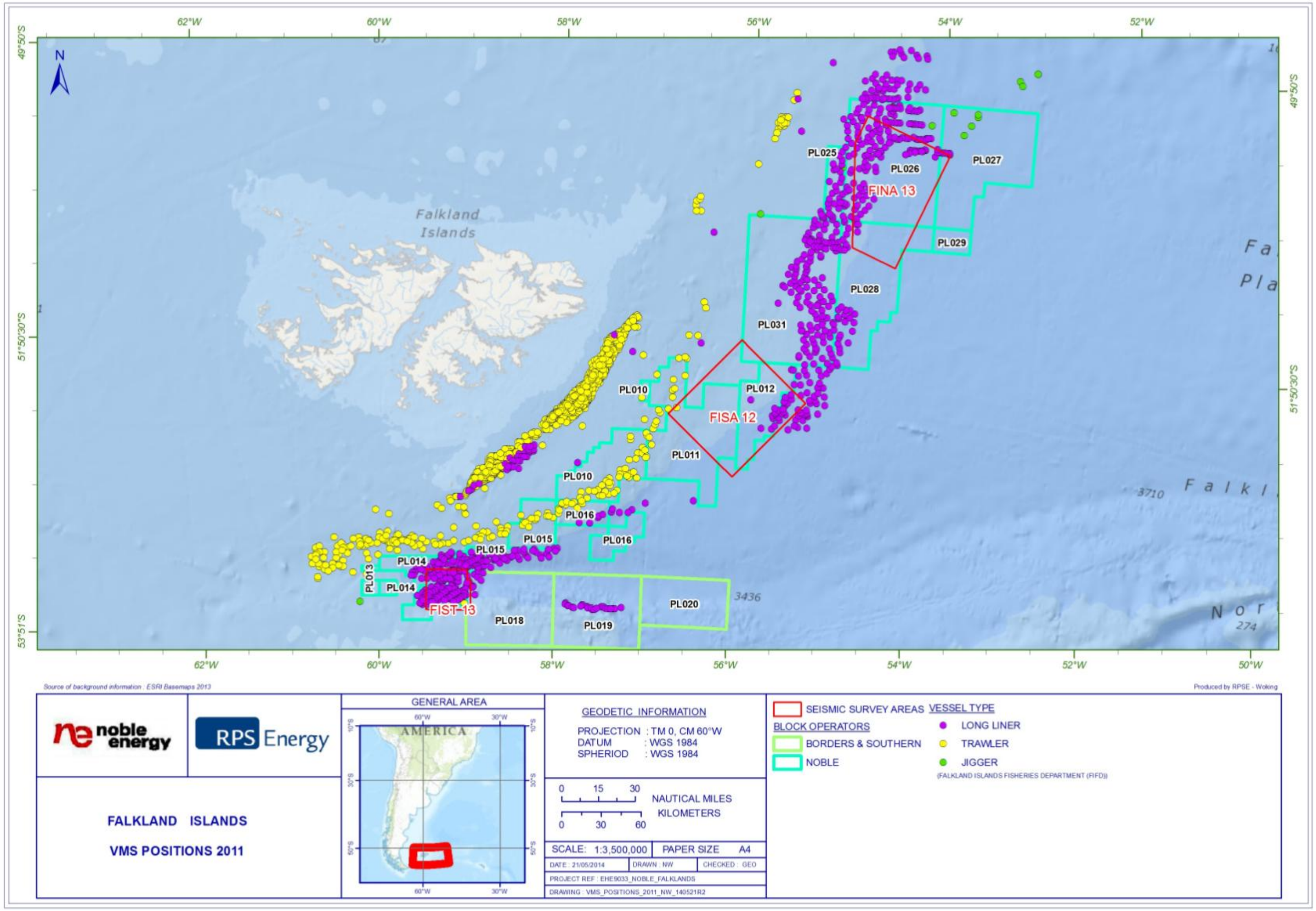


Figure E.17a: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2012 for January to March (FIG Department of Natural Resources – Fisheries Department, 2013)

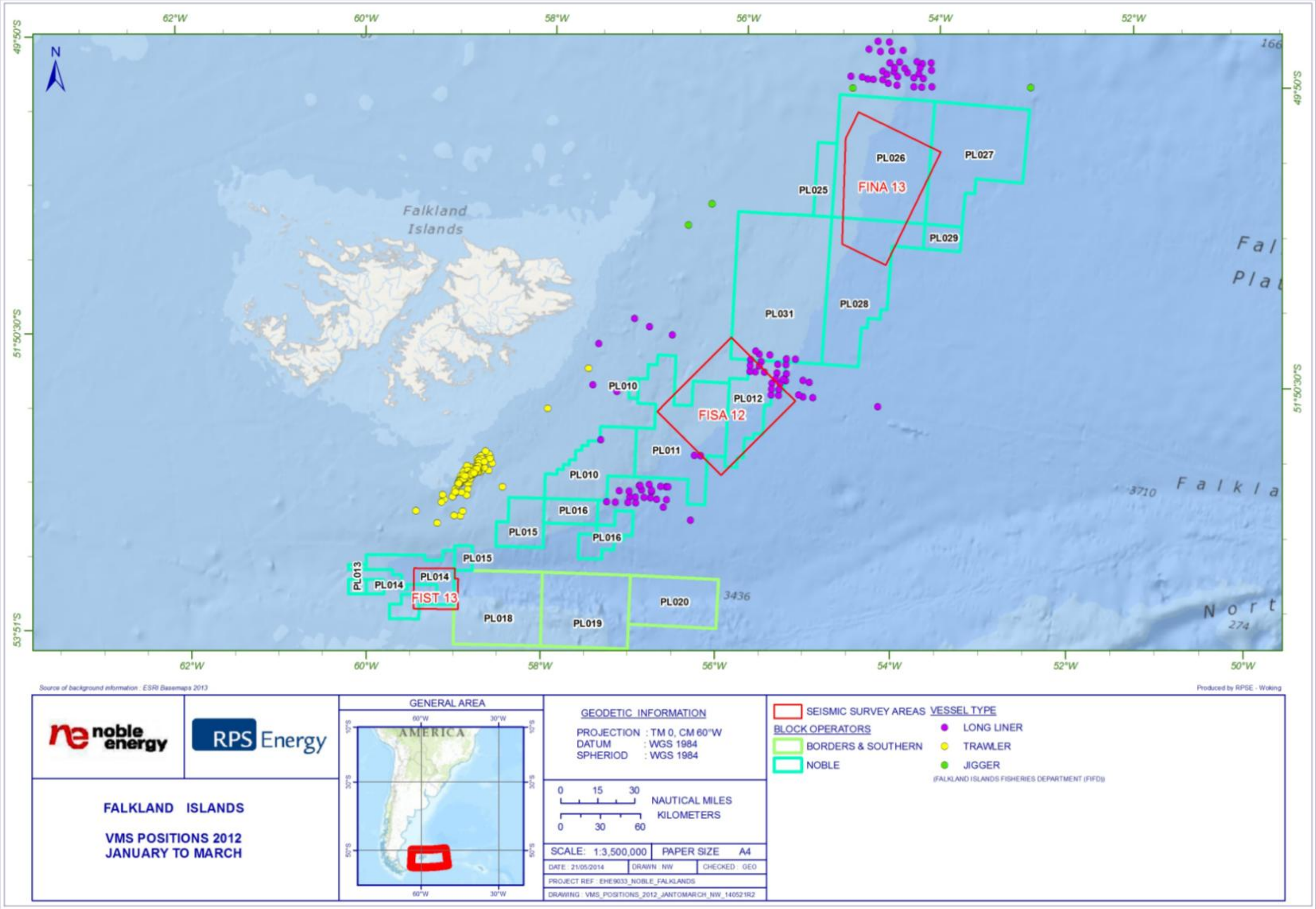


Figure E.17b: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2012 for April to June (FIG Department of Natural Resources – Fisheries Department, 2013)

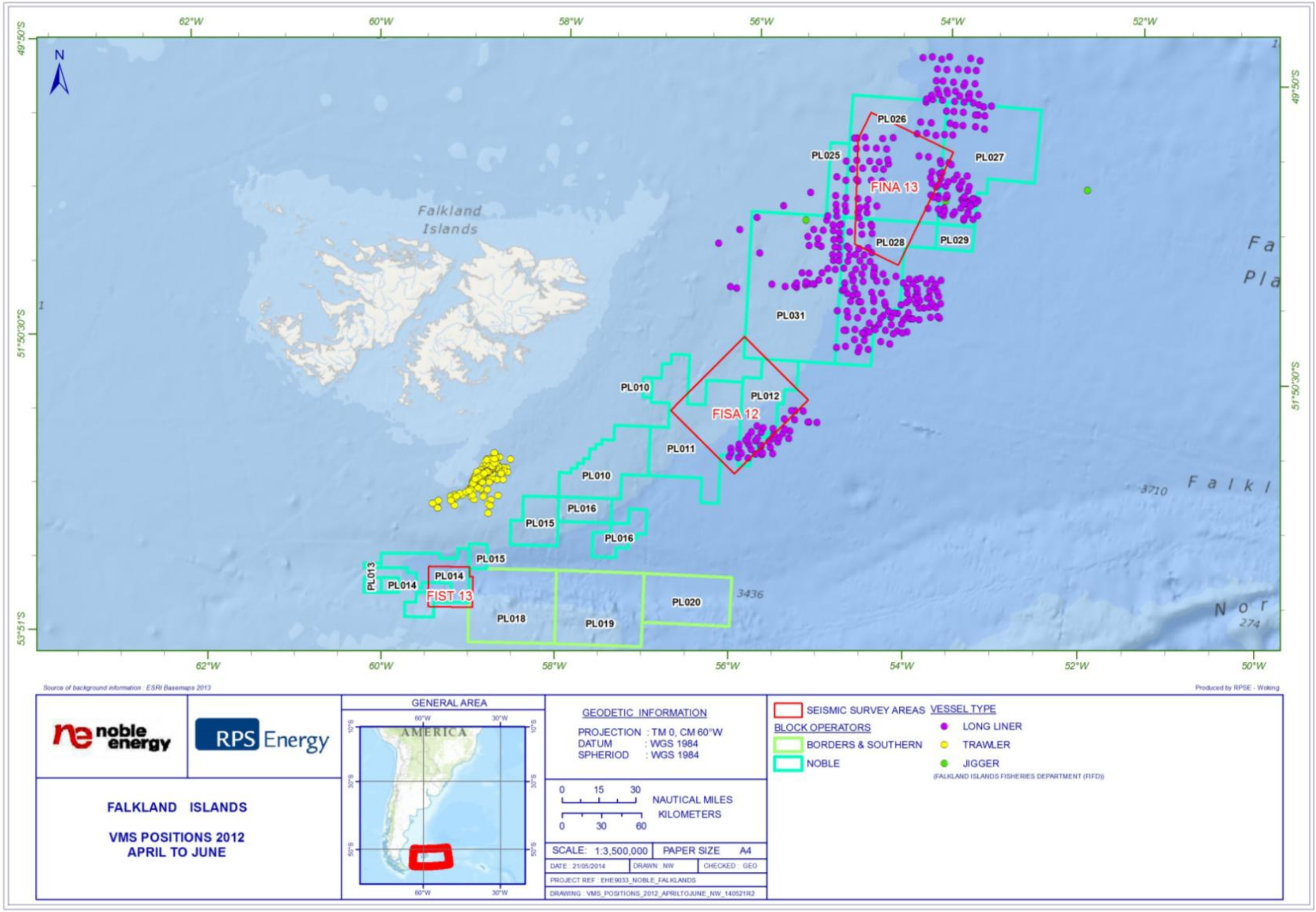


Figure E.17c: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2012 for July to September (FIG Department of Natural Resources – Fisheries Department, 2013)

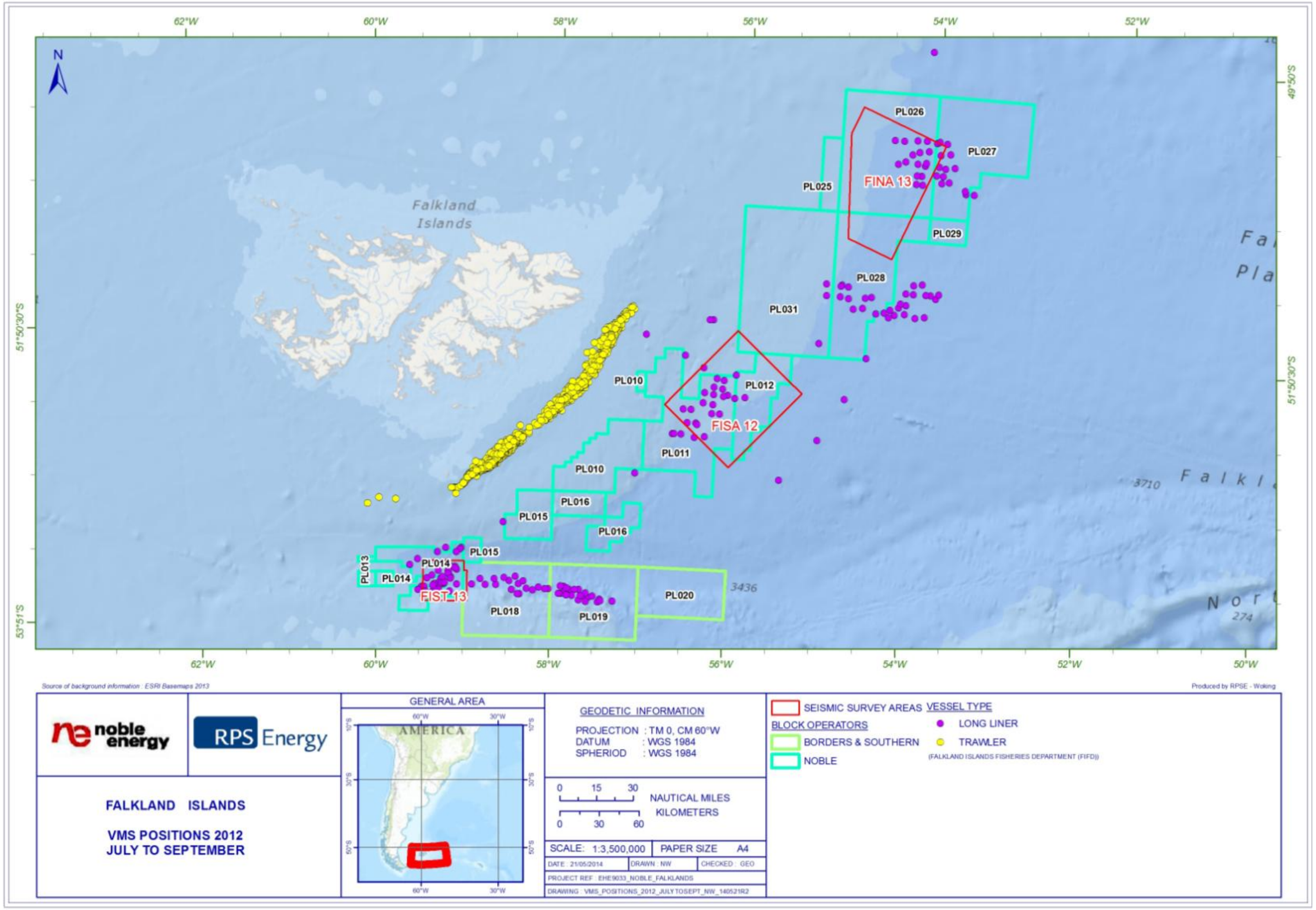


Figure E.17d: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2012 for October to December (FIG Department of Natural Resources – Fisheries Department, 2013)

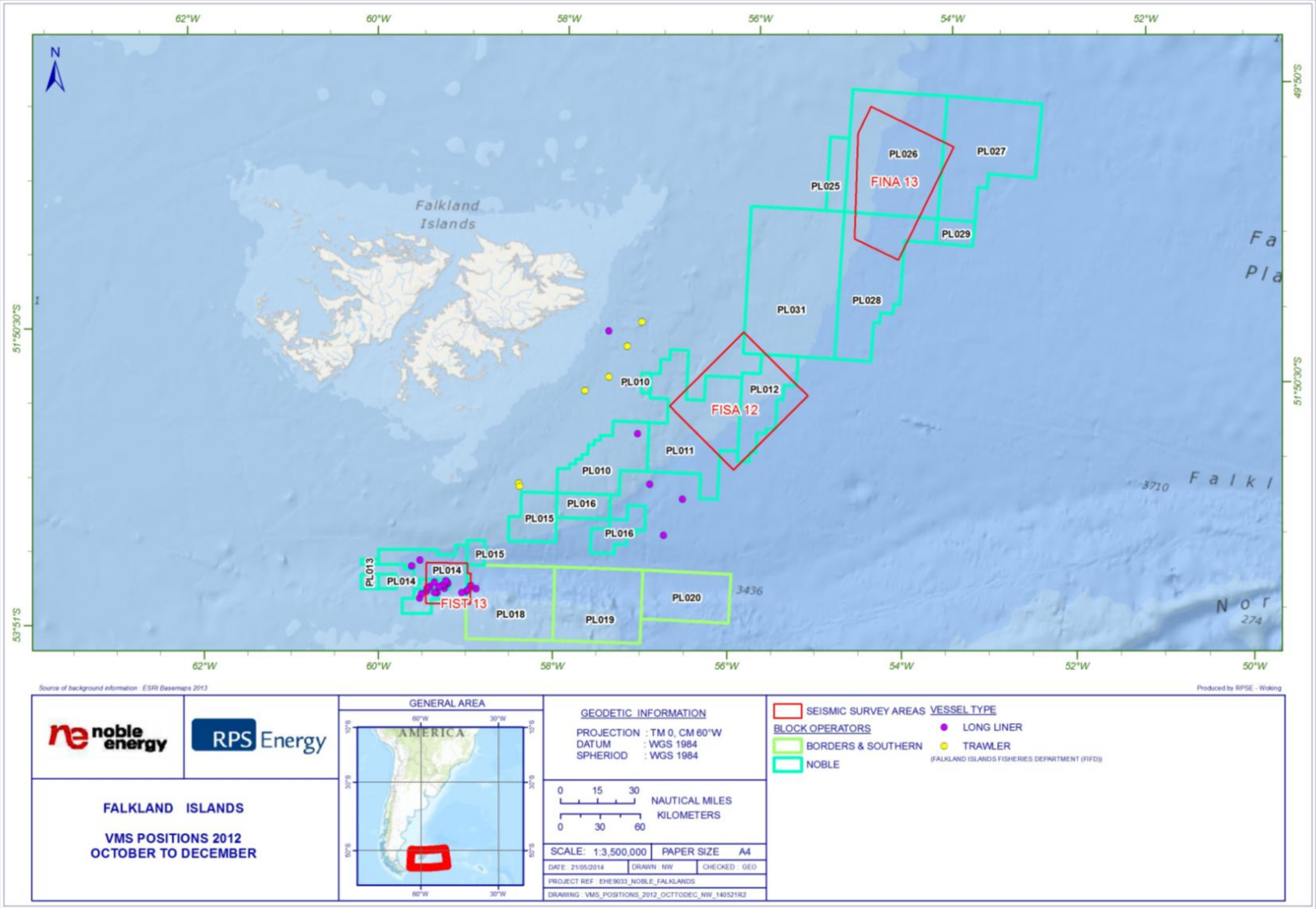


Figure E.17e: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands in 2012, all months (FIG Department of Natural Resources – Fisheries Department, 2013)

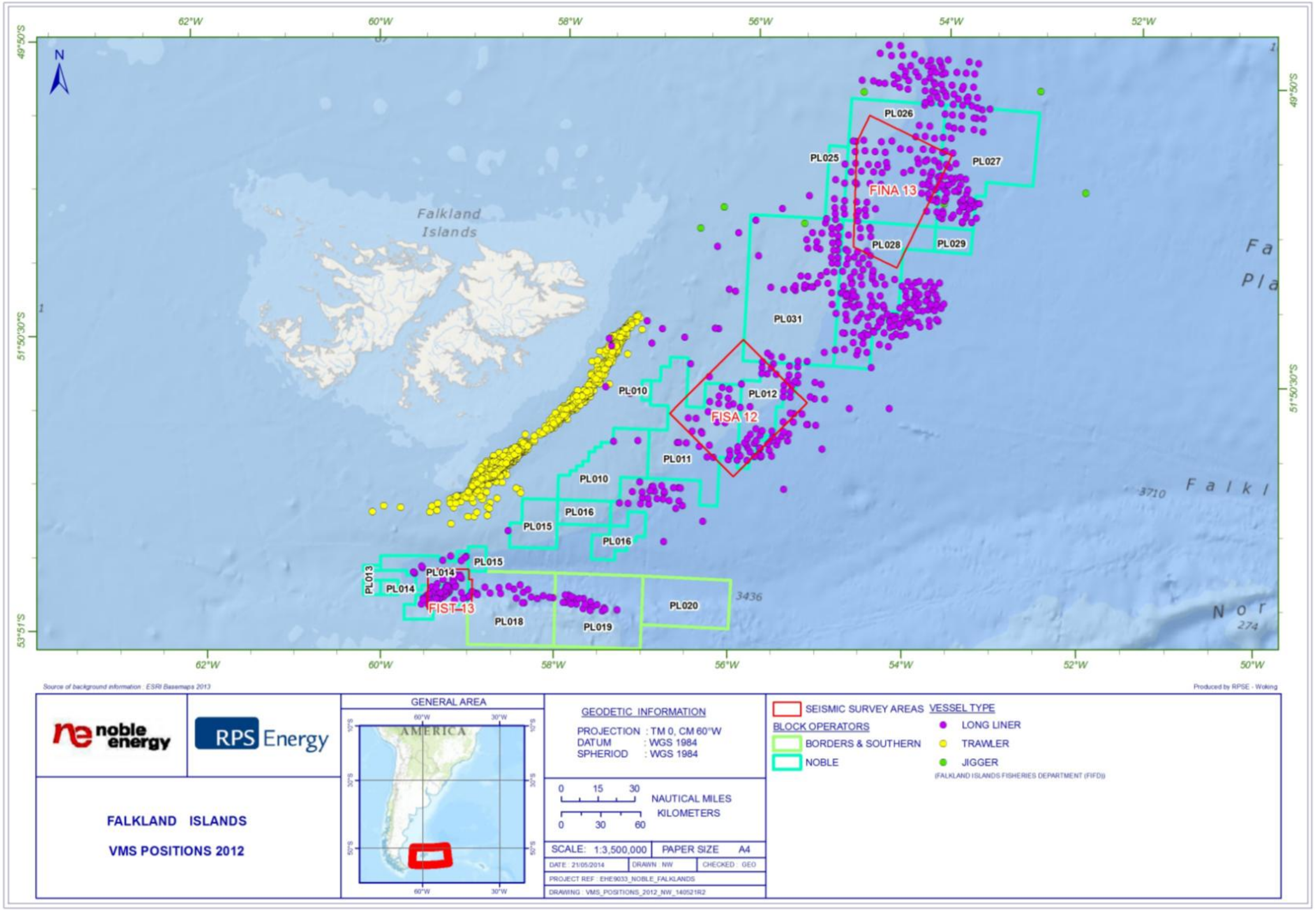


Figure E.18: Fishing Vessel Monitoring System (VMS) data for fishing vessels offshore the Falkland Islands from 2008 to 2012, all months (FIG Department of Natural Resources – Fisheries Department, 2013)

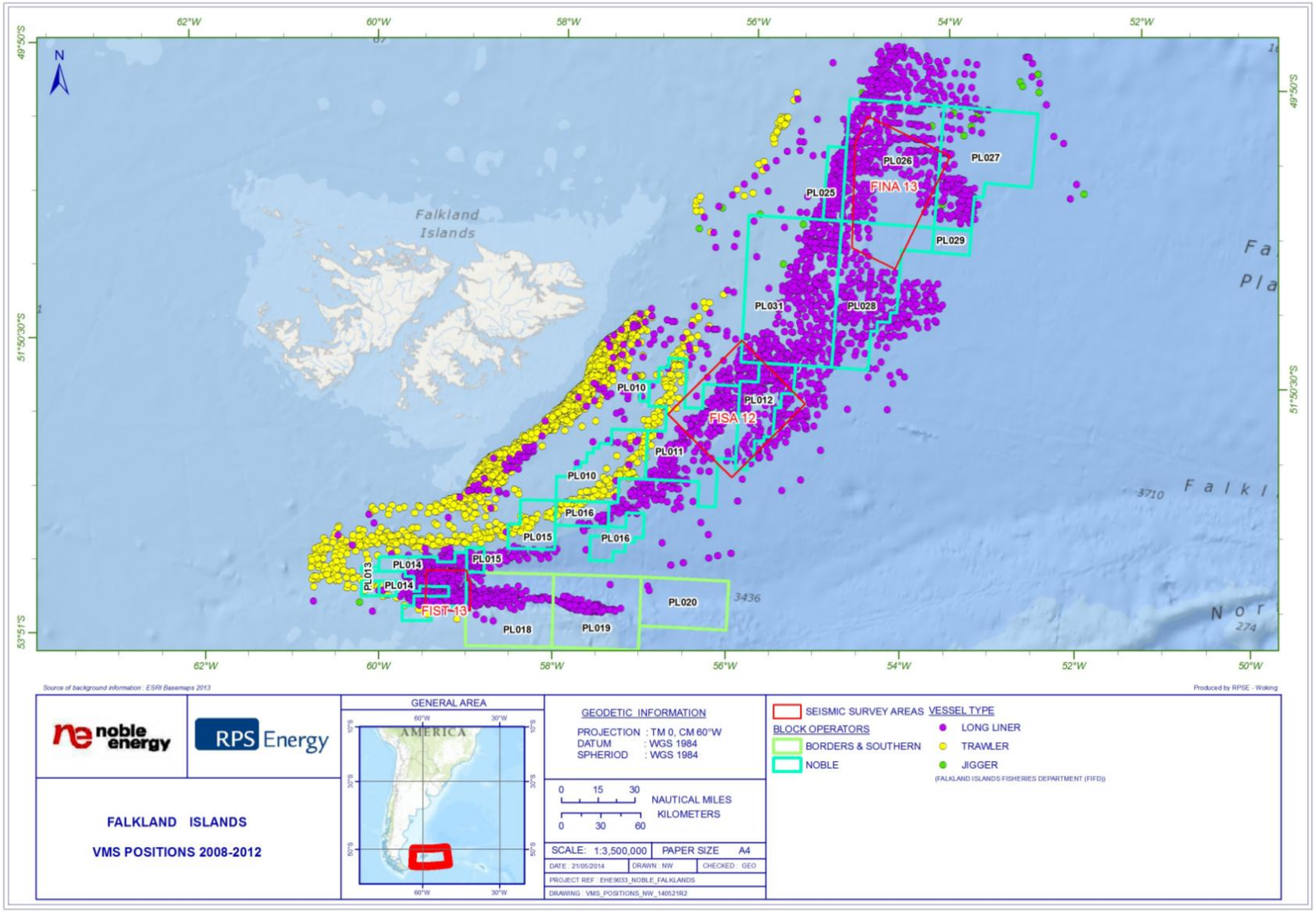


Figure E.19: Fishing effort for the year 2008 (FIG Department of Natural Resources – Fisheries Department, 2014)

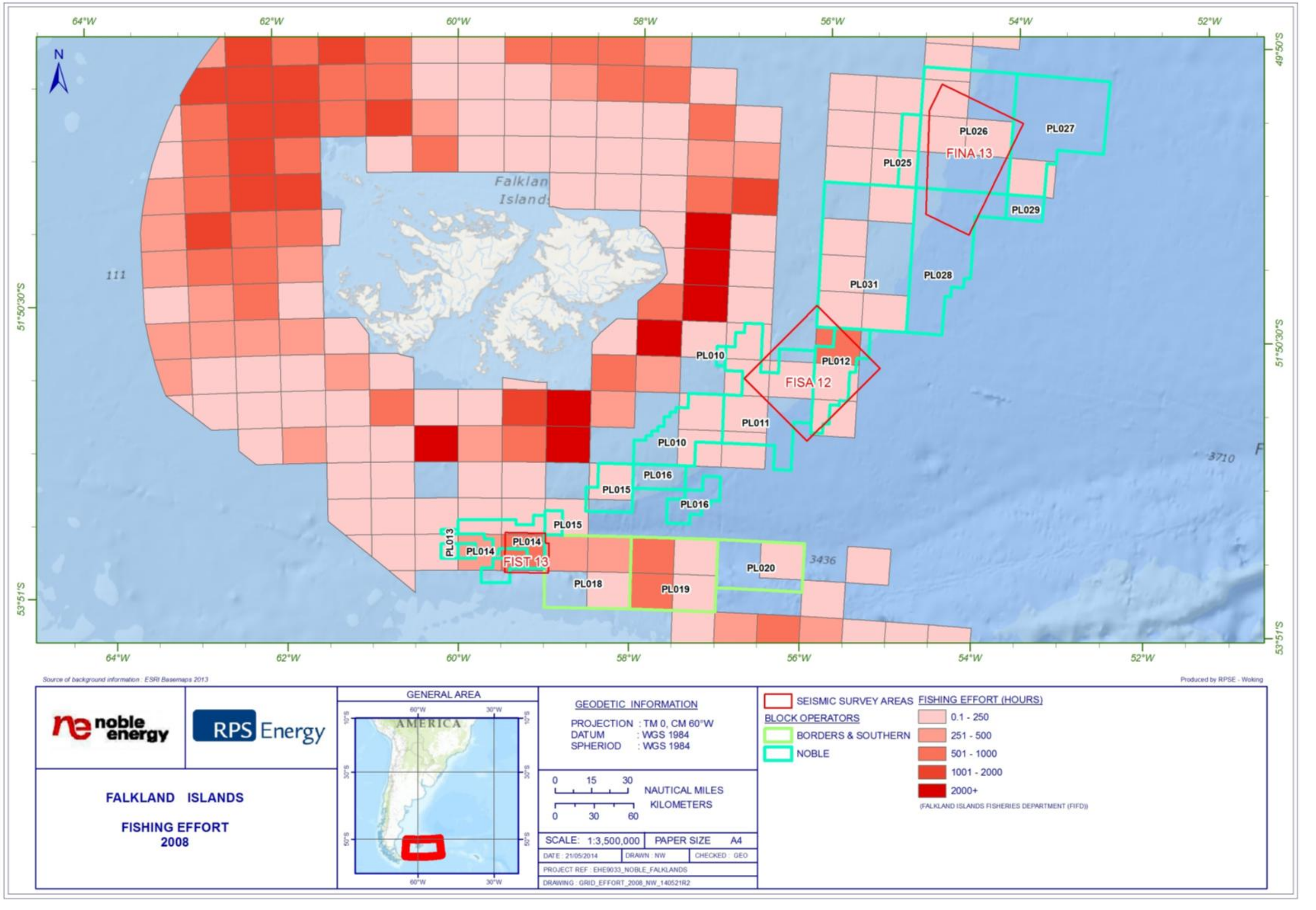


Figure E.20: Fishing effort for the year 2009 (FIG Department of Natural Resources – Fisheries Department, 2014)

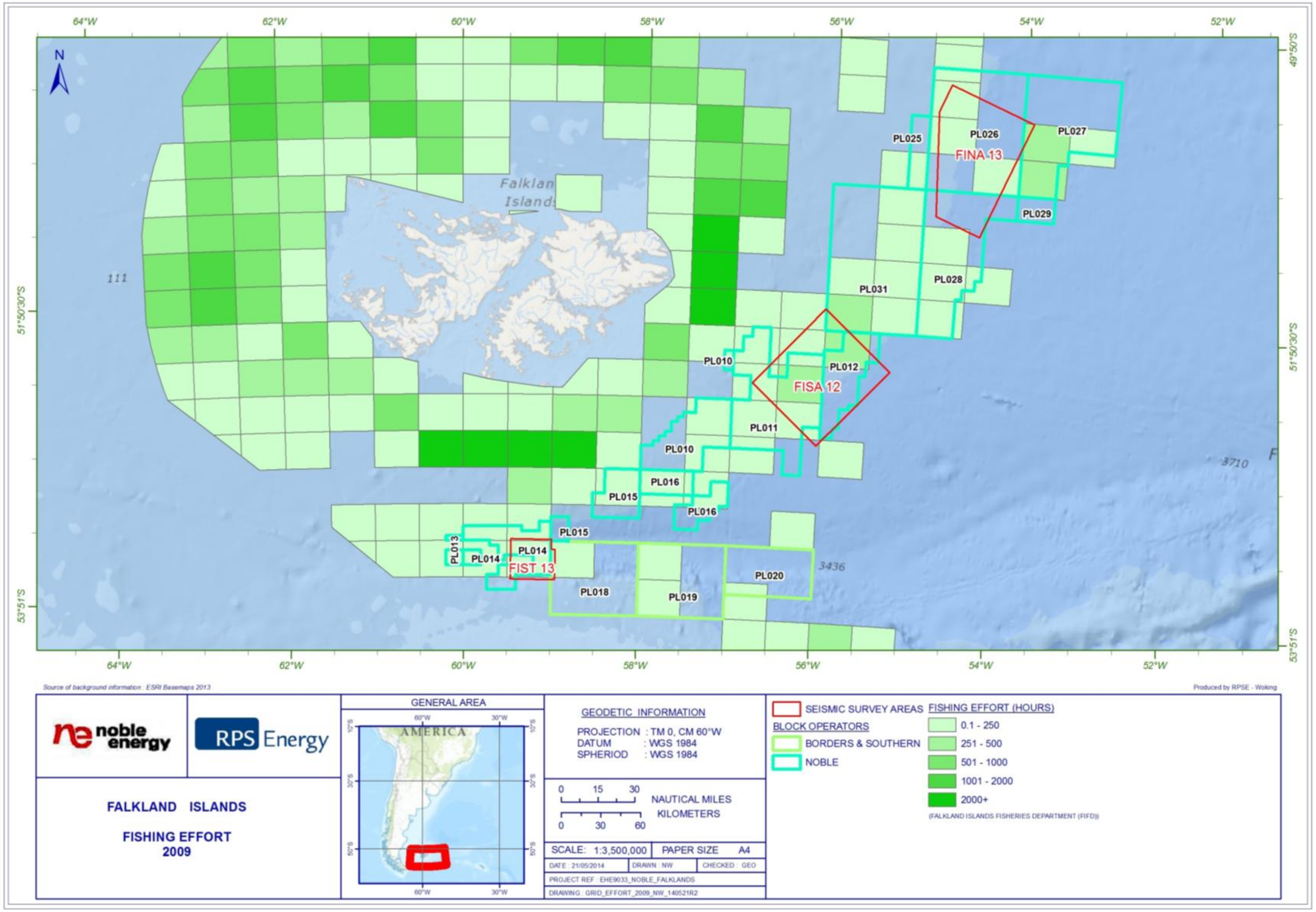


Figure E.21: Fishing effort for the year 2010 (FIG Department of Natural Resources – Fisheries Department, 2014)

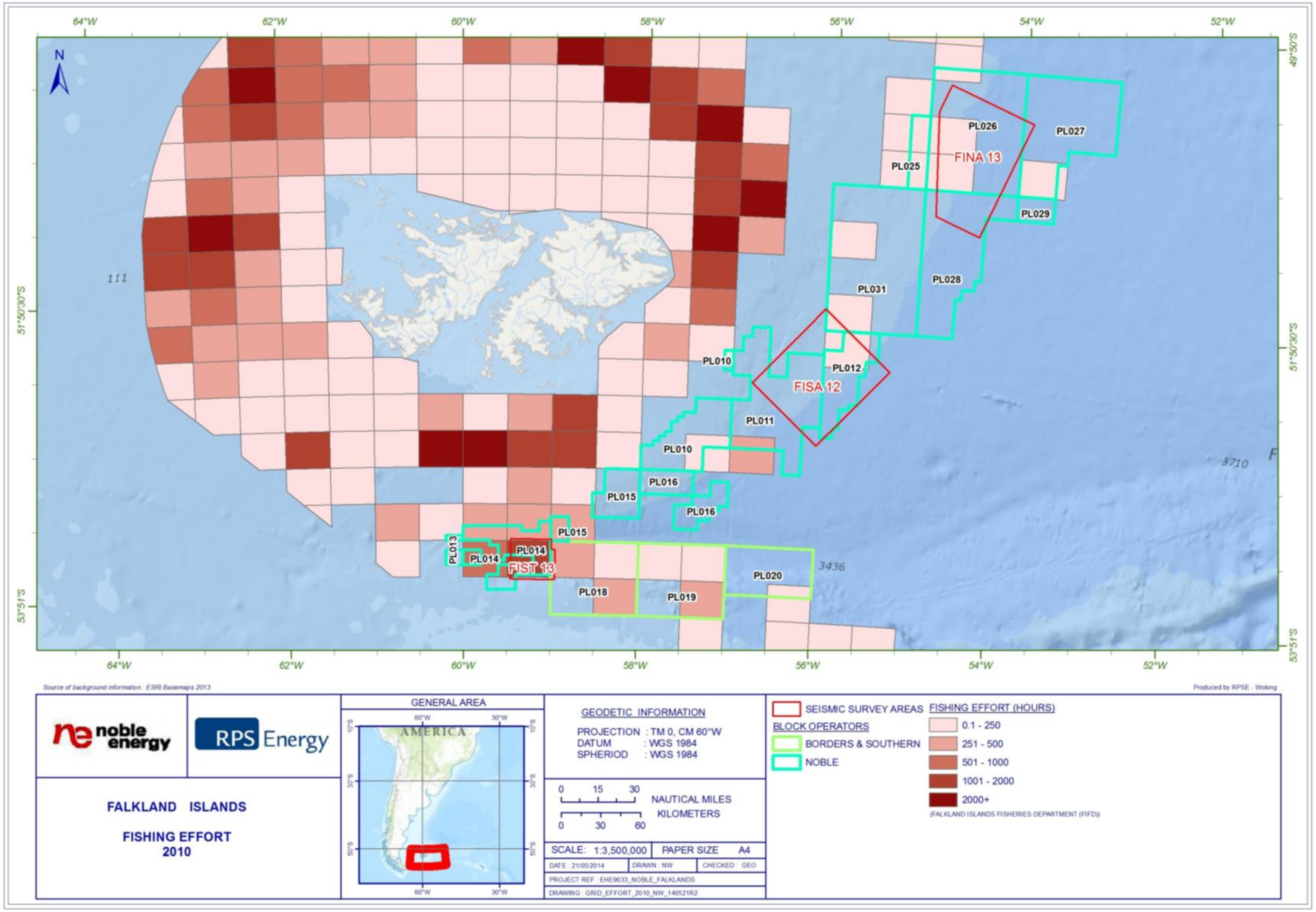


Figure E.22: Fishing effort for the year 2011 (FIG Department of Natural Resources – Fisheries Department, 2014)

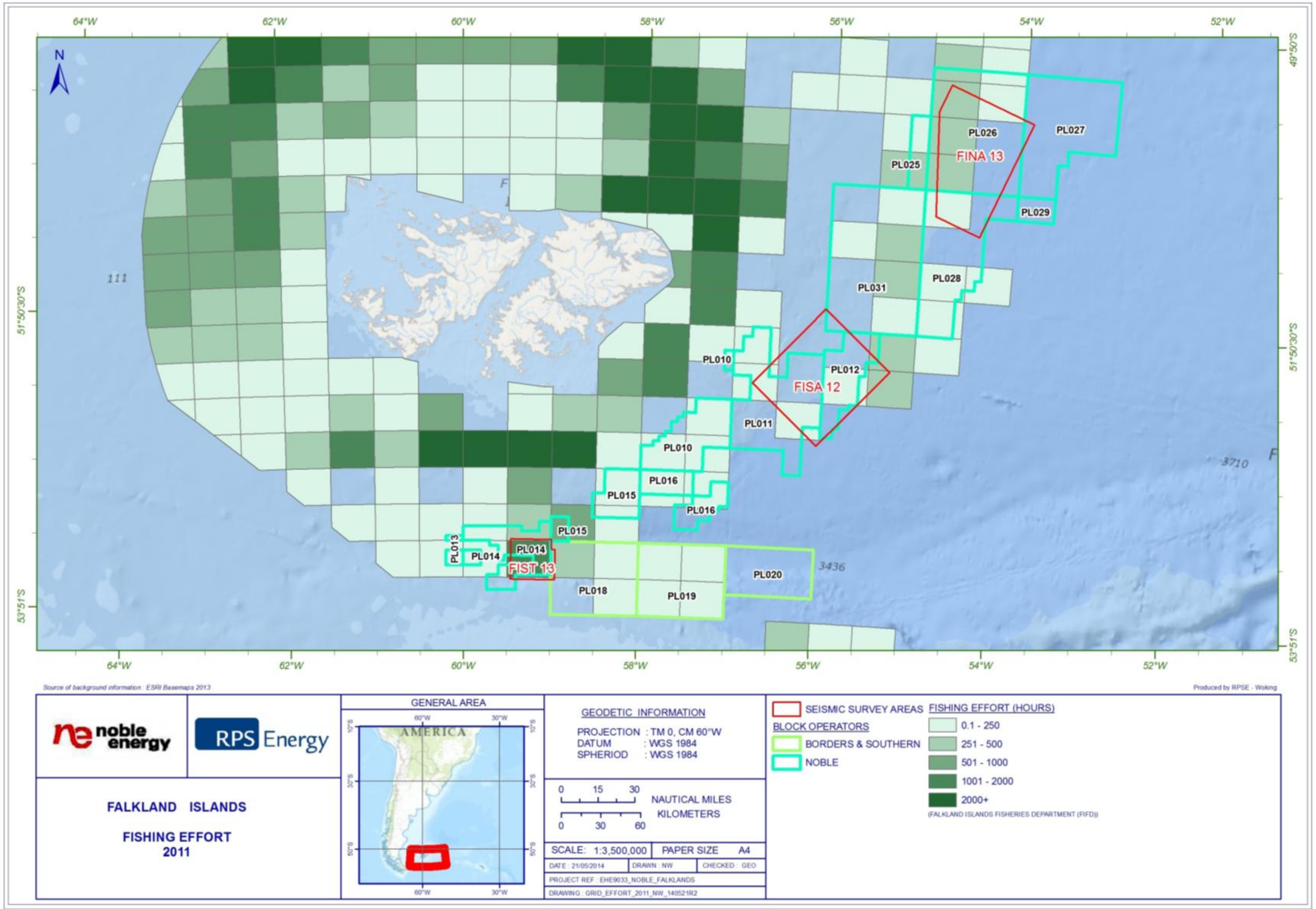
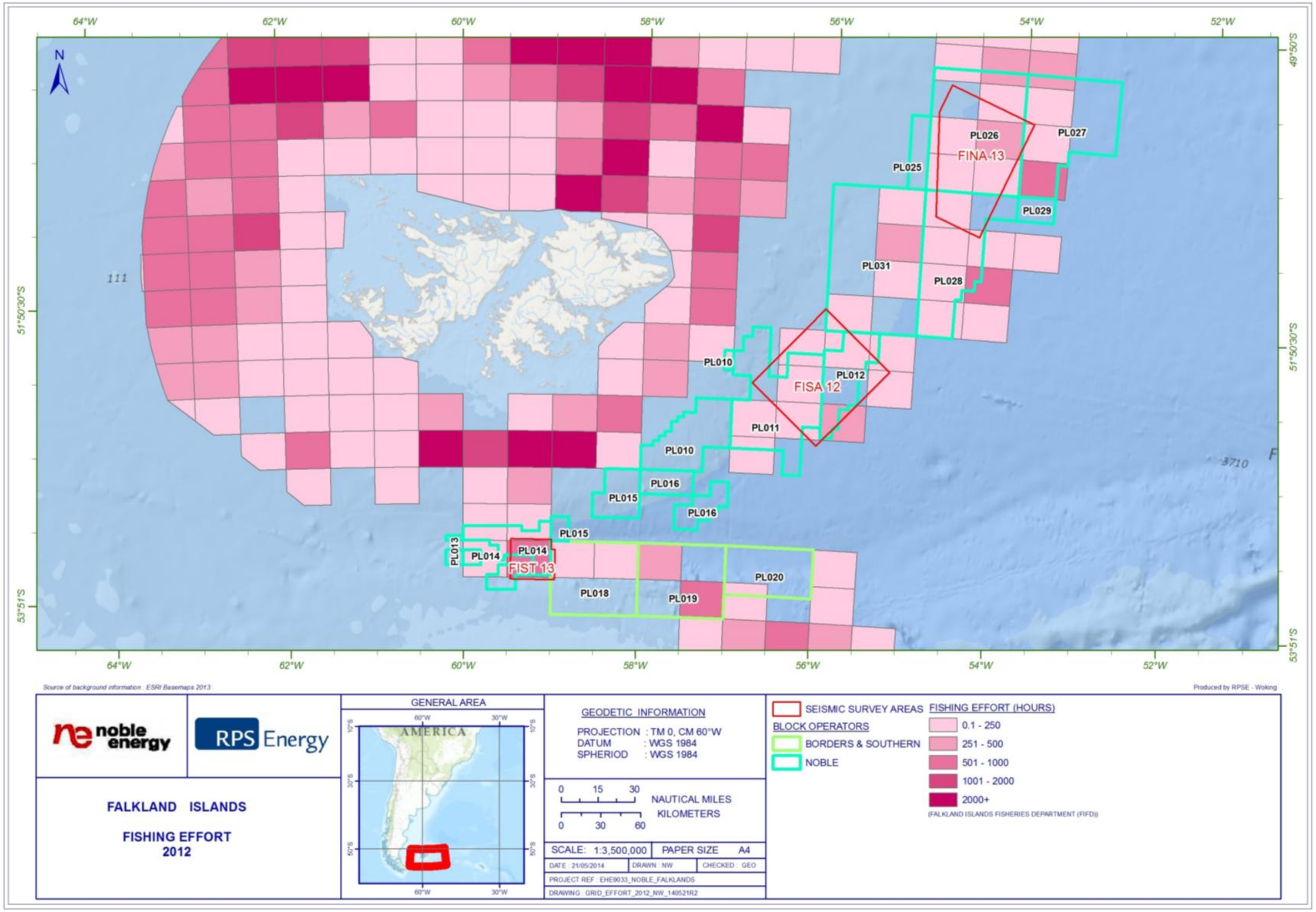


Figure E.23: Fishing effort for the year 2012 (FIG Department of Natural Resources – Fisheries Department, 2014)



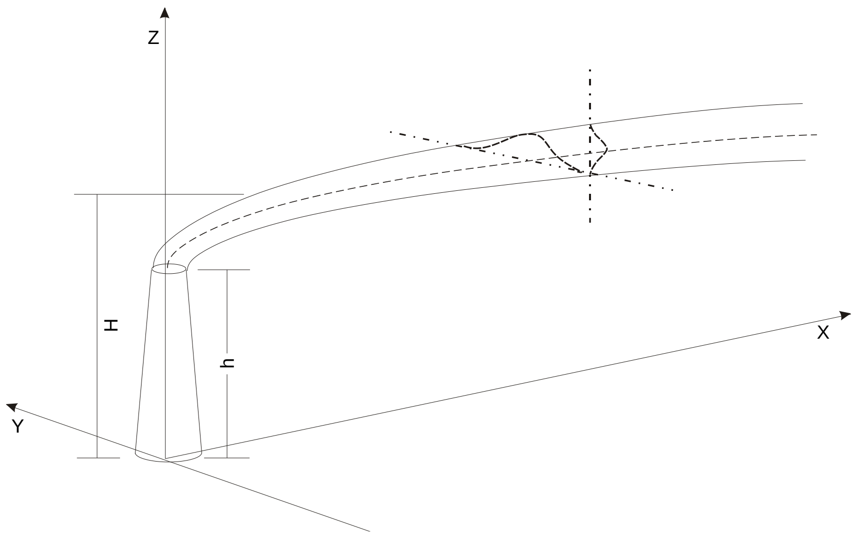
Appendix F: Atmospheric Modelling & Derivation of Global Warming Potential

F.1 Atmospheric Dispersion Modelling

The model used is spreadsheet based and derived from Davis & Cornwell (1991).

The model is an analytical model based on the Gaussian diffusion equation. The Gaussian element refers to the observation that the concentration of a gas released from a point follows an approximate normal distribution perpendicular to the centre line of the plume (Figure F.1).

Figure F.1: Diagram showing Gaussian diffusion



The concentration along the centre line is inversely proportionate to the distance from the source although very close to the source the concentration is decreased due to plume rise. Thus, a skewed concentration curve is characteristic of this sort of model. The governing equation is:

$$X(x,y,0,H) = \left[\frac{Q}{\pi s_y s_z u}\right]\left[\exp\left[-\frac{1}{2}\left(\frac{y}{s_y}\right)^2\right]\right]\left[\exp\left[-\frac{1}{2}\left(\frac{H}{s_z}\right)^2\right]\right]$$

where *X(x,y,0,H)* = downwind concentration at ground level, g/m^3

Q = emission rate of pollution, g/s

sy,sz = plume standard deviations, m

u = wind speed, m/s

The basic Gaussian diffusion equation has the following assumptions:

- Atmospheric stability, that is the amount of mechanical mixing in the air, is uniform throughout the layer into which the gas stream is discharged (normally the boundary layer).
- Turbulent diffusion is random and therefore the dilution of the contaminated gas stream in both the vertical and horizontal direction can be described by the Gaussian or normal equation.

- The gas stream is released into the atmosphere at a distance above ground level that is equal to the stack height plus the plume rise (caused by convection if the released gas is hotter than the ambient temperature).
- The degree of dilution is inversely proportional to the wind speed (although wind speed data is not actually used within this model).
- Pollutant material that reaches the ground is totally reflected back into the atmosphere.

The calculation of *H* is obtained from adding ΔH and h via Holland's formula:

$$\Delta H = \frac{v_s d}{u}\left[1.5 + \left(2.68 \times 10^{-2}(P)\left(\frac{T_s - T_a}{T_s}\right)d\right)\right]$$

where v_s = stack velocity, m/s

d = stack diameter

P = Pressure, kPa

T_s = stack temperature, K

T_a = air temperature, K

Specific assumptions for the modelling of the gas emissions associated with the Noble drilling programme are given in the following sections.

F.1.1 Assumptions

Physical Parameters

- Height of discharge (h) 50 metres above lowest astronomical tide (LAT) (taken to represent ground level).
- Temperature of (Ts) 200 degrees Celsius (473 Kelvin).

Atmospheric Conditions

- Text Wind speed (u) of 10 metres per second.
- Temperature (Ta) 15 degrees Celsius (288 Kelvin).
- Pressure (P) 95.0 kPA (thousand Pascals).
- Overcast conditions (neutral stability).

Discharge Characteristics

Power Generation:

- Molecular weight of gas of 22.
- Emission factors from UKOOA, 2006.

F.2 Calculating Global Warming Potential (GWP)

Just as radiative forcing (the difference between radiant energy (sunlight) received by the Earth and energy radiated back to space) provides a simplified means of comparing the various factors that are believed to influence the climate system to one another, global-warming potentials (GWPs) are one type of simplified index based upon radiative properties that can be used to estimate the potential future impacts of emissions of different gasses upon the climate system in a relative sense. GWP is based on a number of factors, including the radiative efficiency (infrared-absorbing ability) of each gas, relative to that of carbon dioxide, as well as the decay rate of each gas (the amount removed from the atmosphere over a given number of years) relative to that of carbon dioxide.

The **radiative forcing capacity** (RF) is the amount of energy per unit area, per unit time, absorbed by the greenhouse gas that would otherwise be lost to space. It can be expressed by the formula:

$$RF = \sum_{n=1}^{100} Abs_i * F_i / (pathlength * density)$$

where the subscript *i* represents an interval of 10 inverse centimeters, Abs_i represents the integrated infrared absorbance of the sample in that interval, and F_i represents the RF for that interval.

The Intergovernmental Panel on Climate Change (IPCC) provides generally accepted values for GWP. An exact definition of how GWP is calculated is to be found in the IPCC's 2001 Third Assessment Report. The GWP is defined as the ratio of the time-integrated radiative forcing from the instantaneous release of 1 kg of a trace substance relative to that of 1 kg of a reference gas:

$$GWP\,(x) = \frac{\int_0^{TH} a_x \cdot [x(t)]\, dt}{\int_0^{TH} a_r \cdot [r(t)]\, dt}$$

where TH is the time horizon over which the calculation is considered; a_x is the radiative efficiency due to a unit increase in atmospheric abundance of the substance (i.e., $Wm^{-2}\ kg^{-1}$) and [x(t)] is the time-dependent decay in abundance of the substance following an instantaneous release of it at time t=0.

The denominator values (a_r and r) contain the corresponding quantities for the reference gas (i.e. CO_2). The radiative efficiencies a_x and a_r are not necessarily constant over time. While the absorption of infrared radiation by many greenhouse gasses varies linearly with their abundance, a few important ones display non-linear behaviour for current and likely future abundances (e.g., CO_2, CH_4, and N_2O). For those gases, the relative radiative forcing will depend upon abundance and hence upon the future scenario adopted.

Since all GWP calculations are a comparison to CO_2, which is non-linear, all GWP values are affected. Assuming otherwise, as is done above, will lead to lower GWPs for other gasses than a more detailed approach. Clarifying this, while increasing CO_2 has less and less effect on radiative absorption as concentrations rise, more powerful greenhouse gasses like methane and nitrous oxide have different thermal absorption frequencies to CO_2 that are not filled up (saturated) as much as CO_2. Therefore, rising concentrations of these gasses are far more significant.

Appendix G: Air Quality Limits

G.1 World Health Organisation (WHO) Guidelines

Data on air quality offshore is limited. Emissions of carbon dioxide (CO_2), oxides of nitrogen (NOx), and oxides of sulphur (SOx) will result from power generation by the drilling rig and by any associated vessels which are required to support drilling operations.

The World Health Organisation (WHO) first published Air Quality Guidelines for Europe in 1987, and these were subsequently updated in 2000 and partially again in 2005 (Table G.1). The Guidelines aim to provide a basis for protecting public health from the adverse effects of environmental pollutants, and eliminating or minimising exposure to those pollutants that are known or likely to be hazardous to human health or wellbeing.

Although health effects were the major consideration behind the establishment of the Guidelines, ecologically-based Guidelines for preventing adverse effects on terrestrial vegetation were also considered, and guideline values for vegetation protection for nitrogen and sulphur oxides and ozone have been established.

Table G.1: WHO Air Quality Guidelines for Europe

Gas	Guideline Value	Averaging Time
Carbon Monoxide	100 mg/m3	15 min
	60 mg/m3	30 min
	30 mg/m3	1 hour
	10 mg/m3	8 hour
Ozone	120 µg/m3	8 hour
Nitrogen Dioxide	200 µg/m3	1 hour
	40 µg/m3	annual
Sulphur Dioxide	500 µg/m3	10 min
	125 µg/m3	24 hour
	50 µg/m3	annual
VOCS		
Benzene	6 x 10-6 (µg/m3)-1	UR / lifetime
1,3 Butadiene	no guideline	
Dichloromethane	3 mg/m3	24 hour
Formaldehyde	0.1 mg/m3	30 min
PAH (BaP)	8.7 x 10-5 (ng/m3)-1	UR / lifetime
Styrene	0.26 mg/m3	1 week
Tetrachloroethylene	0.25 mg/m3	annual
Toluene	0.26 mg/m3	1 week
Trichloroethylene	4.3 x 10-7 (µg/m3)-1	UR / lifetime
Ecotoxic Effects		
SO2 critical level	10 - 30 µg/m3 a	annual
NOx critical level	30 µg/m3	annual
Ozone critical level	0.2 - 10 ppm.h a	5 days - 6 months

The European Union Framework Directive 2008/50/EC[1] on ambient air quality assessment and management has been derived from the recommendations of the WHO. This directive came into force in May 2008 and had to be implemented by Member States, including the UK, by June 2010. The Directive aims to protect human health and the environment by avoiding, reducing or preventing harmful concentrations of air pollutants. The limit values are legally binding and the Secretary of State, on behalf of the UK Government, is responsible for their implementation.

G.2 Air Quality Strategy

The UK Air Quality Strategy (AQS) describes the Government's strategy for improving air quality in the UK. The current UK AQS[2] was published in July 2007 and updates the original strategy to set out new objectives. The current AQS includes objectives for eight pollutants: benzene, 1,3-butadiene, ozone, carbon monoxide, lead, nitrogen dioxide, particulates and sulphur dioxide. AQS objectives are in some cases more onerous than the limit values set out within the relevant EU Directives and the Air Quality Standards Regulations 2010.

There is no legal requirement to meet objectives set within the UK AQS, except where equivalent limit values are set within the EU Directives.

The limit values and objectives relevant to this assessment are summarised in Table G.2.

Table G.2: Summary of Relevant Air Quality Limit Values and Objectives

Pollutant	Averaging Period	Objectives/ Limit Values	Not to be Exceeded More Than
Nitrogen Dioxide (NO2)	1 hour	200 µg.m-3	18 times per calendar year
	Annual	40 µg.m-3	-
Sulphur Dioxide (SO2)	15 minute**	266 µg.m-3	35 times per calendar year
	1 hour	350 µg.m-3	24 times per calendar year
	24 hour	125 µg.m-3	3 times per calendar year

***This Air Quality Objective is within the AQS but not the Regulations, therefore there is no legal requirement to meet this objective.*

1 European Commission (EC) Council Directive 2008/50/EC of 21 May 2008 on Ambient Air Quality and Cleaner Air for Europe.

2 Defra (2007), The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, Volume 2.

Appendix H: Cuttings Dispersion Modelling Study

Falkland Islands | Preliminary Results – Drilling Discharges Modeling at Caperea-1

Table of Contents

List of Figures

List of Tables

1. Project Background and Geographic Location

RPS Group, plc. has contracted Applied Science Associates, Inc. (dba RPS ASA) to evaluate seabed deposition associated with operational drilling discharges within the FISA12 and FIST13 license areas, south and east of the Falkland Islands. Four exploration wells have been selected for dispersion modeling representing drilling at depths between 1,273 m and 1,880 m (Table 1).

Table 1. Location of the discharge sites selected for modeling offshore the Falkland Islands (grey text represents wells that will be included in future modeling).

Site Name	Block Name	Latitude (S)	Longitude (W)	Water Depth (m)
Caperea-1	FISA 12 area	52.40496	56.06709	1,333
Humpback	FISA 12 area	52.14670	55.73342	1,273
Finback	FISA 12 area	52.20798	55.85475	1,285
Scharnhorst North	FIST 13 area	53.58889	59.06030	1,880

Preliminary drilling plans have been developed for each site, however, as the schedule of discharges is expected to change with further refinement of the drilling program, both RPS and their client (Noble Energy) have requested initial modeling only at the Caperea-1 site. The location was selected because the site (a) falls within the shallower of the two licence blocks (FISA12), and (b) is the closest proposed well to a site of cultural heritage (the *SMS Scharnhorst* wreck). Caperea-1 is located 150 km east of the Falkland Islands coastline at an approximate water depth of 1,330 m (Figure 1). Additional modeling will be performed for the remaining sites as the drilling periods and discharge schedules become available.

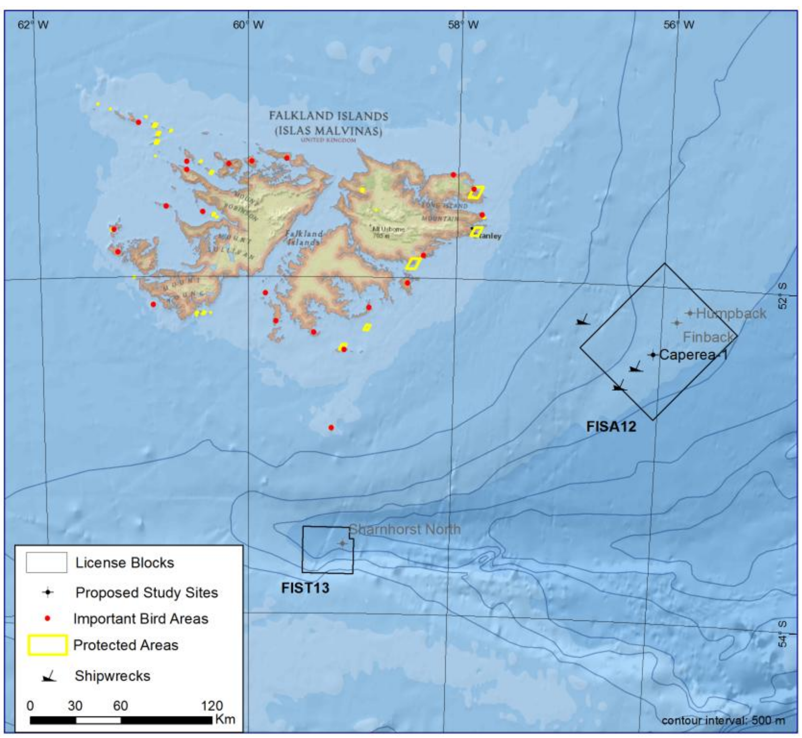


Figure 1. Drilling locations and nearby protected areas (future modeling sites shown in grey).

Discharge simulations at Caperea-1 were completed using ASA's MUDMAP modeling system (Spaulding et al., 1994). The MUDMAP model predicts the transport of solid releases in the marine environment and the resulting seabed deposition. The model requires information regarding the discharge characteristics (release location, rate of discharge, etc.), the properties of the sediment (particle sizes, density), and environmental characteristics (bathymetry and ocean currents), to predict the transport of solids through the water column. A technical description of the MUDMAP model is included in Appendix A.

2. Model Inputs

2.1. MetOcean Data

Hydrodynamic data from the HYCOM (HYbrid Coordinate Ocean Model) 1/12 degree global simulation was used as an environmental forcing for the discharge simulations. The HYCOM model is run daily by the U.S. Navy to provide a 5-day hydrodynamic forecast (+ 5 day of hindcast as best estimate) composed of 3-D daily mean temperature, salinity, sea surface height, zonal velocity and meridional velocity fields. Ocean dynamics including geostrophic and wind driven currents are reproduced by the model. The system uses the Navy Coupled Ocean Data Assimilation (NCODA) system for data assimilation (Cummings, 2005). The model domain has a spatial resolution defined by a 1/12 degree grid in the horizontal direction and a daily temporal resolution, which for this study was obtained for the period from January 2009 to December 2012.

Daily currents were obtained by interpolating the values from the nearest HYCOM model grid points. At the model cell closest to Caperea-1 release site, the water column is represented in 21 discrete vertical layers. Because the drilling period is currently unknown, vertically and time varied currents for two seasonal periods (beginning in January and June, 2012) were subset from the full HYCOM dataset and used as forcing for the MUDMAP dispersion model. The year 2012 was chosen as a representative period based on a qualitative assessment of the HYCOM record. The HYCOM record at Caperea-1 is presented in the following figures:

- Stick plot of HYCOM current speeds and directions with depth (2009-2012).
- Vertical profiles of current velocity based on the full HYCOM record.
- Current roses showing the distribution of current speed/direction at various depths and time periods.
- Monthly averaged current speeds derived from the HYCOM model at the sea surface and the seabed.

All figures display current data in the oceanographic convention (stick vectors/roses indicate the direction *toward* which currents are flowing).

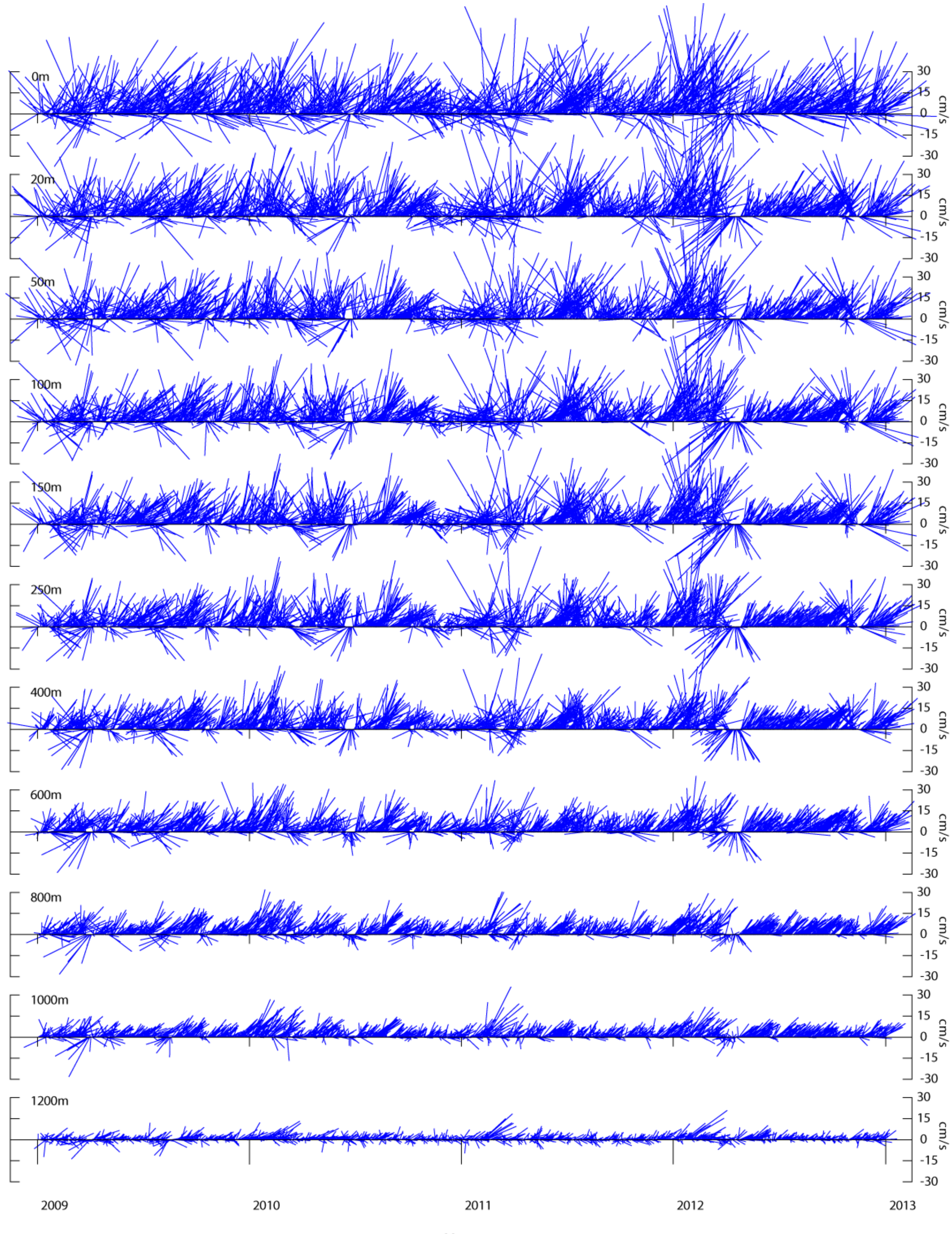


Figure 2. Time series of HYCOM model currents with depth at the Caperea-1 discharge site. Daily HYCOM currents for each depth interval are plotted as vectors representing current speed and direction. For clarity, every other depth interval is plotted.

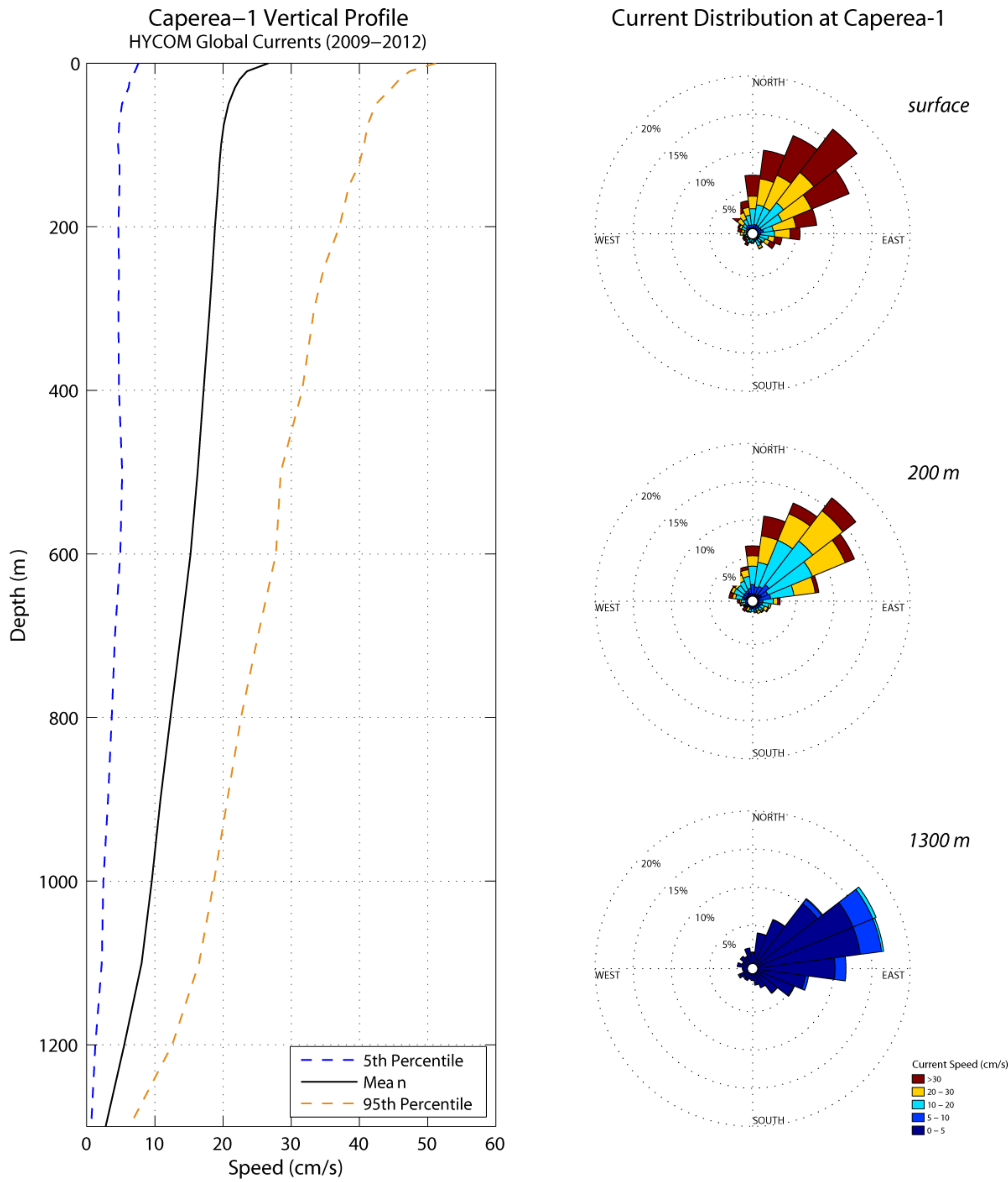


Figure 3. Vertical profile of averaged current speeds (left) and current roses showing the distribution of current speeds and directions (right) for Caperea-1, derived from HYCOM model currents between 2009 and 2012.

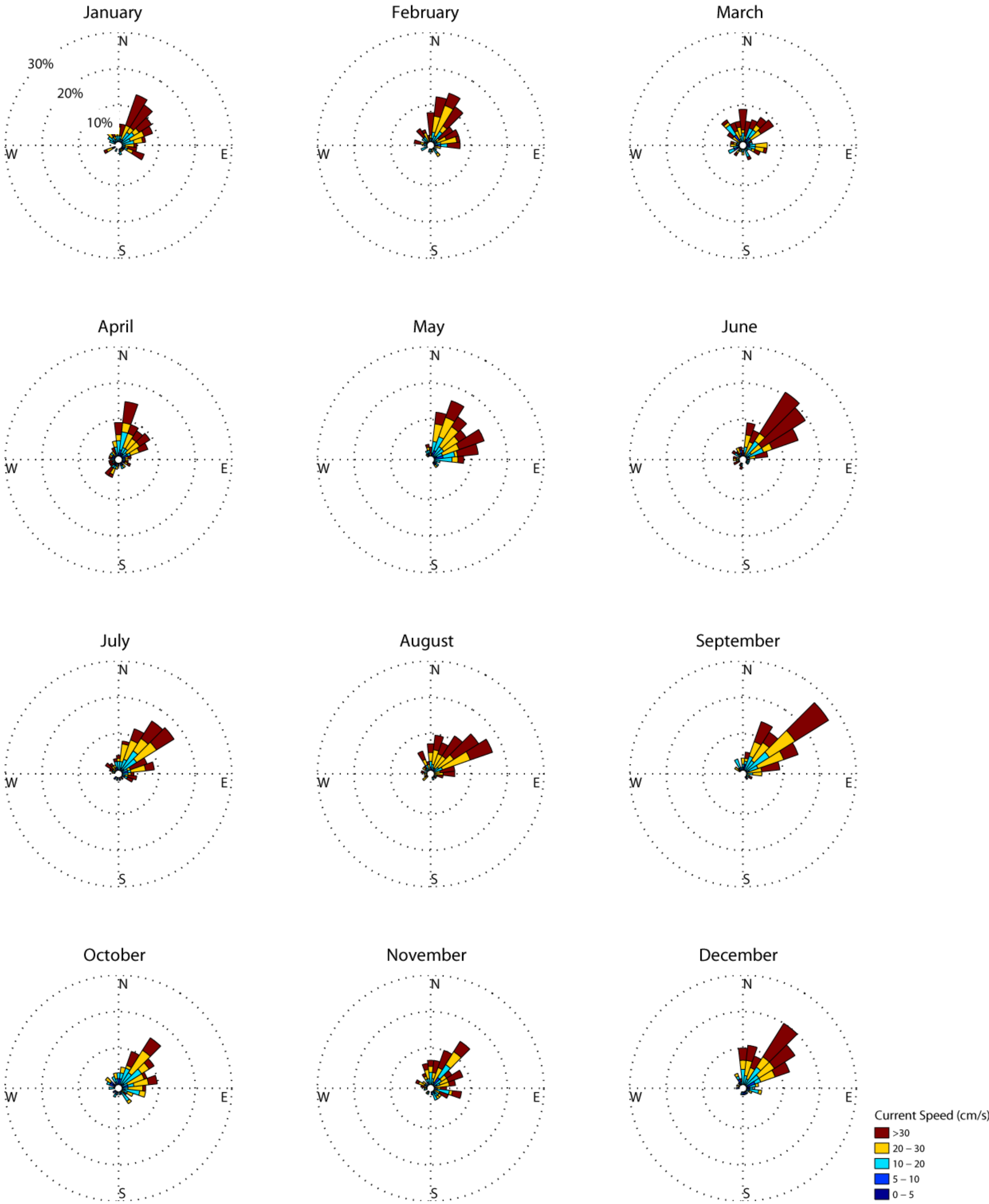
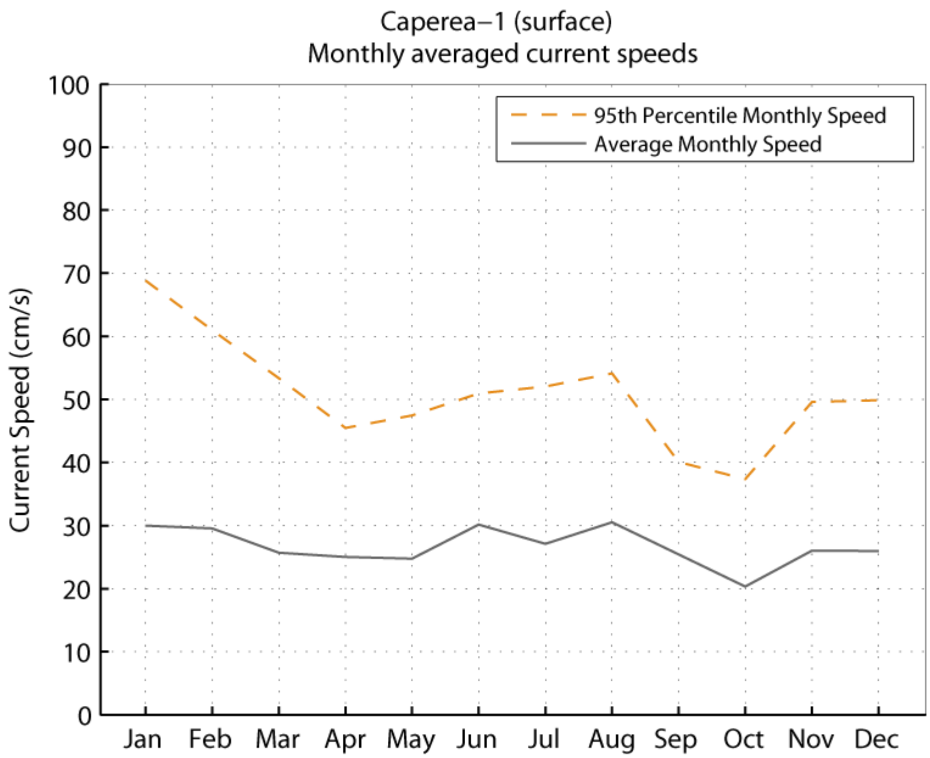


Figure 4. Current roses showing the distribution of HYCOM surface currents (speed and direction) by month at the Caperea-1 drill site (model period: 2009 and 2012).



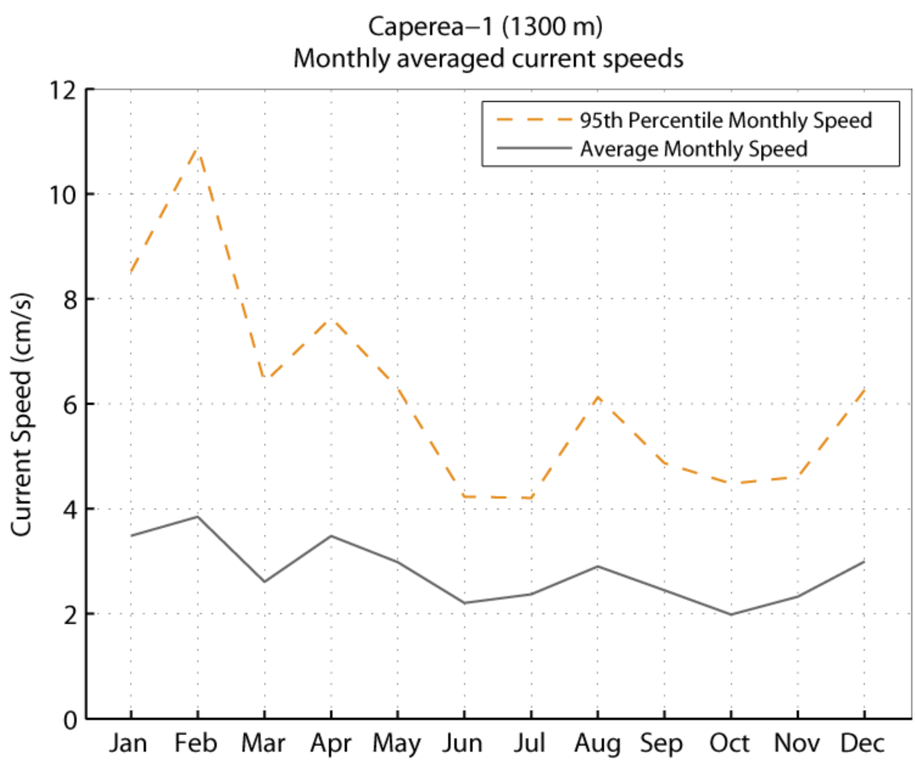


Figure 5. Monthly averaged current speeds at Caperea-1 derived from the HYCOM dataset. Average current speeds are shown for the surface (top figure) and 1,300 m (bottom figure) water depths.

2.2. Drilling Schedule

The preliminary schedule of discharges provided by RPS/Noble indicates that drilling at Caperea-1 will include (a minimum of) four well sections ranging from 42” to 12 ¼” (inches) in diameter. There is also the potential for drilling an additional by-pass section and a geological sidetrack hole for further reservoir evaluation (sections 5 and 6). The first two sections (riserless) are expected to utilize drilling fluid comprised of seawater and bentonite sweeps, which will be discharged directly to the seabed. All subsequent sections will require the use of a high performance water based mud and all cuttings and drilling fluids will be discharged from the drilling platform. The discharge of cuttings and muds is expected to occur continuously during drilling, over 75 days. For all intervals, barite is the primary weighting element of the drilling fluid.

Because the drilling programme may change, model simulations were performed for different periods (seasons) in order to evaluate the influence of potential variability in regional ocean currents. Based on a review of ocean circulation model data within the project area, operational releases were simulated for two (2) discharge periods to compare the impacts of drilling during the austral summer (Jan-Mar; Period 1), and winter (Jun-Aug; Period 2). Local currents are slightly weaker and more directionally variable during summer months as compared to the winter, which is characterized by relatively strong currents that are oriented toward the northeast at most depths.

Table 2. Drilling discharge program used for model simulations at Caperea-1.

Section (in)	Release Depth[1]	Release Duration (day)	Cuttings Discharges		Drilling Fluids Discharges	
			m^3	MT	m^3	MT Barite
42"	seabed	2.5	67	174	67	58
26"	seabed	7.5	493	1282	493	1293.75
17-1/2"	sea surface	10	219	571	219	152.01
12-1/4"	sea surface	19.5	108	281	108	89.53
8-1/2” BP	sea surface	20.5	52	135	52	62.13
12-1/4” ST	sea surface	15	118	307	118	97.83
Total (tonnes)				**2750**		**1753.25**
Discharged at Seabed (tonnes)				**1456**		**1351.75**
Discharged at Surface (tonnes)				**1294**		**401.5**

Notes: 1. Releases were simulated at 5 m above seabed and 2 m below sea surface.

2.3. Discharged Solids Characteristics

Table 3. Composition of drilling discharges used for modeling (Brandsma and Smith, 1999).

Discharged material	Bulk density (pounds per gallon [ppg])	Average SG of solids fraction
WBM cuttings	2650	2.65
WBM (all sections)	1132	3.377

Table 4. WBM cuttings settling velocities used for simulations (Brandsma and Smith, 1999; Dames and Moore, 1978).

Size Class	Percent Volume	Settling Velocity	
		(cm/s)	(m/day)
1	8.00	1.350E-04	0.12
2	6.00	1.686E-03	1.46
3	7.00	2.182E-02	18.86
4	3.00	2.328E-01	201.14
5	2.00	1.447E+00	1250.37
6	18.00	4.011E+00	3465.65
7	16.00	9.796E+00	8463.98
8	15.00	1.352E+01	11679.45
9	25.00	2.598E+01	22442.45

Table 5. Drilling mud (WBM) settling velocities used for simulations (Brandsma and Smith, 1999; O'Reilly et al., 1988).

Size Class	Percent Volume	Settling Velocity	
		(cm/s)	(m/day)
1	7.01	2.74E-03	2.37
2	7.99	6.10E-03	5.27
3	5.00	1.48E-02	12.77
4	10.00	3.00E-02	25.94
5	13.26	4.36E-02	37.66
6	13.26	5.12E-02	44.24
7	19.24	6.40E-02	55.30
8	19.24	8.23E-02	71.10
9	4.00	4.27E-01	368.69
10	1.00	1.12E+00	969.12

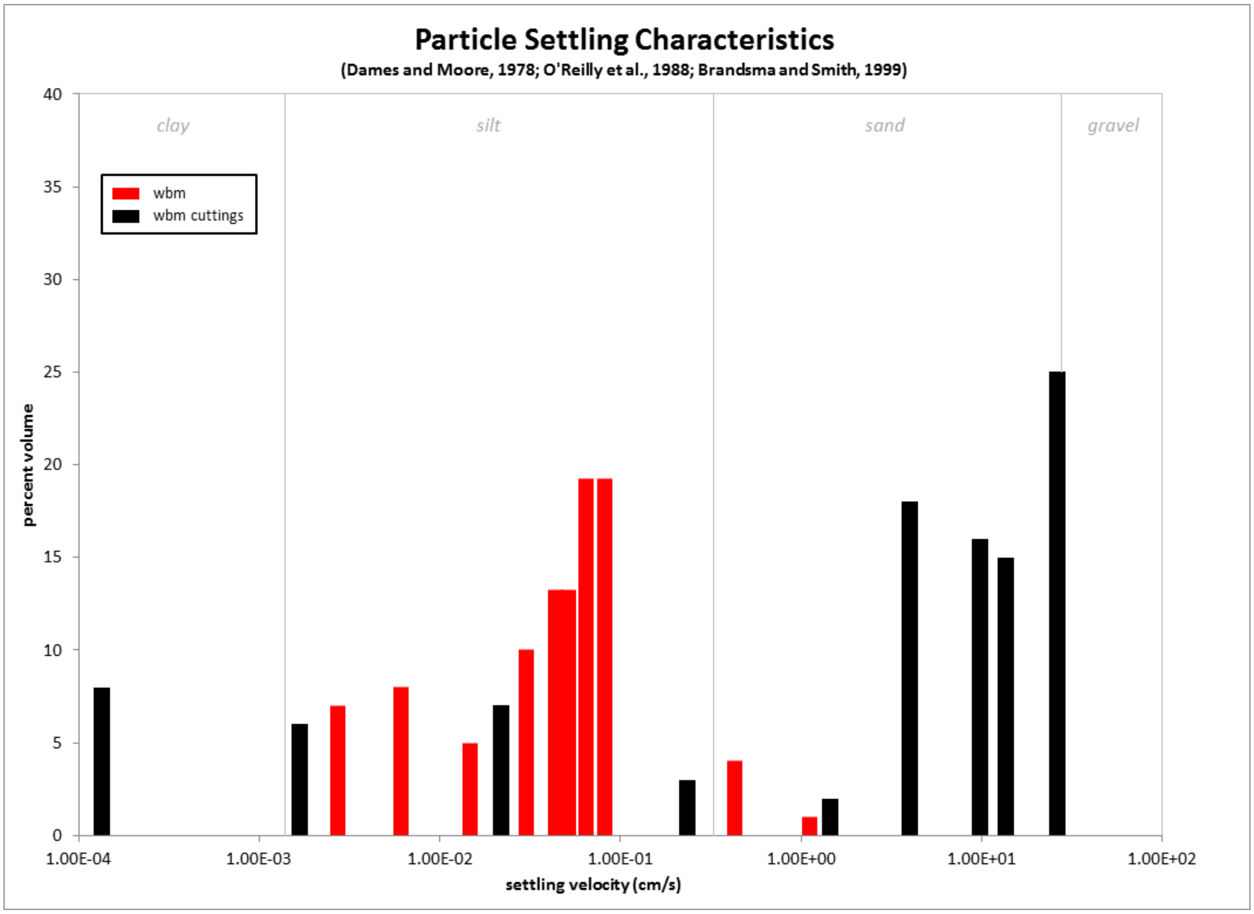


Figure 6. Comparison of settling velocities for solid discharges used in the modeling study. Size class divisions are from Gibbs et al. (1971).

3. Model Results

The fate of mud and cuttings released from operational drilling were assessed through two discharge model scenarios corresponding to the drilling schedule and release volumes shown in Table 6. For each scenario, the MUDMAP model was used to predict the resulting bottom deposition from individual drilling sections at Caperea-1, along with the pattern of cumulative deposits. Simulations were designed to continue tracking the far field dispersion for a minimum of 72 hours following the completion of each section, to account for settling of fine material from the water column. Figure 7 and Figure 8 show the plan view extents of the model-predicted seabed deposition during the austral summer (Period 1) and winter (Period 2), respectively. Table 7 through Table 8 summarize the areal extent of deposition for each scenario. Deposit thicknesses were calculated based on mass accumulation on the seabed and assume a sediment bulk density of 2,500 kg/m^3 and no void ratio (zero porosity).

Table 6. Summary of model parameters used for each scenario.

Model Scenario	Discharge Period	Description	Discharged Cuttings (MT)	Discharged Mud (MT Barite)	Duration of Discharges (d)
Scenario 1	Jan-Mar 2012	WBM and cuttings from sections 1-6	2,750	1,753	75
Scenario 2	Jun-Aug 2012	WBM and cuttings from sections 1-6	2,750	1,753	75

For both scenarios, the thin, broad blanket of sediment that extends ~1-2 km from the discharge site results from the accumulation of very fine particles (which experience more variation in the current regime as they settle) and from discharges that originate at the sea surface (which disperse widely while settling in deep water). To that end, stronger and more uniform currents during Period 2 produce a cumulative deposit that is more elongated and extends nearly 2 km from the discharge site toward the northeast. The extent of deposition is considerably larger for thicknesses < 1 mm during Period 2. For Period 1, the overall deposit is more rounded and the footprint is confined to 945 m from the Caperea-1 site. Both scenarios impact a similar cumulative area for contours > 1mm, as shown Figure 9. Deposition at or above 10 mm is uniform and concentric around the well, which indicates that dispersion processes are nearly as influential as advection from currents due to the settling characteristics of material being released and the release depths.

Finally, Figure 10 shows the integrated footprint from both discharge scenarios with respect to the best known coordinates of the *SMS Scharnhorst* (as reported by Wrecksite.eu), a shipwrecked German cruiser (lost December 1914) that lies within the FISA12 license area. The results from all model runs were integrated to define the likely area of coverage for both current conditions modelled above the 0.1 mm minimum thickness threshold. A 10 km buffer has been applied to the wreck location due to the positional uncertainty of the shipwreck.

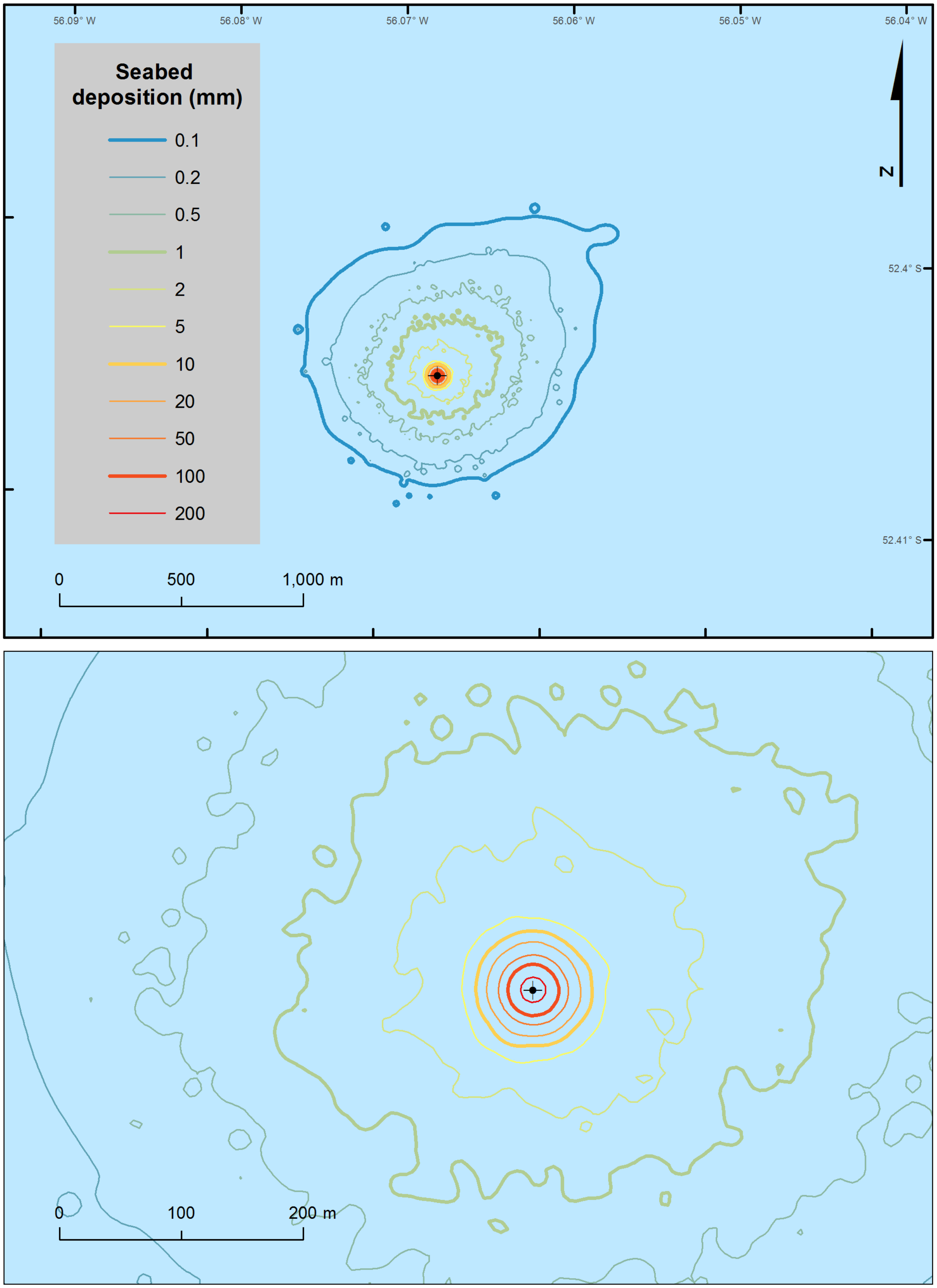


Figure 7. Predicted thickness of drilling discharges at Caperea-1 (Period 1; Jan-Mar). Top: composite deposition resulting from all drilling intervals. Bottom: contours above 1 mm (bold green) shown at an expanded scale.

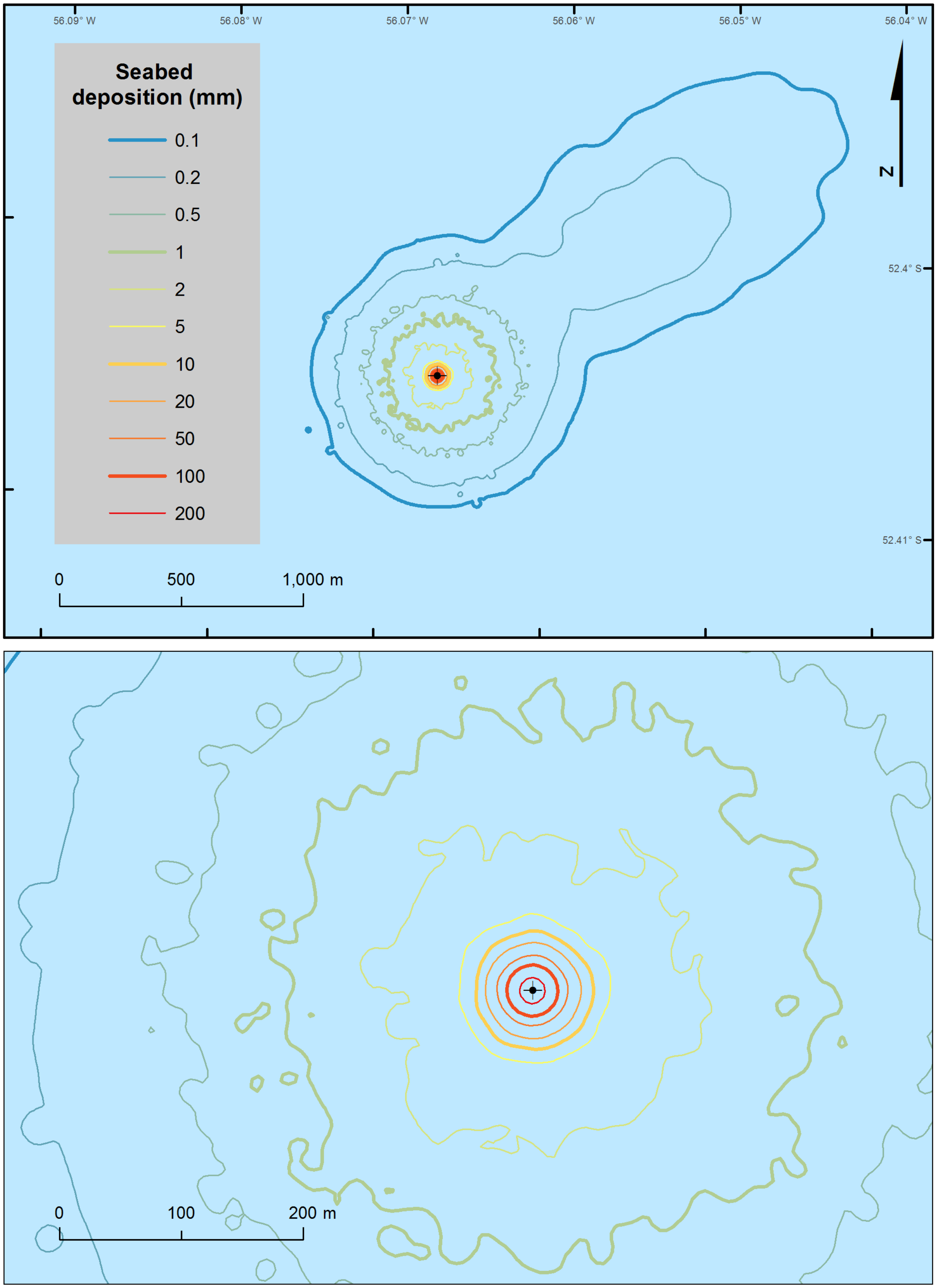


Figure 8. Predicted thickness of drilling discharges at Caperea-1 (Period 2; Jun-Aug). Top: composite deposition resulting from all drilling intervals. Bottom: contours above 1 mm (bold green) shown at an expanded scale.

Table 7. Areal extent of seabed deposition (by thickness interval) for each model scenario.

Deposition Thickness (mm)	Cumulative Area Exceeding (ha)	
	Period 1	Period 2
0.1	**103.164**	**193.141**
0.2	63.706	97.999
0.5	29.838	31.589
1	**13.747**	**15.713**
2	4.316	5.200
5	1.124	1.149
10	**0.693**	**0.718**
20	0.464	0.466
50	0.257	0.247
100	**0.135**	**0.142**
200	0.035	0.032

Table 8. Maximum extent of thickness contours (distance from release site) for each model scenario.

Deposition Thickness (mm)	Maximum extent from discharge point (m)	
	Period 1	Period 2
0.1	945	1980
1	308	265
10	50	50
100	22	22

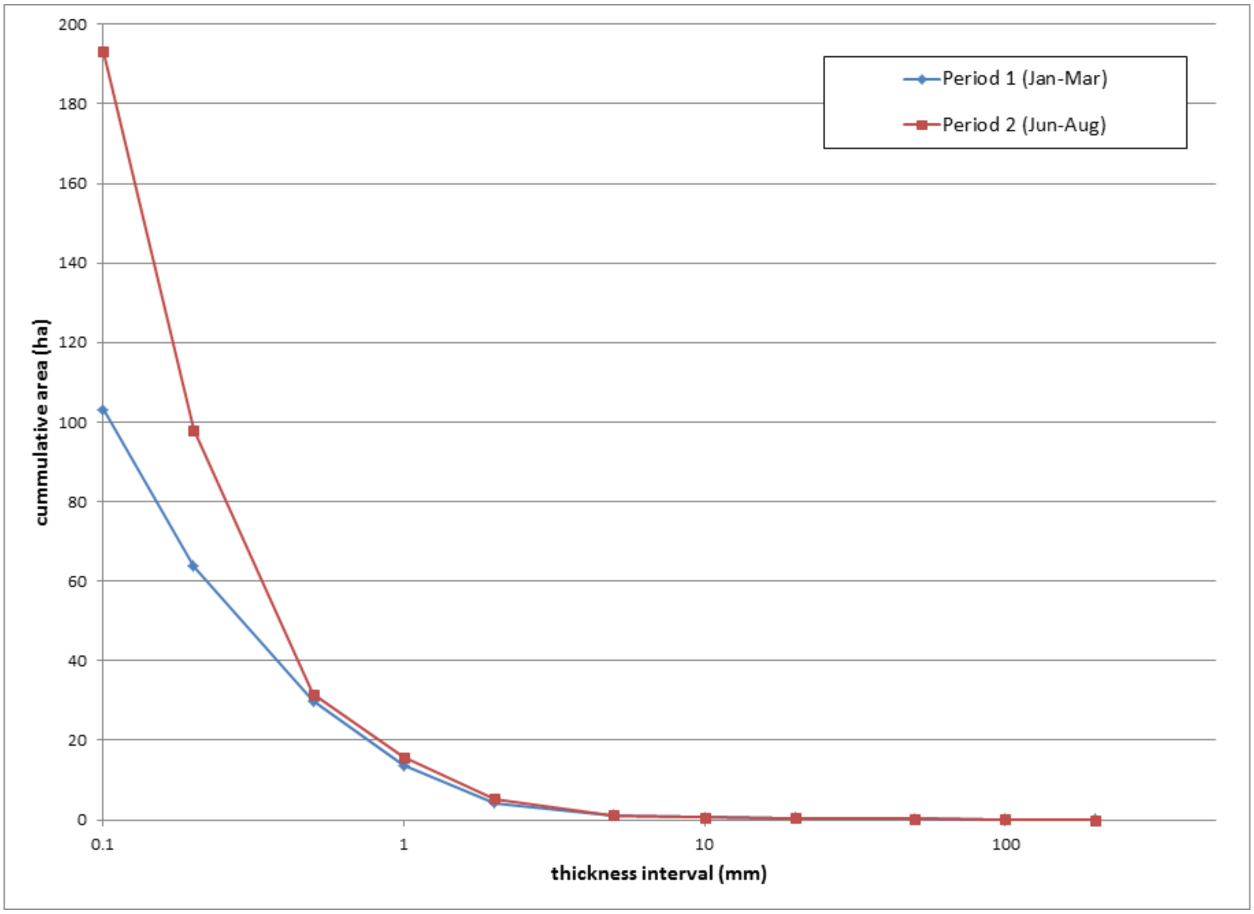


Figure 9. Comparison of seabed deposition (by thickness interval) for discharges originating from Caperea-1. Blue – discharges during the Jan-Mar period, Red – discharges during the Jun-Aug period.

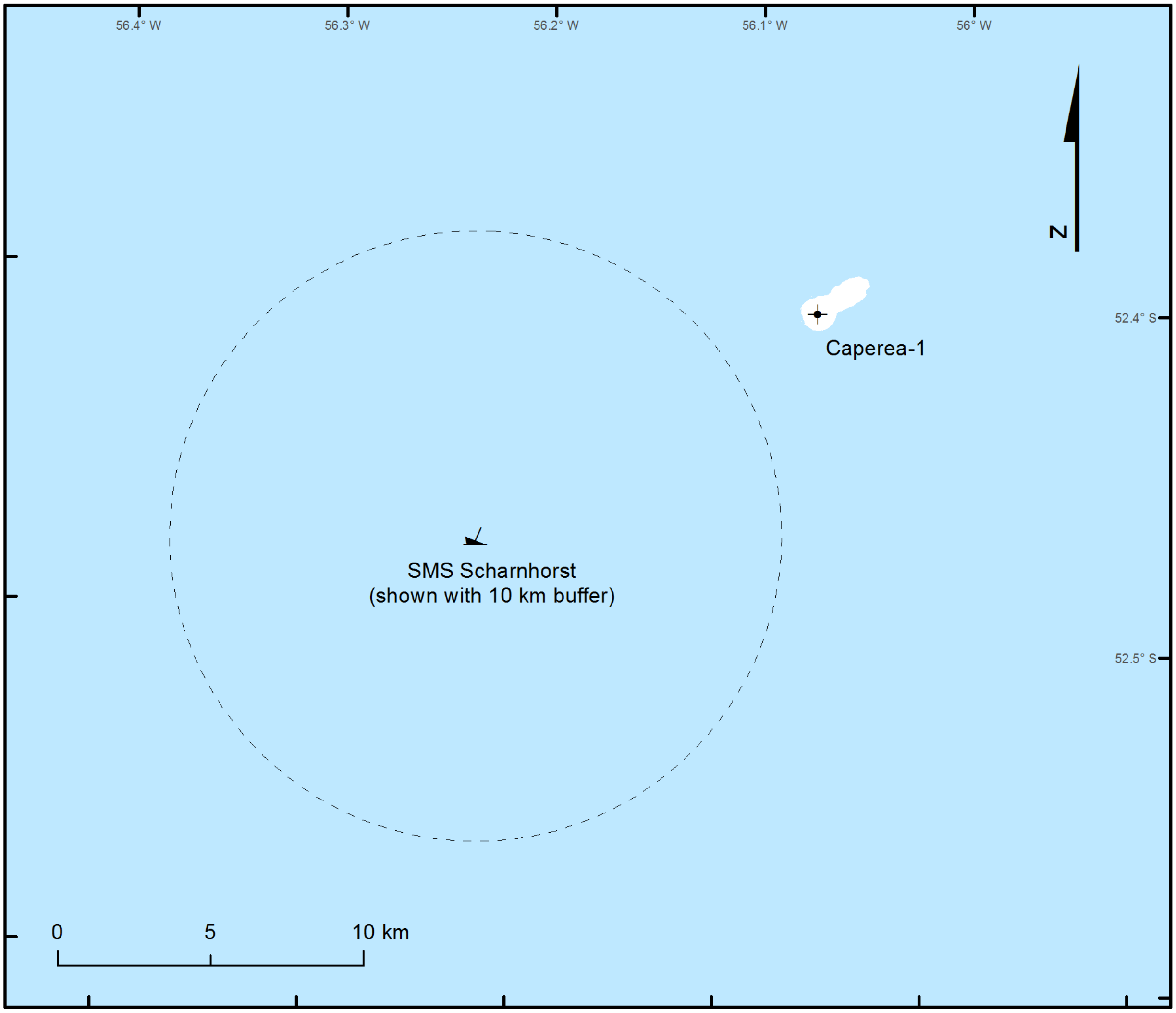


Figure 10. Integrated footprint of deposition at Caperea-1 for both model periods (white polygon) shown with shipwreck location (SMS Scharnhorst) (as reported by Wrecksite.eu). Dashed line shows the positional uncertainty (10 km) of the wreck.

4. References

Brandsma, M.G. & Smith, J.P., 1999. Offshore Operators Committee mud and produced water discharge model – report and user guide. Exxon Production Research Company, December 1999.

Cummings, J.A., 2005. Operational multivariate ocean data assimilation. *Quart. J. Royal Met. Soc.*, Part C, 131(613), 3583-3604.

Dames and Moore, 1978. Drilling fluid dispersion and biological effects study for the lower Cook inlet C.O.S.T. well." *Report submitted to Atlantic Richfield Co. by Dames and Moore, Anchorage, AK*. April 1978.

Gibbs, R.J., Matthews, M.D. and Link, D.A., 1971. The relationship between sphere size and settling velocity. *Journal of Sedimentary Research*, v. 41, 7-18.

O'Reilly, J., T.C. Sauer, Jr., R.C. Ayers, Jr., R.P. Meek and M.G. Brandsma, 1989. OOC mud discharge model: field verification study. *In: Drilling Wastes. Engelhardt, F.R., Ray, J.P., Gillam, A.H., Eds.* Elsevier Applied Science. New York. 1989.

Spaulding, M. L., T. Isaji, and E. Howlett, 1994. MUDMAP: A model to predict the transport and dispersion of drill muds and production water, Applied Science Associates, Inc, Narragansett, RI.

Wrecksite.eu, 2014, Wrecksite Database, [Internet], available: <www.wrecksite.eu>.

Appendix A: MUDMAP Model Description

MUDMAP is a personal computer-based model developed by ASA to predict the near and far-field transport, dispersion, and bottom deposition of drill muds and cuttings and produced water (Spaulding et al; 1994). In MUDMAP, the equations governing conservation of mass, momentum, buoyancy, and solid particle flux are formulated using integral plume theory and then solved using a Runge Kutta numerical integration technique. The model includes three stages:

Stage 1: **Convective decent/jet stage** – The first stage determines the initial dilution and spreading of the material in the immediate vicinity of the release location. This is calculated from the discharge velocity, momentum, entrainment and drag forces.

Stage 2: **Dynamic collapse stage** – The second stage determines the spread and dilution of the released material as it either hits the sea surface or sea bottom or becomes trapped by a strong density gradient in the water column. Advection, density differences and density gradients drive the transport of the plume.

Stage 3: **Dispersion stage –** In the final stage the model predicts the transport and dispersion of the discharged material by the local currents. Dispersion of the discharged material will be enhanced with increased current speeds and water depth and with greater variation in current direction over time and depth.

MUDMAP is based on the theoretical approach initially developed by Koh and Chang (1973) and refined and extended by Brandsma and Sauer (1983) and Khondaker (2000) for the convective descent/ascent and dynamic collapse stages. The far-field, passive diffusion stage is based on a particle based random walk model. This is the same random walk model used in ASA's OILMAP spill modeling system (ASA, 1999).

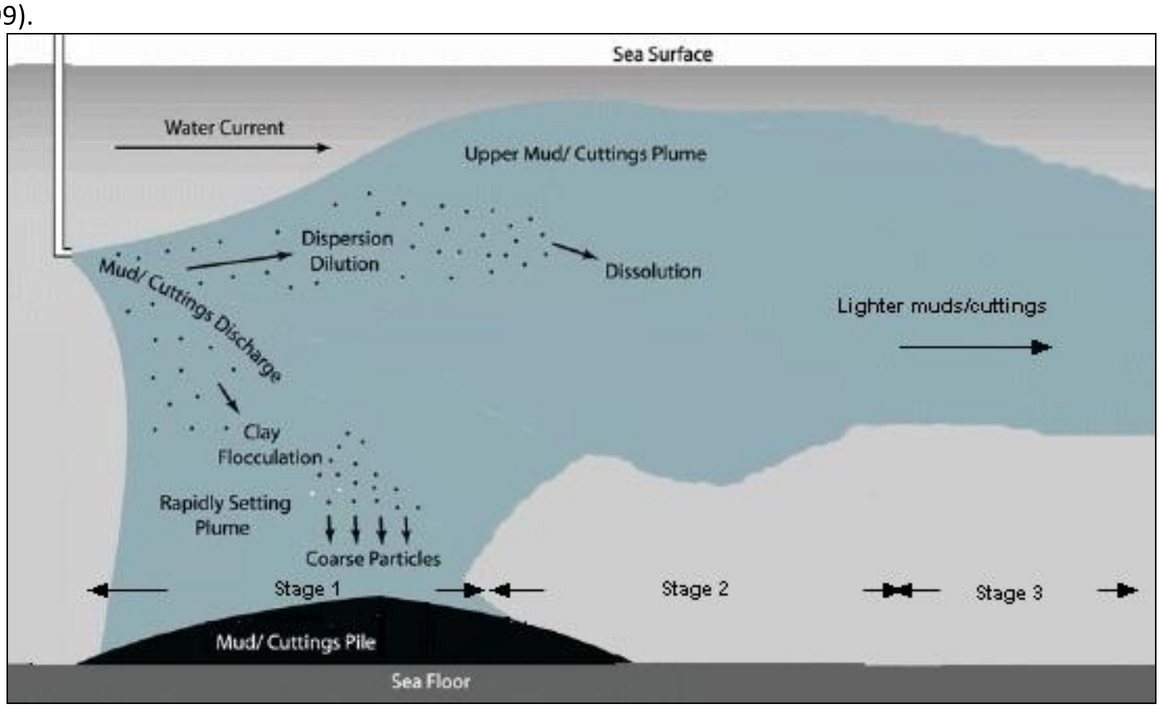


Figure A1. Conceptual diagram showing the general behavior of cuttings and muds following discharge to the ocean and the three distinct discharge phases (after Neff 2005).

The model's output consists of calculations of the movement and shape of the discharge plume, the concentrations of soluble (i.e. oil in produced water) and insoluble (i.e. cuttings and muds) discharge components in the water column, and the accumulation of discharged solids on the seabed. The model predicts the initial fate of discharged solids, from the time of discharge to initial settling on the seabed As MUDMAP does not account for resuspension and transport of previously discharged solids, it provides a conservative estimate of the potential seafloor concentrations (Neff 2005).

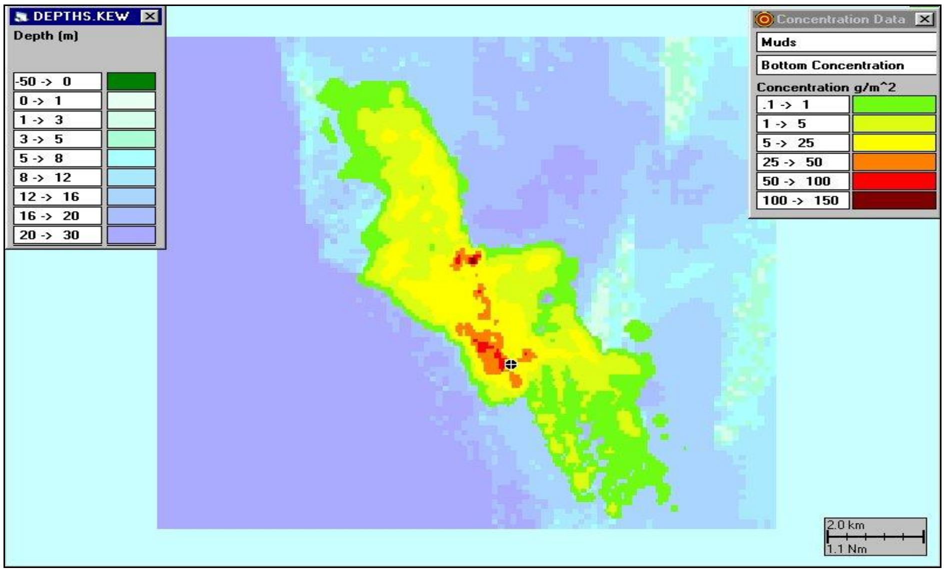


Figure A2. Example MUDMAP bottom concentration output for drilling fluid discharge.

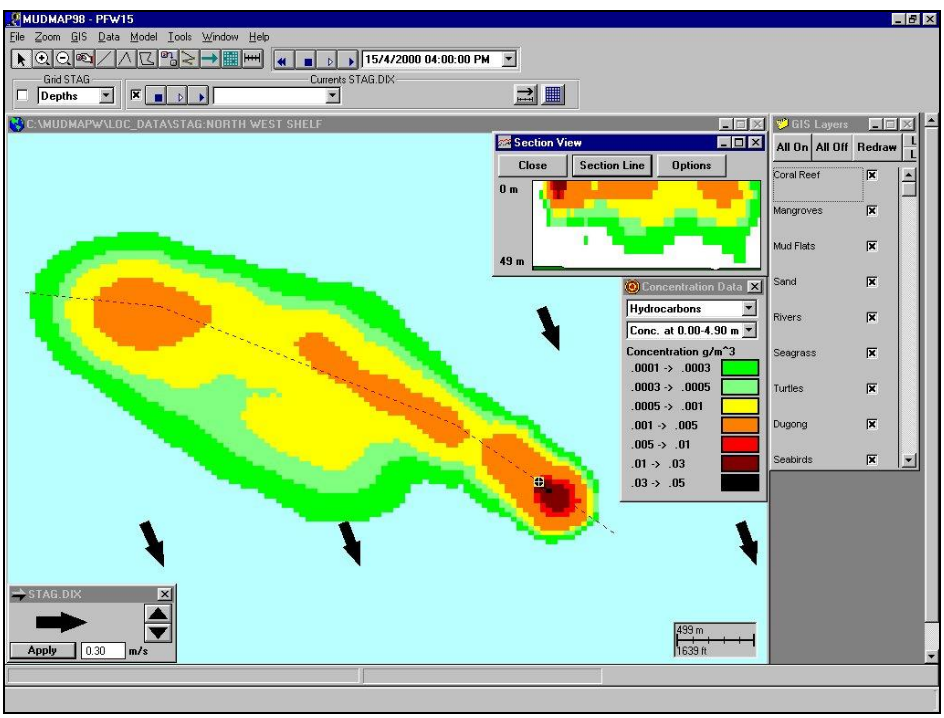


Figure A3. Example MUDMAP water column concentration output for drilling fluid discharge.

MUDMAP uses a color graphics-based user interface and provides an embedded geographic information system, environmental data management tools, and procedures to input data and to animate model output. The system can be readily applied to any location in the world. Application of MUDMAP to predict the transport and deposition of heavy and light drill fluids off Pt. Conception, California and the near-field plume dynamics of a laboratory experiment for a multi-component mud discharged into a uniform flowing, stratified water column are presented in Spaulding et al. (1994). King and McAllister (1997, 1998) present the application and extensive verification of the model for a produced water discharge on Australia's northwest shelf. GEMS (1998) applied the model to assess the dispersion and deposition of drilling cuttings released off the northwest coast of Australia.

MUDMAP References

Applied Science Associates, Inc. (ASA), 1999. OILMAP technical and user's manual, Applied Science Associates, Inc., Narragansett, RI.

Brandsma, M.G., and T.C. Sauer, Jr., 1983. The OOC model: prediction of short term fate of drilling mud in the ocean, Part I model description and Part II model results. Proceedings of Workshop on an Evaluation of Effluent Dispersion and Fate Models for OCS Platforms, Santa Barbara, California.

GEMS - Global Environmental Modelling Services, 1998. Quantitative assessment of the dispersion and seabed depositions of drill cutting discharges from Lameroo-1 AC/P16, prepared for Woodside Offshore Petroleum. Prepared by Global Environmental Modelling Services, Australia, June 16, 1998.

King, B., and F.A. McAllister, 1997. Modelling the dispersion of produced water discharge in Australia, Volume I and II. Australian Institute of Marine Science report to the APPEA and ERDC.

King, B., and F.A. McAllister, 1998. Modelling the dispersion of produced water discharges. APPEA Journal 1998, pp. 681-691.

Koh, R.C.Y., and Y.C. Chang, 1973. Mathematical model for barged ocean disposal of waste. Environmental Protection Technology Series EPA 660/2-73-029, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Khondaker, A. N., 2000. Modelling the fate of drilling waste in marine environment – an overview. Journal of Computers and Geosciences Vol. 26, pp. 531-540.

Neff, J., 2005. Composition, environment fates, and biological effect of water based drilling muds and cuttings discharged to the marine environment: A synthesis and annotated bibliography. Report prepared for Petroleum Environment Research Forum and American Petroleum Institute.

Spaulding, M. L., T. Isaji, and E. Howlett, 1994. MUDMAP: A model to predict the transport and dispersion of drill muds and production water, Applied Science Associates, Inc, Narragansett, RI.

Appendix I: Oil Spill Modelling Study

RPS | Falkland Islands. Preliminary Oil Spill Modelling Results

Table of Contents

List of Figures

List of Tables

1. Geographic Location - Area of Interest

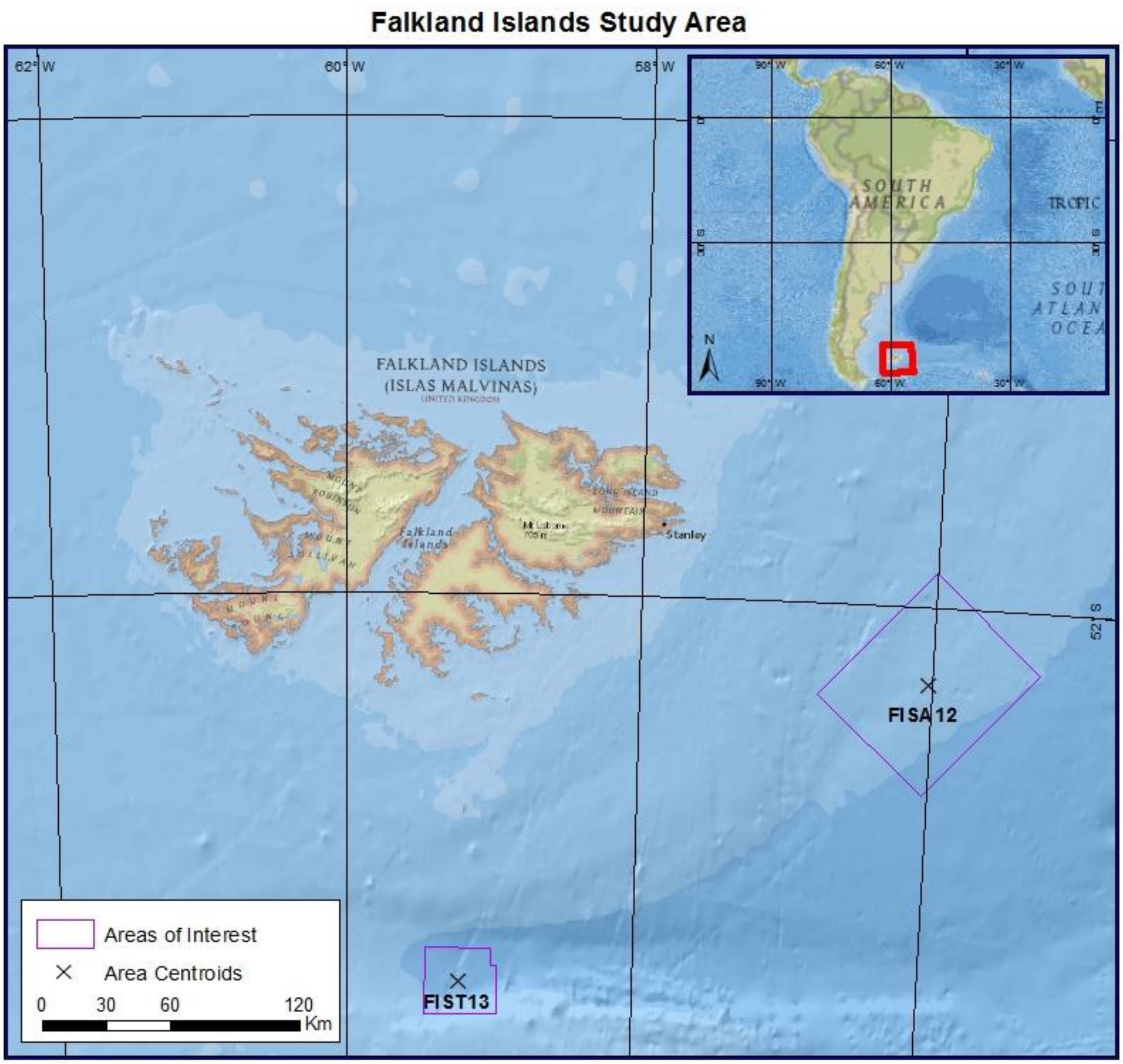


Figure 1. Geographic location of the study area.

Table 1. Coordinates of the sites of interest.

Site Name	Comments	Latitude N	Longitude E	Distance from land (km)	Approximate Water Depth (m)
FISA12	Center of FISA12	-52.3232	-56.0231	137 (Cape Pembroke)	1,177
FIST13	Center of FIST13	-53.6283	-59.2109	76 (Beauchene Island)	1,527

2. Environmental Data Analysis

The environmental datasets used for this study include the temperature and salinity dataset, WOA-13 (hosted by the National Oceanographic and Atmospheric Administration), the wind dataset, NOGAPS (a product of the United States Navy) and the current dataset, HYCOM (a product of the National Oceanographic Partnership Program). All wind and current figures presented in this report use subsets of these datasets that cover the period from January 1, 2009 to December 31, 2012. All wind roses follow standard meteorological convention (showing the direction from which winds are blowing) while all current roses follow standard oceanographic convention (showing the direction towards which currents are flowing).

2.1. Wind Dataset – NOGAPS

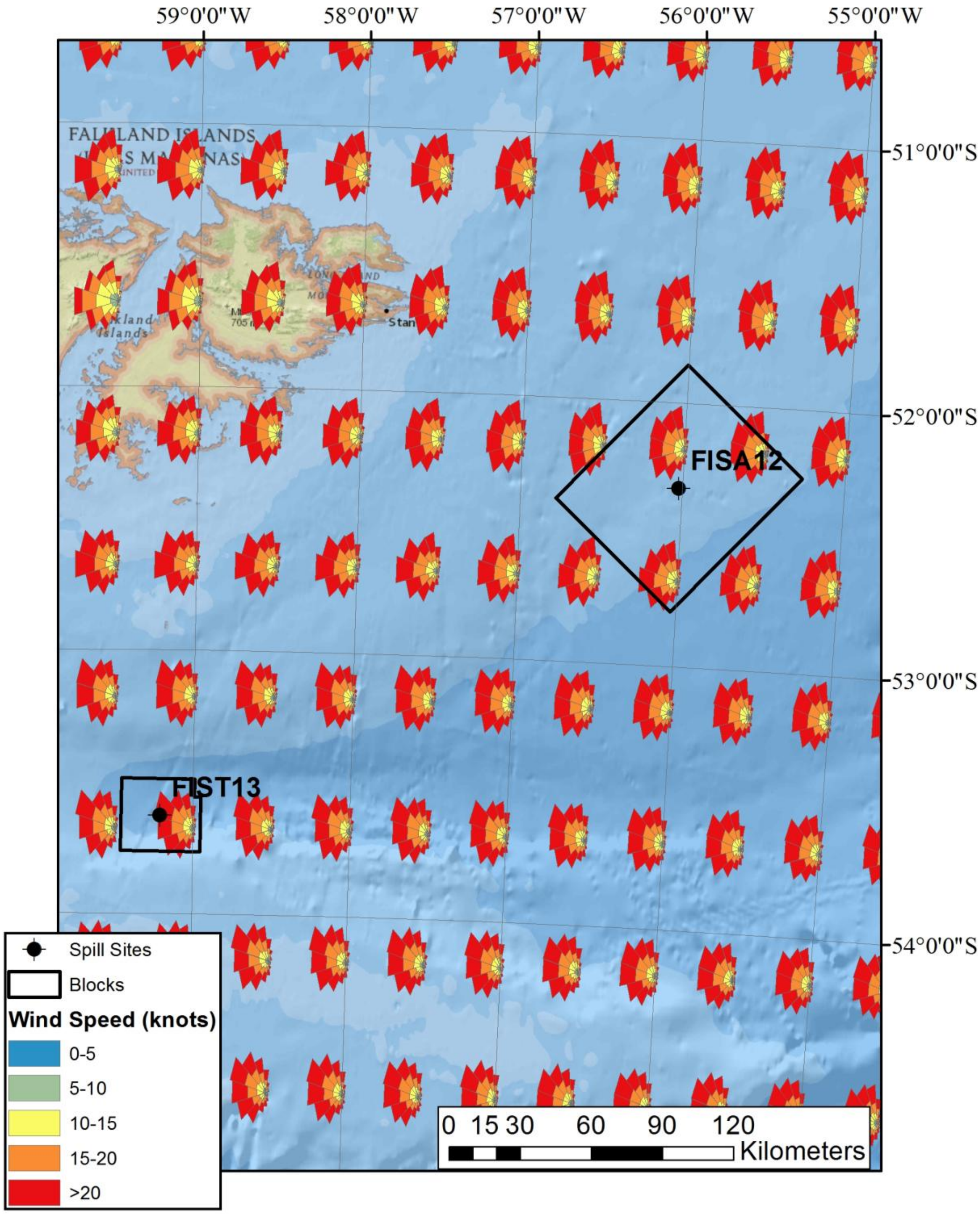


Figure 2. Annually-averaged NOGAPS wind roses representing the spatial variability of the wind field in the area of interest.

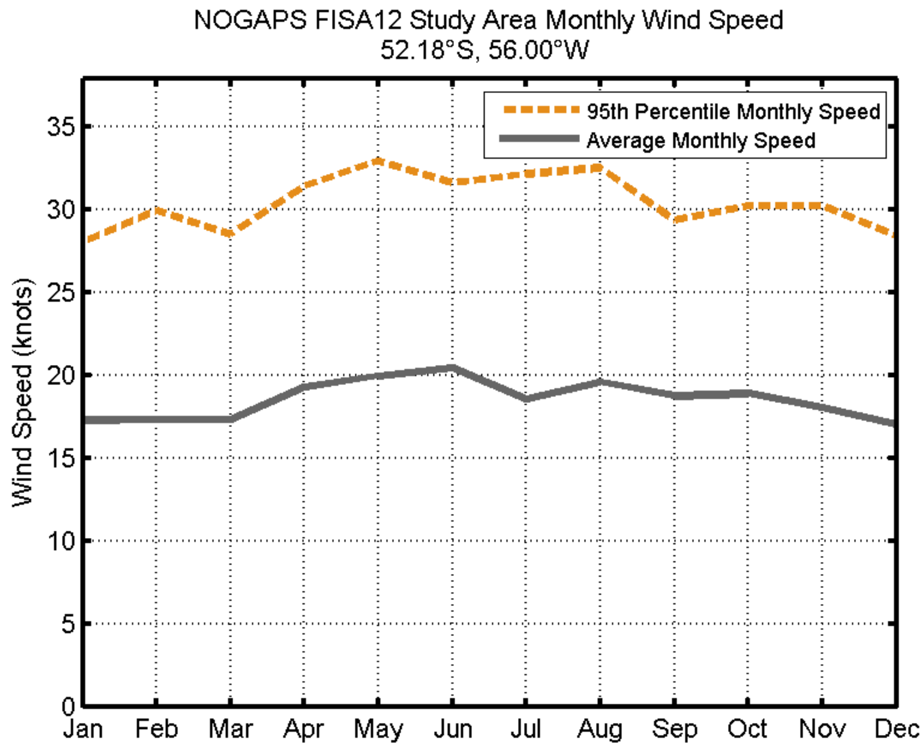


Figure 3. NOGAPS monthly wind speed statistics for FISA12.

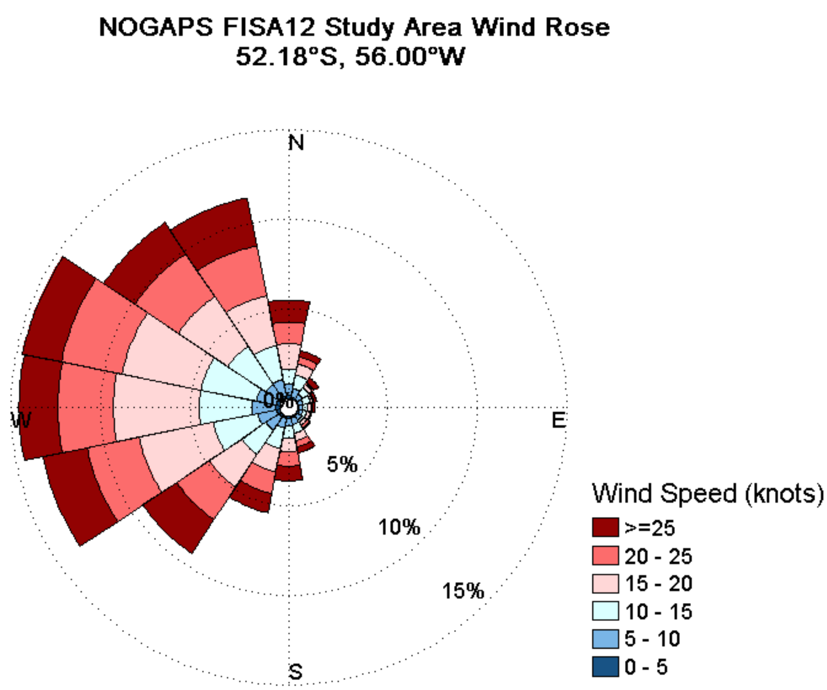


Figure 4. Annually-averaged NOGAPS wind rose for FISA12.

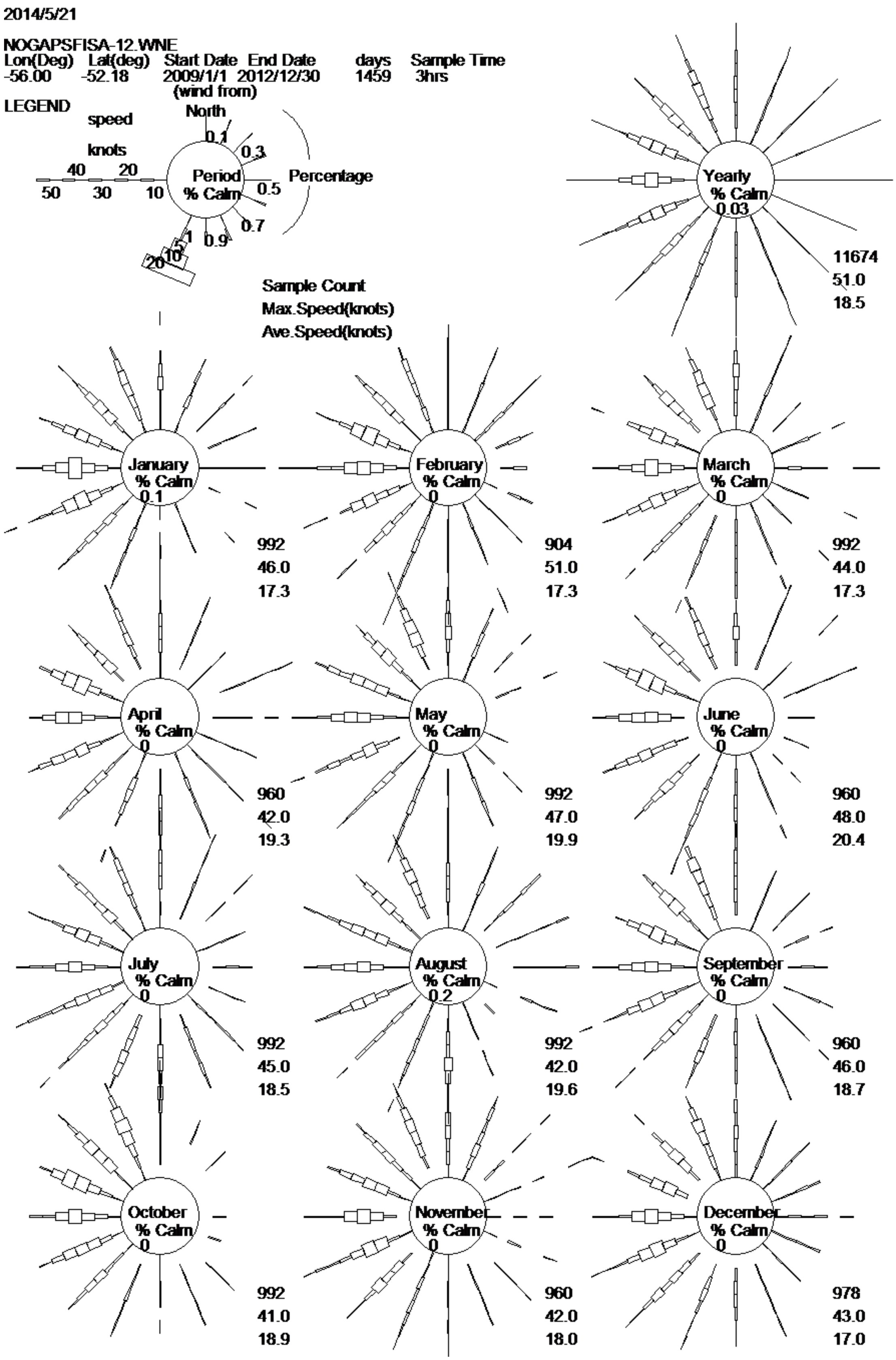


Figure 5. Monthl-y and annually-averaged NOGAPS wind roses for FISA12.

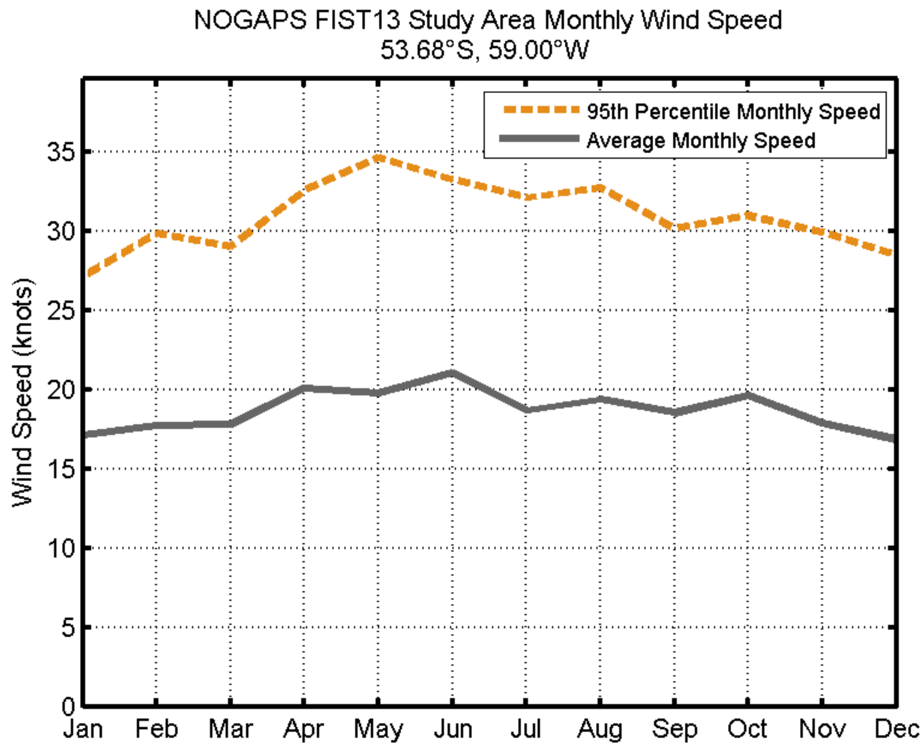


Figure 6. NOGAPS monthly wind speed statistics for FIST13.

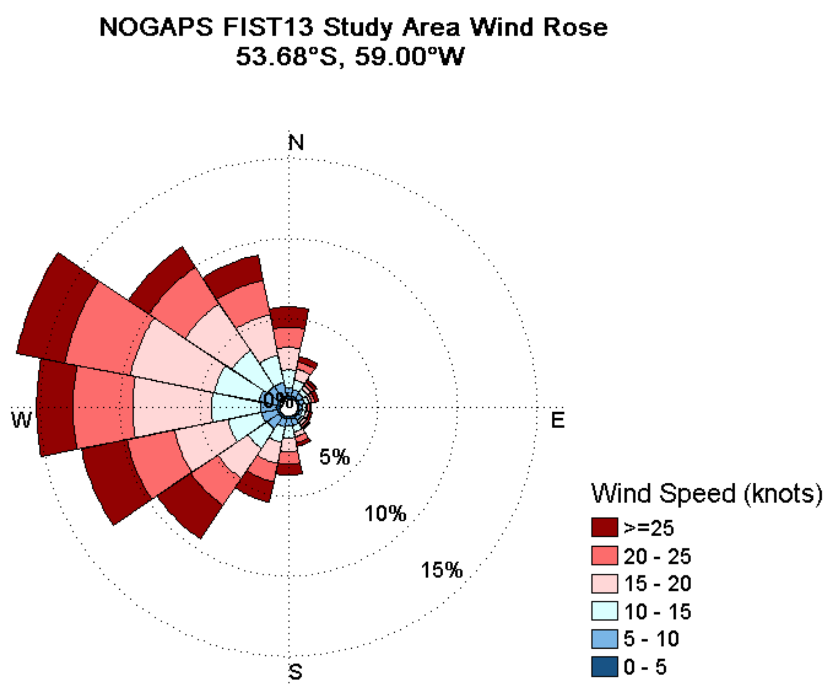


Figure 7. Annually-averaged NOGAPS wind rose for FIST13.

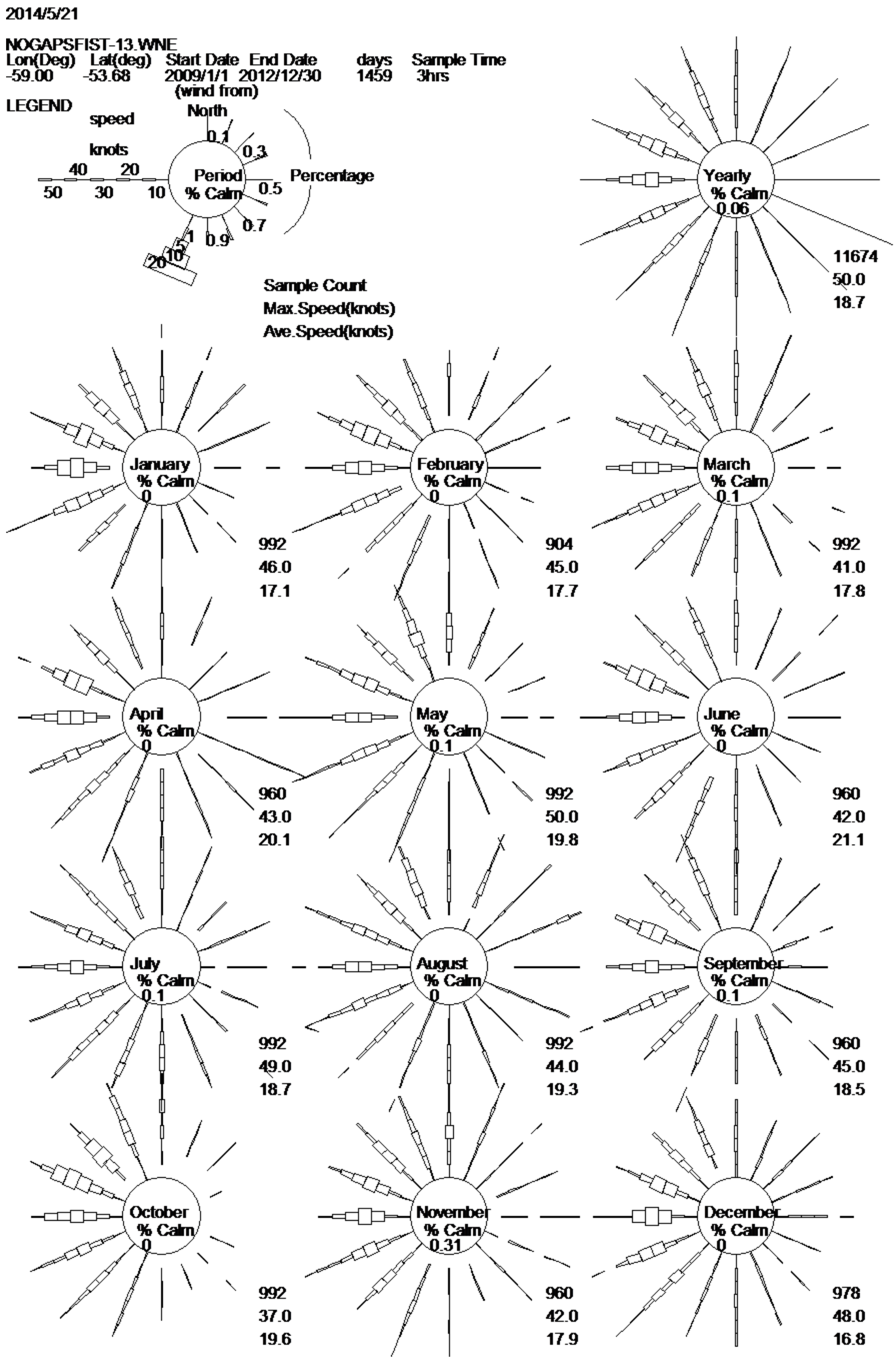


Figure 8. Monthl-y and annually-averaged NOGAPS wind roses for FIST13.

2.2. Current Dataset – HYCOM

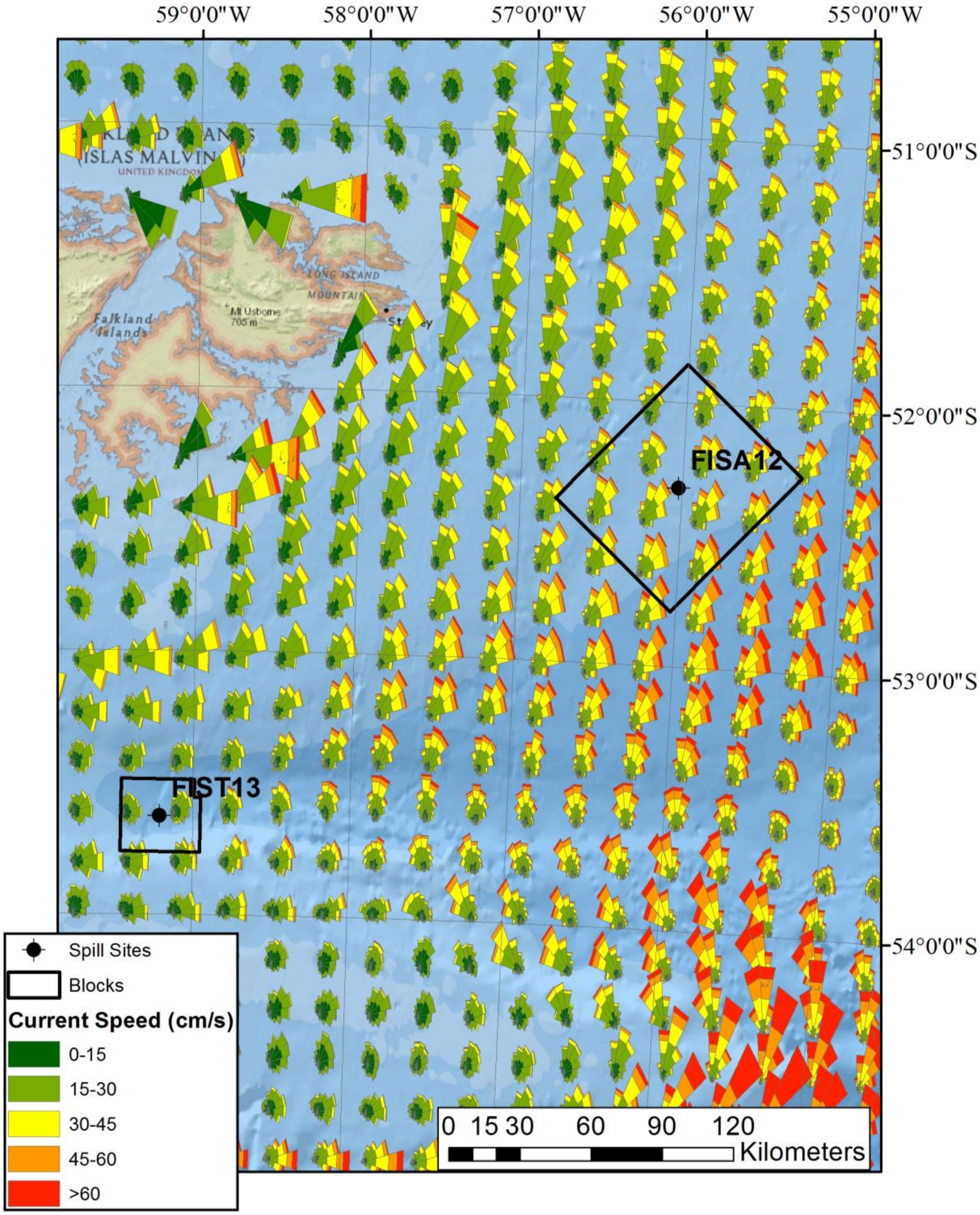


Figure 9. Annually-averaged HYCOM current roses representing the spatial variability of currents in the area of interest.

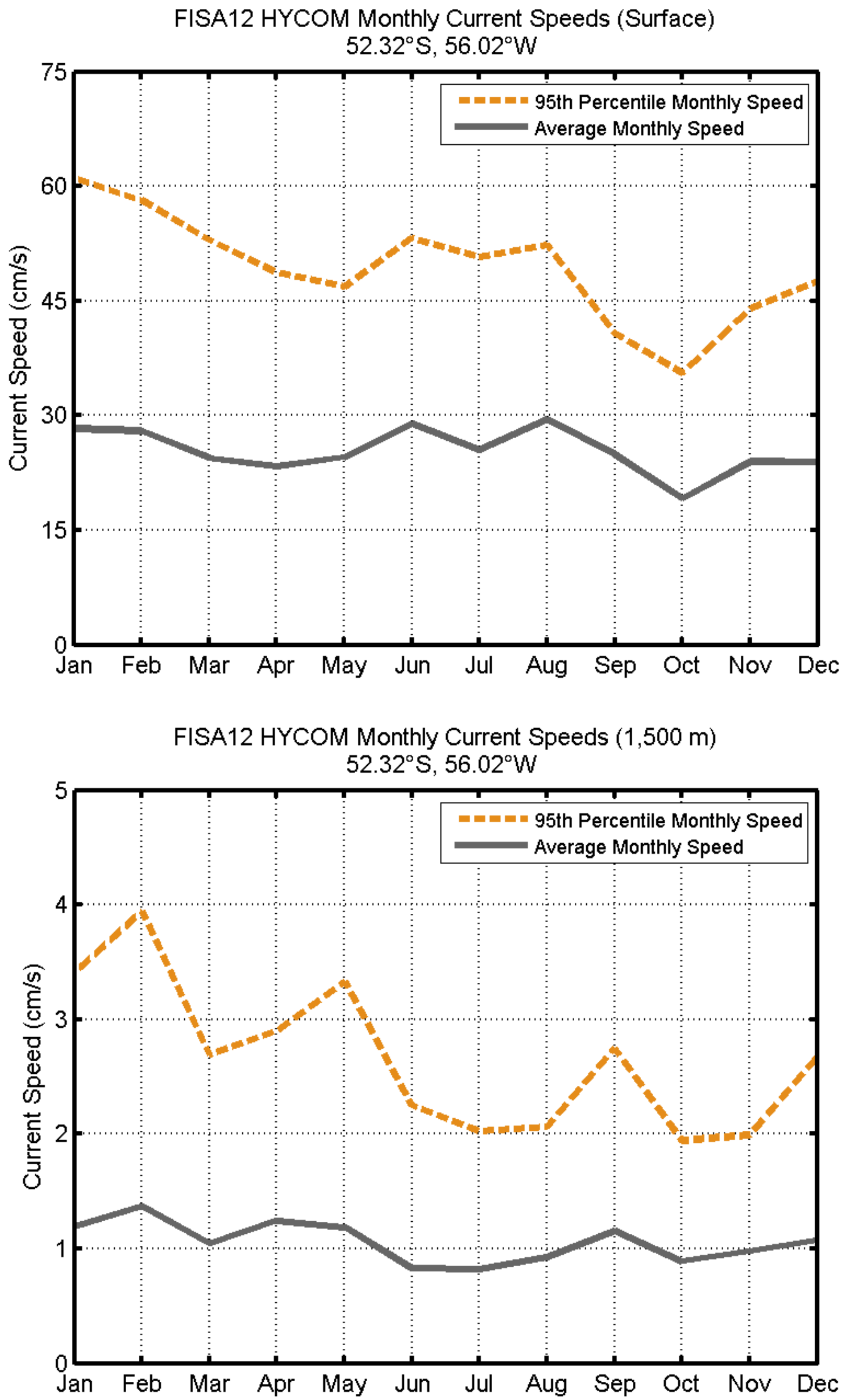


Figure 10. HYCOM monthly current speed statistics for FISA12.

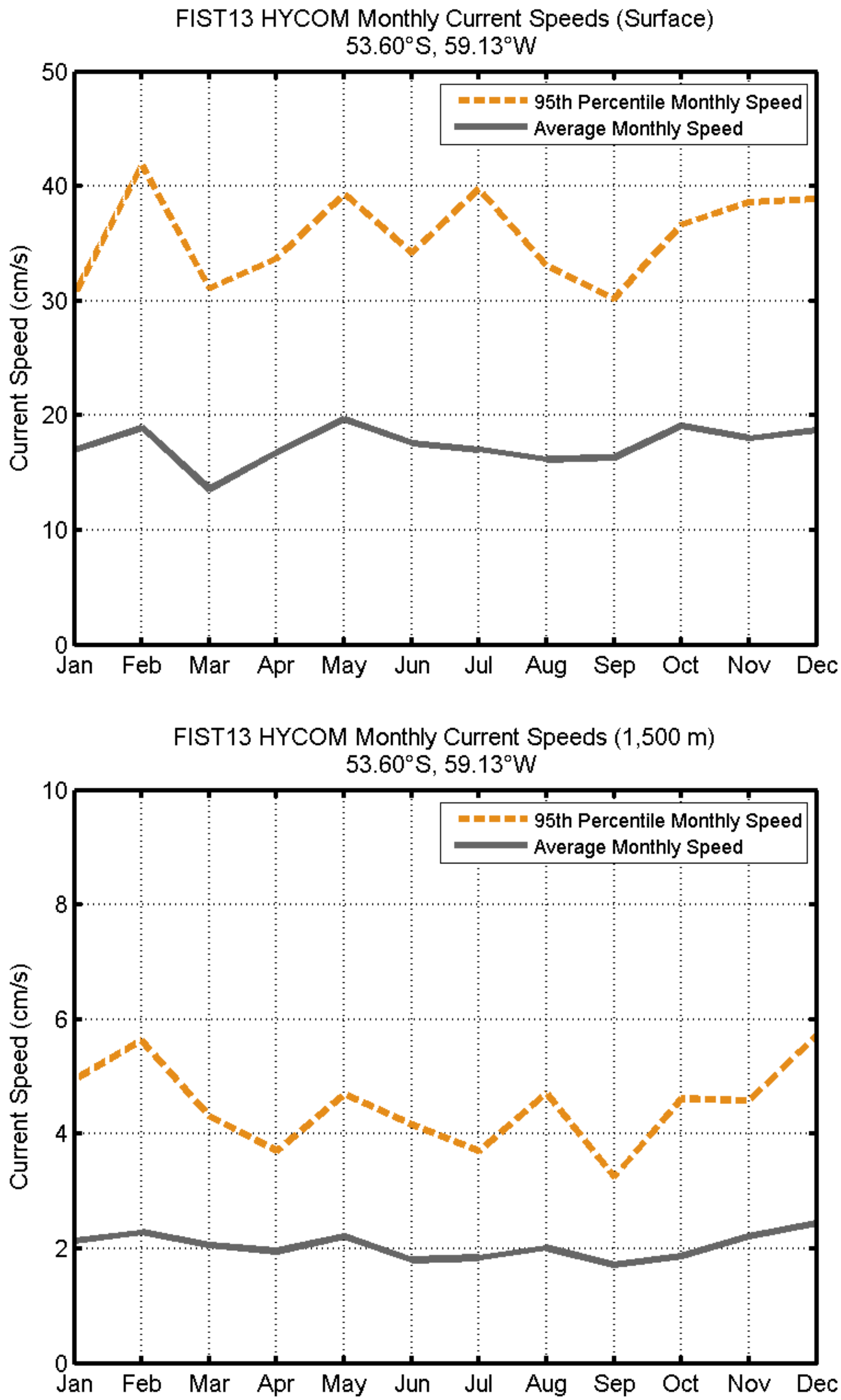
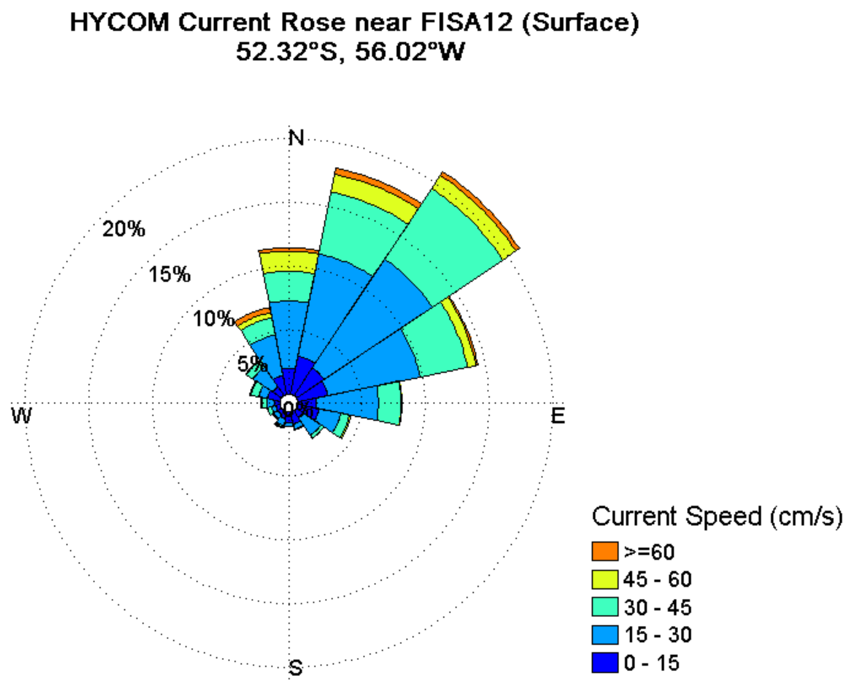


Figure 11. HYCOM monthly current speed statistics for FIST13.



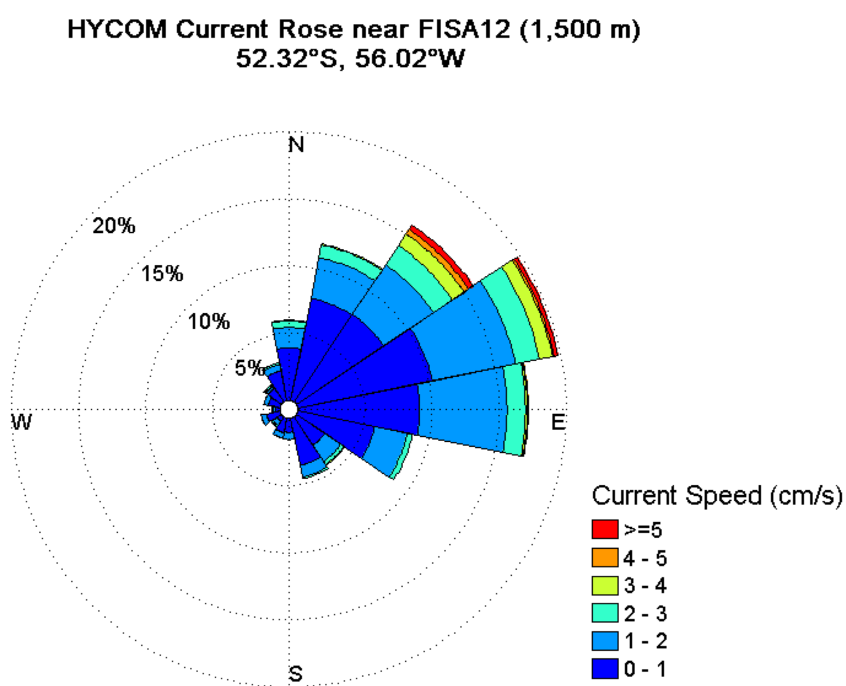


Figure 12. Annually-averaged HYCOM current roses for FISA12.

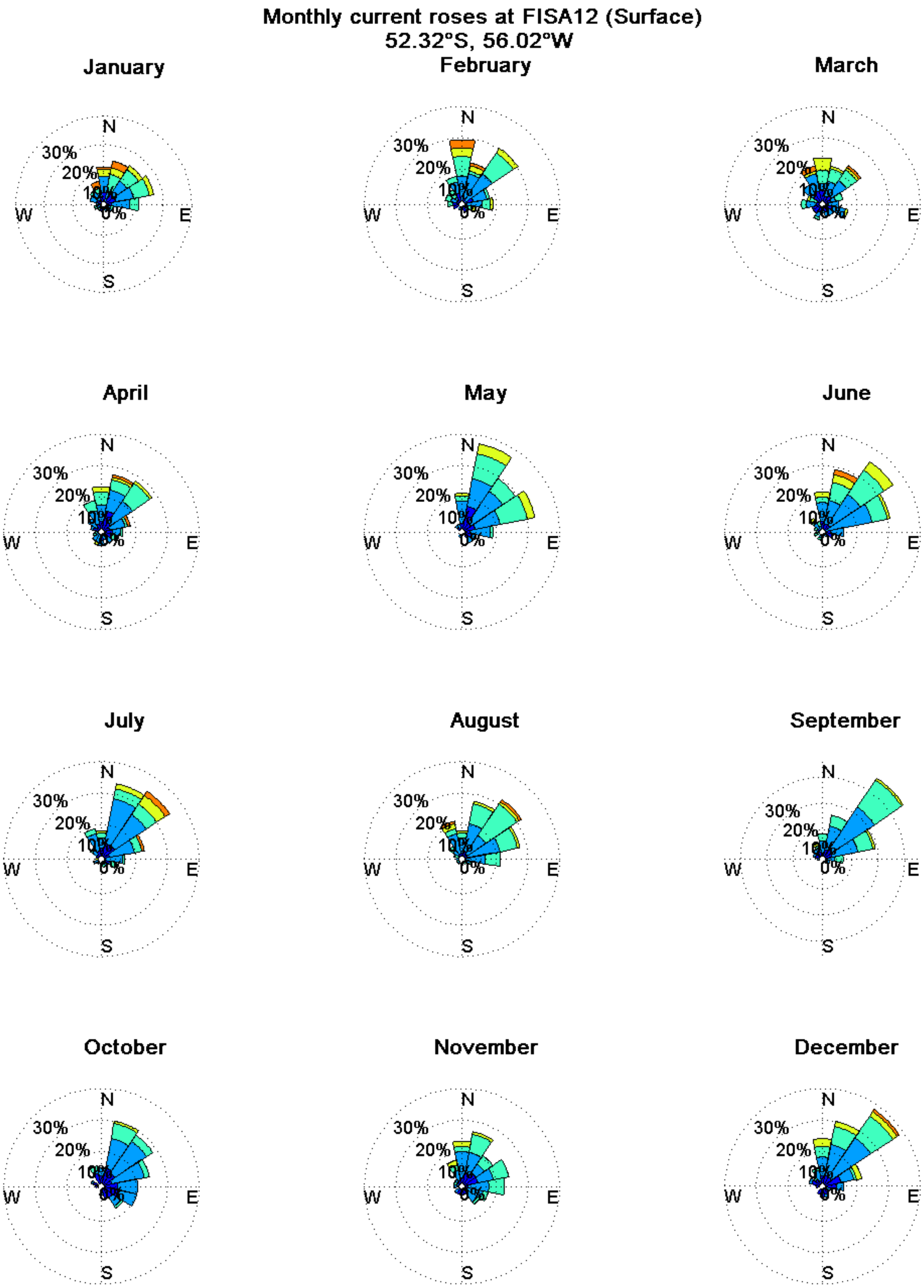
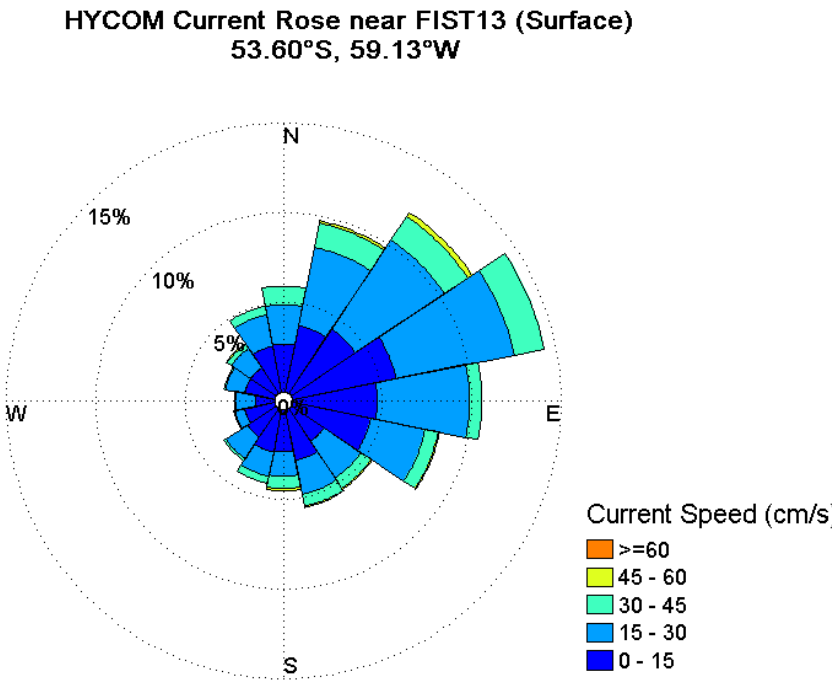


Figure 13. Monthly-averaged HYCOM current roses for FISA12.



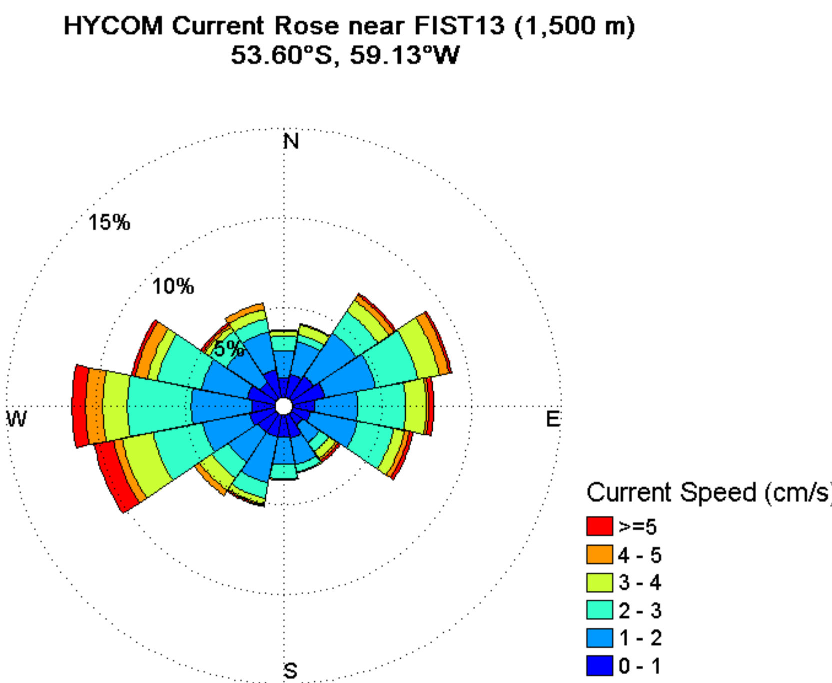


Figure 14. Annually-averaged HYCOM current roses for FIST13.

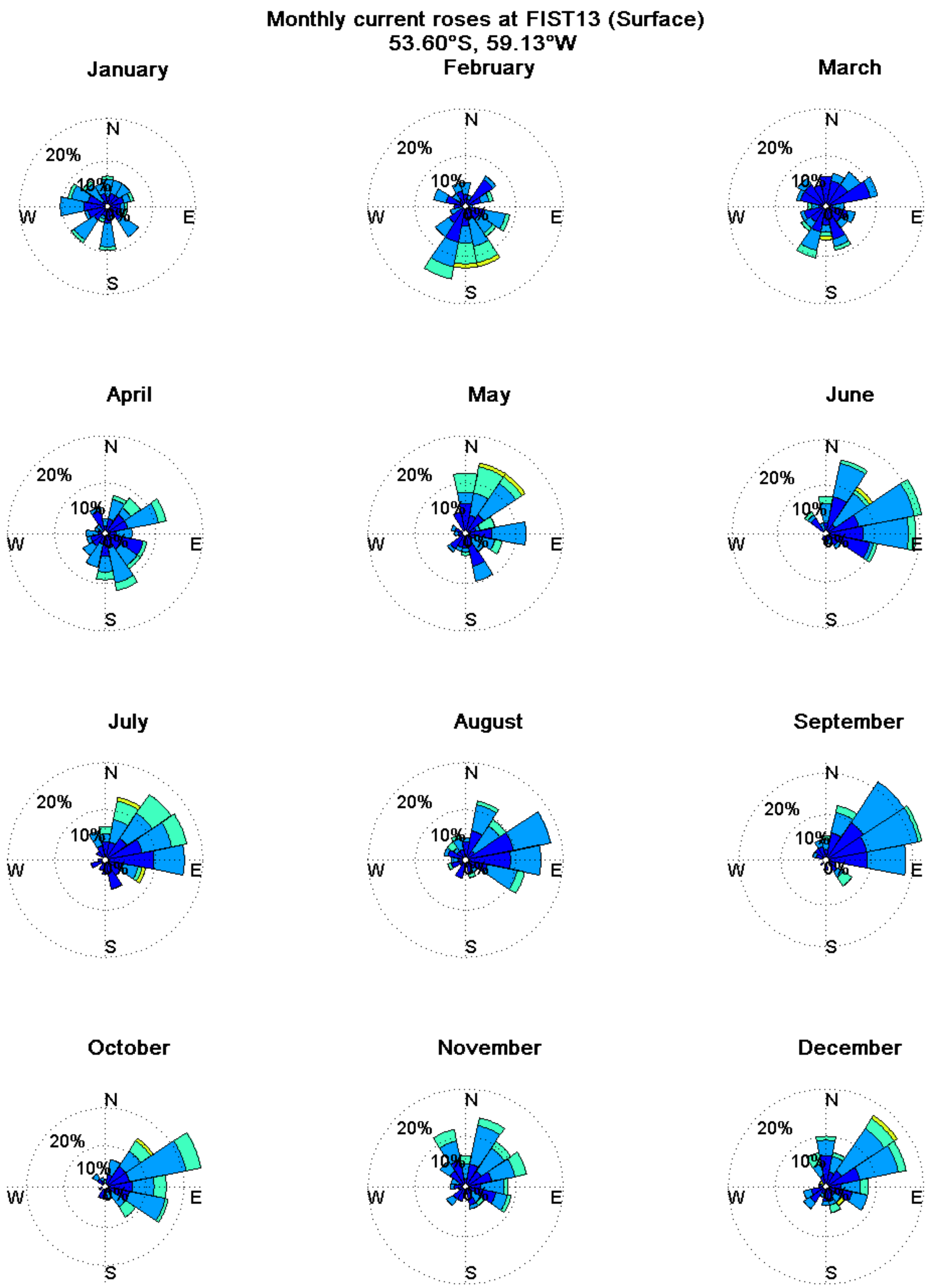


Figure 15. Monthly-averaged HYCOM current roses for FIST13.

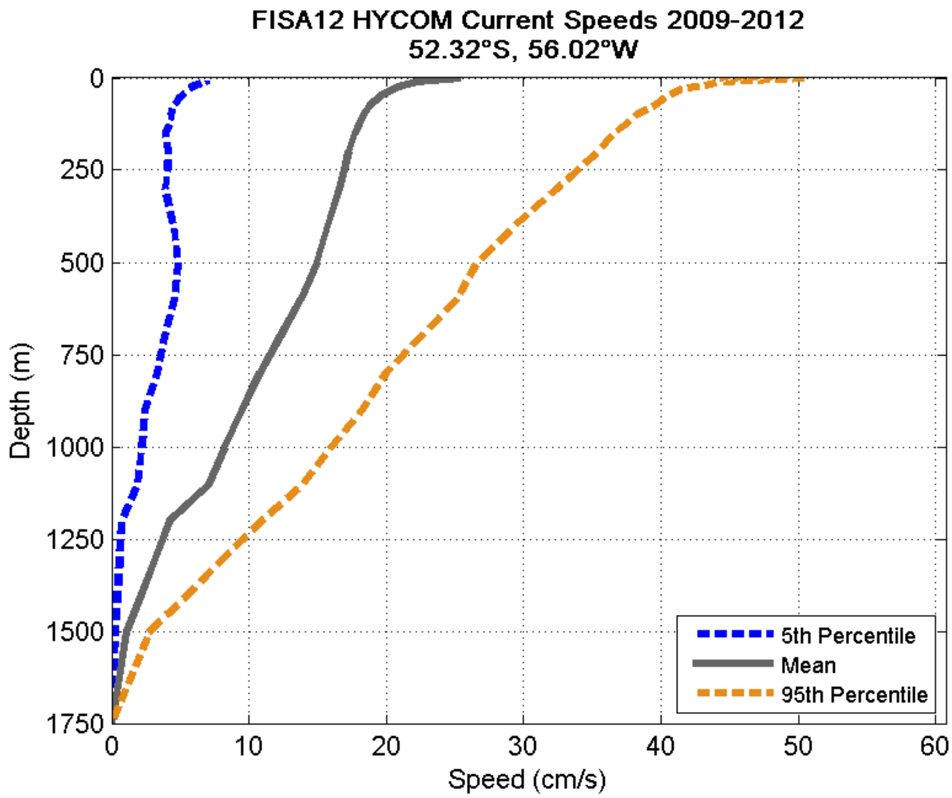


Figure 16. Annually-averaged HYCOM current speed statistics with depth for FISA12.

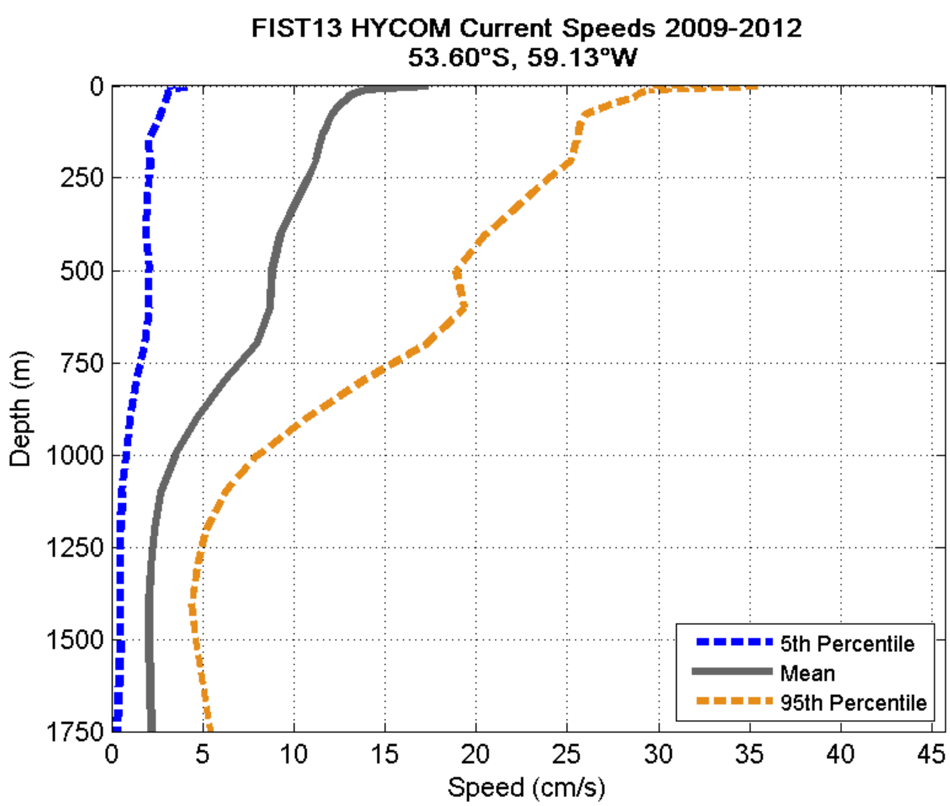


Figure 17. Annually-averaged HYCOM current speed statistics with depth for FIST13.

2.3. Water Column Vertical Structure

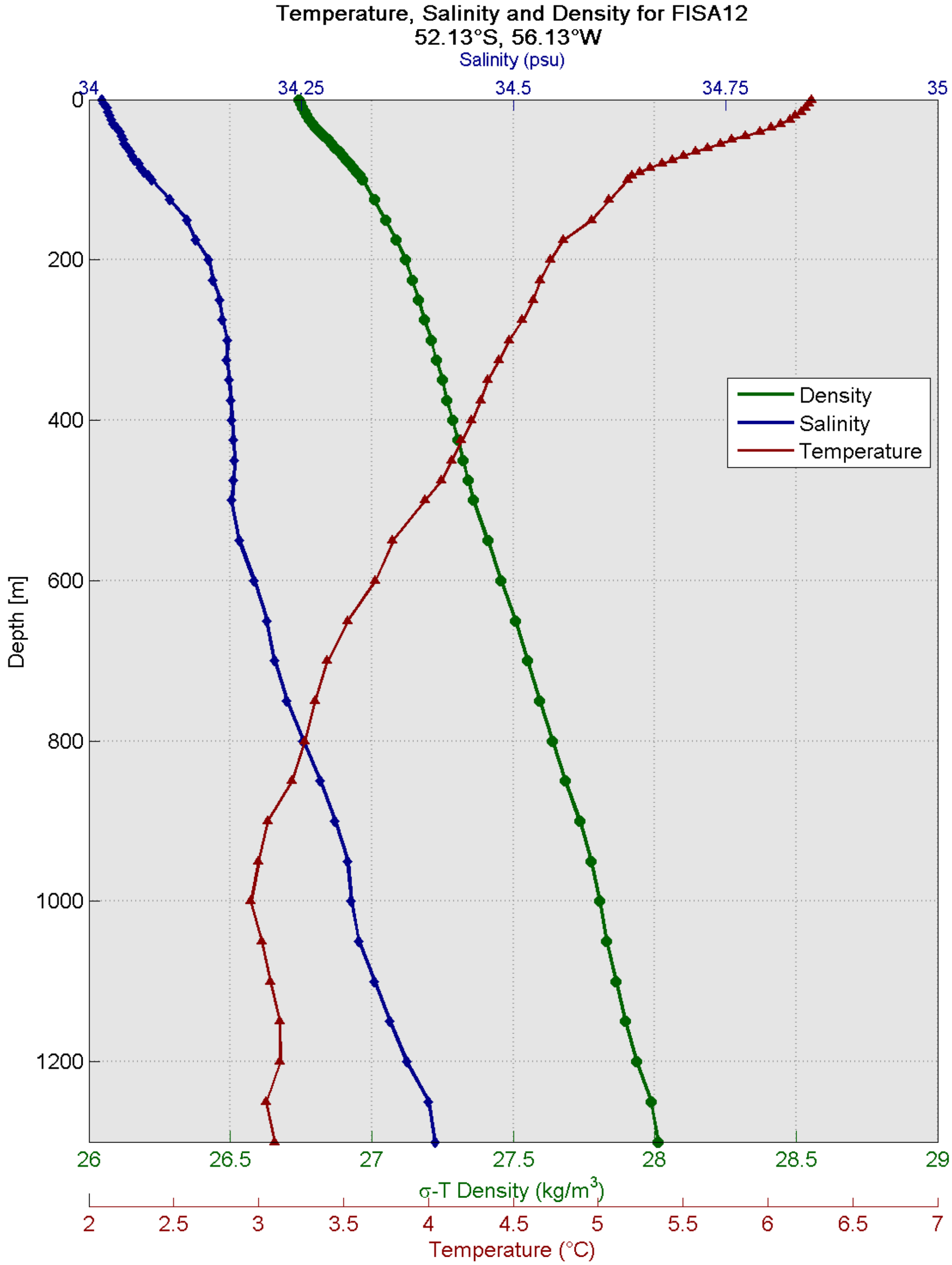


Figure 18. Annually-averaged temperature, salinity, and density vertical profiles for FISA12.

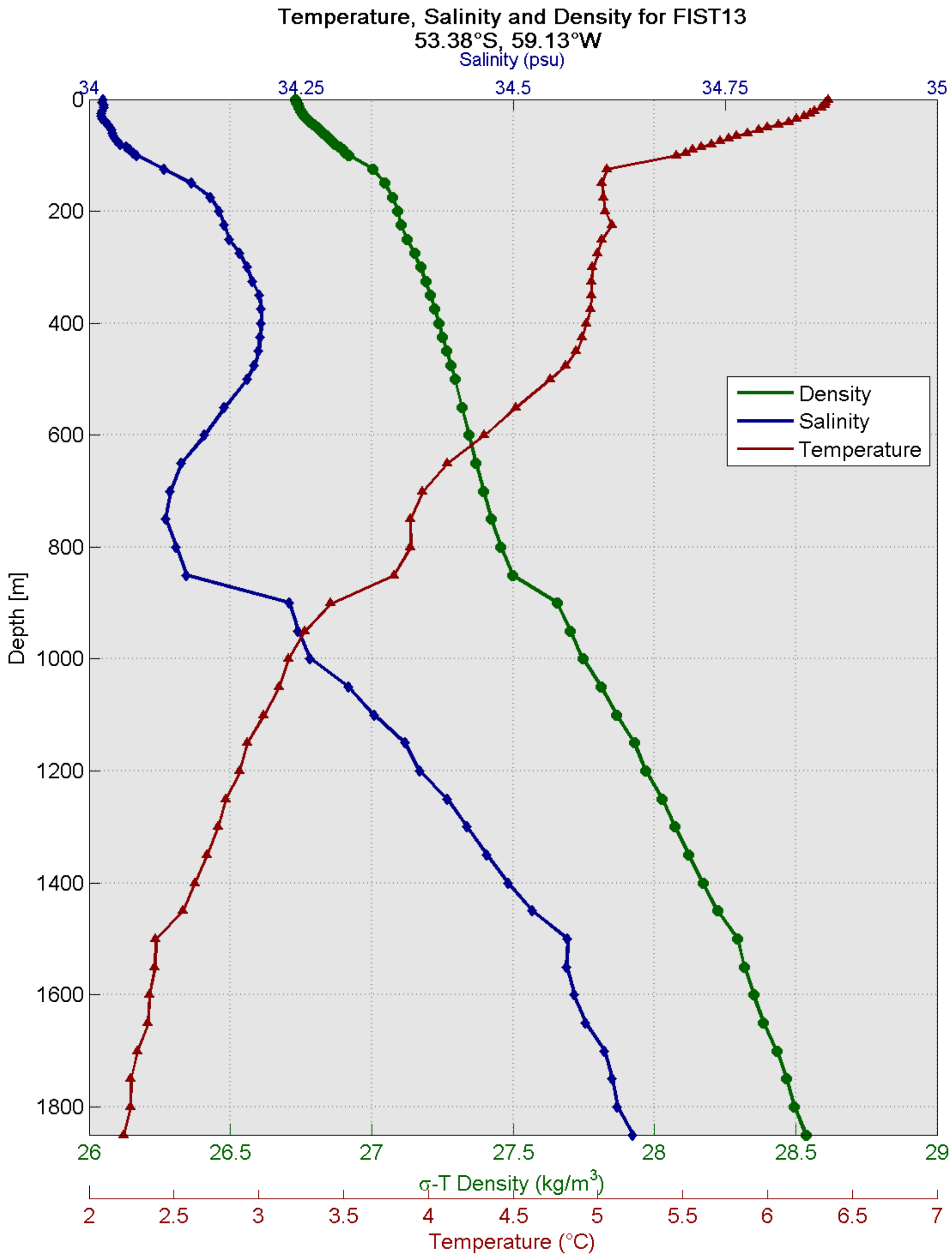


Figure 19. Annually-averaged temperature, salinity, and density vertical profiles for FIST13.

3. Oil Spill Simulations – Preliminary Results

3.1. Modelling Inputs

Table 2. Summary of oil properties used in the simulations.

Oil Type	API Gravity (°)	Viscosity (cP at 25°C)	Interface Tension (dyne/cm)	Emulsion maximum Water Content (%)
Light Crude	38.9	4.00	26.1	89.6
Diesel	38.8	2.76	27.5	0

Table 3. Blowout conditions used in the subsurface simulation.

Site	Water Depth of the release (m)	Gas to Oil Ratio (e.g. scf/bbl)	Opening Diameter (e.g. inches)	Discharge Temperature (°C)
FISA12	1,177	600 scf/bbl	13.375”	104
FIST13	1,527	600 scf/bbl	13.375”	104

Table 4. Simulation periods used.

Period	Months to Use
Period 1: Austral Summer	October - February
Period 2: Austral Winter	March - September

Table 5. Parameters of the oil spill scenarios.

ID	Spill Site	Spill Event	Oil Type	Period	Spill Rate	Spill Duration	Total Spilled Volume	Simulation Duration
Stochastic Scenarios								
1	FISA12	Drilling Rig Fuel Oil Inventory	Diesel	Period 1 (10-2)	Instant	Instant	4,631 m^3	14 Days
2	FISA12	Drilling Rig Fuel Oil Inventory	Diesel	Period 2 (3-9)	Instant	Instant	4,631 m^3	14 Days
3	FIST13	Drilling Rig Fuel Oil Inventory	Diesel	Period 1 (10-2)	Instant	Instant	4,631 m^3	14 Days
4	FIST13	Drilling Rig Fuel Oil Inventory	Diesel	Period 2 (3-9)	Instant	Instant	4,631 m^3	14 Days
5	FISA12	Surface Blowout	Crude Oil	Period 1 (10-2)	50,071 bbl/d	10 days	500,710 bbl	30 Days
6	FISA12	Surface Blowout	Crude Oil	Period 2 (3-9)	50,071 bbl/d	10 days	500,710 bbl	30 Days
7	FIST13	Surface Blowout	Crude Oil	Period 1 (10-2)	50,071 bbl/d	10 days	500,710 bbl	30 Days
8	FIST13	Surface Blowout	Crude Oil	Period 2 (3-9)	50,071 bbl/d	10 days	500,710 bbl	30 Days
9	FISA12	Subsurface Blowout	Crude Oil	Period 2 (3-9)	50,071 bbl/d	10 days	500,710 bbl	30 Days
10	FIST13	Subsurface Blowout	Crude Oil	Period 2 (3-9)	50,071 bbl/d	10 days	500,710 bbl	30 Days
Deterministic Scenarios (Worst Cases from Stochastic)								
5	FISA12	Surface Blowout (worst case: shortest time from stochastic)	Crude Oil	Period 1 (10-2)	50,071 bbl/d	10 days	500,710 bbl	30 Days
6	FISA12	Surface Blowout (worst case: shortest time from stochastic)	Crude Oil	Period 2 (3-9)	50,071 bbl/d	10 days	500,710 bbl	30 Days
7	FIST13	Surface Blowout (worst case: shortest time from stochastic)	Crude Oil	Period 1 (10-2)	50,071 bbl/d	10 days	500,710 bbl	30 Days
8	FIST13	Surface Blowout (worst case: shortest time from stochastic)	Crude Oil	Period 2 (3-9)	50,071 bbl/d	10 days	500,710 bbl	30 Days

3.2. Blowout Near-Field Modelling Results

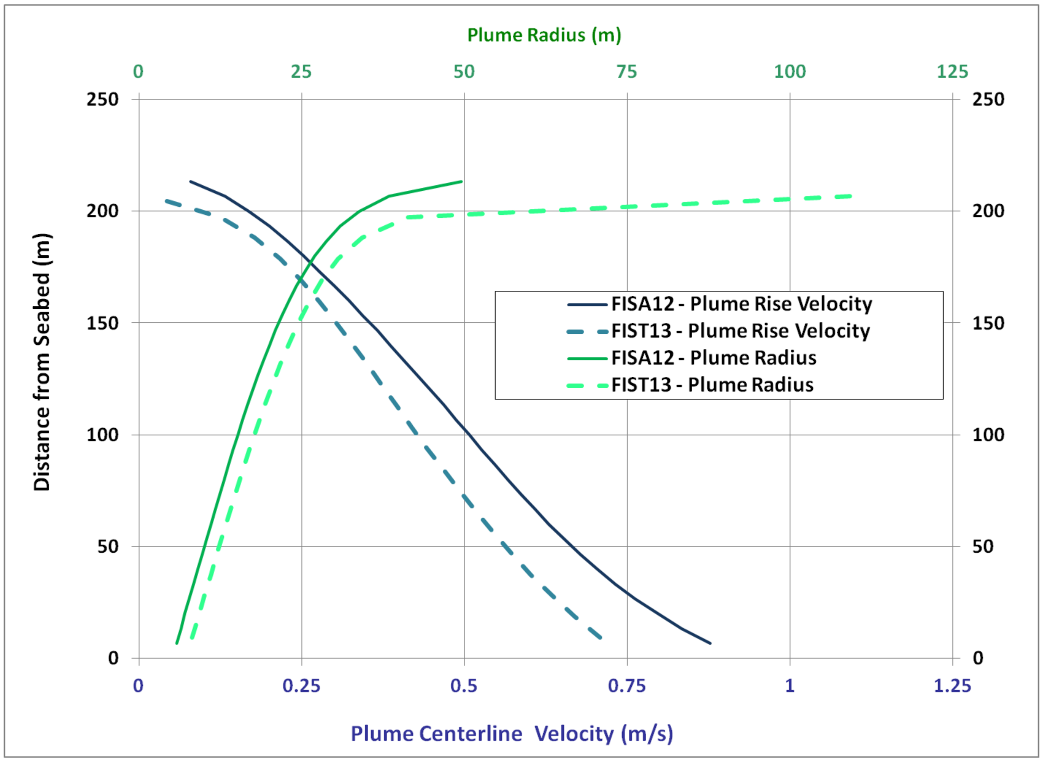


Figure 20. Predicted plume radius and plume centreline velocity for the subsurface blowout events.

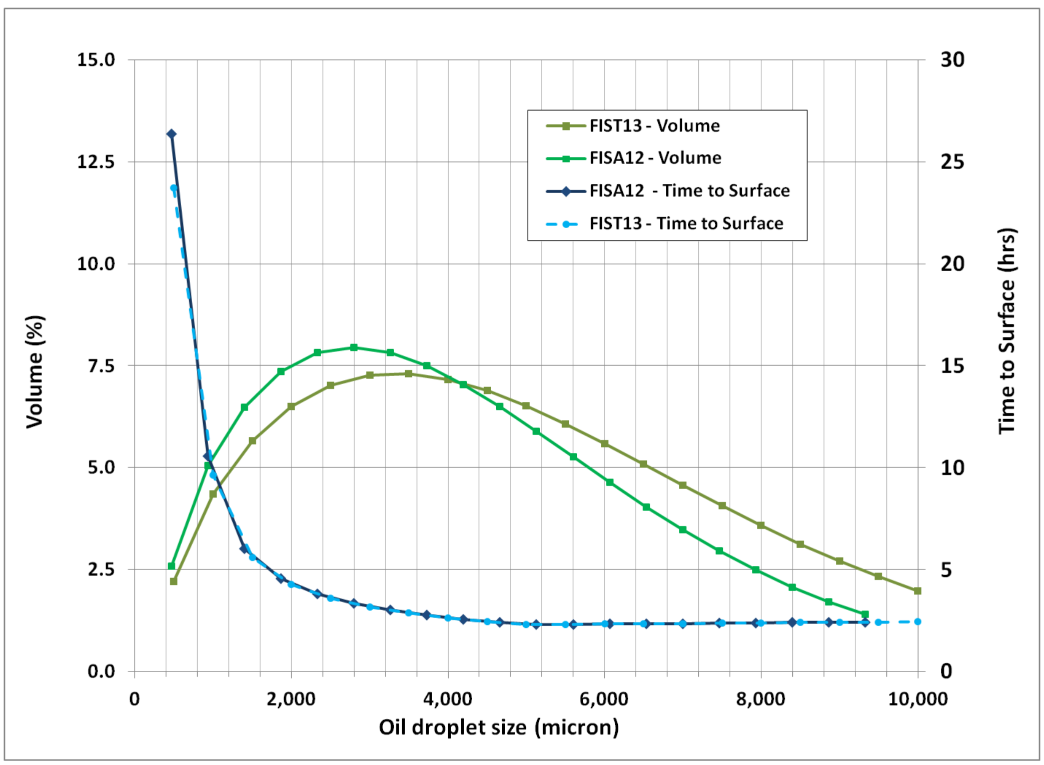


Figure 21. Predicted droplet size distribution and droplet rise time for the subsurface blowout events.

3.3. Stochastic Modelling Results

Table 6. Oil Spill Stochastic results – Predicted shoreline impacts.

Spill Site	Oil Type	Spill Type	Simulation Period	Total Volume Released	Sims. Reaching Shore (%)	Time to Reach Shore (days)	
						Min.	Avg.
FISA12	Diesel	Drilling Rig Fuel Oil Inventory	Period 1 (10-2)	4,631 m^3	0	-	-
FISA12	Diesel	Drilling Rig Fuel Oil Inventory	Period 2 (3-9)	4,631 m^3	0	-	-
FIST13	Diesel	Drilling Rig Fuel Oil Inventory	Period 1 (10-2)	4,631 m^3	0	-	-
FIST13	Diesel	Drilling Rig Fuel Oil Inventory	Period 2 (3-9)	4,631 m^3	0	-	-
FISA12	Crude Oil	Surface Blowout	Period 1 (10-2)	500,710 bbl	0	-	-
FISA12	Crude Oil	Surface Blowout	Period 2 (3-9)	500,710 bbl	2	10.0	10.5
FIST13	Crude Oil	Surface Blowout	Period 1 (10-2)	500,710 bbl	13	1.7	16.3
FIST13	Crude Oil	Surface Blowout	Period 2 (3-9)	500,710 bbl	32	1.7	10.2
FISA12	Crude Oil	Subsurface Blowout	Period 2 (3-9)	500,710 bbl	2	11.0	12.0
FIST13	Crude Oil	Subsurface Blowout	Period 2 (3-9)	500,710 bbl	18	4.0	10.9

The following figures illustrate the spatial extent of surface and shoreline oiling probabilities and associated minimum travel times for the spills; only oiling above a threshold of 0.04 µm is included.

For each scenario, two figures are presented. For scenarios where there is a model-predicted potential for shoreline oiling, two additional figures are presented.

1. **Probability of surface oil exceeding 0.04 µm**: The map defines the area in which sea surface oil has at least a 1% chance to exceed 0.04 µm and the associated probability of exceeding the threshold based on analysis of the resulting trajectories from the ensemble of individual simulations run for each spill scenario. The map does not imply that the entire contoured area would be covered with oil in the event of a spill. The map also does not provide any information on the amount of oil in a given area.

2. **Minimum time for surface oil to exceed 0.04 µm**: The footprint on this map corresponds to the surface probability map, and illustrates the shortest time required for oil to reach any point within the footprint. These results are also based on the ensemble of all individual simulations.

3. **Probability of shoreline oil exceeding 0.04 µm**: The map defines the area in which beached oil has at least a 1% chance to exceed 0.04 µm and the associated probability of exceeding the threshold based on analysis of the resulting trajectories from the ensemble of individual simulations run for each spill scenario. The map does not imply that the entire area would be covered with oil in the event of a spill. The map also does not provide any information on the amount of oil in a given area. In the absence of data, all shoreline segments are assumed to be 10-m-wide sandy beaches. Using actual shoreline data may alter the results, but the results provided are likely on the conservative side for shoreline impacts.

4. **Minimum time for shoreline oil to exceed 0.04 µm**: The footprint on this map corresponds to the shoreline probability map, and illustrates the shortest time required for oil to reach any point within the footprint. These results are also based on the ensemble of all individual simulations. In the absence of data, all shoreline segments are assumed to be 10-m-wide sandy beaches. Using actual shoreline data may alter the results, but the results provided are likely on the conservative side for shoreline impacts.

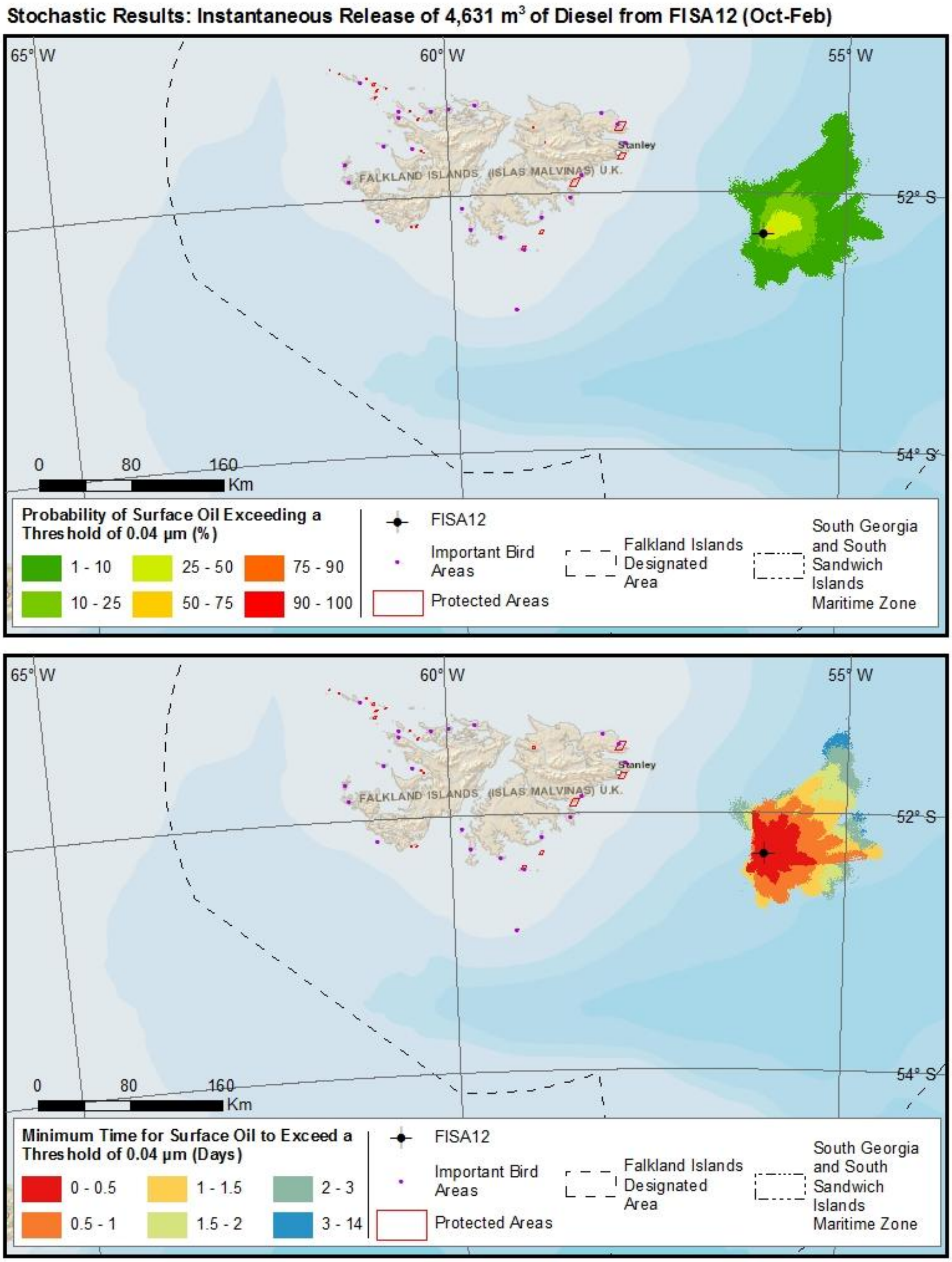


Figure 22. Scenario 1 stochastic maps for potential water surface contamination.

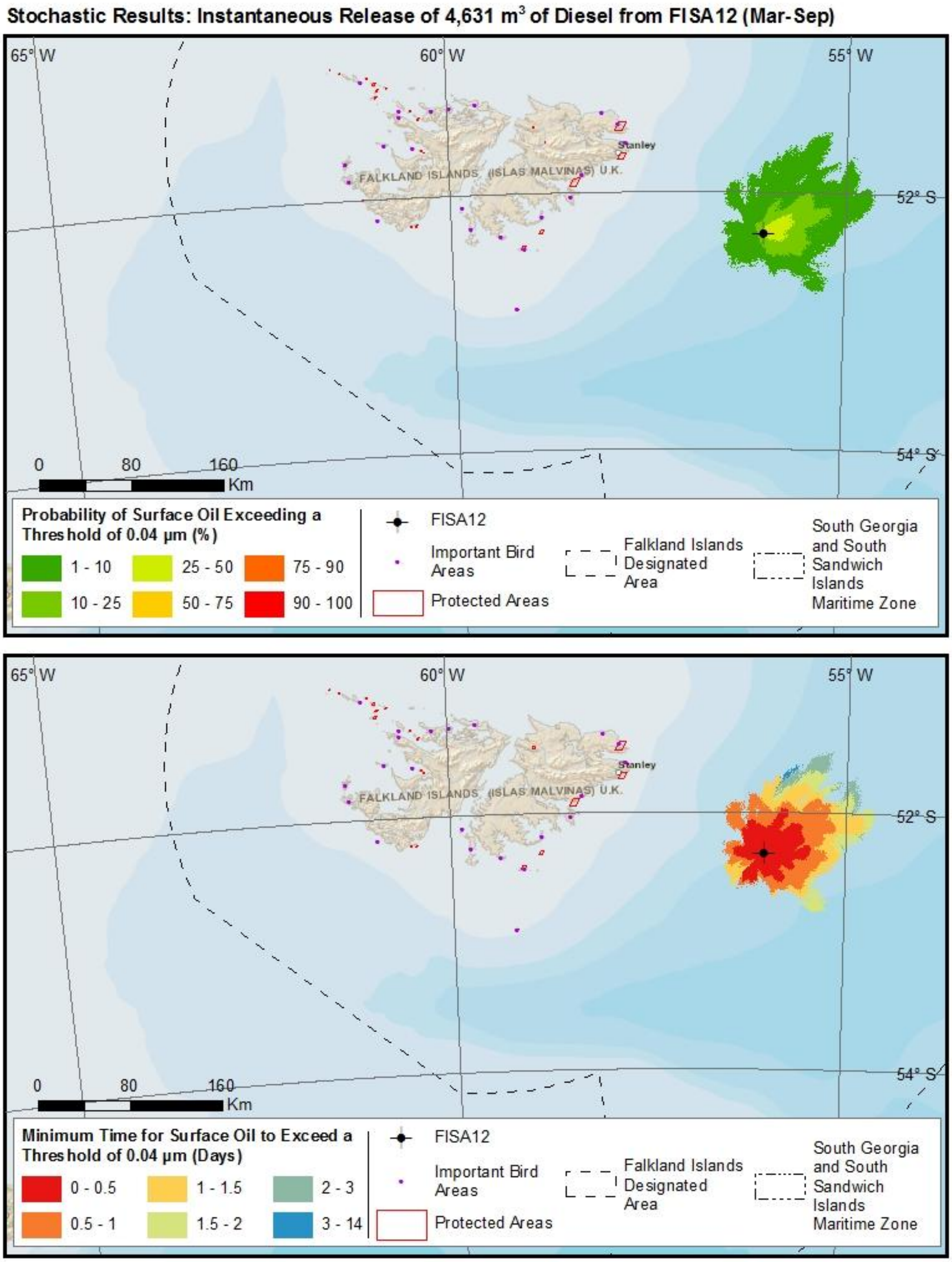


Figure 23. Scenario 2 stochastic maps for potential water surface contamination.

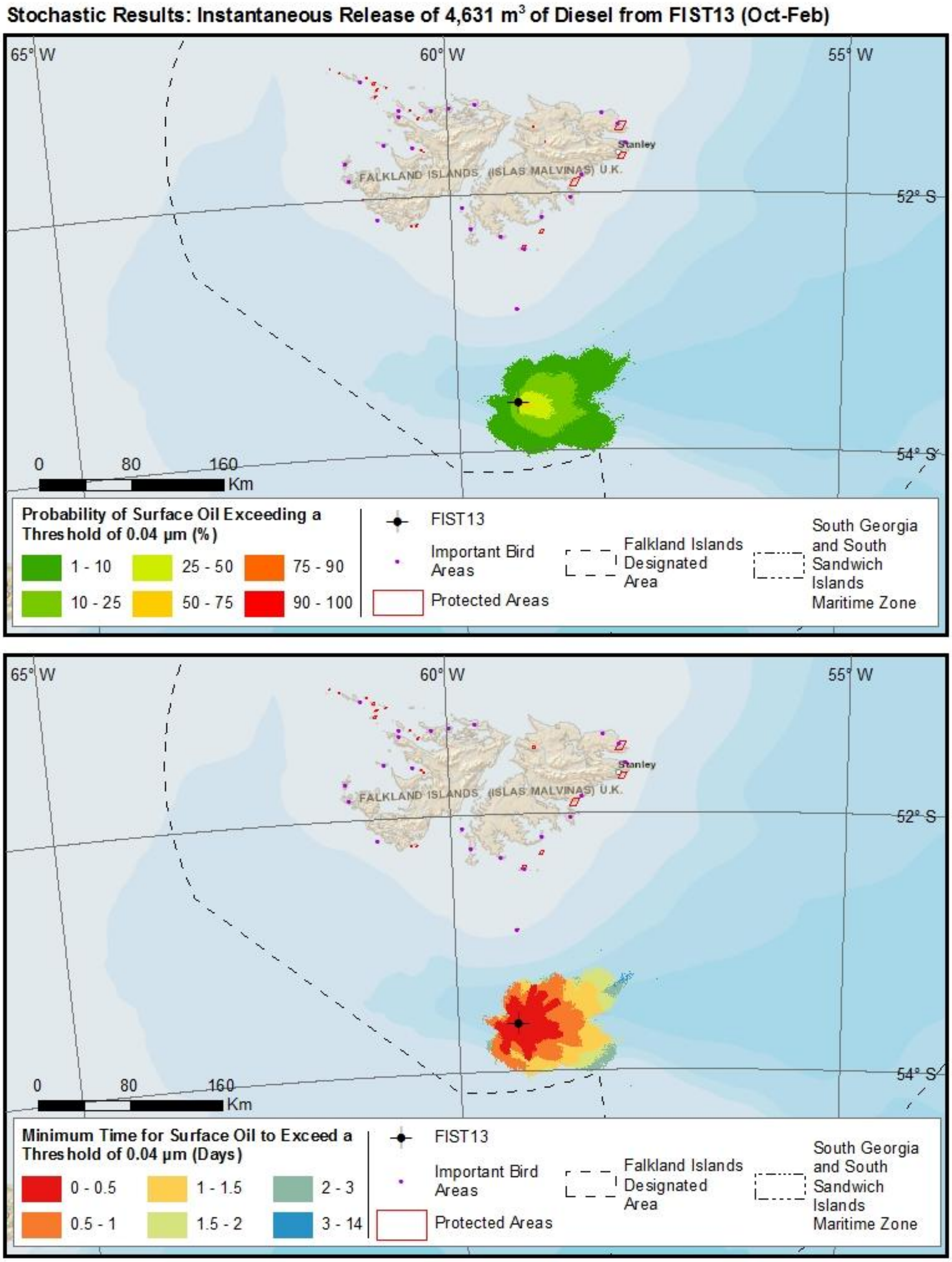


Figure 24. Scenario 3 stochastic maps for potential water surface contamination.

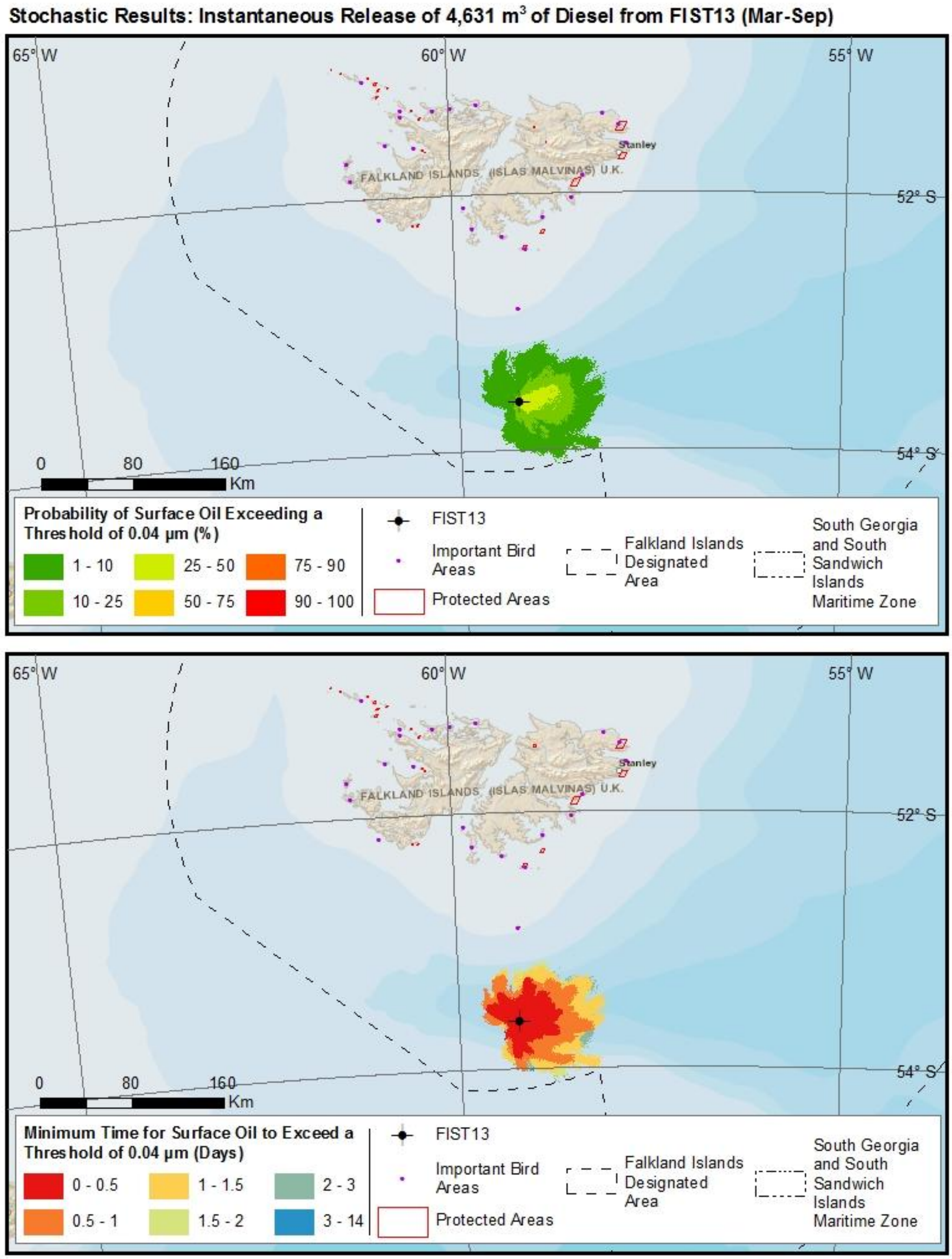


Figure 25. Scenario 4 stochastic maps for potential water surface contamination.

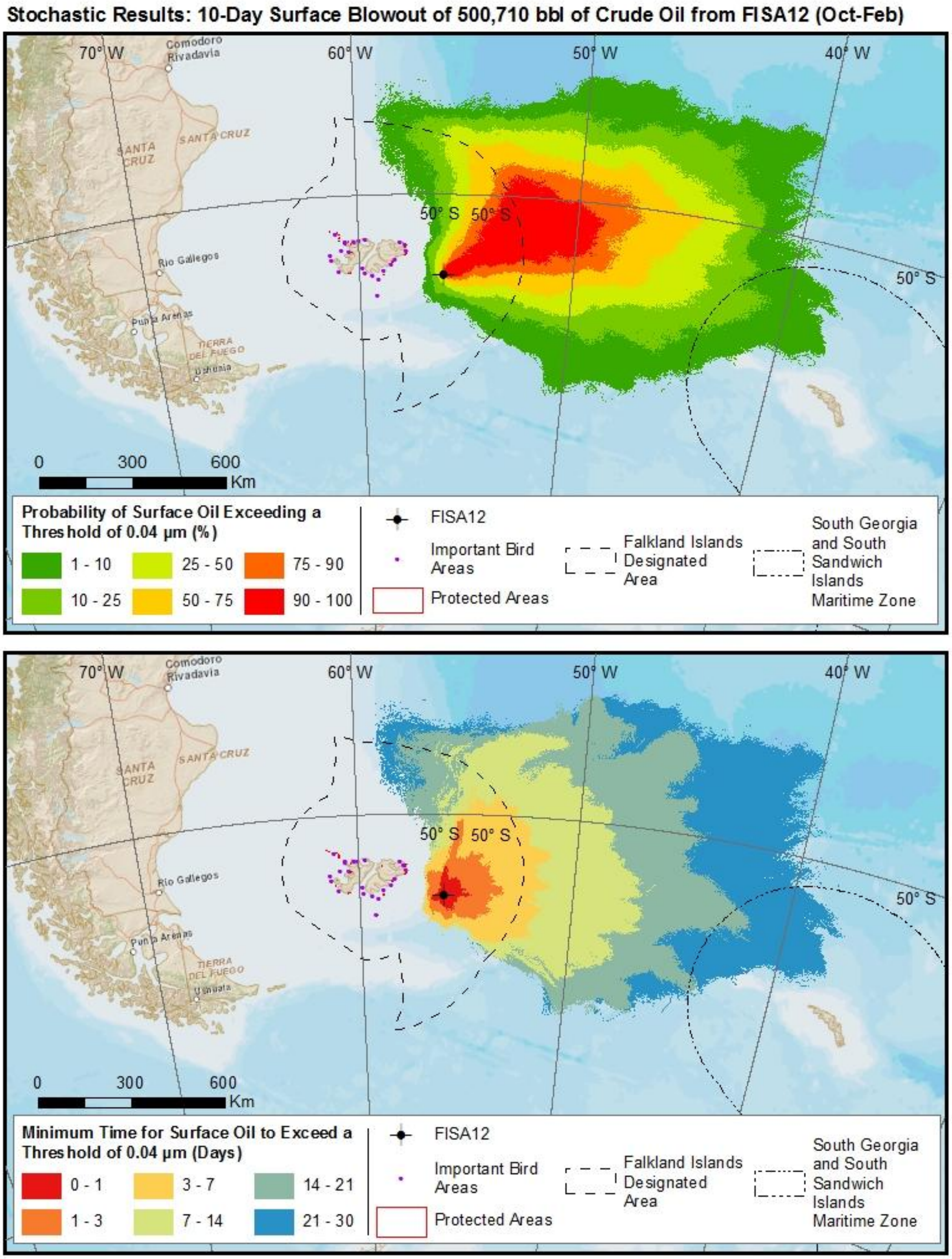


Figure 26. Scenario 5 stochastic maps for potential water surface contamination.

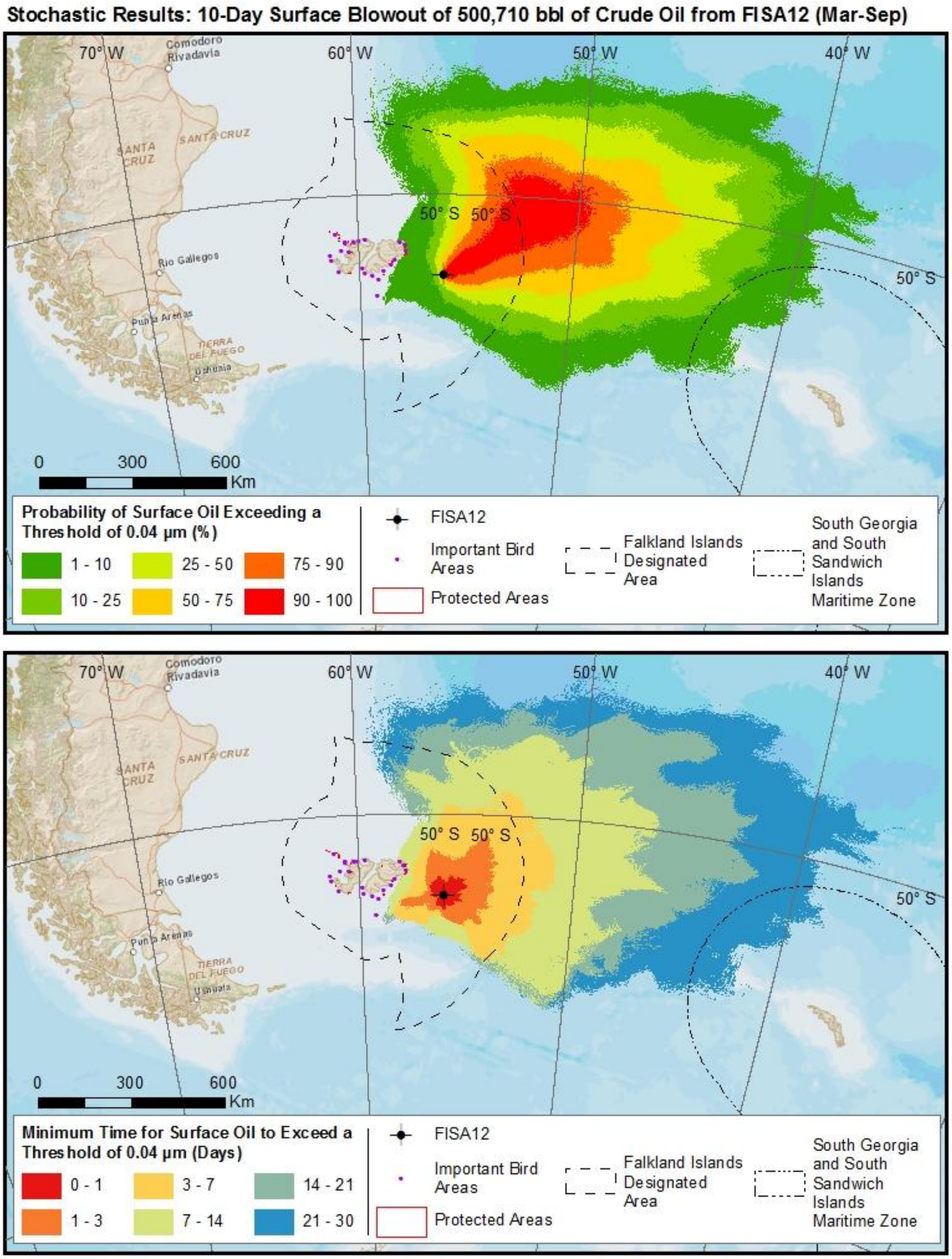


Figure 27. Scenario 6 stochastic maps for potential water surface contamination.

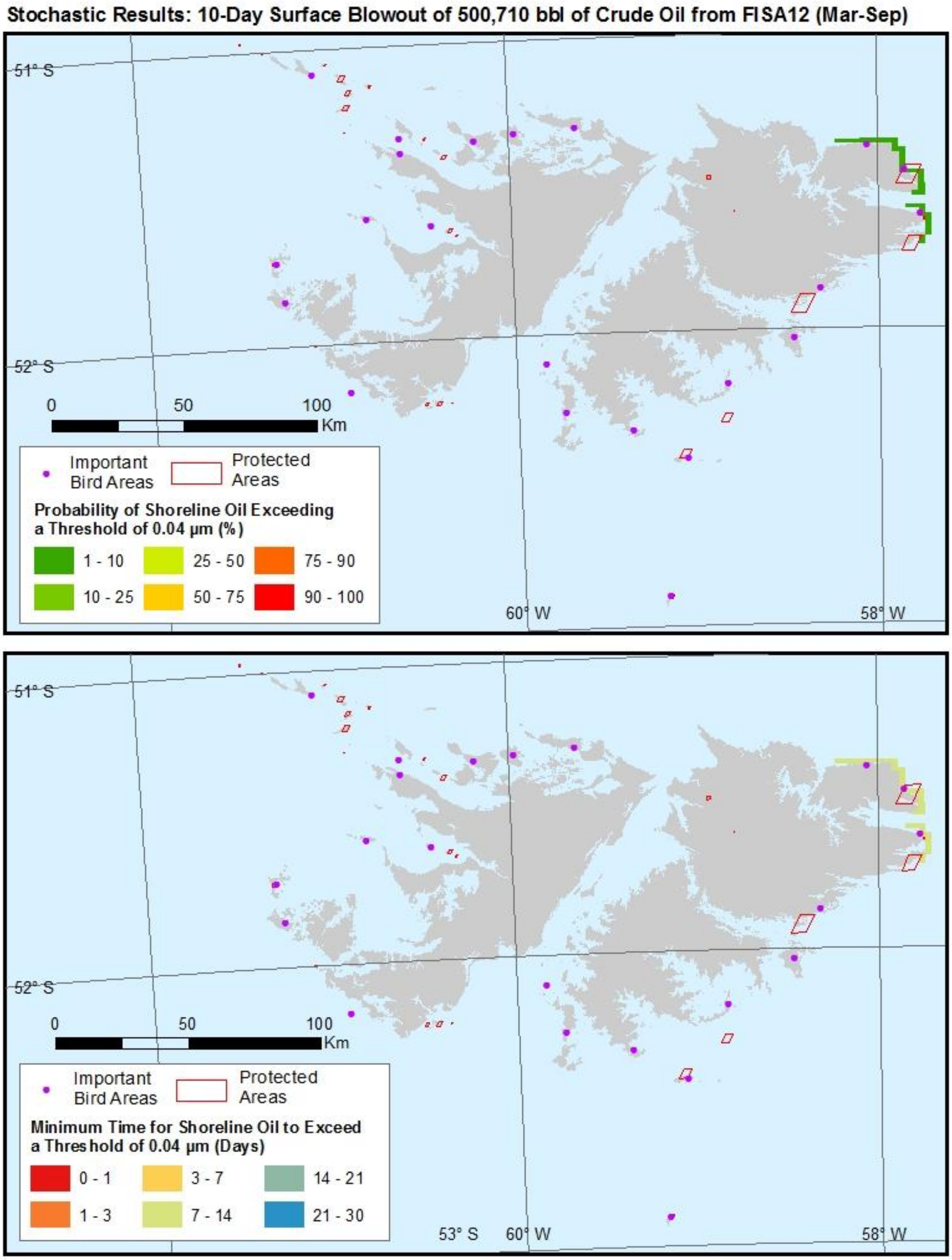


Figure 28. Scenario 6 stochastic maps for potential shoreline contamination.

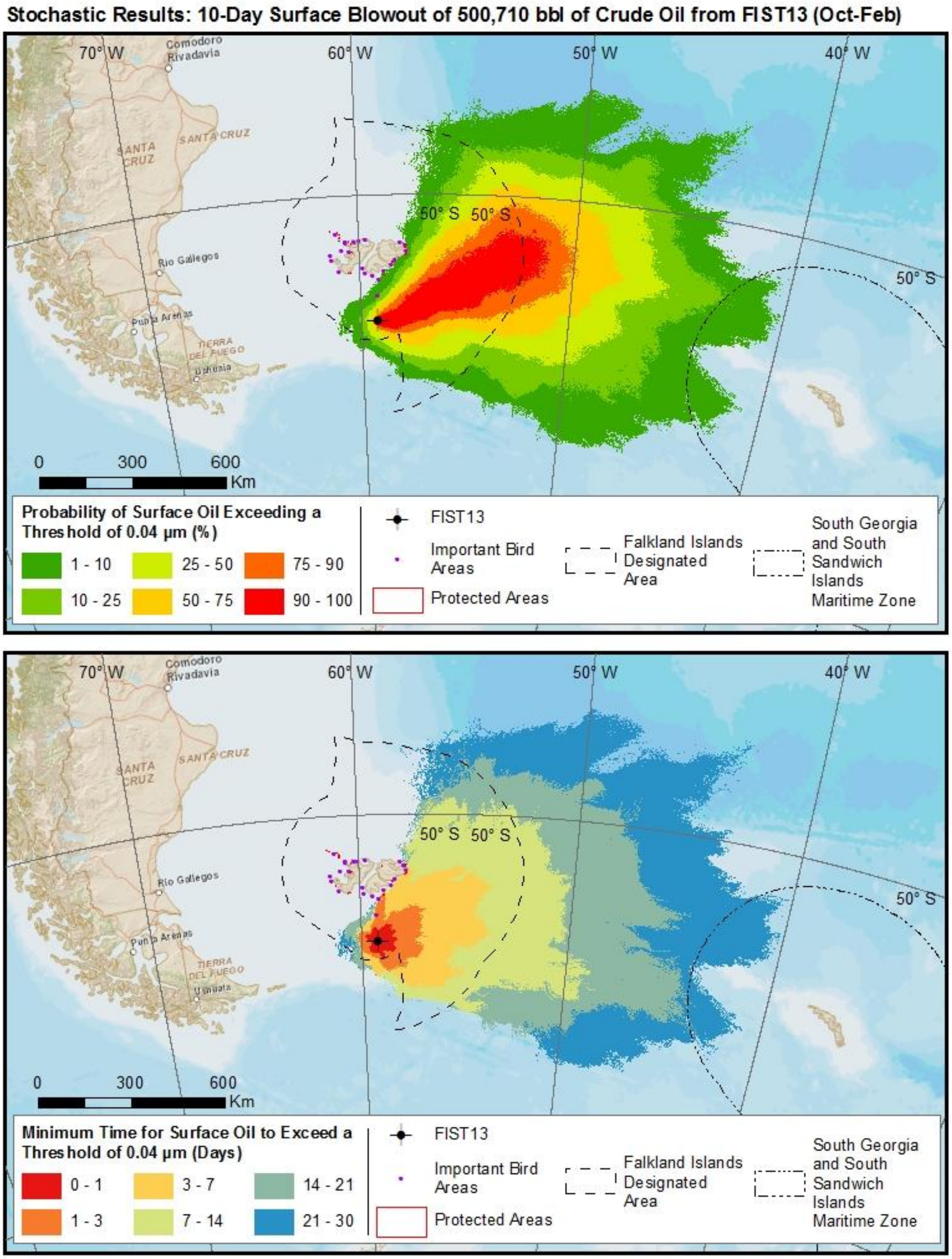


Figure 29. Scenario 7 stochastic maps for potential water surface contamination.

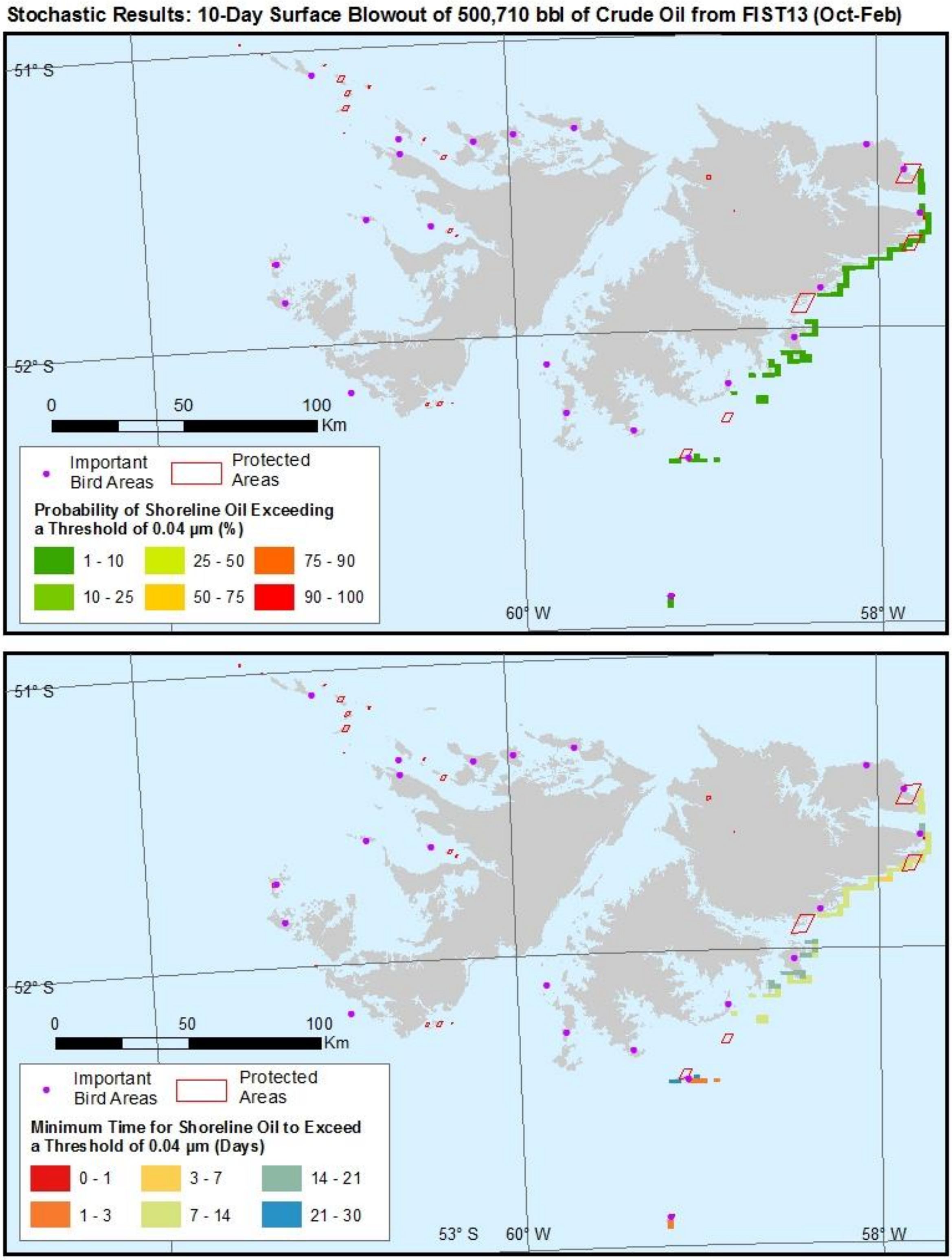


Figure 30. Scenario 7 stochastic maps for potential shoreline contamination.

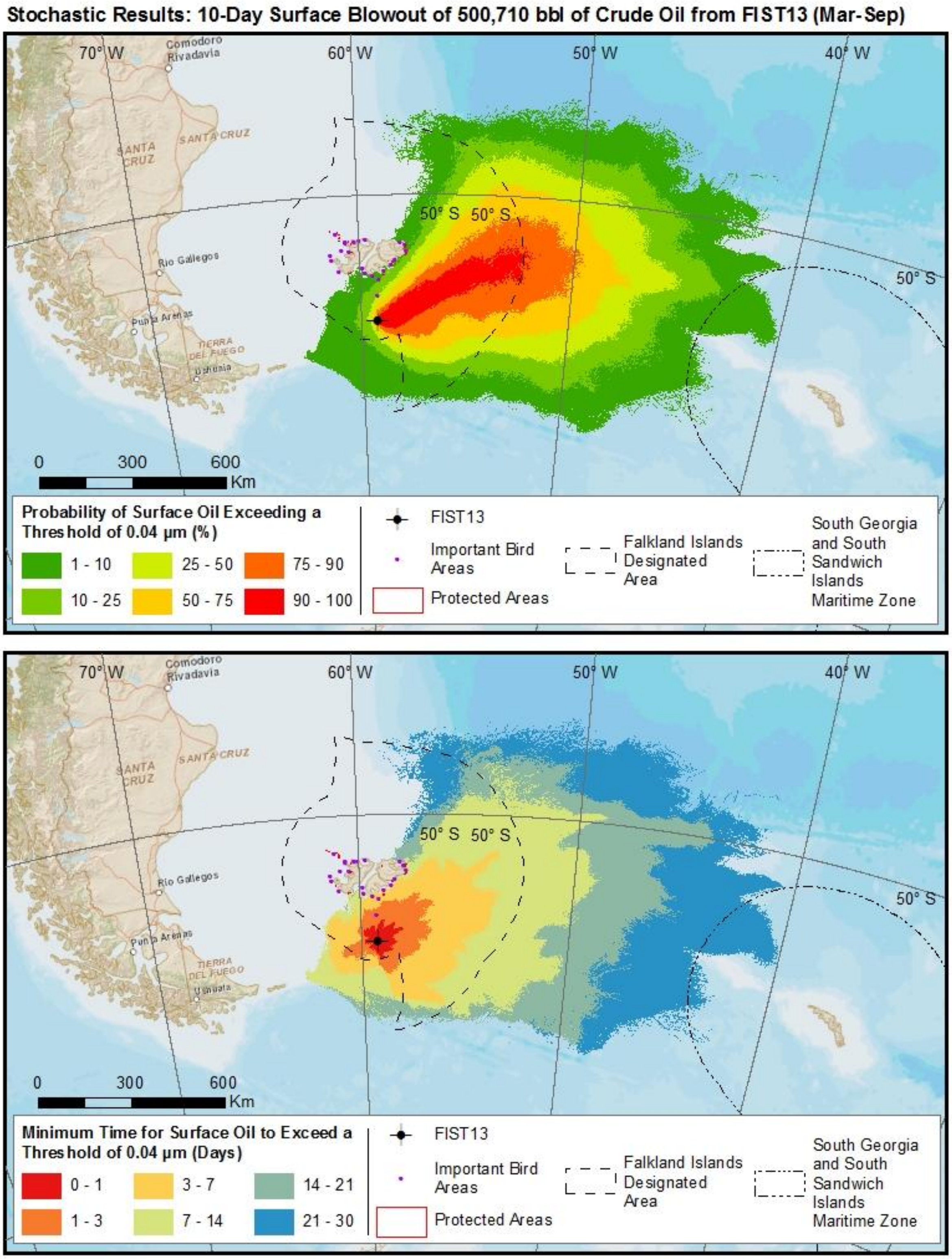


Figure 31. Scenario 8 stochastic maps for potential water surface contamination.

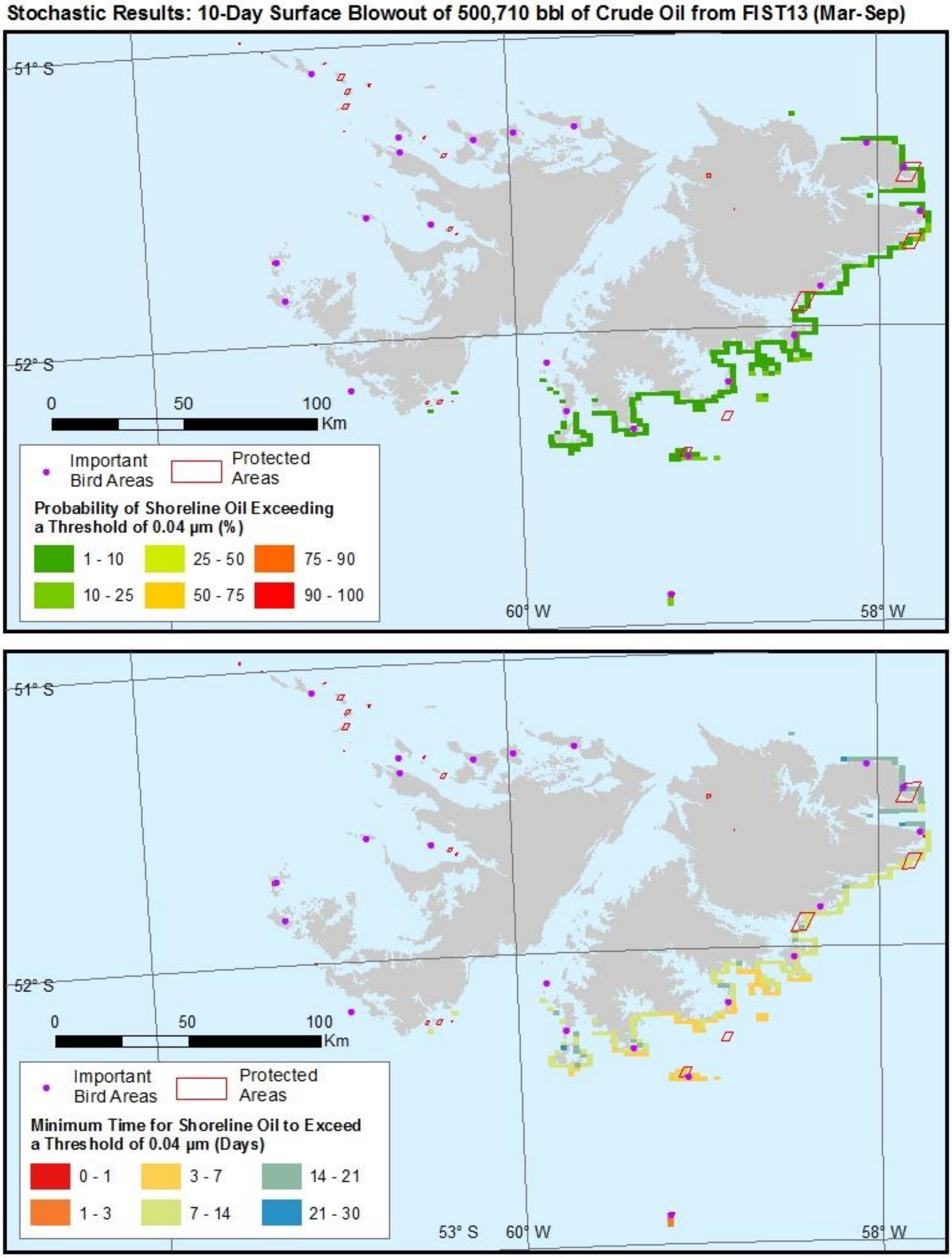


Figure 32. Scenario 8 stochastic maps for potential shoreline contamination.

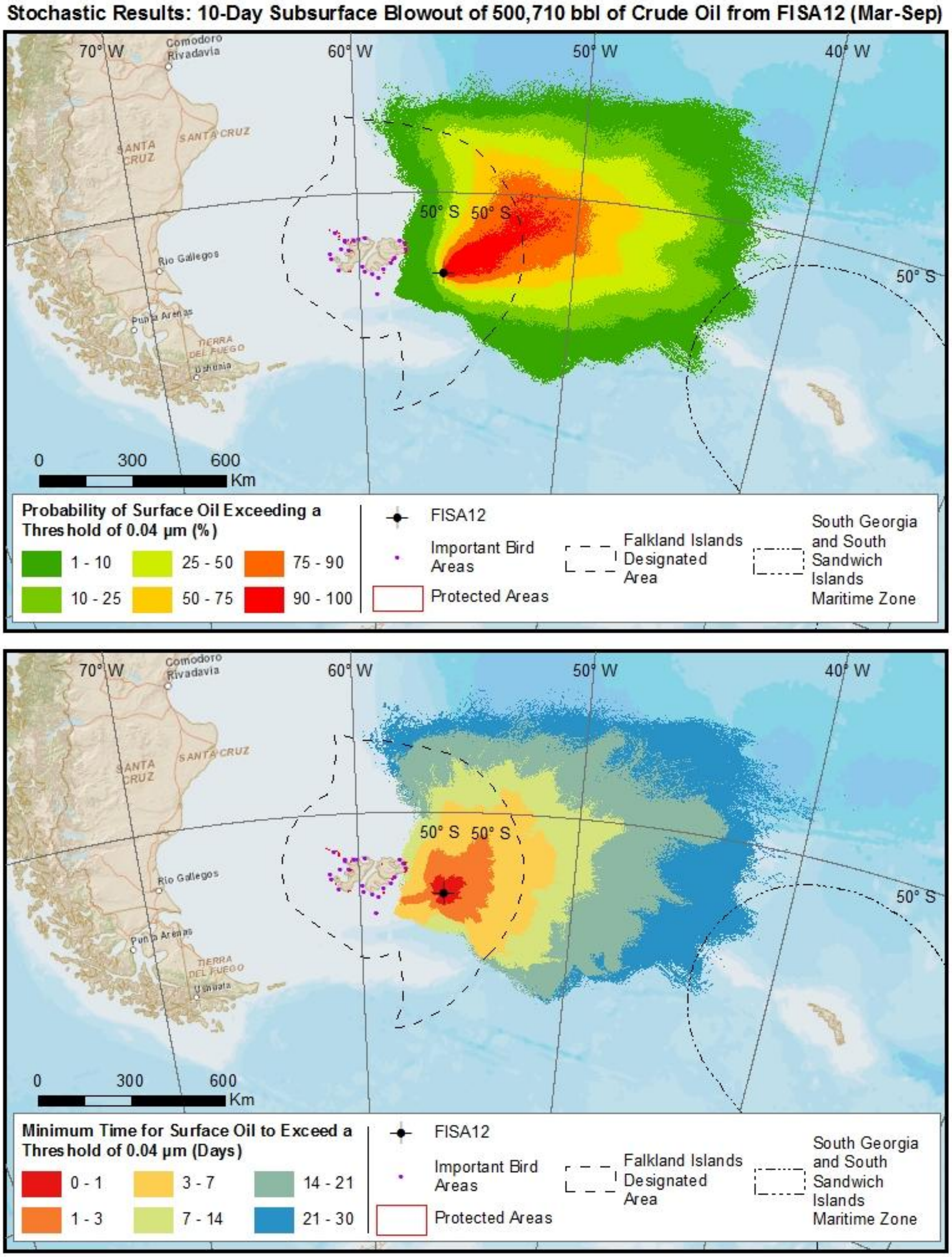


Figure 33. Scenario 9 stochastic maps for potential water surface contamination.

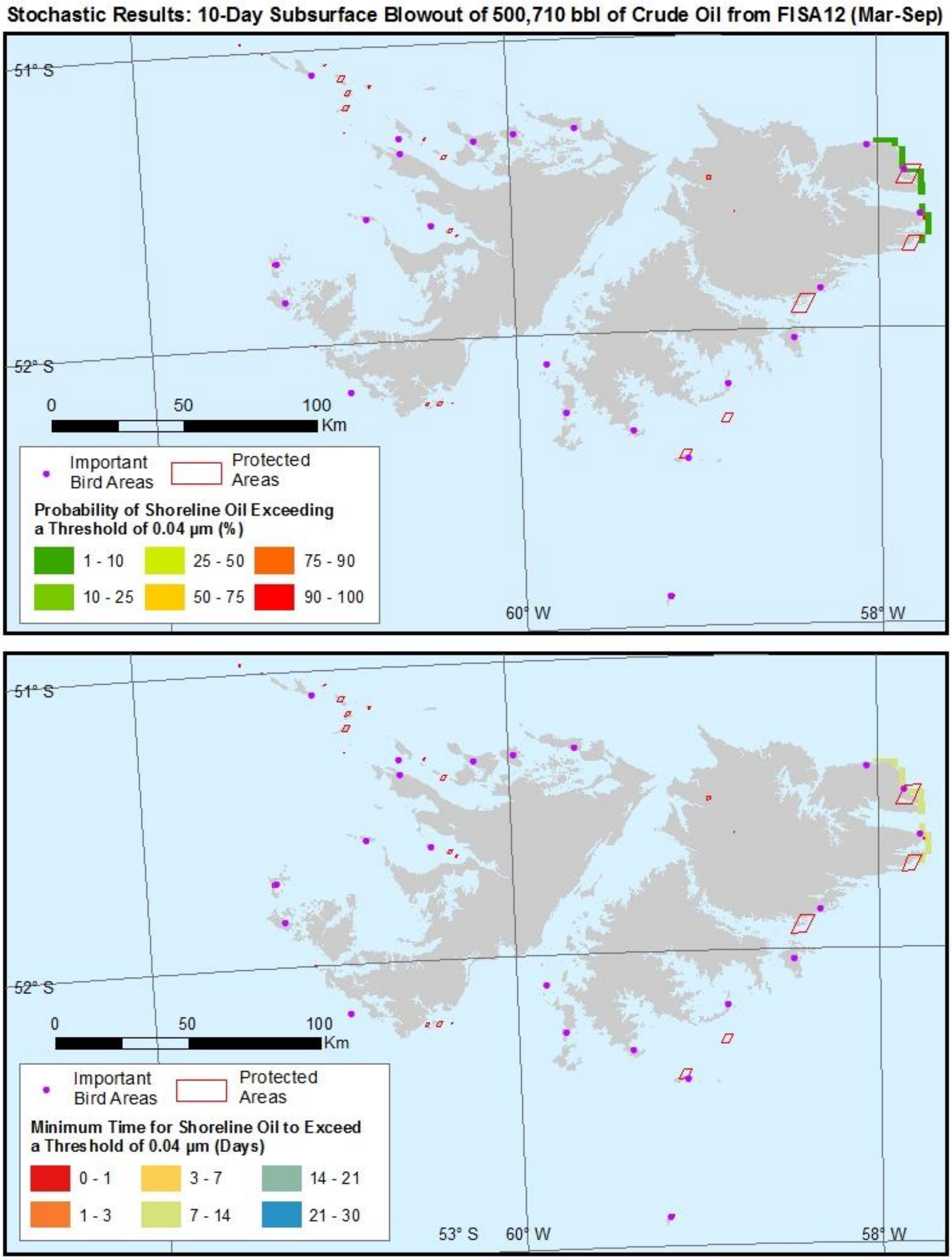


Figure 34. Scenario 9 stochastic maps for potential shoreline contamination.

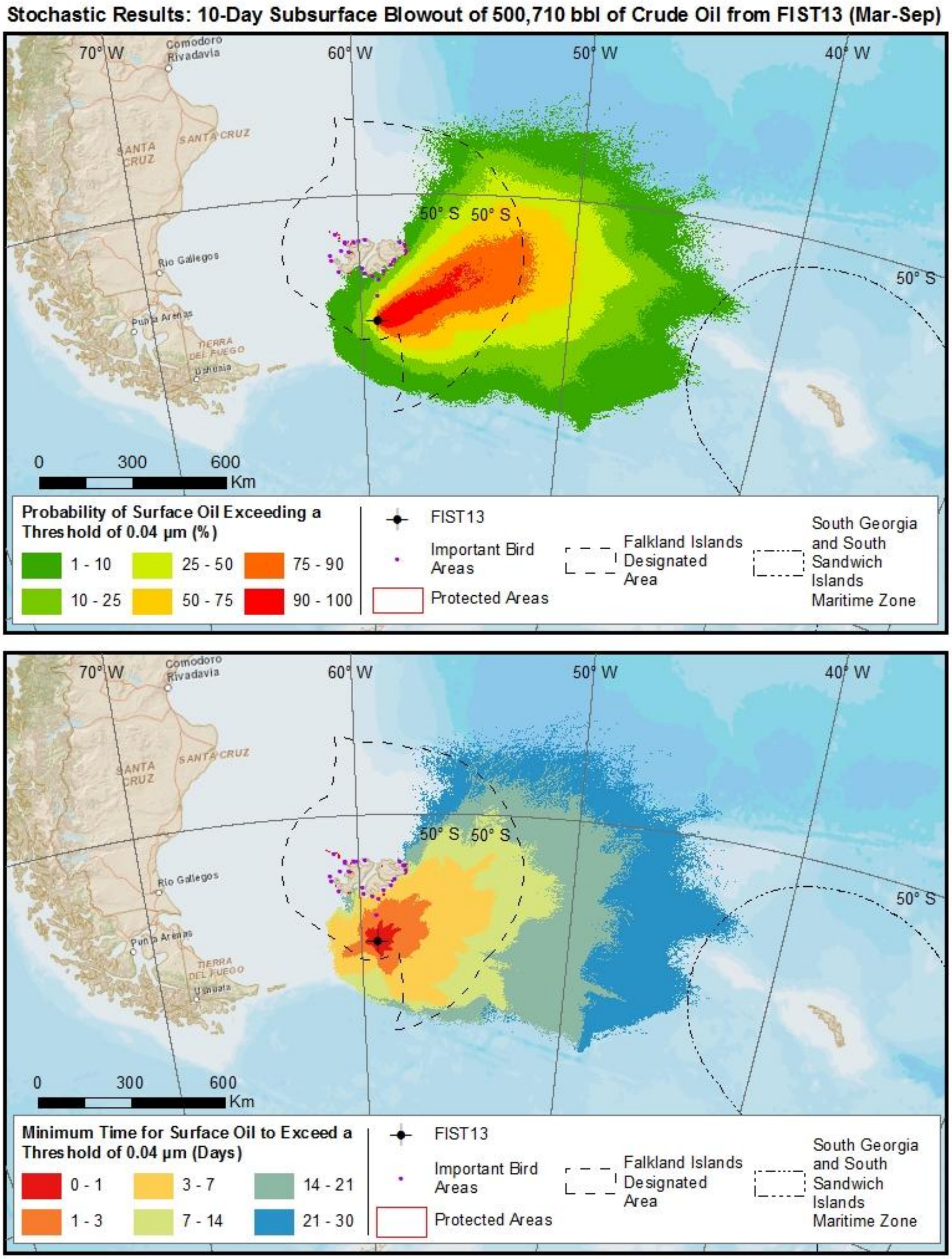


Figure 35. Scenario 10 stochastic maps for potential water surface contamination.

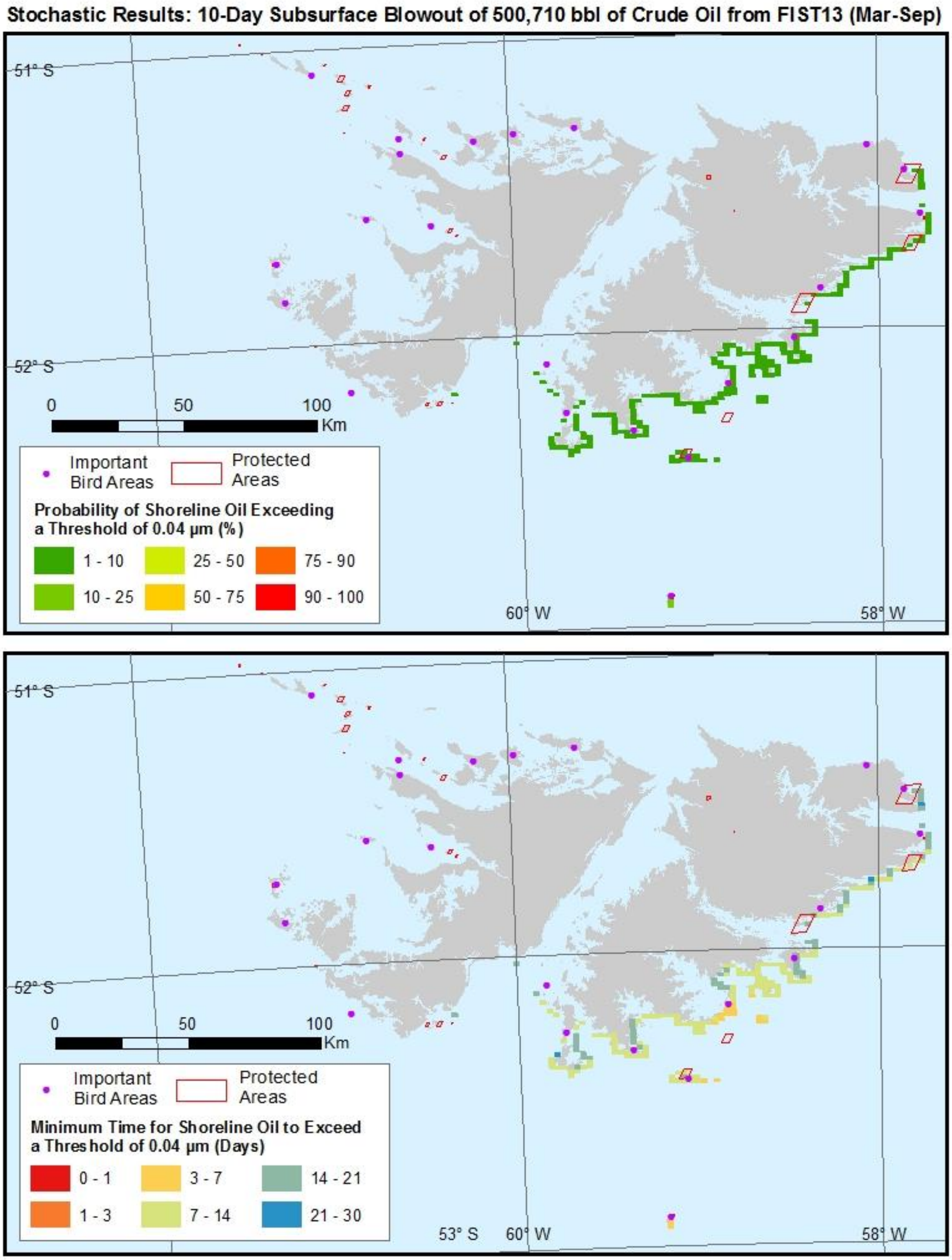


Figure 36. Scenario 10 stochastic maps for potential shoreline contamination.

3.4. Deterministic Modelling Results

For each stochastic surface blowout scenario where there was any shoreline impact, a worst case scenario was selected based on the time it took for oil to arrive at the shore. From each of these stochastic scenarios, the individual trajectory that impacted the coast in the shortest time was chosen for the deterministic modelling scenario. This criterion was chosen to represent the worst case because it would require the quickest response efforts. For the surface blowout scenario where no shoreline oiling was predicted, the trajectory that came closest to impacting the Falkland Islands was chosen as a representative case.

All trajectory/fate simulations were run using the same variable winds and current forcing used for the corresponding stochastic simulation from which it was identified.

Table 7. Selected worst case deterministic runs for each spill scenario.

ID	Spill Site	Oil Type	Spill Type	Total Spilled Volume (bbl)	Selected Deterministic Case	Run Type
5	FISA12	Crude Oil	Surface Blowout	500,710	2/21/2011	Representative
6	FISA12	Crude Oil	Surface Blowout	500,710	8/12/2009	Worst Case
7	FIST13	Crude Oil	Surface Blowout	500,710	2/13/2010	Worst Case
8	FIST13	Crude Oil	Surface Blowout	500,710	3/13/2010	Worst Case

Table 8. Predicted shoreline contamination information for the selected deterministic runs.

ID	Spill Site	Oil Type	Spill Type	Total Spilled Volume (bbl)	Time To Shore (days)	Amount of oil Ashore (bbl)	
						Peak	End
5	FISA12	Crude Oil	Surface Blowout	500,710	-	-	-
6	FISA12	Crude Oil	Surface Blowout	500,710	10	9,646	8,012
7	FIST13	Crude Oil	Surface Blowout	500,710	1.6	2,309	1,803
8	FIST13	Crude Oil	Surface Blowout	500,710	1.7	506	309

The following figures are presented for the deterministic modelling results:

1. **Maximum mass of floating oil per unit area (~ oil slick thickness)**: The map depicts the maximum mass per unit area of oil on the water surface that passed by a given area at some point during the simulation.

2. **Maximum mass of shoreline oil per unit area (for trajectories that impacted the coast)**: The map depicts the maximum mass per unit area of oil that beached on a given area of the shoreline at some point during the simulation. In the absence of data, all shoreline segments are assumed to be 10-m-wide sandy beaches. Using actual shoreline data may alter the results, but the results provided are likely on the conservative side for shoreline impacts.

3. **Predicted mass balance**: The graph shows the model-predicted mass balance for the spilled oil. The mass balance graph shows the degree of weathering that the oil undergoes during the period of the simulation.

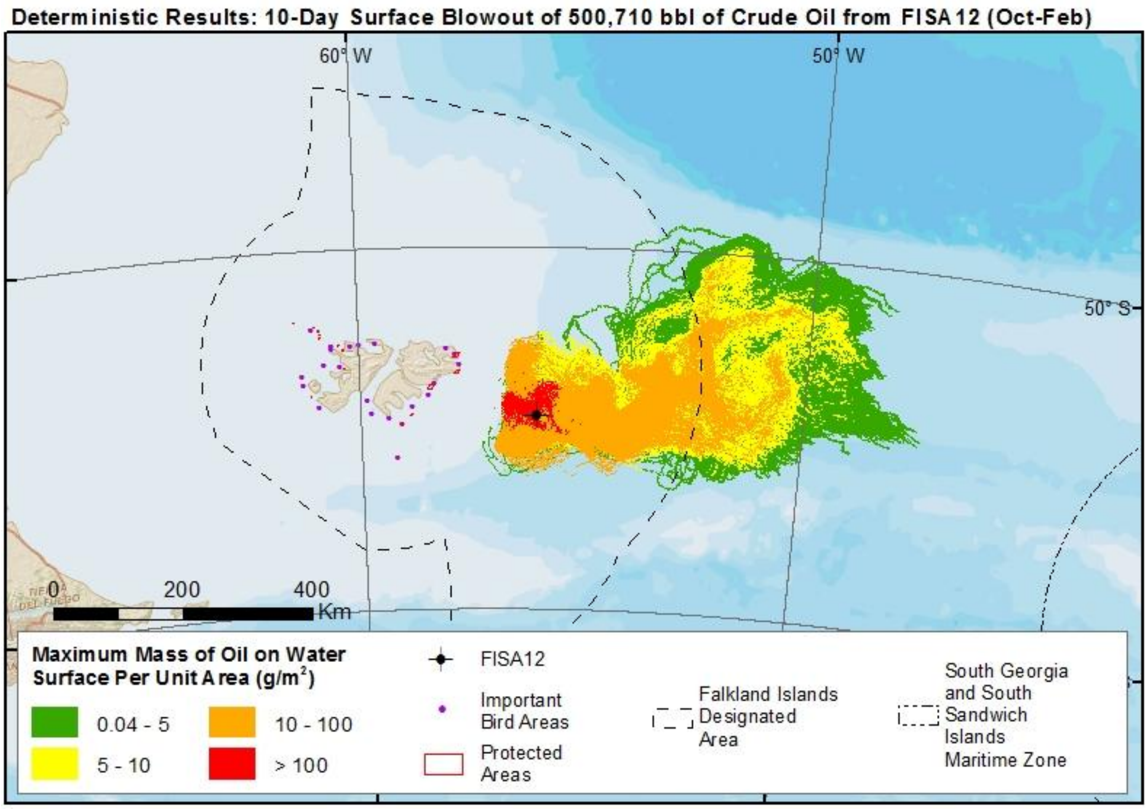


Figure 37. Scenario 5 deterministic map for potential water surface contamination.

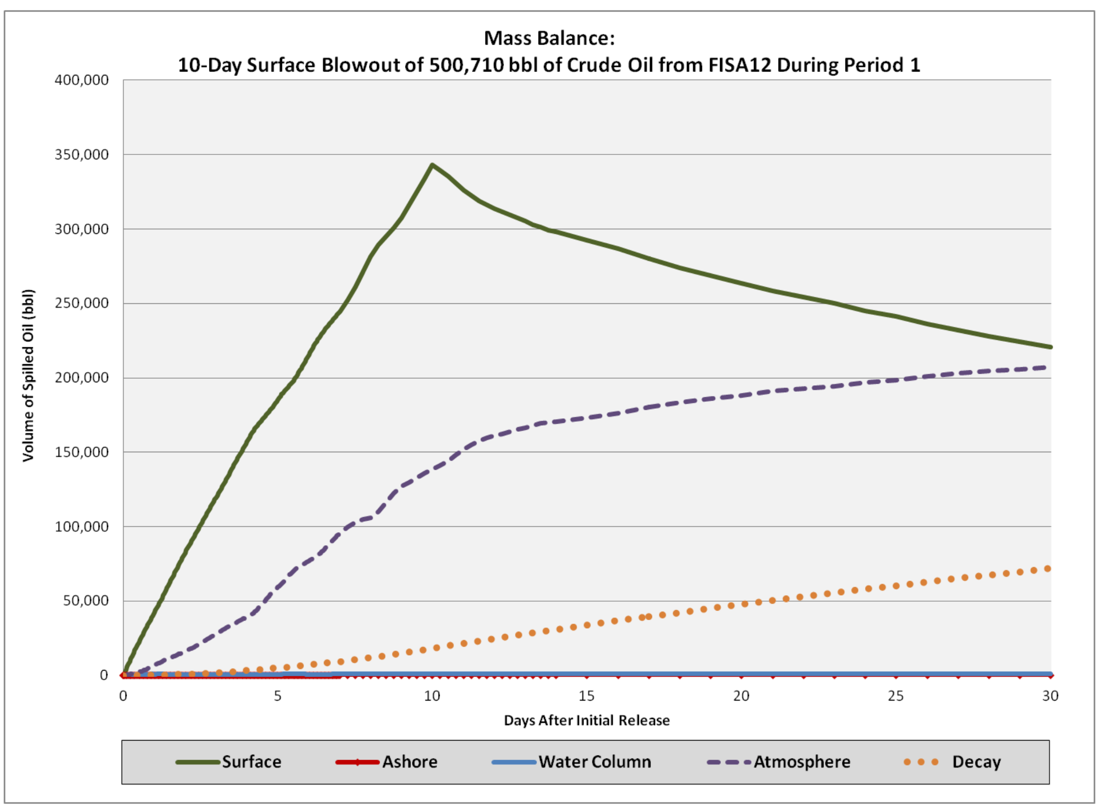


Figure 38. Scenario 5 mass balance graph.

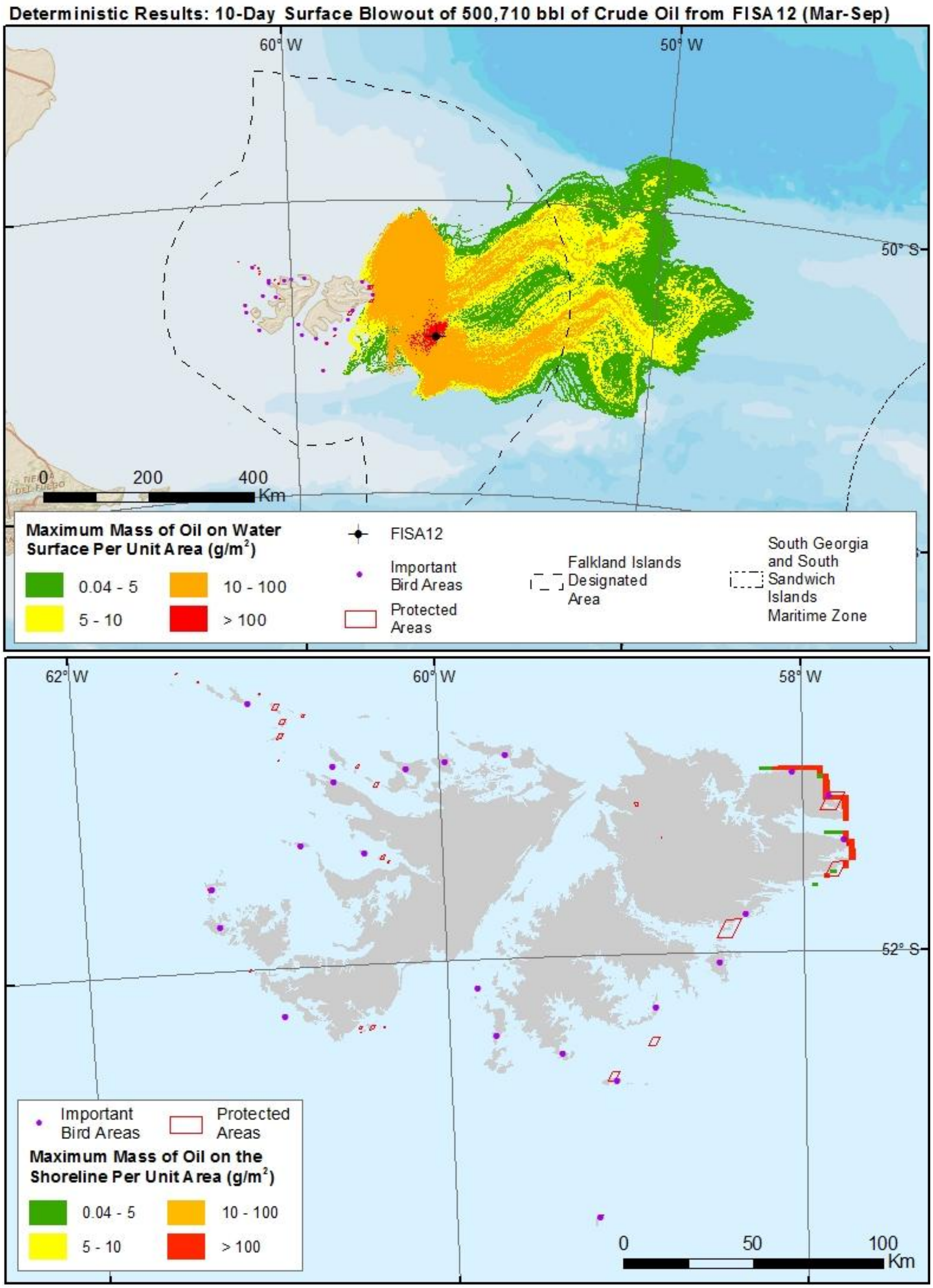


Figure 39. Scenario 6 deterministic maps for potential water surface (top) and shoreline (bottom) contamination.

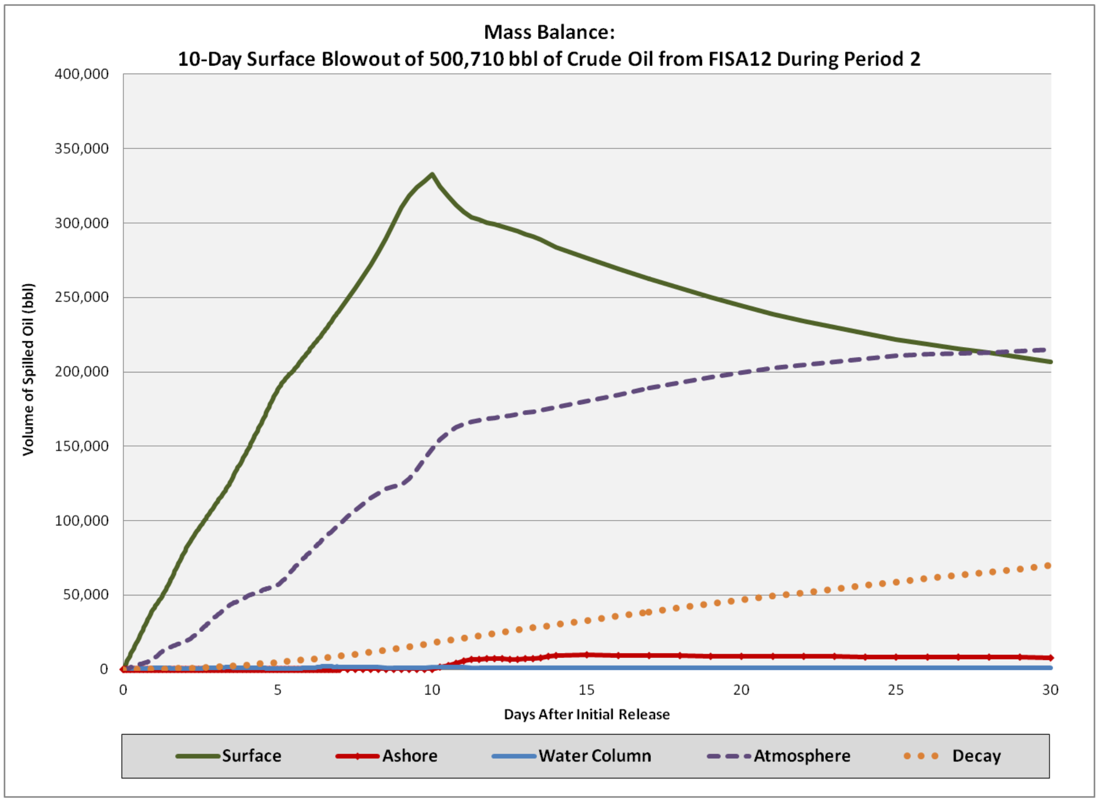


Figure 40. Scenario 6 mass balance graph.

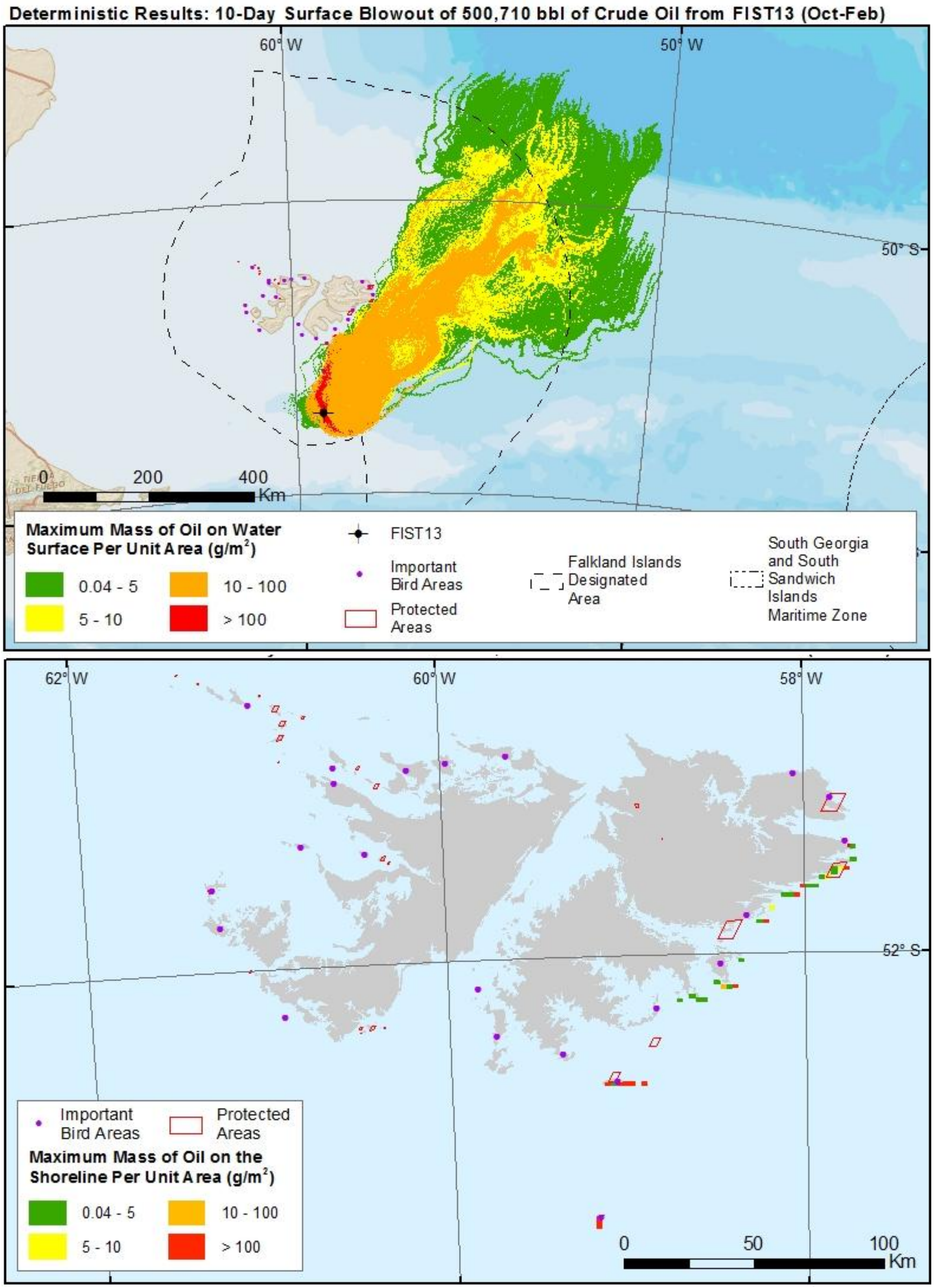


Figure 41. Scenario 7 deterministic maps for potential water surface (top) and shoreline (bottom) contamination.

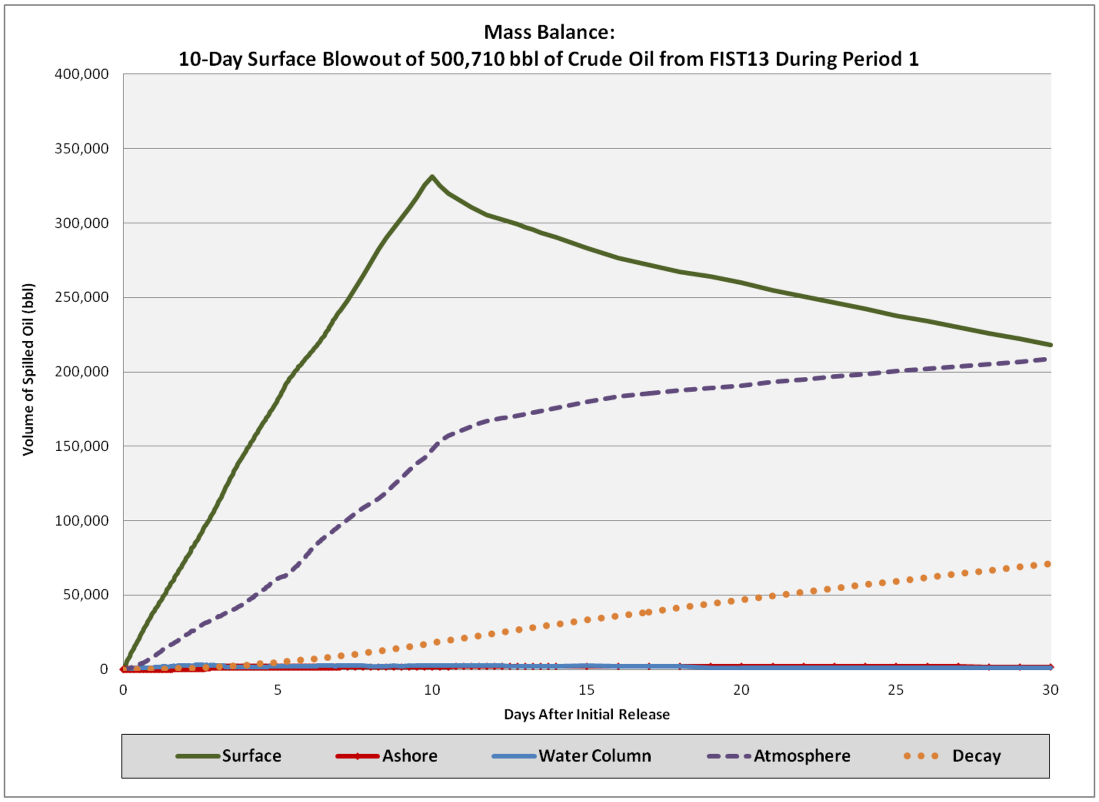


Figure 42. Scenario 7 mass balance graph.

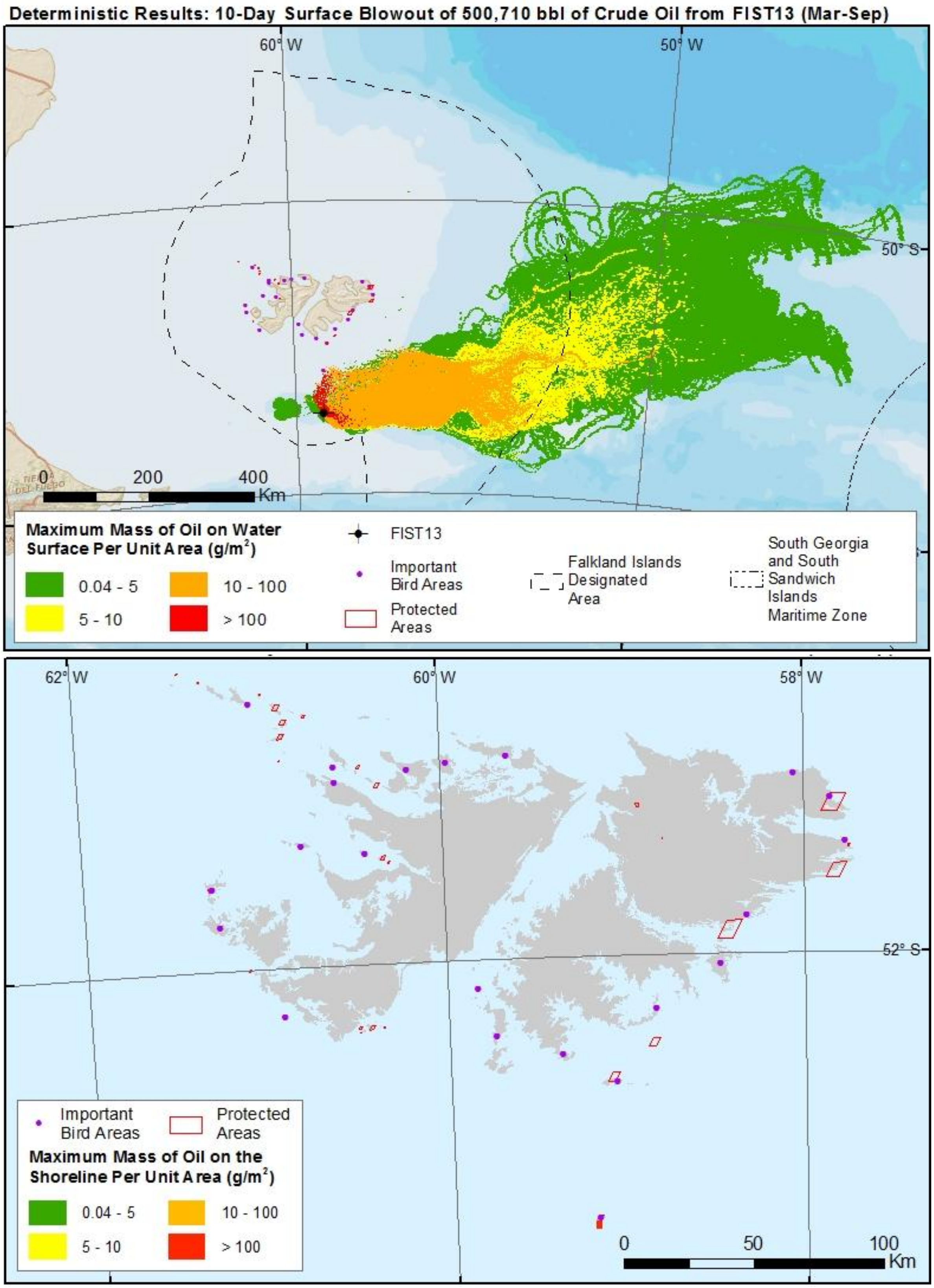


Figure 43. Scenario 8 deterministic maps for potential water surface (top) and shoreline (bottom) contamination.

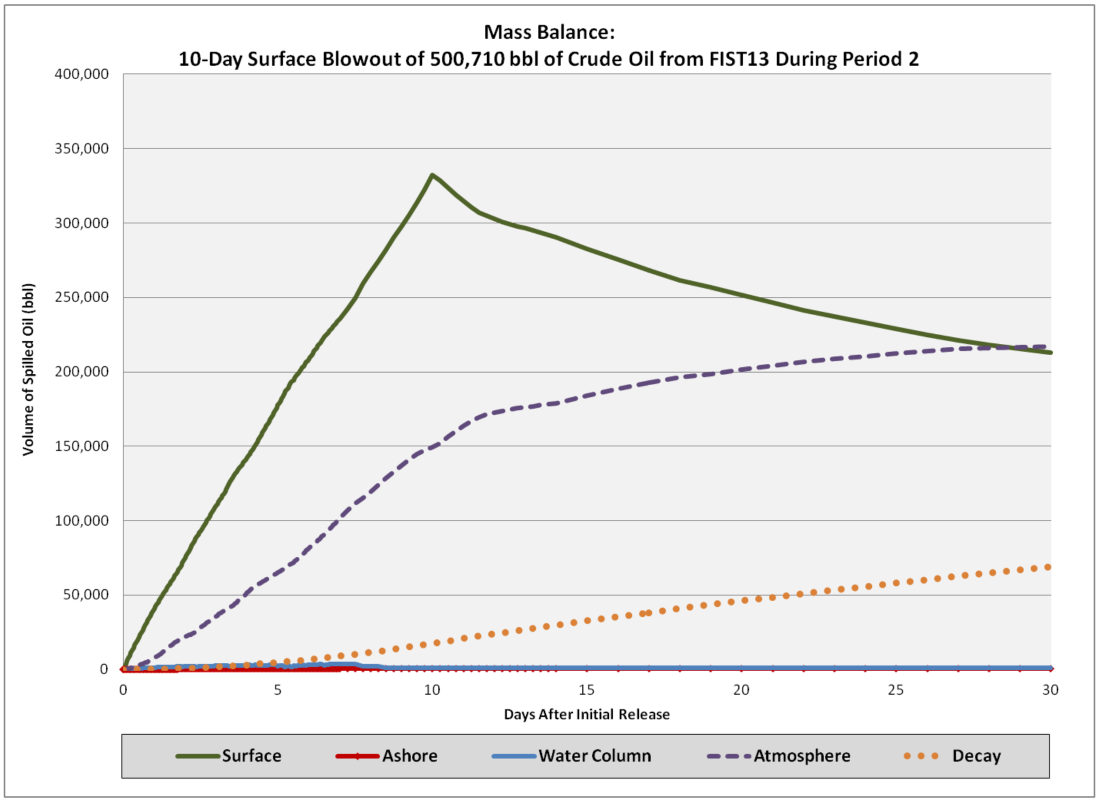


Figure 44. Scenario 8 mass balance graph.

RPS | Falkland Islands. Results of the Oil Spill Modelling DECC Scenarios

Table of Contents

List of Figures

List of Tables

1. Geographic Location - Area of Interest

Falkland Islands Study Area

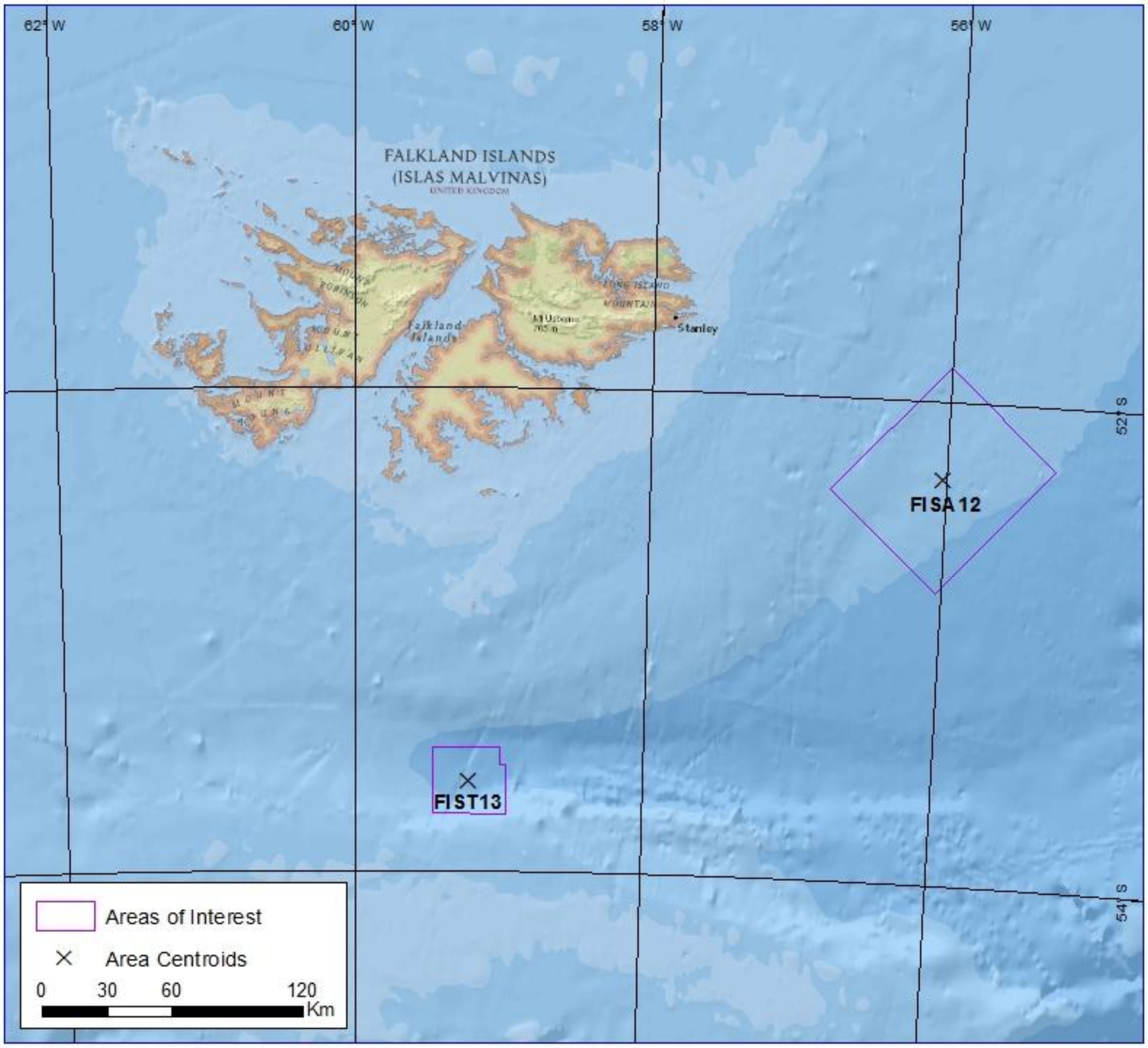


Figure 1. Geographic location of the study area.

Table 1. Coordinates of the sites of interest.

Site Name	Comments	Latitude N	Longitude E	Distance from land (km)	Approximate Water Depth (m)
FISA12	Center of FISA12	-52.3232	-56.0231	137 (Cape Pembroke)	1,177
FIST13	Center of FIST13	-53.6283	-59.2109	76 (Beauchene Island)	1,527

2. Oil Spill Simulations – Preliminary Results

2.1. Modelling Inputs

Each surface blowout scenario has been evaluated to fulfil what is currently referred to as "worst case" conditions under DECC guidelines. These worst case conditions require a constant 30-knot wind speed to be used in both the direction of the closest shoreline as well as the direction of the closest median line. These conditions are expected to provide information on necessary response measures considering the time to shore as well as the time to reach foreign waters.

Table 2. Summary of oil properties used in the simulations.

Oil Type	API Gravity (°)	Viscosity (cP at 25°C)	Interface Tension (dyne/cm)	Emulsion maximum Water Content (%)
Light Crude	38.9	4.00	26.1	89.6

Table 3. Parameters of the oil spill scenarios.

ID	Spill Site	Spill Event	Wind Direction	Oil Type	Spill Rate (bbl/d)	Spill Duration (days)	Total Spilled Volume (bbl)	Simulation Duration (days)
Deterministic Scenarios (Current DECC Scenarios)								
1	FISA12	30 knot onshore wind speed (surface)	From ESE	Crude Oil	50,071	10	500,710	30
2	FISA12	30 knot wind speed towards median line (surface)	From ENE	Crude Oil	50,071	10	500,710	30
3	FIST13	30 knot onshore wind speed (surface)	From S	Crude Oil	50,071	10	500,710	30
4	FIST13	30 knot wind speed towards median line (surface)	From ENE	Crude Oil	50,071	10	500,710	30

2.2. Deterministic Modelling Results

For each scenario, 6 maps are provided with snapshots of the mass per unit area of oil on the water surface at specific times after the release. Due to the uniform wind direction, oil slowly beaches in the same location until the holding capacity of the shoreline is met. After that point, additional oil collects on the water surface against the shoreline. This excess oil is referred to as “shoreline overflow” in Table 5. Under normal environmental conditions, the wind and current variability may result in more extensive transport along the shore, thereby increasing the amount of shoreline oil and decreasing shoreline overflow. Note that volumes listed in Table 5 are specific to artificial parameters (30 knot onshore winds) and in reality, the natural variability of environmental conditions in the area would likely result in very different volumes.

Table 4. Predicted impact information for each deterministic run.

ID	Spill Site	Wind Direction	Total Spilled Volume (bbl)	Time To Shore (days)	Time To Median Line (days)	Countries Impacted	
						Water Surface	Shore
1	FISA12	Onshore (from ESE)	500,710	3.0	-	Falkland Islands	Falkland Islands
2	FISA12	Median Line (from ENE)	500,710	16	8.3	Falkland Islands; Argentina	Argentina
3	FIST13	Onshore (from S)	500,710	1.7	-	Falkland Islands	Falkland Islands
4	FIST13	Median Line (from ENE)	500,710	7.8	2.0	Falkland Islands; Argentina	Argentina

Table 5. Predicted volumes ashore (including shoreline overflow) for 6 time steps.

Scenario	Approximate Volume Ashore + Shoreline Overflow (bbl)					
	Day 1	Day 3	Day 7	Day 10	Day 20	Day 30
1	-	-	110,257	190,604	235,070	206,992
2	-	-	-	-	102,500	205,700
3	-	14,670	115,586	188,413	221,630	196,356
4	-	-	-	30,719	231,400	207,000

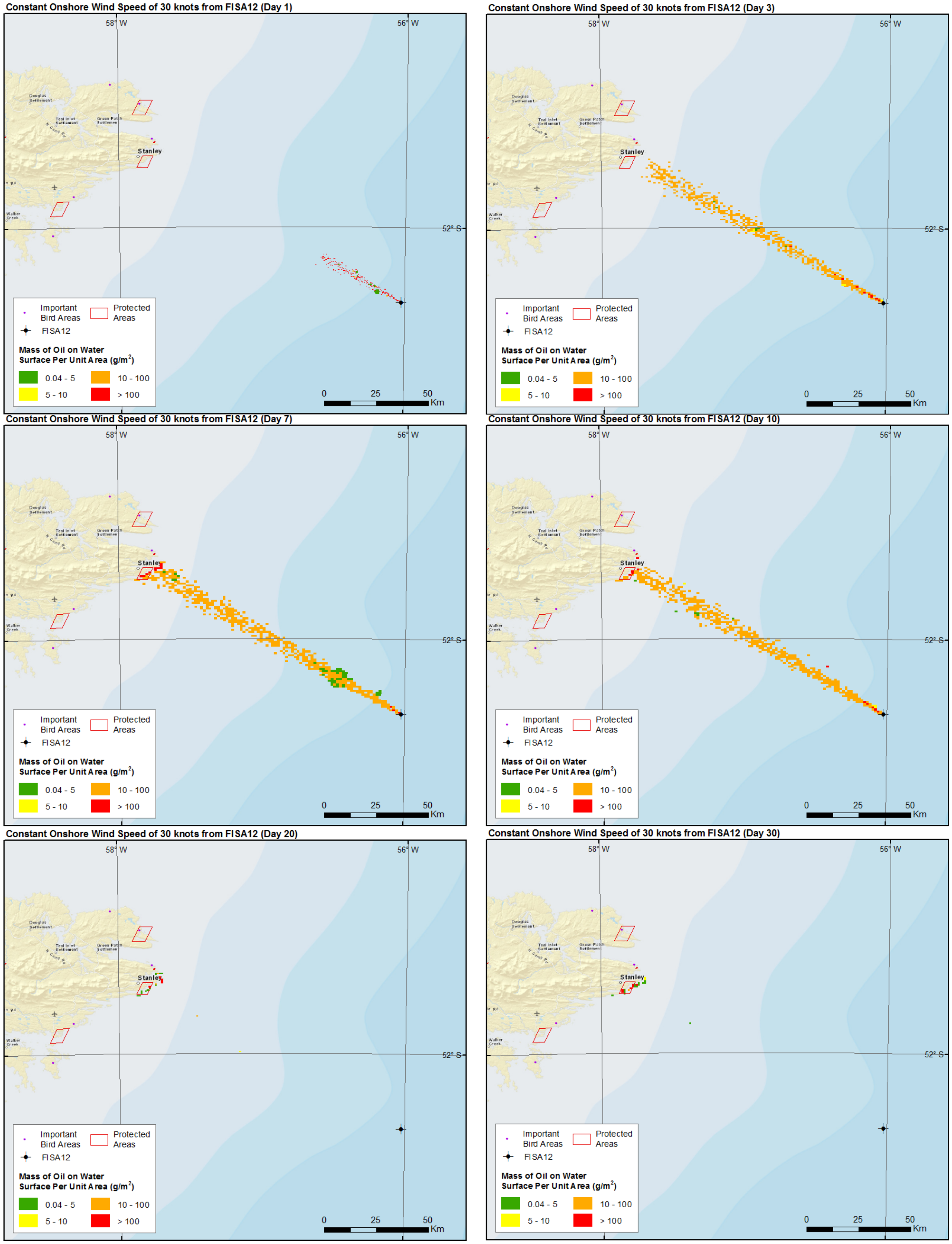


Figure 2. DECC1 deterministic snapshots.

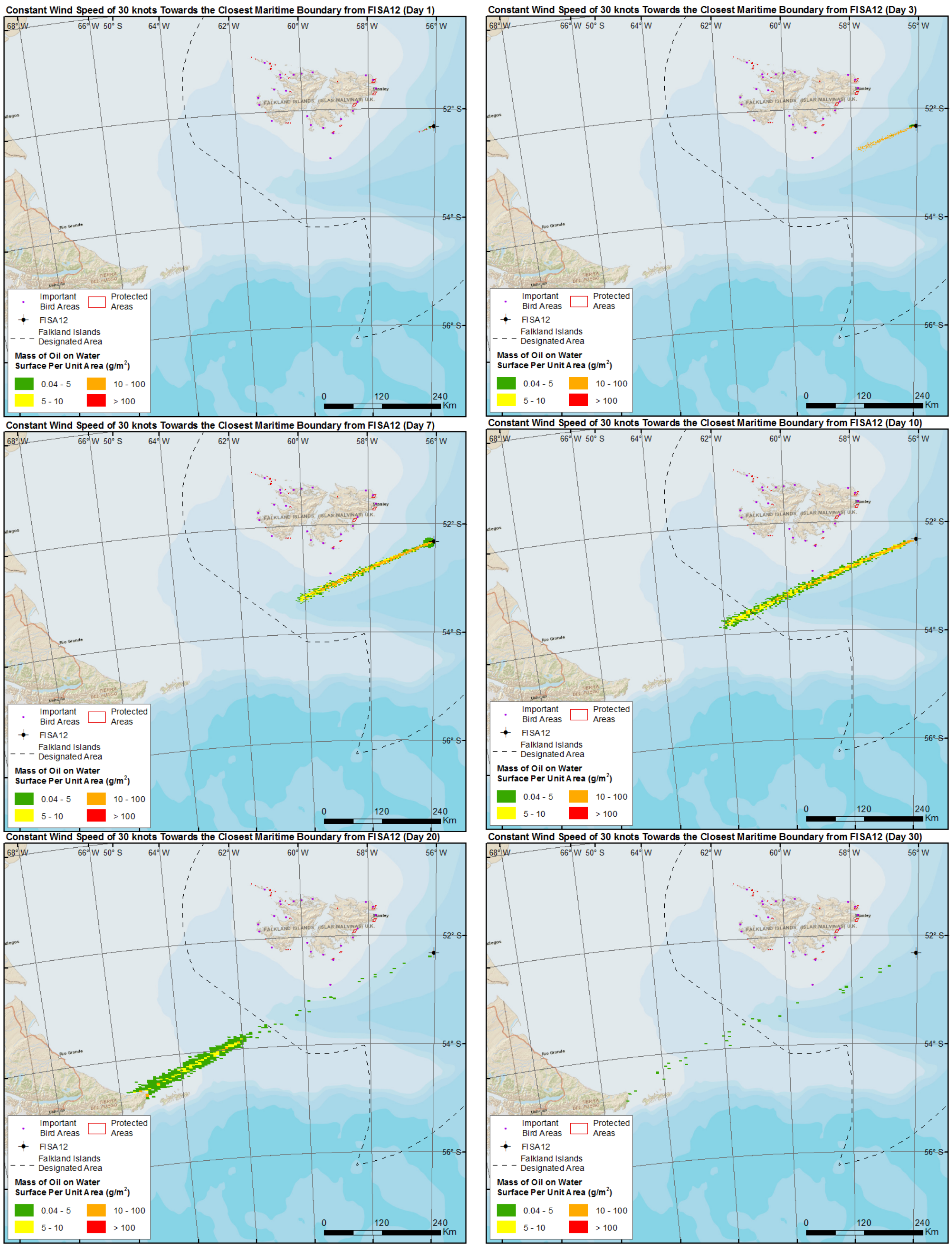


Figure 3. DECC2 deterministic snapshots.

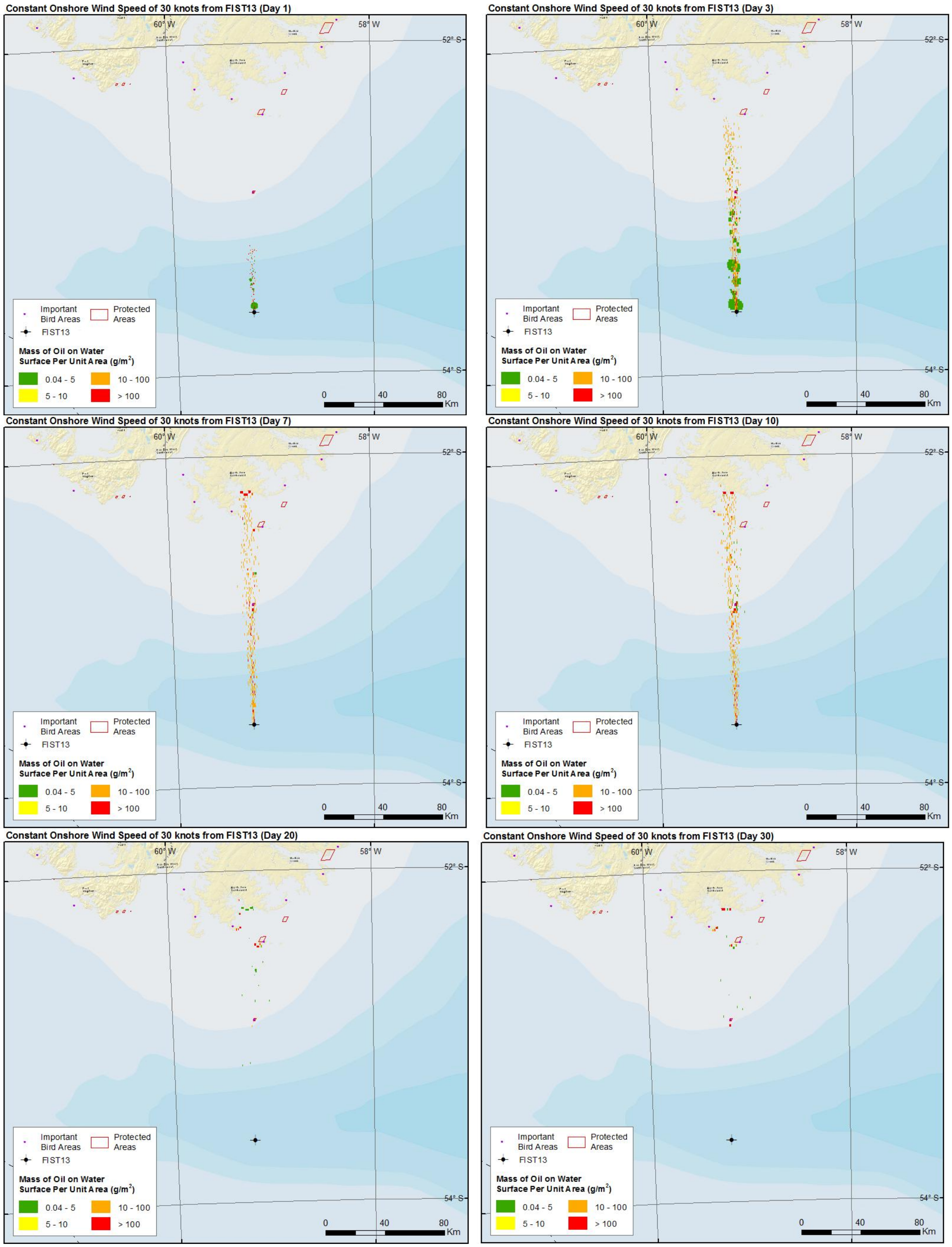


Figure 4. DECC3 deterministic snapshots.

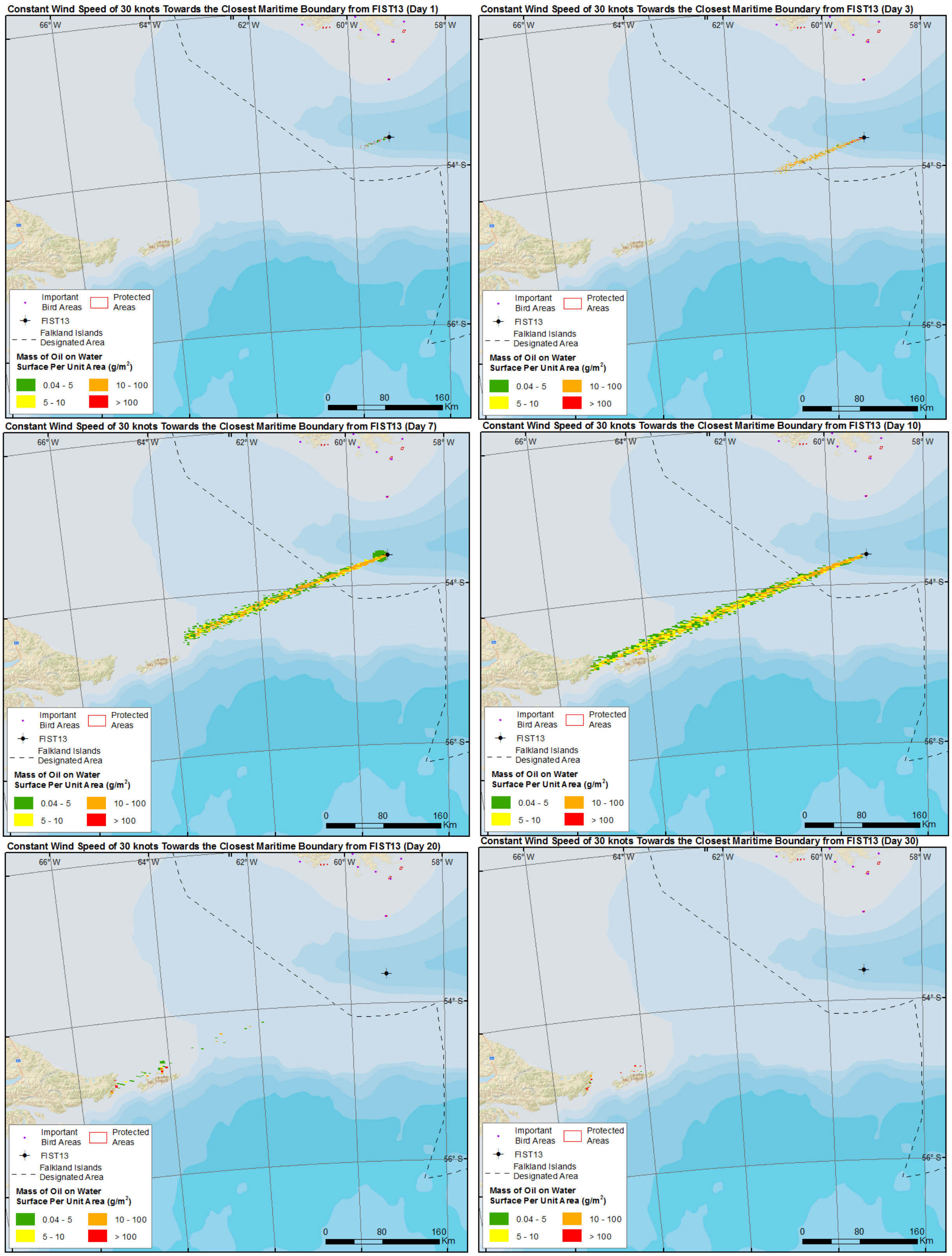


Figure 5. DECC4 deterministic snapshots.

Appendix J: Stakeholder Engagement Plan (SEP)

Noble Energy Falklands Limited

Stakeholder Engagement Plan: Falkland Islands Exploration Drilling Environmental, Social and Health Impact Assessment (ESHIA)

Date: *May 2014*

Revision: *00L*

Noble Energy Falklands Limited

Stakeholder Engagement Plan: Falkland Islands Exploration Drilling Environmental, Social and Health Impact Assessment (ESHIA)

DATE	VERSION	DESCRIPTION	PREPARED	CHECKED	APPROVED
06.09.13	00J	Update to Appendix B	SJS	AJP	
14.01.14	00K	Update to Appendix B	SJS	AJP	
08.05.14	00L	Update to Appendix B and timeframe	SJS	AJP	
File Reference: P:\RPS (RBA) USA\EHE9033 - RPS Noble Exploration ESIA\03_Deliverables\05_Stakeholder Engagement Plan\02_Final					

noble energy

NOBLE ENERGY DOCUMENT CONTROL

DATE	VERSION	DOCUMENT OWNER	DOCUMENT APPROVER
08.05.14	00L	EHSR Coordinator – International Frontier Ventures	EHSR Manager – International Frontier Ventures
Document Number: 178-13-EHSR-SEP-PA-T4			

Prepared by: Steve Saunders

May 2014

RPS Energy
HSE and Risk Management
1st Floor
14 Cornhill
London
EC3V 3ND

Tel +44 (0)207 280 3200

Fax +44 (0)207 283 9248

Email: saunderss@rpsgroup.com

RPS Energy

Table of Contents

Abbreviations

Abbreviation	Description
CBO	Community Based Organisation
DECC	Department of Energy and Climate Change
EHS Guidelines	Environmental, Health and Safety Guidelines
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EP	Equator Principles
ESHIA	Environmental, Social and Health Impact Assessment
ESMP	Environmental and Social Management Plan (ESMP)
Espoo	UNECE Convention on Environmental Impact Assessment in a Trans-boundary Context (Espoo Convention)
ExCo	Executive Council
FCZ	Falklands Conservation Zone
FGD	Focus Group Discussion
FI	Falkland Islands
FIG	Falkland Islands Government
FIFCA	Falkland Islands Fishing Companies Association
FIGAS	Falkland Islands Government Air Service
FOGL	Falkland Oil and Gas Company
ICP	Informed Consultation and Participation
IFC	International Finance Corporation
IFC PS	IFC Performance Standards
JNCC	Joint Nature Conservation Committee
NGO	Non-Governmental Organisation
NOSCP	National Oil Spill Contingency Plan
NTS	Non-Technical Summary
SAERI	South Atlantic Environmental Research Institute
SEP	Stakeholder Engagement Plan
SMSG	Shallow Marine Surveys Group
TOR	Terms of Reference

Definitions

Terms	Description
Comment Form	A standard 'hard copy' form in which stakeholders can submit written comments, views and opinions. Often distributed at public meetings and made available in locations accessible to stakeholders.
Culturally appropriate	An engagement process that identifies a practical and appropriate approach for sharing information and comments/views/opinions that is compatible with local cultural norms and behaviour.
Espoo Convention	UNECE Convention on Environmental Impact Assessment in a Transboundary Context (named after the town of Espoo in Finland where the meeting that produced the Convention was held).
Engagement	Generic term for activity including both two-way disclosure of information/consultations and feedback to stakeholders on the way in which their inputs to an ESHIA process were used.
Formal meeting	Face-to-face meeting with a stakeholder (or stakeholders) organized in advance, by letter or e-mail, often with an agreed agenda and held on the premises of a stakeholder. Refer to 'Informal' meeting' below.
Grievance	A complaint from an individual, or group, who raise a concern about any aspect of the project, or the way in which stakeholder engagement activities are being implemented.
Grievance Procedure	A description of the process used to record, track and respond to a grievance, after it has been raised, until the grievance is resolved.
Informal meeting	Face-to-face meeting with a stakeholder (or stakeholders) organized in advance, by letter, email or phone, to discuss project-related issues. Can occur in any mutually agreeable location(s).
Disadvantaged and vulnerable groups	Individuals and groups that may be directly and differentially or disproportionately affected by the project because of their disadvantaged or vulnerable status. This disadvantaged or vulnerable status may stem from an individual's or group's race, colour, gender, language, religion, political or other opinion, national or social origin, property, birth, or other status. In addition, other factors may be relevant, such as age, ethnicity, culture, literacy, sickness, physical or mental disability, poverty or economic disadvantage, and dependence on unique natural resources.
Mitigation	Specific measures developed through the ESHIA process to, prevent, avoid and reduce adverse impacts to a level considered to be as low as reasonably practical. Can also include measures to enhance positive outcomes.
Project leaflet	Brief publication containing information about a project which is made available to stakeholders.
Public disclosure	Disclosure of project or ESHIA–related information to stakeholders undertaken during a wider consultation process.
Public meeting	A meeting held in a suitable location which is open to any individual.
Stakeholders	Stakeholders are persons or groups who are directly or indirectly affected by a project, as well as those who may have interests in a project and/or the ability to influence its outcome, either positively or negatively.
Stakeholder Engagement	A process of sharing information, ideas and concerns in a two-way dialogue between project proponent and stakeholders, allowing stakeholders to express their views and opinions, and for these views and opinions to be considered in the 'project' design and the project 'approval' decision-making processes.
Stakeholder Identification	A process of identifying who is likely to be affected by the project both directly and indirectly, and who may have an interest in the project or influence over the project.
Stakeholder Mapping	Process of identifying stakeholders for the purpose of an ESHIA project.

1 Introduction

This document is the Stakeholder Engagement Plan (SEP) that has been prepared for the Environmental, Social and Health Impact Assessment (ESHIA) of the proposed exploration drilling and seismic survey operations in the Diomedia and Tilted Fault Block areas of the southern licence region (the project), offshore the Falkland Islands. The project is being led by Noble Energy Falklands Limited (hereafter referred to as Noble). The SEP presents and describes the stakeholder engagement activities (primarily information acquisition, disclosure and consultations, and disclosure and dissemination of key issues/results) that will take place during key stages of the ESHIA.

This document is a live document and will be updated throughout the project as necessary.

1.1 Objectives of the Stakeholder Engagement Plan

The objectives of this Stakeholder Engagement Plan (SEP) are to:

- Describe the regulatory, lender, company (i.e. Noble) and/or other requirements for consultation and disclosure;
- Identify and prioritise key stakeholder groups, focusing on Affected Communities;
- Describe the strategy and present the timetable for sharing information and consulting with each of these groups;
- Describe the internal resources and individual responsibilities assigned to implement stakeholder engagement activities; and
- Describe how the effectiveness of the SEP will be monitored and how lessons learned will be recorded, with the aim of improving stakeholder engagement activities during the ESHIA and during future implementation of the project itself.

1.2 Project Description

1.2.1 Background

Noble Energy Inc. is a US-based company with a headquarters in Houston, Texas, which is engaged in global oil and gas exploration and production operations.

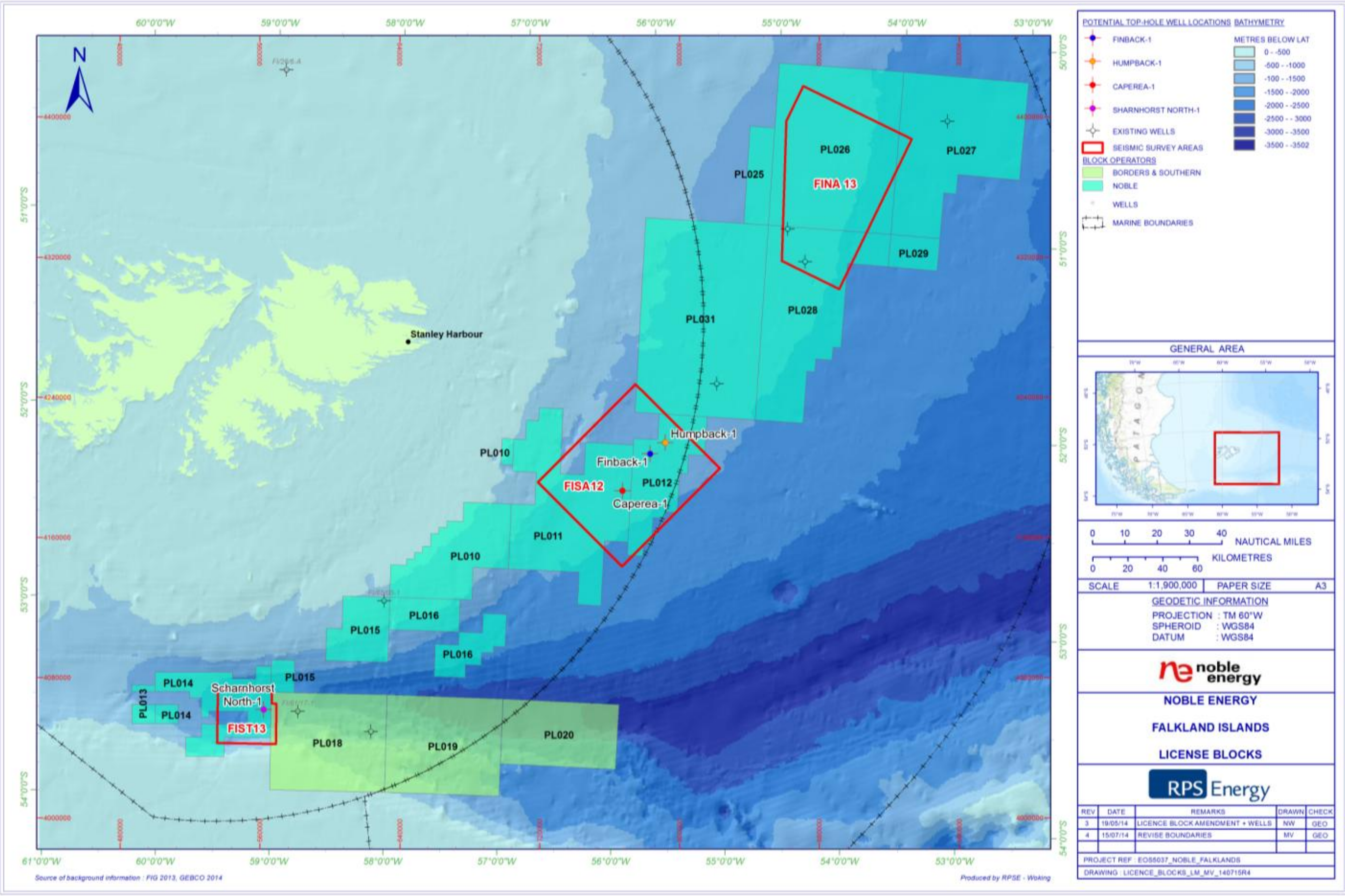
In 2012, Noble acquired licence interests in the southern and northern licence areas offshore the Falkland Islands. As of 2014, Noble currently holds operatorship of these licenses. Figure 1.1 shows the location of the Noble operated licenses, and the areas that have been subject to seismic survey.

1.2.2 Proposed Southern Licence Area Exploration

The planned drilling programme consists of two exploration wells and one optional exploration/appraisal well (a potential total of three wells), all to be located within the southern area licenses.

In accordance with the Falkland Islands regulatory regime, an Environmental Impact Assessment (EIA) process is required for the project leading to the preparation of an Environmental Impact Statement (EIS). Noble has decided to prepare an Environmental, Social and Health Impact Assessment (ESHIA), which meets the requirements outlined in the *Offshore Minerals Ordinance 1994*, Noble internal policies and guidelines, and the requirements of the Equator Principles (EQ) and International Finance Corporation (IFC) Sustainability Framework (2012) which includes the IFC Performance Standards (PS) and accompanying Environmental, Health, and Safety (EHS) Guidelines (2007).

Figure 1.1: Noble Falkland Islands licence areas



1.3 Document Structure

This SEP contains the following sections:

Section 2: Regulations and requirements;

Section 3: Summary of previous stakeholder engagement activities;

Section 4: Stakeholder identification;

Section 5: Stakeholder engagement programme;

Section 6: Engagement timescale;

Section 7: Internal and external roles and responsibilities;

Section 8: Noble Energy Community Feedback Mechanism; and

Section 9: Monitoring and reporting.

2 Regulations & Requirements

This section provides a summary of the applicable regulations and requirements for stakeholder engagement that have contributed to the development of this SEP.

2.1 National Regulatory Requirements

The *Offshore Minerals Ordinance 1994* PART VI 'Miscellaneous and General' Sections 64 to 67, provides the regulatory framework associated with EIAs and EISs in the Falkland Islands.

Section 64 of the *Offshore Minerals Ordinance 1994*, "*Environmental Impact Assessments and Environmental Impact Statements*", provides for whether or not an EIA or EIS will be required. An EIA or EIS may be required if it is considered by the Governor, that the environment may be substantially affected by the activity in question. Paragraph 2 states that:

> *"(2) The Governor may, if he considers that the environment might be substantially affected were he to grant an application, cause an environmental impact assessment to be prepared and submitted to him by such person or persons as the Governor directs and in relation to the likely adverse and beneficial effects upon the environment if the application were to be granted, and Schedule 4 shall have effect as to the matters to be dealt with by an environmental impact assessment*".

Paragraph 1 defines EIA and EIS as follows:

> *"(1) (c) "environmental impact assessment" means an assessment commissioned by the Governor under subsection (2);*
>
> *(1) (d) "environmental impact statement" means a statement prepared by or on behalf of the applicant pursuant to a requirement made by the Governor under subsection (3) and dealing with all, or such as the Governor may require of the matters mentioned in paragraph 2 of Schedule 4".*

The basic scope and content of an EIA and EIS are specified within Schedule 4 of the *Offshore Minerals Ordinance 1994* and are essentially the same. An EIA commissioned by the Governor does not have to go through a public consultation period, whereas an EIS submitted by an applicant will be required to go through a 42 calendar day public consultation period.

Sections 65 and 66 of the *Offshore Minerals Ordinance 1994* contain general provisions for commissioning by the Governor of an EIA.

Section 67 *of the Offshore Minerals Ordinance 1994* contains general provisions for applicants who have prepared an EIS and the provision of further information:

> *"(1) The Governor, when dealing with an application in relation to which the applicant has furnished an environmental impact statement (and whether pursuant to a requirement under section 71(3) or otherwise), may require the applicant to provide such further information as the Governor may specify concerning any matter which is required to be, or may be, dealt with in the environmental impact statement.*
>
> *(2) The Governor may in writing require an applicant to produce such evidence as he may reasonably call for to verify any information in the applicant's environmental impact statement.*
>
> *(3) For the purposes of section 65(4) and 66(2), further information furnished pursuant to subsection (1) of this section and evidence furnished pursuant to subsection (2) of this section shall be treated as forming part of the applicant's environmental impact statement".*

The *Offshore Minerals Ordinance 1994* was updated in 2011 by the *Offshore Minerals Amendment Ordinance 2011*. The update contains additional requirements within Sections 64 to 67 in the form of new Sections 64A to 64C being inserted after Section 64:

Section 64A "*Environmental impact assessment and environmental impact statements required for applications to drill regulated wells in controlled waters*" states that:

> *"(1) An environmental impact assessment and an environmental impact statement are required for each application for permission to drill a regulated well in controlled waters".*
>
> *(2) An applicant for permission to drill a regulated well in controlled waters must comply with the requirements of section 64C(1) before making the application".*

Section 64B provides powers to require EIA or EIS for applications for activity other than exploratory drilling.

Section 64C contains general provisions for EIA and EIS contents and considerations of the Governor prior to granting consent:

> *"(1) If an environmental impact assessment and an environmental impact statement are required for an application:*
>
> *(a) the applicant must conduct an environmental impact assessment of the likely adverse and beneficial effects upon the environment that there would be if the application were to be granted;*
>
> *(b) the applicant must deliver to the Governor an environmental impact statement that contains (at least) the information required by schedule 4; and*
>
> *(c) the applicant must publish that environmental impact statement and consult upon it in accordance with sections 65, 65A and 65B.*
>
> *(2) The Governor must not determine an application for which an environmental impact assessment and an environmental impact statement are required until the applicant has complied with subsection (1).*
>
> *(3) If an environmental impact assessment and an environmental impact statement are required for an application and the Governor grants that application:*
>
> *(a) the Governor may impose conditions on the consent for one or more of the following purposes:*
>
> *(i) to eliminate or reduce significant adverse effects on the environment of the project and the infrastructure associated with the project;*
>
> *(ii) if possible, to remedy those effects; and*
>
> *(iii) to offset them; and*
>
> *(b) the Governor may impose those conditions even if there is no other power to do so.*
>
> *(4) When considering an application for which an environmental impact assessment and an environmental impact statement are required, the Governor must take the following into account before deciding whether or not to grant it and whether or not to impose conditions:*
>
> *(a) the environmental impact statement;*
>
> *(b) if the Governor has sent the environmental impact statement to a technical expert for review, the representations made by that technical expert;*

(c) representations from the public (and representations in reply from the applicant) submitted to the Governor in accordance with section 65B; and

(d) if the Governor has requested additional information or evidence under section 66, that additional information or evidence".

Section 65 provides further information on the consultation and approval process, including new sections 65A and 65B:

"(1) Whenever an environmental impact statement is delivered by an applicant to the Governor in accordance with section 64C(1)(b), the applicant must seek to agree with the Governor the date on which the process of consultation on it will start.

(2) If no agreement is reached within a reasonable period, the Governor may give a direction as to the date on which the process will start.

(3) In sections 65A and 65B, the following definitions apply in relation to an environmental impact statement —

(a) "start date" means either —

(i) the date agreed between the applicant and the Governor under subsection (1); or

(ii) the date directed by the Governor under subsection (2);

(b) "closing date" means the date 42 days after the start date;

(c) "consultation period" (during which members of the public may make representations) means the period starting on the start date and ending on the closing date; and

(d) "follow-up period" (during which the applicant may make representations in reply) means the period —

(i) starting on the date on which confirmation is given to the applicant under section 65B(3) that copies of all of the representations made during the consultation period have been forwarded under section 65B(2); and

(ii) ending on the date 28 days after that date".

65A. Publicity for environmental impact statement and consultation process

"(1) The Governor must arrange for a notice to be issued in the Gazette on the start date for each environmental impact statement.

(2) That notice must refer to the publication of the environmental impact statement and describe the consultation process.

(3) The applicant must make arrangements for each of the following things to happen:

(a) throughout the consultation period, a paper copy of the environmental impact statement must be available in Stanley (and, if the Governor directs, at one or more other places in the Falkland Islands) for the public to inspect (without charge) during at least normal government office hours;

(b) a paper copy of the non-technical summary of the environmental impact statement must be provided (without charge and as soon as possible) to each member of the public who requests one during the consultation period;

(c) an electronic copy of the environmental impact statement must be provided (without charge, as soon as possible and in a format that has been approved by or on behalf of the Governor) to each member of the public who requests one during the consultation period;

and;

(d) an electronic copy of the non-technical summary of the environmental impact statement must be provided (without charge, as soon as possible and in a format that has been approved by or on behalf of the Governor) to each member of the public who requests one during the consultation period.

(4) The applicant must also arrange for the publication of the environmental impact statement and the arrangements made under subsection (3) to be advertised in the following way:

(a) on the start date, there must be at least one announcement on the broadcast service provided by the Media Trust under section 5(1)(aa) of the Media Trust Ordinance (Title 59.1);

(b) throughout the rest of the consultation period, there must be further announcements on that radio service either —

(i) as agreed with the Governor; or

(ii) if an agreement cannot be reached, as directed by the Governor; and

(c) throughout the consultation period, there must be a notice in each edition of the newspaper published by the Media Trust under section 5(1)(a) of the Media Trust Ordinance.

(5) The announcements made and notices given under subsection (4) must also inform members of the public about —

(a) their right to make representations under section 65B;

(b) how to make those representations; and

(c) the closing date (by which those representations need to be made).

(6) The applicant may take other steps to publish the environmental impact statement and publicise the consultation process".

65B. Representations

"(1) During the consultation period, anyone who wishes to do so may make written representations to the Governor about:

(a) the contents of the environmental impact statement; and

(b) in particular, the applicant's proposals to protect the environment from adverse effects that there might be if the application were to be granted.

(2) The Governor must arrange for copies of the written representations made during the consultation period to be forwarded to the applicant as soon as possible after they are received.

(3) The Governor must arrange that, as soon as copies of all of the representations made during the consultation period have been forwarded under subsection (2), this is confirmed to the applicant.

(4) During the follow-up period, the applicant may make written representations to the Governor in reply to representations made under subsection (1)".

Section 66 provides amendments to the text relating to the provision of further information in support of the EIS or evidence to verify the content of the EIS.

Section 67 provides powers for the applicant to request an exemption from the requirement of EIA on the basis that the environment would not be significantly affected. However, for drilling operations, it is generally accepted that an EIS is required.

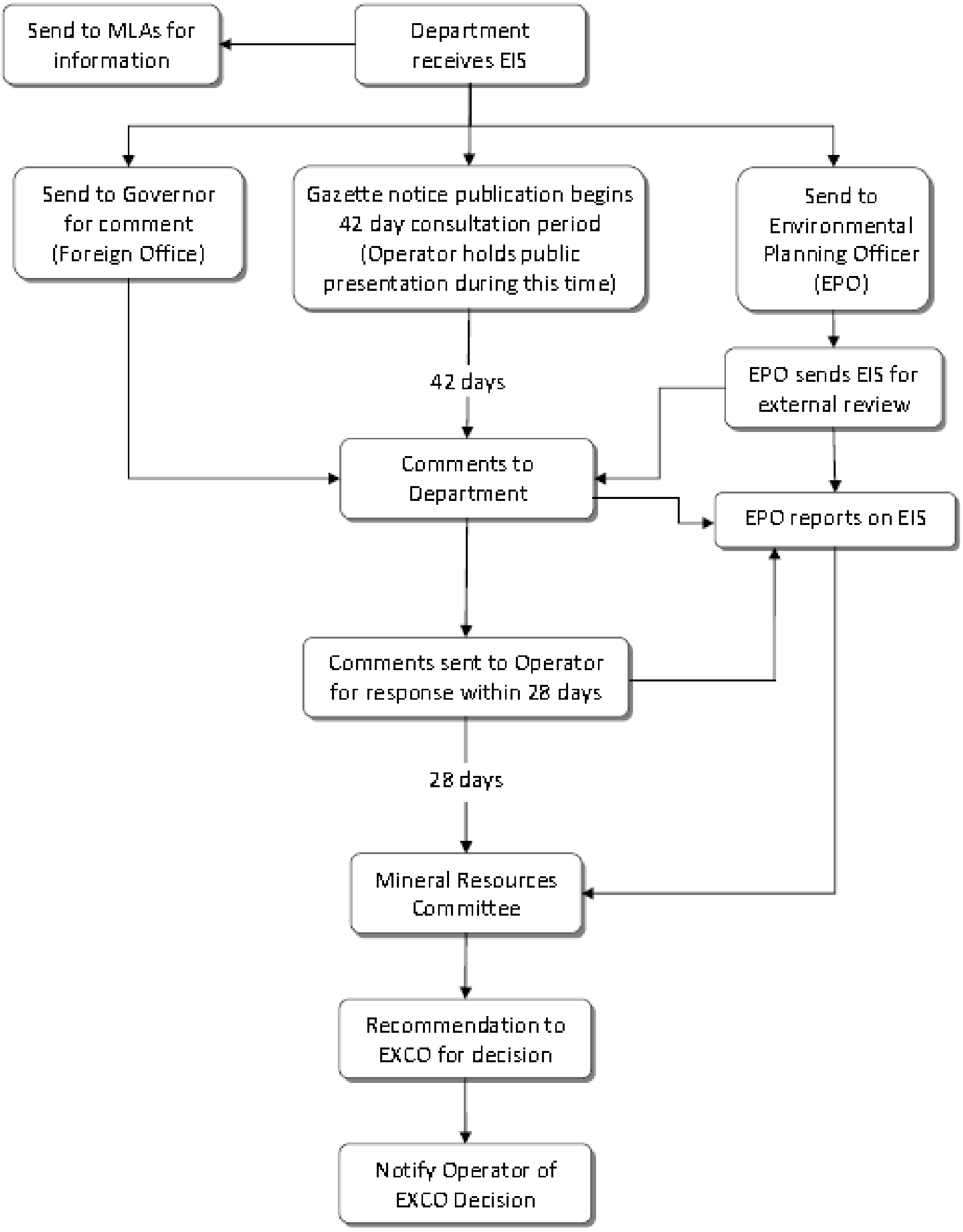
Amendments to Schedule 4 are also provided which contain further clarification on the requirements of the basic content of an EIS.

The *Offshore Minerals ordinance 1994* is currently the only piece of legislation in the Falkland Islands related to EIA for the oil and gas industry.

2.1.1 Guidance on the EIS Submission Process

The FIG Department of Mineral Resources has provided guidance to RPS on the way in which the ESHIA should be submitted and used for the basis of consultation during the approval process. A copy of a flow chart diagram received is provided in Figure 2.1.

Figure 2.1: Falkland Islands Government EIA / EIS consultation and approval process (Department of Mineral Resources, 2012)



2.1.2 RPS' Interpretation on guidance received from the Department of Mineral Resources

The FIG Department of Mineral Resources (DMR) and Environmental Planning Department (EPD) are responsible for assessment of applications under the *Offshore Minerals Ordinance 1994 (as* *amended)*. Impact assessment documents are submitted to the DMR, however, their review is independently led by the EPD. Figure 3.1 outlines Nobles process for submission and approval of the exploration drilling ESHIA, and includes an outline of the Falkland Islands application and public consultation process, which is described below.

Preparation & Submission of the ESHIA

Following receipt of comments on the Scoping Report, the ESHIA document will be prepared. Once complete, the ESHIA will be submitted to the FIG DMR. At this point, an advertisement will be placed in the Falkland Islands Gazette, which will outline the project and state that a formal public consultation period is now open. An announcement will also be made to this end on the local radio station. The consultation period starts on the day that the advertisement is published in the Falkland Islands Gazette. The consultation period lasts for 42 calendar days.

The 42 calendar day period is the period from the date when the availability of the ESHIA is advertised in the FI Gazette, to the deadline for comments closing. During this time, the document is also presented to the Executive Council by FIG.

Accessibility of the ESHIA

During the consultation period, two copies of the ESHIA document will be made available in a public place for review, which will be the public library in Stanley. This will be made clear in the advertisement in the FI Gazette and during the announcement on the local radio station.

Fifteen full colour hard copies of the ESHIA document will be supplied to the DMR as part of the submission for internal FIG use and distribution. Hard copies should also be made available to interested local agencies from the Noble local office in Stanley during the consultation process to whoever requests such a copy. These hard copies will be printed locally in the Falkland Islands in the local print shop in Stanley. Demand is anticipated to be less than 50 copies.

FIG may also choose to host and publicise the ESHIA on its own website.

Public Disclosure Meetings & Stakeholder Comment on the ESHIA

During the 42 day consultation period, Noble will hold two public disclosure meetings in Stanley on consecutive days to present the ESHIA to the public. The meeting format will comprise a formal presentation given by Noble and/or RPS, outlining the project activities and the key findings of the ESHIA process, followed by an opportunity for members of the public to ask questions. This public session will be held in the second half of the 42 calendar day consultation period in order to give the public time to receive and review the report.

It is envisaged that the two public disclosure meetings will take place in the FIG Chamber of Commerce (subject to availability) and that the minutes from both days, will be recorded to comprise a formal consultation record. The meeting may also be used to provide general material relating to the project, in the form of public information leaflets and/or posters.

During the public consultation period, stakeholders will be able to comment on the ESHIA, using comment forms available on the day, or sending comments directly to the DMR and/or by attending and verbally commenting at one of the two public disclosure meetings.

ESHIA Review

At the end of the formal public consultation period, the FIG DMR, EPD and Mineral Resources Committee formal review of the ESHIA will take place. The review of the document will be led by the EPD. EPD often contracts an external UK scientific agency for review of the document, in addition to their own review. EPD also contact other UK government agencies for review of the document, which may include the UK Department of Energy and Climate Change (DECC) and/or the Joint Nature Conservation Committee (JNCC), although these agencies have no direct powers of intervention in any decision or recommendation made by FIG. This process can take up to an additional 12 weeks from the date of the end of the 42 day public consultation period.

Responses to Comments

After the formal review period, FIG will submit their comments to Noble on the ESHIA. There is a limited timeframe to reply to these comments (normally 28 calendar days). A direct formal reply to the comments in the form of a separate document is normally an adequate response and an updated ESHIA incorporating all comments is not normally required. However, the ESHIA report can be updated, if this is deemed necessary.

From previous experience on Falklands EIA projects it has been noted that the timing of comments received on the document can be sporadic; they can appear at various times throughout the formal FIG review period. RPS Energy will endeavour to respond to comments received as soon as possible upon their receipt. RPS Energy will draft responses to comments and submit them to Noble for review. Noble will have final approval of any response to comments and reserves the right to coordinate the response communication.

During the process, FIG will ensure that all responses received from the operator on stakeholder comments are satisfactory.

Notification of Decision

Notification of the Authorities decision on the ESHIA will be made formally by the FIG DMR, EPD and Mineral Resources Committee shortly after they are satisfied that all stakeholder comments have been addressed. The approval is in the form of a formal letter issued by the DMR. The decision is likely to be publicised by FIG on its own website. There may be certain conditions and requirements for the consented drilling activities and/or for further work or reports attached to any approval.

2.2 International Requirements from the IFC

The requirement for stakeholder engagement is outlined in IFC Performance Standard (PS) 1, paragraphs 26 through to 31 which, in general terms, require the following:

- Stakeholder analysis and planning;
- Disclosure and dissemination of information;
- Consultation and participation;
- The availability of a grievance mechanism; and
- On-going reporting to affected communities.

Specifically, IFC PS1 requires the following:

- The development and implementation of a Stakeholder Engagement Plan (this document) that is scaled to the project risks and impacts and development stage; and
- The disclosure of relevant project information to help Affected Communities and other stakeholders understand the risks, impacts and opportunities of the project. The client (Noble) should provide Affected Communities with access to relevant information on:
    - The purpose, nature, and scale of the project;
    - The duration of proposed project activities;
    - Any risks to and potential impacts on such communities and relevant mitigation measures;
    - The envisaged stakeholder engagement process; and
    - The grievance mechanism.

When Affected Communities are subject to identified risks and adverse impacts from a project, the client (Noble) will undertake a process of consultation in a manner that provides the Affected

Communities with opportunities to express their views on project risks, impacts and mitigation measures, and allows the client to consider and respond to them (this will take place during the 42 calendar public disclosure and consultation period using the ESHIA).

Furthermore, IFC PS1 emphases that effective consultation is a two-way process that should:

- Begin early in the process of identification of environmental and social risks and impacts (i.e. during ESHIA Scoping) and continue on an ongoing basis as risks and impacts arise;
- Be based on the prior disclosure and dissemination of relevant, transparent, objective, meaningful and easily accessible information which is in a culturally appropriate local language(s) and format and is understandable to Affected Communities;
- Focus inclusive engagement on those directly affected as opposed to those not directly affected;
- Be free of external manipulation, interference, coercion, or intimidation;
- Enable meaningful participation, where applicable; and
- Be documented.

IFC PS1 also requires, for projects with potentially significant adverse impacts on Affected Communities, an Informed Consultation and Participation (ICP) process be conducted that results in the Affected Communities' informed participation. ICP involves a more in-depth exchange of views and information, and an organized and iterative consultation. This process leads to the client's incorporating the views of the Affected Communities on matters that affect them directly, such as the proposed mitigation measures, the sharing of development benefits and opportunities, and implementation issues into the decision-making process.

3 Summary of Previous Stakeholder Engagement Activities

This section provides an overview of issues and concerns raised by specific stakeholders during previous exploration and drilling environmental impact assessments carried out by RPS Energy.

Table 3.1: Summary of previous stakeholder engagement and issues raised

Stakeholders	Issues Raised			Summary
	Argos Resources Limited (April 2011) **Exploration and Appraisal Drilling EIS (Licence PL001)**	**Borders & Southern Petroleum plc. (February 2010)** **Offshore Falkland Islands Exploration Drilling EIS (Licence PL018)**	**Falklands Oil and Gas Limited (November 2011)** **Exploration Drilling EIS (Licences PL011, 12, 26, 27, 28)**	
Falklands Islands Department of Mineral Resources	Review of FIG Oil and Gas Legislation. Argos to provide technical updates.	Borders & Southern to provide technical updates.	FOGL to provide technical updates and mitigation measures in line with DECC Guidance (July 2011).	Operator to provide mitigation measures for negative impacts.
Civil Aviation and Stanley Airport **Falkland Islands Government Air Service (FIGAS)**	MoD is integral to all aviation issues. Charter flights to the Islands can be organised.	MoD is integral to all aviation issues. Charter flights to the Islands can be organised.	Adequate aerial surveillance can be provided by FIGAS, but no dispersant spraying capability exists in the event of an oil spill.	FIGAS can provide adequate aerial surveillance in the event of an oil spill, however they have no dispersant spraying capacity (such as that comparable to the UKCS dispersant aircraft).

<table>
<tr><th rowspan="2">Stakeholders</th><th colspan="3">Issues Raised</th><th rowspan="2">Summary</th></tr>
<tr><th>Argos Resources Limited (April 2011)

Exploration and Appraisal Drilling EIS (Licence PL001)</th><th>Borders & Southern Petroleum plc. (February 2010)

Offshore Falkland Islands Exploration Drilling EIS (Licence PL018)</th><th>Falklands Oil and Gas Limited (November 2011)

Exploration Drilling EIS (Licences PL011, 12, 26, 27, 28)</th></tr>
<tr><td>Environmental Planning Department

Falklands Conservation</td><td>Collection and incorporation of updated environmental data.

Impact of drilling activities on benthic communities is currently a “hot topic” which should be considered in the EIA process.

Seabirds are the main vulnerability due to the risk of oil spills.</td><td>Seabirds are the main vulnerability due to the risk of oil spills.</td><td>Limited waste disposal capacity on the islands; only non-hazardous waste can be accepted whereas hazardous waste must be shipped to UK.

Highlighted international protection status of a number of vulnerable areas within the FI and lack of local protection measures.

Seabirds and mammals are the main vulnerability to any offshore work (through spills).

Emphasised limited capabilities for Wildlife response (Tier 1) and operator’s responsibility for arranging Tier 2/3 response.

Need for survey programmes and research on marine wildlife to improve the knowledge on baseline environment.</td><td>Environmental Planning Department:

Limited waste disposal capacity for waste, no hazardous waste can be received, it must be exported. International protection measures for a number of vulnerable areas in the Islands and current lack of local protection measures in the event of an oil spill.

Falklands Conservation:

Seabirds and marine mammals are the main vulnerability to any offshore oil and gas activities through possible oil spills, therefore oil spills are of concern. Concerns over limited capabilities of the Falkland Islands for wildlife response in the event of a pollution incident (Tier 1) and the operator’s responsibility for arranging Tier 2/3 response. The need for further survey programmes and research on marine wildlife to improve the knowledge on baseline environment has also often been mentioned.</td></tr>
</table>

Stakeholders	Issues Raised			Summary
	Argos Resources Limited (April 2011) **Exploration and Appraisal Drilling EIS (Licence PL001)**	**Borders & Southern Petroleum plc. (February 2010)** **Offshore Falkland Islands Exploration Drilling EIS (Licence PL018)**	**Falklands Oil and Gas Limited (November 2011)** **Exploration Drilling EIS (Licences PL011, 12, 26, 27, 28)**	
Department of Fisheries and Marine Resources	Notice to Mariners via Fisheries and Marine Resources, and minimal response capability for oil spills. Dispersant Use Policy.	Notice to Mariners via Fisheries and Marine Resources, and minimal response capability for oil spills.	Notice to Mariners via Fisheries and Marine Resources. Minimal response capability for oil spills. Emphasised operator's responsibility for responding to small and large spill in cooperation with other Oil & Gas operators and FIG.	Disruption to fishing activities, concerns regarding oil spills, limited capacity for responding to oil spills in the Falklands.
Department of Public Works	Waste – very limited capacity for storage, management and/or onshore processing. Recycling is an option, but very limited.	Waste – very limited capacity for storage, management and/or onshore processing. Some recycling is available but is very limited.	Waste – very limited capacity for storage, management and/or onshore processing. Some recycling is available. Water resources are scarce during dry summer months and may impose restrictions on water demands for multiple drilling operations.	Waste storage, handling and onshore processing, as the Falkland Islands have very limited waste capacity. Water resources can be scare during dry summer months and may impose restrictions on water demands.
Emergency Response: **FI Defence Force, Fire/Rescue Service, KEMH, Police Chief**	FIG Major Incident Plan. FIG National Oil Spill Contingency Plan.	National Emergency Response Plan.	National Emergency Response Plan.	Emergency plans developed by operators must take into account the Falkland Islands National Emergency Response Plan. Oil Spill Contingency Plans Developed must also take into account the National Oil Spill Contingency Plan (NOSCP).

Stakeholders	Issues Raised			Summary
	Argos Resources Limited (April 2011) **Exploration and Appraisal Drilling EIS (Licence PL001)**	**Borders & Southern Petroleum plc. (February 2010)** **Offshore Falkland Islands Exploration Drilling EIS (Licence PL018)**	**Falklands Oil and Gas Limited (November 2011)** **Exploration Drilling EIS (Licences PL011, 12, 26, 27, 28)**	
British Military Base at Mount Pleasant	Understanding military operations and resources, and communicating with the military on proposed activities.	Understanding military operations and resources, and communicating with the military on proposed activities.	Not engaged with.	Keep military informed of all proposed activities.

4 Stakeholder Identification

4.1 Introduction

In accordance with the IFC Sustainability Framework (2012) Guidance Note 1 on IFC PS1 paragraph 95, stakeholders are defined as: *"persons, groups or communities external to the core operations of a project who may be affected by the project or have interest in it. This may include individuals, businesses, communities, local government authorities, local nongovernmental and other institutions, and other interested or affected parties".*

The Falklands Islands are characterised by a relatively isolated, geographically constrained collection of communities (settlements) primarily based on East Falkland. This is reinforced by the relatively low population of the Falkland Islands which in the 2012 census (*Falkland Islands Government, 2013*) was recorded to be 3,135 people; this includes 295 persons who were classified as temporary visitors to the island. Almost all of the population lives on East Falkland (75% in Stanley) and elsewhere, with just 200 people living on West Falkland.

Due to the recent high level of oil and gas exploration activity, which was started by Desire Petroleum plc exploration drilling in February 2010, there is an established precedent of stakeholder groups who are regularly engaged for planned oil and gas activities.

4.2 Identification Process

For the purpose of the ESHIA, the process used to identify stakeholders comprised the following steps:

- Identifying individuals, groups, local communities and other stakeholders that may be affected by the project, positively or negatively, and directly or indirectly, particularly those directly and adversely affected by project activities, including those who are disadvantaged or vulnerable (*this includes representatives of the fishing, tourism industry and local residents [refer to note about Affected Communities below]*);
- Identifying broader stakeholders who may be able to influence the outcome of the project because of their knowledge about the Affected Communities or political influence over them (*this includes national regulators and public institutions who are able to influence the outcome of the ESHIA*);
- Identifying legitimate stakeholder representatives, including elected officials, non-elected community leaders, leaders of informal or traditional community institutions, and elders within the Affected Community (*for the purpose of the ESHIA this has been expanded to include representatives of civil society groups such as NGOs)*; and
- Mapping the impact zones by placing the Affected Communities within a geographic area, which should help the client define or refine the project's area of influence (*see note about Affected Communities below).*

The economic benefits derived from offshore hydrocarbon extraction have the potential to impact all the communities and residents of the Falklands Island through increased provision of social infrastructure services (such as improved road transport, and social resources such as health and educational establishments), as well as increased employment available within the oil and gas sector.

Any significant, environmental, socio-economic or health impact from the offshore oil and gas industry, (such as, for example, a large unintentional released of hydrocarbons (e.g. a blowout event) during drilling that results in an oil spill impacting the coastline and fishing industry) has the potential to directly or indirectly affect all communities and residents on the Falkland Islands. This type of impact is likely to be perceived by local communities and residents as an 'island-wide' event potentially impacting the onshore economy, the price of goods and services (such as food), the fishing and tourism industries and the farming industry. Due to the reasons outlined above, and for the purpose of the ESHIA, the communities and residents of the Falklands Islands have been considered in the SEP to comprise a single 'Affected Community'.

4.2.1 Categories of Stakeholders to be consulted

Table 4.1 describes the categories of stakeholders who will be consulted during the ESHIA process.

Table 4.1: Categories of stakeholders to be contacted

Stakeholder Group	Connection to the Project
Public institutions and regional authorities	Ministries, departments and agencies who implement legislation associated with planning and approval for oil and gas exploration activities, statutory agencies associated with environmental protection or that have a role in the project planning and approval process. The Governor of the Falkland Islands and functional departments within the administration with regulatory responsibilities delegated from the Falkland Islands Government (FIG) that are relevant to the project planning and approval process.
Local businesses	Private companies with interest in the Falkland Islands whose business may be impacted by the proposed exploration drilling activities. Service companies that are relevant to the project (including for example, logistics support).
Users of the sea	People and businesses reliant on the quality of the sea and seashore for fishing, recreational activities, and tourism.
Affected Communities	The communities and residents on the Falkland Islands who collectively, represent a single Affected Community that may potentially be impacted (either directly or indirectly) by various aspects of the proposed exploration drilling activities. This includes disadvantaged people and/or vulnerable groups.
Local, national and international environmental NGOs and research institutions	Organisations with interests in sustainability and the environment, who aim to represent the views and interests of their members and/or the general public with regards to exploration drilling activities.

4.2.2 Stakeholder Identification

The identities of stakeholders who will be engaged with during the ESHIA are presented in Table 4.2.

Table 4.2: Stakeholders to be engaged with during the ESHIA process

Stakeholder Identity	Stakeholder profile and justification for Inclusion into the SEP
Public institutions and regional authorities	
Falkland Islands Department of Mineral Resources	Government department responsible for providing exploration and production licences for oil and gas activities within the Falkland Islands Designated Exploration Area. Expected to have updated recent socio-economic data associated with fishing activity.
Falklands Islands Environmental Planning Department	Government department responsible for town planning, building and the environment, including waste management. The department also administers the Mineral Resources Committee.
British Military Base at Mount Pleasant	Centre of military defence in the Falkland Islands. There is a potential for the project to interfere with planned, or ongoing, military operations within the offshore blocks. The military must also be kept informed of any proposed oil and gas activity.
Civil Aviation and Stanley Airport and Falkland Islands Government Air Service (FIGAS)	Government-operated airline that provides regular military and passenger services between the Falkland Islands and the UK. Can provide aerial surveillance in the event of an offshore oil spill response that may be implemented in the event of a major unintentional hydrocarbon release during the project.
Falkland Islands Fisheries Department	Government department responsible for the sustainable development of the fisheries occurring within the waters of the Falkland Conservation Zones (FCZs). Details about how a marine notice to mariners can be issued are required, as this comprises a key mitigation measure associated with avoiding marine accidents and vessel collisions.
Falkland Islands Public Works Department	Responsible for the provision of services in the Falkland Islands which include, but are not limited to, waste management infrastructure. The project will generate quantities of non-hazardous and hazardous waste.
The Royal Falkland Islands Police	Responsible for the development and implementation of the Falkland Island National Oil Spill Response Plan that may be implemented in the event of a major incident during the project.
Falkland Islands Tourist Board	Government department responsible for the management and promotion of tourism activities on the Falkland Islands.
The UK Joint Nature Conservation Committee (JNCC)	Public body that advises the UK Government and devolved administrations on UK-wide and international nature conservation. Originally established under the *Environmental Protection Act 1990*, JNCC was reconstituted by the *Natural Environment and Rural Communities (NERC) Act 2006*.
Users of the sea	
Falkland Islands Fishing Companies Association (FIFCA)	An organisation that aims to jointly represent the business interests of companies involved in fishing activities. Information on the location, type and intensity of fishing activities within the offshore blocks is required.
Falkland Islands Yacht Club	Formed in 2010 to promote boating activities in the Islands and aims to represent the interests of the recreational boating community. Information on the location, type and intensity of recreational sailing within the offshore blocks is required.
Affected Communities	
Affected Community of the Falkland Islands	The communities and residents of the Falkland Islands. Taking consideration of the views and opinions of Affected Communities in the decision making process is an IFC requirement.
Local, national and international environmental NGOs and research institutions	
Falklands Conservation	An NGO working to protect all the wildlife in the Falkland Islands for future generations. Undertakes practical conservation projects, surveys and scientific studies, conducts annual monitoring of seabird populations, rescues wildlife in trouble, publishes guides and information on many aspects of the Falkland Islands environment, and involves islanders of all ages in its activities. May have recent environmental data that is of relevance to the ESHIA.
Shallow Marine Surveys Group (SMSG)	Local organisation that exists to coordinate and conduct assessments of the status of inshore resources around the Falkland Islands. Headed by a core group of experienced biologists, divers and assisted by volunteers from the local community, they have been collecting, identifying and photographing marine animals since June 2006. May have recent environmental data that is of relevance to the ESHIA.
South Atlantic Environmental Research Institute (SAERI)	Locally active academic organisation conducting scientific research in the South Atlantic from the tropics down to the ice in Antarctica. SAERI's remit includes the natural and physical sciences. Aims to conduct world class research, teach students, and build capacity within and between the South Atlantic Overseas Territories. May have recent environmental data that is of relevance to the ESHIA.
New Island Conservation Trust	Locally active NGO that aims to promote the study and appreciation of ecology and wildlife conservation throughout the Falkland Islands, and to assist in developing plans for the management and conservation of its exceptional natural environment for the future. May have recent environmental data that is of relevance to the ESHIA.
Birdlife International	Global partnership of conservation organisations that strives to conserve birds, their habitats and global biodiversity, working with people towards sustainability in the use of natural resources. May have recent environmental data that is of relevance to the ESHIA.

This page is intentionally blank

5 Stakeholder Engagement Programme

Stakeholder engagement activities will take place at the following key stages of the ESHIA process: During ESHIA Scoping, content development of the ESHIA Scoping Report and content development of the ESHIA.

5.1 ESHIA Scoping

The way in which stakeholders will be engaged with during ESHIA Scoping is summarised in Table 5.1.

Table 5.1: Stakeholders to be engaged with during ESHIA Scoping

<table>
<tr><th>Stakeholder Name</th><th>Format to be used for Engagement</th><th>Materials to be Disclosed</th><th>Method used to Record Results</th></tr>
<tr><td>Falklands Islands Department of Mineral Resources</td><td rowspan="8">Initial contact made by e-mail.

A formal meeting held individually at their office.</td><td rowspan="10">A 4-page summary of the project will be sent to the stakeholder as an attachment to the initial e-mails.

During the meetings, a large-scale, annotated, UK Hydrographic Office Admiralty Chart will be used to identify the project area.</td><td rowspan="10">ESHIA Scoping Consultation Record. A copy of the template to be used is provided in Appendix A.</td></tr>
<tr><td>Falkland Islands Environmental Planning Department</td></tr>
<tr><td>British Military Base at Mount Pleasant</td></tr>
<tr><td>Civil Aviation and Stanley Airport and Falkland Islands Government Air Service (FIGAS)</td></tr>
<tr><td>Falkland Islands Fisheries Department</td></tr>
<tr><td>Falkland Islands Public Works Department</td></tr>
<tr><td>The Royal Falkland Islands Police</td></tr>
<tr><td>Falkland Island Tourist Board</td></tr>
<tr><td>Falkland Islands Fishing Companies Association</td><td rowspan="2">Initial contact made by e-mail.

A combined meeting.</td></tr>
<tr><td>Falkland Island Yacht Club</td></tr>
<tr><td>The UK Joint Nature Conservation Committee (JNCC)</td><td rowspan="2">Formal letter.</td><td rowspan="2">A 4-page summary of the project will be sent to the stakeholder as an attachment to the letter.</td><td rowspan="2">The stakeholder's written response will be filed.</td></tr>
<tr><td>BirdLife International</td></tr>
<tr><td>Falklands Conservation</td><td rowspan="5">Initial contact made by e-mail.

A round-table meeting will be held with all stakeholders on the same day.</td><td rowspan="5">A 4-page summary of the project will be sent to the stakeholder as an attachment to the e-mails.

During the meetings, a large-scale, annotated, UK Hydrographic Office Admiralty Chart will be used to identify the project area.</td><td rowspan="5">ESHIA Scoping Consultation Record. A copy of the template to be used is provided in Appendix A.</td></tr>
<tr><td>Birdlife International</td></tr>
<tr><td>Shallow Marine Surveys Group (SMSG)</td></tr>
<tr><td>South Atlantic Environmental Research Institute (SAERI)</td></tr>
<tr><td>New Island Conservation Trust</td></tr>
<tr><td>Affected Community of Falkland Island</td><td>A single, 3-hour focus group discussion (refer to Section 5.1.1).</td><td>PowerPoint slides to provide a summary of the project.</td><td>Formal minutes of meeting.</td></tr>
</table>

5.1.1 Focus Group Discussion

A single, 3-hour focus group discussion (FGD) will be held with 12-15 people during ESHIA Scoping. The aim of the FGD is to gather a collection of local residents who can provide their views and opinions on the project in a transparent and semi-formal environment, at an early stage in the impact identification and evaluation process. In order to achieve a representative group of the Falkland Island Affected Community, the following selection criteria and targets will be used for the individuals attending:

- Gender - with the aim of achieving a male/female ratio of at least 60:40 so that the views and interests of women are adequately represented;
- Age - so that both young people and the elderly are adequately represented;
- Vulnerability - so that any individuals or groups who may be proportionally disadvantaged by the project are adequately represented;
- Representatives of educational establishments such as teachers or educational professionals; and
- Location - individuals from West Falkland will be specifically invited to attend, particularly those involved in farming activities.

In order to facilitate the FGD, RPS will provide suitable hotel facilities, refreshments and a positive, relaxed atmosphere. The FGD will be facilitated by an experienced RPS professional.

5.2 Content of the ESHIA Scoping Report

The way in which stakeholders will be engaged with using the content of the ESHIA Scoping Report is summarised in Table 5.2.

Table 5.2: Stakeholders to be engaged with, using the ESHIA Scoping Report

Stakeholder Name	Format to be used for Engagement	Materials to be Disclosed	Method used to Record Results
Falklands Islands Department of Mineral Resources	Electronic exchange of report.	Electronic copy of the ESHIA Scoping Report.	The stakeholder's written response will be filed.
Falklands Islands Environmental Planning Department			
British Military Base at Mount Pleasant			
Civil Aviation and Stanley Airport and Falkland Islands Government Air Service (FIGAS)			
Falkland Islands Fisheries Department			
Falkland Islands Public Works Department			
The Royal Falkland Islands Police			
Falkland Island Tourist Board			
Falkland Islands Fishing Companies Association			
Falkland Island Yacht Club			
The UK Joint Nature Conservation Committee (JNCC)			
Birdlife International			
Falklands Conservation			
Shallow Marine Surveys Group (SMSG)			
South Atlantic Environmental Research Institute			
New Island Conservation Trust			
Affected Community of Falkland Island	(none)		

5.3 Content of the ESHIA

The way in which stakeholders will be engaged with using the content of the ESHIA is prepared is summarised in Table 5.3.

Table 5.3: Stakeholders to be engaged with, using the ESHIA

Stakeholder Name	Format to be used for Engagement	Materials to be Disclosed	Method used to Record Results
Falklands Islands Department of Mineral Resources	Electronic and/or hardcopy exchange of report.	Electronic and/or colour hard copy of the ESHIA.	The stakeholder's written response will be filed.
Falklands Islands Environmental Planning Department			
British Military Base at Mount Pleasant			
Civil Aviation and Stanley Airport and Falkland Islands Government Air Service (FIGAS)			
Falkland Islands Fisheries Department			
Falkland Islands Public Works Department			
The Royal Falkland Islands Police			
Falkland Island Tourist Board			
Falkland Islands Fishing Companies Association			
Falkland Island Yacht Club			
The UK Joint Nature Conservation Committee (JNCC)			
Birdlife International			
Falklands Conservation			
Shallow Marine Surveys Group (SMSG)			
South Atlantic Environmental Research Institute			
New Island Conservation Trust			

Stakeholder Name	Format to be used for Engagement	Materials to be Disclosed	Method used to Record Results
Affected Community of Falkland Islands (including the public).	42 calendar day public consultation process. 2 separate day walk-in sessions.	Notice placed in the Falkland Islands Gazette indicating the availability of the ESHIA. A radio announcement advertising the availability of the ESHIA will be made on the start date of the public consultation period via the local radio service. All announcements made in the Falkland Island Gazette and radio will inform the public about their right to make a representation, how this should be done and the applicable closing date. An electronic copy of the ESHIA and non-technical summary may (at the discretion of the Governor) be available on the FIG website/other websites during the consultation period. Colour hard copy of the ESHIA and non-technical summary will be available for inspection at the public library in Stanley (and other locations if the Governor directs) for review throughout the consultation period during normal government office hours Additional hard/electronic copies of the ESHIA and non-technical summary will be available to any member of the public who requests it, without charge or undue delay during the consultation period.	Comment forms. Written submission to the Governor or other public institution.

6 Engagement Timescale

The time schedule for the engagement that will take place during the ESHIA is provided in Table 6.1.

Table 6.1. Time schedule for stakeholder engagement

ESHIA Stage	*Indicative Schedule*
ESHIA Scoping Consultation	*29th July 2013 to 13th September 2013*
ESHIA Scoping Report	*6th May to 20th May 2014*
ESHIA	*Public consultation will take place for 42 days following submission.*

7 Internal & External Roles & Responsibilities

In relation to implementation of the SEP, RPS will be responsible for the following:

- The initial preparation of the SEP and any subsequent updates;
- Day-to-day coordination of all stakeholder engagement activities;
- The practical and logistical organisation of all stakeholder engagement activities including contacting stakeholders to arrange meeting times/locations;
- The preparation and issuing of all stakeholder engagement invitation letters by e-mail;
- The preparation of all stakeholder engagement disclosure materials which includes e-mails, PowerPoint slides, public advertisements, and the ESHIA Scoping Report and the ESHIA;
- Actions associated with the use of the Community Feedback Mechanism in close liaison with representatives from Noble;
- Attendance/facilitation of all stakeholder engagement meetings/discussions, including hotel conference room meetings, and the recording of all results and issues raised;
- Placement of the advertisement in the Falklands Island Gazette and The Penguin News at the start of the 42 days public consultation process; and
- The printing of all stakeholder engagement disclosure materials, including hard-copies of the ESHIA Scoping Report and hard-copies of the ESHIA for public consultation.

Noble is responsible for the following:

- Review and approval of the SEP and any subsequent updates;
- The approval of all stakeholder engagement disclosure materials, prior to their use; and
- Actions associated with the use of the Community Feedback Mechanism in close liaison with RPS.

8 Noble Energy Community Feedback Mechanism

A dedicated local telephone number and e-mail address have been set up for the Falkland Islands community to provide feedback directly to Noble:

- Phone line: +500 22986
- Email address: FalklandsSocialResponsibility@nobleenergyinc.com

The feedback mechanism is to be used by any party to raise any concerns, questions or complaints associated with the project at any stage of the project lifecycle.

9 Monitoring & Reporting

During the implementation of the SEP, stakeholder engagement activities and results will be closely recorded with the aim of improving the overall process of engagement over time.

For example, after each formal meeting at the start of the ESHIA Scoping Phase, an internal discussion will be held to review the success of the meeting and the way in which information was disclosed to try and improve on the overall performance of engagement, during subsequent meetings.

In the event that a grievance is received on the way in which stakeholder engagement activities are being conducted, all activities may temporarily cease until the grievance is resolved.

10 References

Department of Mineral Resources (2012), Guidance Notes on the Production of Offshore Environmental Impact Statements for Field Developments, Paper 158/12, 27th June 2012.

Equator Principles (2013), The Equator Principles (EP) III, 4 June 2013, [internet], available: <http://www.equator-principles.com/index.php/ep3/ep3>.

Falklands Islands; The Offshore Minerals Ordinance 1994 (No. 16 of 1994), published in the FI Gazette Vol. 5, No. 28, 9th December 1994.

Falkland Islands; The Offshore Minerals (Amendment) Ordinance 2011, (No. 10 of 2011).

Falkland Islands Government (2013), Falkland Islands Census 2012: Statistics and Data Tables, Falkland Islands Government Policy Unit, April 2013.

International Finance Corporation (IFC) (2007), International Finance Corporation Environmental, Health and Safety Guidelines, [internet], available: <http://www.ifc.org/wps/wcm/connect/Topics_Ext_Content/IFC_External_Corporate_Site/IFC+Sustainability/Sustainability+Framework/Environmental,+Health,+and+Safety+Guidelines/>.

International Finance Corporation (IFC) (2012), International Finance Corporation 2012 Performance Standards and Guidance Notes, [internet], available: <http://www.ifc.org/wps/wcm/connect/Topics_Ext_Content/IFC_External_Corporate_Site/IFC+Sustainability/Sustainability+Framework/Sustainability+Framework+-+2012/Performance+Standards+and+Guidance+Notes+2012/>.

noble energy

APPENDIX A: ESHIA Scoping Template Consultation Record

<table>
<tr><td>Stakeholder Name:</td><td></td><td>Attendance / Representatives name:</td><td></td></tr>
<tr><td>Date and Time (start/end):</td><td></td><td>Location:</td><td></td></tr>
<tr><td>Specific objectives of consultation:</td><td colspan="3"></td></tr>
<tr><td colspan="4" align="center">Record of Information Disclosed</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4" align="center">Scoping results – key areas of stakeholder concern</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4" align="center">Baseline data</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4" align="center">Influence on content of ESHIA</td></tr>
<tr><td colspan="4"></td></tr>
</table>

APPENDIX B: Stakeholder Contact Information

Stakeholder	Website	Main contact and email address:	Tel/ Fax	Postal address:
Falkland Islands Government Department of Mineral Resources:	http://www.bgs.ac.uk/falklands-oil/	Steve Luxton; sluxton@mineralresources.gov.fk Roberto Cordiero; RCordeiro@mineralresources.gov.fk	T: +500 27322 F: +500 27321	Department of Mineral Resources, Falkland Islands Government, Government House, Ross Road, Stanley, Falkland Islands FIQQ 1ZZ.
Falkland Islands Government Environmental Planning Department	http://www.epd.gov.fk/	Nick Rendell (Environmental Officer) NRendell.planning@taxation.gov.fk epdfig@mail.com	T: +500 28480 F: +500 27391	Environmental Planning Department, Falkland Islands Government, Government House, Ross Road, Stanley, Falkland Islands FIQQ 1ZZ.
British Military Base at Mount Pleasant	http://www.raf.mod.uk/currentoperations/opsfalklands.cfm	Roy Smith (Environmental Officer) hqtepo@MOUNTPLEASANT.mod.uk	+500 76845 (Mobile: +500 76049)	Ministry of Defence, Mount Pleasant Airbase, Darwin Road, Falkland Islands FIQQ 1ZZ
Civil Aviation and Stanley Airport and Falkland Islands Government Air Service	*No website*	Jan Ross jross@figas.gov.fk	+500 27219	FIGAS, Port Stanley Airport, Airport Road, Port Stanley, Stanley, Falkland Islands FIQQ 1ZZ.
Falkland Islands Government Department of Natural Resources - Fisheries Department	http://fis.com/falklandfish/	John Barton (Director of Fisheries) director@fisheries.gov.fk Dr. Paul Brewin (Scientific Officer) PBrewin@fisheries.gov.fk	T: +500 27260 F: +500 27265	Falkland Islands Fisheries Department, PO BOX 598, Stanley, Falkland Islands FIQQ 1ZZ.
Falkland Islands Public Works Department	http://www.falklands.gov.fk/	Manfred Keenleyside (Director of Public Works) admin@pwd.gov.fk	T: +500 27193 F: +500 27191	Falkland Islands Public Works Department, Falkland Islands Government, Government House, Ross Road, Stanley, Falkland Islands FIQQ 1ZZ.
Attorney Generals Chambers	http://www.crownofficechambers.com/	Alison Carter CrownCounsel@sec.gov.fk Mark Lewis MLewis@sec.gov.fk	T: +500 28461	-

Stakeholder	Website	Main contact and email address:	Tel/ Fax	Postal address:
Royal Falkland Islands Police	http://www.falklands.gov.fk/	Barry Marsden (Director of Emergency Services, Chief Police Officer and Principal Immigration Officer). Lisa Martin (Secretary) LMartin@police.gov.fk	T: +500 28100 F: +500 28110	Royal Falkland Islands Police Headquarters, Ross Road, Stanley, Falkland Islands FIQQ 1ZZ.
Falkland Islands Tourist Board	http://www.falklandislands.com/	Tony@falklandislands.com	T: +500 22215	Falkland Islands Tourist Board, Jetty Visitor Centre, PO BOX 618, Stanley, Falkland Islands FIQQ 1ZZ.
Stanley Services	http://www.stanley-services.co.fk/	Robert Rowlands rrowlands@stanley-services.co.fk	T: +500 22622 F: +500 22623	Stanley Services Limited, Airport Road, P.O Box 117, Stanley, Falkland Islands FIQQ 1ZZ
Falkland Islands Company	http://www.the-falkland-islands-co.com/	Roger Spink rks@fic.co.fk	T: +500 27600 F: +500 27603	-
UK Joint Nature Conservation Committee (JNCC)	http://jncc.defra.gov.uk/page-4402	Anne Saunders (UK South Atlantic Overseas Territories Officer). Anne.Saunders@jncc.gov.uk	-	Joint Nature Conservation Committee, P.O. Box 585, Stanley, Falkland Islands, FIQQ 1ZZ.
Falkland Islands Harbour Master / Port Authority	-	Malcolm Jamieson MJamieson@fisheries.gov.fk	-	-
Falkland Islands Fishing Companies Association (FIFCA)	*No website*	Andy Pollard (Secretary). fifca@horizon.co.fk	T: +500 22317	PO Box 664, Room 11, Stanley Services, By-Pass Road, Stanley, Falkland Islands FIQQ 1ZZ.
Falkland Islands Yacht Club (FIYC)	http://www.falklandsailing.com/index.html	Tony Blake (Chair – Falkland Islands Yacht Club Committee). sailing@horizon.co.fk Ken Passfield kenpassfield@yahoo.co.uk	-	-
Falklands Conservation	http://www.falklandsconservation.com/	Dr. David Doxford (Chief Executive Officer) ceo@conservation.org.fk Andrew Stanworth CO@conservation.org.fk	T: +500 22247 F: +500 22288	Falklands Conservation, Jubilee Villas, Ross Road, Stanley, Falkland Islands FIQQ 1ZZ. (UK contact: Sarah Brennan, Tel: 01767 650 639).

Stakeholder	**Website**	**Main contact and email address:**	**Tel/ Fax**	**Postal address:**
Shallow Marine Surveys Group	http://smsg-falklands.org/	Paul Brickle (Fisheries Biologist / Marine Ecologist). pbrickle@smsg-falklands.org	T: +500 27260	Shallow Marine Surveys Group, PO Box 598, Stanley, East Falkland, Falkland Islands FIQQ 1ZZ.
South Atlantic Environmental Research Institute (SAERI)	http://www.south-atlantic-research.org/	Paul Brickle (Fisheries Biologist / Marine Ecologist). pbrickle@env.institute.ac.fk	T: +500 27374	PO Box 609, Stanley Cottage, Stanley, Falkland Islands FIQQ 1ZZ.
New Island Conservation Trust	http://www.falklandswildlife.com/	Phyl Rendell phylrendell@horizon.co.fk	-	New Island Conservation Trust, The Dolphins, Snake Hill, Stanley, Falkland Islands FIQQ 1ZZ.
Beaver Island Land Care	-	Sally Poncet sallyponcet@horizon.co.fk	-	-
Birdlife International	http://www.birdlife.org/worldwide/national/falkland_islands/	Professor John Croxall (Chair BirdLife International Global Seabird Programme). John.Croxall@birdlife.org	-	*As per Falklands Conservation.*
Rural Business Association	-	Nyree Heathman rba@horizon.co.fk	-	-

Appendix K: FISA12 Environmental Baseline Survey Report

Client | Contractor

Project: **Noble Energy Falklands Limited**

FINAL

NOBLE ENERGY; SOUTH FALKLANDS BASIN ENVIRONMENTAL AND GEOCHEMICAL PROGRAM
December 2013 – March 2014

FISA ENVIRONMENTAL BASELINE AND HABITAT SURVEY REPORT

MG3 Document No. Vol 3 FISA_EBS_Report_Rev3.Docx.Docx

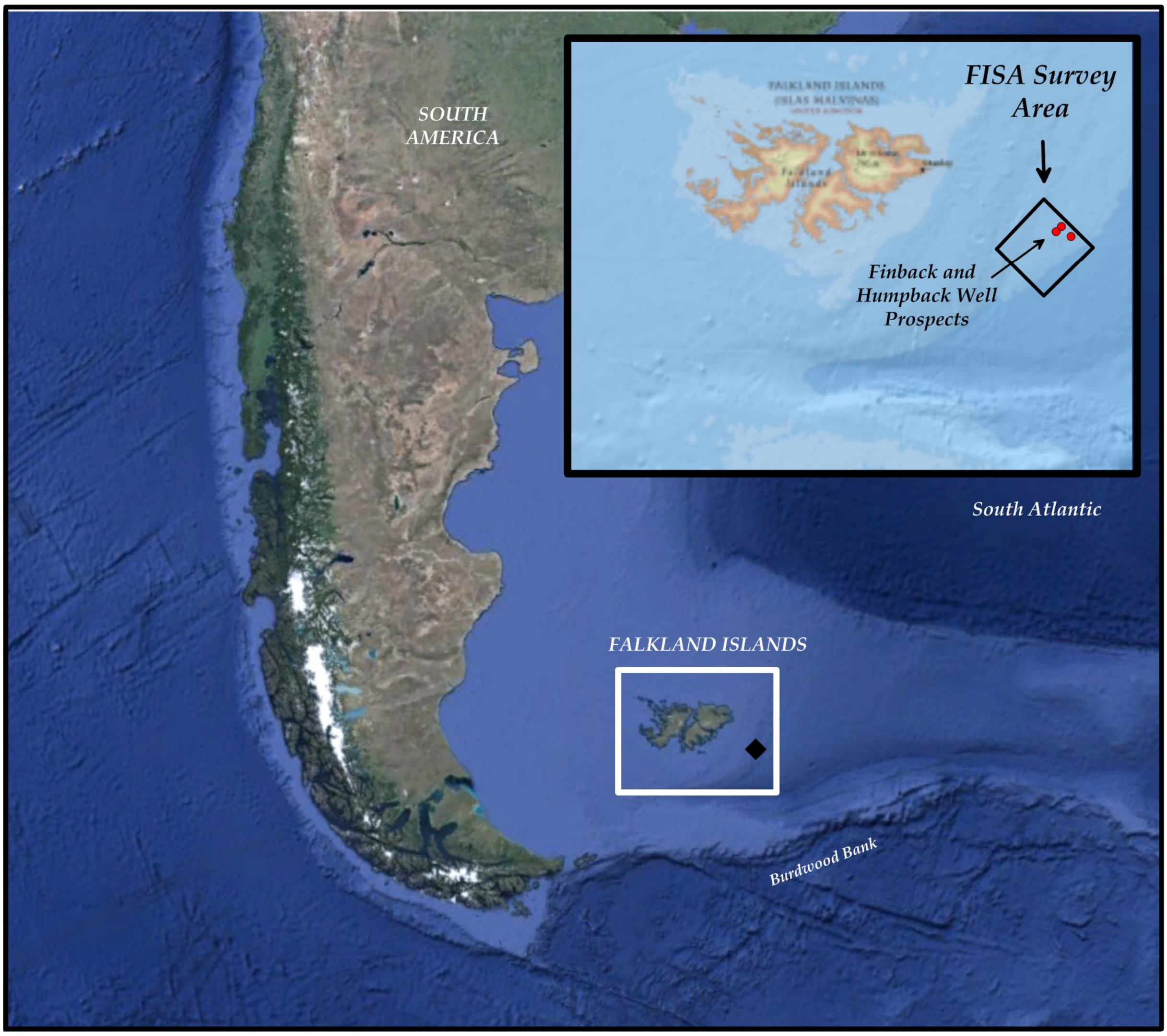
3	08/01/2015	Further reissue with regulator comments	HL	SJA	NCA
2	18/09/2014	Reissue to client following comments	HL	SJA	NCA
1	22/08/2014	Issued to client	HL	SJA	NCA
Rev	Date	Reason for Revision	Prepared	Checked	Approved

DOCUMENT AUTHORISATION AND DISTRIBUTION

Document Authorisation and Distribution			
Client	Noble Energy Falklands Limited		
FAO	Fraser Johnston		
Document Ref.	Vol 3 FISA_EBS_Report_Rev2.Docx		
Title	FISA Environmental Baseline and Habitat Survey Report		
Authors	Hung Liu	Date	: 08/01/2015
Checked	Ian Wilson	Date	: 18/09/2014
Prepared By:	MG3 (Survey) UK Ltd The Chantry 34 High Street Warminster United Kingdom Tel. +44 (0) 1985 215 734	Benthic Solutions Limited Elanco Works, Marsh Road, Hoveton, United Kingdom Tel: +44 (0) 1603 784726	

	DOCUMENT	ISSUED TO
Authorised Copies	Original	Client
	Copy No. 1	MG3

LOCATION MAP



CONTENTS

LOCATION MAP
CONTENTS PAGE
GLOSSARY
EXECUTIVE SUMMARY

FIGURES

TABLES

GLOSSARY

BDC	Biodiversity Committee
Bedform	Morphology of the seabed created by currents (i.e. ripples)
Bioherm	Mound or rock composed mainly of sedentary organisms (i.e. corals, algae, or molluscs) and surrounded by rock of different origin
Bioturbation	Reworking of surface sediments by marine benthos
Box Corer (BC)	Type of seabed sampler (0.25m^2 surface area)
BSL	Benthic Solutions Limited
Burdwood Bank	A large Bank approximately 200m in depth, part of the Scotia Arc projecting approximately 600km from Cape Horn 200km south of the Falkland Islands
CBD	Convention on Biological Diversity
CCAMLR	Convention on the Conservation of Antarctic Marine Living Resources
CITES	Convention on International Trade in Endangered Species
Clast	Large fragment of rock, typically pebble through to boulder in size
Drop stones	Drop stones are gravel sized rock found in sedimentary material deposited on the sea floor by glacial activity and ice rafting
EBS	Environmental Baseline Survey report
EHD	European Habitats Directive (92/43/EEC)
EOL	Camera end of line
Finback-1	Proposed exploration well site
FISA	Falkland Island South Area, encompassing proposed Humpback-1 and Humpback-2 well location
FCO	Falkland Islands Constitution
HC	Hydrocarbons (saturates and polycyclic aromatics)
HCl	Hydrogen Chloride
HM	Heavy and trace metals
HSG	Headspace gas
Humpback-1 & 2	Proposed exploration well site
Vinson	Historical well location and survey in the south of FISA
IMS	Industrial Methylated Spirit
IUCN Red List	International Union for the Conservation of Nature Red List of Threatened Species
lebensspuren	Evidence of life in the sediment (i.e. animal tracks, burrows etc.)
LPH	Liquid phase hydrocarbons
MDAC	Methane derived authigenic carbonate
MEA	Multi-lateral environmental agreements
MG3	MG3 (Survey) Limited
MPOG	Microbial prospecting for oil and gas
MSL	Mean Sea Level
Natura 2000	Habitats designated for protection under the European Habits Directive
OSPAR	Oslo-Paris Commission
PSA	Particle size analysis
Red List Codes	Extinct (EX), extinct in the wild (EW), regionally extinct (RE), critically endangered (CR), endangered (EN), vulnerable (VU), near threatened (NT) or data deficient (DD).
SAC	Special Areas of Conservation
SOL	Camera start of line
SPA	Special Protection Areas
SS.SSa.OSa	Offshore circalittoral sand (UK JNCC Habitat Classification)
CR.LCR	Low energy circalittoral rock (UK JNCC Habitat Classification)
TOC	Total organic carbon

EXECUTIVE SUMMARY

A regional environmental survey was carried out within the FISA prospect area of the South Falklands Basin for Noble Energy Falklands by MG3 (Survey) Limited and their subcontractor Benthic Solutions Limited (BSL) in December, 2013 to March, 2014. The FISA site is located to the east of the Falklands Islands, covers an area of approximately 80km x 70km and surrounds two proposed well locations (Humpback-1 and Humpback-2) located within the northeast of the survey area.

The water depth within the FISA survey area varied from approximately 950m to 1650m. A regional habitat assessment was undertaken using a combination of acoustic and environmental ground truthing techniques. This was reviewed onboard in order to interpret the potential for environmentally sensitive habitats within the survey area. Field ground truthing was undertaken using a combination of high resolution seabed imagery and seabed sampling using different sampling devices.

The survey data revealed four general seabed types within the FISA survey area. The dominant sediment type in the north and west was relatively homogeneous, slightly gravelly, silty sand associated with some Holocene sedimentary material over a glacial sediment. In the deeper water to the south and east, the proportion of gravels increased at the surface becoming a non-depositional, gravelly, silty sand. Separating these two areas in the central part of the survey area is a complex bathymetry indicative of an irregular escarpment running from the southwest to the northeast. The sediments here have been interpreted as steep-sloped exposures of low energy bedrock or a hard underlying formation. The remaining sediment type is represented by an intermediate habitat type, marking the transition from homogeneous sands to the rock outcrops. This is also the dominant sediment type along the top of the escarpment. This sediment lies at a depth of 1150m above another sub-cropping geological feature which runs in a northeast-southwest orientation across the length of the survey area.

Environmental baseline sampling undertaken within the FISA regional survey area involved the collection of seabed photography from 34 stations, with 26 stations further analysed for physico-chemical and biological macro-invertebrate properties. In line with the general habitat variations recorded across the survey area, the particle size analysis showed some variation in the different proportions of sands, fines (below 63µm) and gravels (>2mm) with sediments ranging from sandy mud and muddy sand through to a gravelly sand, but with the dominant sediment type comprising slightly gravelly muddy sand as denominated by the Folk characterisation (Folk, 1954). The mean particle size ranged from 45µm to 354µm, demonstrating the slightly elevated proportions of silts and clays at two sites and gravels at four sites. The mean proportion of gravels was typically around 7%, but elevated levels between 16% and 27.3% were recorded at the four stations.

Only two locations recorded a proportion of fines greater than 50%, with a peak of 66.7% recorded at station A/26/ENV, which is the same location as an earlier proposed Finback well prospect. The mean proportion of sediment fines was 32%. In FISA, the majority of softer sediments were recorded above the escarpment feature north and west of the proposed well locations.

The physico-chemistry results for total organic carbon (TOC), total hydrocarbon content (THC) and saturates all showed relatively low background concentrations. THC concentrations gave a mean of

$3.1\mu g.g^{-1}$, whilst alkanes recorded a mean of $313ng.g^{-1}$, approximately 10% of the total THC recovered. Inspection of the individual gas chromatograms at all stations revealed no background fingerprints relating to anthropogenic or petrogenic sources. Analysis of alkanes revealed a predominance of marine related saturates indicative of an offshore site influenced by Antarctic water masses, whilst polycyclic aromatic hydrocarbons (PAHs) recorded only low concentrations of pyrolytic origin. A review, however, of the lighter 2-3 ring PAHs represented by naphthalene, phenanthrene and dibenzothiophene (NPD) and a higher proportion of alkylated PAHs throughout the full range of PAHs, suggests that the site is influenced by very small chromic input from petrogenic origin, albeit at a trace level. This could be the result of migrated thermogenic material relating to a natural hydrocarbon seep in the general vicinity. A similar phenomenon was recorded at neighbouring sites to the south and west as previously recorded within the region (Toroa and Burdwood Bank). Overall total PAH concentrations (2-6 compounds) recorded a mean of $82.8ng.g^{-1}$ whilst the mean of the NPD fraction is $43.8ng.g^{-1}$.

The concentrations of total heavy and trace metals were consistent with historical surveys recorded within the area. The distribution of the metals often correlated with themselves (with other metals) and occasionally other sediment factors. The most obvious of these was that of aluminium (Al) which exhibited a strong correlation with % gravels and sorting coefficient. Iron recorded a huge variability across the survey area ranging from $10.7mg.g^{-1}$ to $135mg.g^{-1}$, interpreted as a function of residual glacial materials of volcanic origin reworked by the currents in many areas. Arsenic (As) showed a close correlation with iron (Fe), albeit at a modest concentration ranging from $3.2\mu g.g^{-1}$ to $12.3\mu g.g^{-1}$. For cadmium (Ca) and mercury (Hg) only trace levels were recorded, whilst the means for lead (Pb), barium (Ba), chromium (Cr), nickel (Ni), copper (Cu), vanadium (V) and zinc (Zn) all gave background concentrations.

Multiple water column profiles and discrete water samples confirmed a consistent water column with limited vertical structure. Temperature varied from around 6.70°C at the surface to around 2.60°C at 1432m. A broad array of analytes relating to water chemistry (metals, nutrients, hydrocarbons etc.) at discrete depths throughout the water column generally recorded trace or undetectable concentrations at all sites and depths sampled.

Macrofaunal analysis was carried out on all 59 replicates obtained from the 26 baseline sediment sites. Macrofaunal taxonomy identified a total of 2,874 individuals and 254 species, with 188 comprising infauna, dominated by small polychaetes and crustaceans. In rank order, the top five key dominant species consisted of the polychaete *Rhamphobrachium (Spinigerium) ehlersi*, the crustacean *Ampelisca,* the polychaete *Gymnonereis fauveli*, followed by a Copepoda and the polychaete and *Apistobranchus* sp I. Whilst the deep water coral *Lophelia pertusa* was recorded in the samples, all incidents were of relic debris with no live animals recovered. Camera operations, however, did identify small live examples of this species, but of morphology insufficient to be considered as an Annex I habitat under the European Habitats Directive, or the OSPAR list of threatened habitats. Also of note from the macrofaunal samples were a group of solitary corals (*Flabellum* sp.) and a very rare mollusc of the group Monoplacophora *(Neopilina).* Only about 150 specimens have ever been found worldwide, belonging to about 25 species. Univariate analysis of the data showed that the species richness and abundance were similar to previous surveys in the area by surface area, whilst multivariate analysis indicated no clear separation of faunal populations, based on geographical location, sediment type or other environmental factors.

In addition to the infaunal community, the qualitative presence of the epifaunal community was reviewed from the seabed samples and photographed, and provided a rich faunal assemblage, especially in areas where drop-stones were common. Key faunal groups included sponges (classes Hexactinellida, Calcarea and Demospongiae) and Cnidaria which were represented by nine genera of thecate and athecate Hydrozoa and two genera of Stylasteridae. Furthermore, solitary corals belonging to the species *Flabellum curvatum* (a potential CITES Appendix II coral species) and several Octocorallia including the sea pens Pennatulidae and two species of Gorgonacea were identified. Bryozoa were also very common constituents on pebbles and stones, with many species endemic.

The remainder of the survey area did not yield any evidence of particularly sensitive habitats, especially within the immediate vicinity of the proposed exploration wells. The habitats in these areas were considered to be homogenous, gravelly or slightly gravelly silty sands with limited sensitivity to the proposed operations.

A review process was completed at the Natural History Museum (NHM) to assess nomenclature and species identification prior to the finalisation of the taxonomic species list included in this report. This is discussed in further detail in Appendix II, Section II.5.2.

Incidental to the environmental baseline datasets, the MG3 were contracted to conduct an additional wreck investigation within the FISA survey area using acoustic survey equipment already installed on the hull of the survey vessel. This was to locate the two First World War wrecks, *SMS Scharnhorst* and *SMS Gneisenau*, which were believed to lie within or in close proximity to this study area. However, after an extensive survey of approximately 30km x 45km no conclusive evidence was found to verify the locations of the wrecks. This is thought to be due to the limitations of the available survey equipment for these water depths and the uncertainty of the actual positions.

1 INTRODUCTION AND SCOPE OF WORK

1.1 GENERAL

In December 2013 Noble Energy Falklands Limited commissioned MG3 to carry out a field environmental survey over a regional area of the South Falklands Basin, encapsulating several prospect areas. This included analysis and interpretation of benthic sample data acquired during the field acquisition program. Field operations were undertaken from the MG3 managed Icelandic survey vessel *MV Poseidon*, using a combination of a deep water camera system and seabed sampling devices. Sampling was undertaken at a total of 34 stations for the FISA survey area relating to sites selected for ground truthing specific bathymetric features and to maintain a good geographical coverage over the prospect area.

1.2 SCOPE OF WORK

Sampling aimed to maximise the knowledge of the region as a whole, so as to provide a context for individual sites and habitats. This includes the proposed well locations Finback-1, Humpback-1 and Humpback-2 (sampled by station A/27/Env; Table 1.1 and Figure 1.1).

The scope of work was as follows:

- To review the bathymetry processed from the seismic 3D surface return over the 80km x 70km area of interest.
- To delineate and map potentially environmentally sensitive seabed features within the survey area. In particular, the presence of potential Annex I Habitat communities (i.e. biogenic reefs such as *Lophelia* and *Madrepora* corals, or cold water seep communities) as specified under the European Habitats Directive.
- To obtain baseline data for all habitat types recorded within close proximity to the proposed drilling operations (via benthic sampling and seabed imagery) in line with international requirements.
- To gain an understanding of the regional environmental conditions and habitats present at the proposed wells.

Environmental survey operations were undertaken following a review of the acoustic data, in order to provide an overall picture of the existing marine habitats. Seabed photography was used to ground truth all key seabed habitats identified by the acoustic datasets. Of particular interest were clear bathymetric features and, if recorded, potential Annex I habitats (European Union Habitats Directive and key sensitive habitats (OSPAR) along with a delineation of their boundaries, and the presence of possible IUCN red list or CITES Appendix II species. A minimum of five high resolution digital photographs were to be acquired at each location, accompanied by a video overview covering a larger seabed area.

Baseline sampling was undertaken based on seabed sampling using either box corer or grab sampler (subject to surface geology), providing detailed physico-chemical information and multiple macro-invertebrate replicates of 0.1m^2 over a 500µm mesh sieve.

1.2.1 Geophysical Survey

Shallow geophysics and bathymetric survey operations were carried out at selected target areas within the proposed survey polygon measuring approximately 80km x 70km. This additional information was overlaid onto the regional bathymetric chart and used to refine the location of ground truthing, or to resolve minor artefacts recorded in the 3D seismic data. The following acoustic equipment packages were used during the survey and reviewed as part of the habitat analysis.

- 3D surface return seismic data that covers the complete survey area. The grid resolution of this dataset was 25m x 25m. This gave excellent coverage of the proposed survey area, but some minor textures and patterns recorded within the data were the result of artefacts within the processing.
- Multibeam echo sounder data were reduced and processed offshore to provide a digital terrain model enabling major bathymetric features and minor bathymetric changes to be identified and highlighted. Although the resolution of the grid produced by the system in this moderate water depth was slightly lower than that of the seismic 3D data (i.e. 40m x 40m), the data was without the same artefacts as previously recorded. Typically, only a single short line was run over each prospective site thereby allowing only a limited resolution of the seabed close to the centre of the line. A larger search area (approximately 35km x 47km) was additionally surveyed to try and locate the position of the Sharnhorst World War I wreck (this was not found, MG3, 2014).
- Sub-bottom profiler of shallow soils was used to clarify changes that might be seen in the seismic and surface bathymetry. The survey was carried out using a hull-mounted 9-element pinger array, but the effectiveness of this system at these water depths was extremely limited and offered only marginal information to the interpretation in the field.

Considering the water depth, the multibeam data were of sufficient quality to adequately map regional seabed types and identify the presence of any anomalous features on the seabed, where present.

1.2.2 Environmental Survey Strategy

Priority targets were selected close to the proposed well centres to investigate key bathymetric features and potential habitat changes as well as to achieve geographical coverage of the area. Additional sample locations were distributed throughout the survey area in order to gain a regional understanding, and to investigate potentially environmentally significant features and habitat changes.

In summary the sampling locations were selected based on the following criteria:

- Proposed well locations.
- Bathymetric features of potential environmental importance (e.g. discrete reefs).
- Bathymetric features expected to represent a change in habitat.
- Slope features expected to show a gradient of habitat change.
- Bathymetric highs and lows within the survey area.
- Geographical coverage of the survey area.

Table 1.1 - Proposed Finback-1, Humpback-1 and Humpback-2 Well Locations

Well Location	Easting	Northing
Finback-1	783,725mE	4,207,331mN
Humpback-1	792,814mE	4,213,086mN
Humpback-2	799,122mE	4,207,171mN

Projection: TM 60W; Spheroid/datum: WGS84

Environmental sampling was attempted at all 34 locations between the 31st December and 16th March 2014. Surveyed sites were generally based on combined seabed sampling and camera operations as summarised in Table 1.2 and shown in Figure 1.1. Table 1.2 also indicates the number of photographs acquired, the video duration and level of sampling for subsequent physico-chemical and biological determination at each site. These samples were processed and are reported in this Environmental Baseline Survey report.

The camera system used in the survey was based on a "Sea Bug" developed by Subsea Technology and Rentals (STR) deployed from a seabed frame. The system is based on a housed G10 Canon Camera which can output up to a 14.7 megapixel quality (5 megapixel used for the current project to reduce operational upload time). Further information is presented in Appendix I. Generally, the images were of good quality and simple to review. Some images were taken from a position above the seabed and therefore of reduced resolution (but showing a greater surface coverage), whilst most were taken from the grounded sled with a fixed oblique view of approximately $1m^2$. All images are scaled by a laser. Whilst high resolution seabed photographs were acquired at regular intervals, occasional lower resolutions images were also obtained directly via screen grabs from the video footage between stills images.

In addition to the seabed photography, a total of 19 box core, 30 double Van Veen grabs and 11 Hamon grab deployments were completed, resulting in 59 successful samples and 18 'no sample' attempts (mostly due to the sampler failing to trigger, see Appendix VI). The penetration of the successful box cores varied from 13cm to 35cm. This is indicative of a relatively compacted seabed which has a significant proportion of sands and coarser granular sediments. Retained material was processed onboard for both macro-invertebrate communities and surface physico-chemistry with an additional small core retained from the centre of the box as a complete archive sample.

Vertical water quality profiles (temperature, depth, salinity) were obtained as well as water samples collected for set of water chemistry analysis (nutrients, heavy metals, TOC, etc.). Further details are shown in Appendix I/I.2.5 with results presented in section 2.8.

Sample positions, including those sampled for baseline purposes, are listed in Table 1.2, plotted in Figure 1.1, and detailed in Appendix VI. Detailed photographic positions are presented in Appendix VII.

1.2.2.1 Sample Analyses

The recovered benthic samples were correctly stored prior to demobilisation and transportation of the material to the correct laboratory. This involved the freezing of all physico-chemical samples on recovery and hand–carried back to the UK, to be forwarded to a laboratory remaining frozen at all times. This material was analysed at the following laboratories:

- BSL: Particle size Analysis
- BSL: Macro-invertebrate Analysis
- Environmental Scientifics Group (ESG/Chemtech): Sediment Chemistry

A second set of residual (backup) material is currently being held by BSL for future analysis or delivery to the authorities following completion of the survey submission. A summary of the analytical methodologies applied and accreditation is given in Appendix II and VIII.

1.2.2.2 Environmental Data Presentation using Contouring Software

To aid in the interpretation and presentation of the environmental information acquired for this report, both hydrographic and environmental variables were processed using contouring and 3D surface mapping software (Surfer v11). This software allows a digital terrain model (DTM), or grid, to be interpolated from irregularly spaced geographical information (XYZ data) using a kriging interpolation algorithm. When large quantities of data are used (such as in swathe bathymetry), the level of interpolation is limited only to small spaces in between the data points. However, when processing environmental variables a diagrammatic circle has been used to colour illustrate the parameter level at each relevant site (the size of this circle is diagrammatically determined to be colour coded based on the scale of the Figures presented in Section 2). It should be remembered that this is done for presentation purposes only and that these data values are “not representative” for the whole of the geographical area covered by the circle. No interpolation is required in this instance except where these circles overlap due to the scaling of the Figure.

Table 1.2 - Summary of Environmental Ground Truthing Locations and Acquisition

Station	Summary Rationale	Type	Easting	Northing	Biological Samples*	Chemistry**	Depth (m)	No. of Photos	Video (mins)
A/3/ENV	Regional sample, very slightly steeper slope from original stations 1 and 2	BC	736830	4188434	Fa, Fb	Environmental chemistry (+ water chemistry)	1134	27	14
		SOL	736983	4188568					
		EOL	737018	4189208					
A/106/ENV	Move upslope to slightly raised linear feature (NE-SW trending)	SOL	743566	4180145	No samples	No samples	1302	24	37
		EOL	743518	4180147					
A/1008/ENV	(Moved from A/8/Env) 200m transect N-S flank of escarpment	DG/HG	784301	4202040	Fa, Fb	Environmental chemistry	1280	41	40
		SOL	784327	4202063					
		EOL	784323	4201775					
A/9/ENV	Sequence through medium amplitude flat seabed feature	DG	774052	4201351	Fa, Fb, Fc	Environmental chemistry	1260	27	31
		SOL	774025	4201278					
		EOL	774051	4201411					
A/10/ENV	Sequence through medium amplitude flat seabed feature	DG	774368	4205141	Fa, Fb, Fc	Environmental chemistry	1261	15	19
		SOL	774451	4205142					
		EOL	774412	4205133					
A/1011/ENV	At deepest point of hollow feature	DG	784810	4213180	Fa, Fb	Environmental chemistry	1325	17	26
		SOL	784868	4213089					
		EOL	784691	4213134					
A/12/ENV	Regional sample, relatively flat seabed	DG/HG	783794	4203737	Fa, Fc	Environmental chemistry	1280	22	25
		SOL	783903	4203852					
		EOL	783796	4203863					
A/1013/ENV	Move into 'eroded' hole location, at deepest point	HG	790680	4204135	Fa, Fb	Environmental chemistry	1350	27	31
		SOL	790773	4204080					
		EOL	790629	4204226					
A/14/ENV	Edge of regional flat area	BC	782519	4194777	Fa, Fb	Environmental chemistry	1316	15	23
		SOL	782529	4194695					
		EOL	782604	4194854					
A/1015/ENV	Move to deepest point of hollow feature	BC	786510	4198430	Fa, Fb	Environmental chemistry	1358	41	41
		SOL	786596	4198429					
		EOL	786309	4198453					
A/18/ENV	High amplitude in low relief area	BC	768352	4173956	Fa, Fb	Environmental chemistry (+ water profile)	1415	24	32
		SOL	768169	4173962					
		EOL	767871	4173444					
A/20/ENV	General area coverage	DG	791101	4195297	Fa, Fb, Fc	Environmental chemistry (+ water profile)	1350	18	33
		SOL	791005	4195281					
		EOL	791066	4195328					
A/21/ENV	General area coverage	BC	798155	4195368	Fa, Fb	Environmental chemistry	1430	31	28
		SOL	798271	4195359					
		EOL	798150	4195466					
A/22/ENV	High amplitude base of slope	BC	767851	4163126	Fa, Fb	Environmental chemistry	1522	27	26
		SOL	768009	4163221					
		EOL	768082	4163559					
A/26/ENV	Close to proposed well location, **(Finback-1)**	DG	783724	4207331	Fa, Fb, Fc	Environmental chemistry	1260	19	21
		SOL	783858	4207372					
		EOL	783861	4207366					
A/27/ENV	Close to proposed well location, **(Humpback-1)**	DG	792420	4213837	Fa, Fb, Fc	Environmental chemistry	1260	25	23
		SOL	792430	4213799					
		EOL	792415	4213974					

A/201/ENV	200m transect perpendicular to scarp in feature 'hole'	SOL	754240	4216058	-	-	1120	41	40
		EOL	734621	4206717					
A/202/ENV	Linked to previous station 5 to pick out base of undulation	BC	754100	4216220	Fa, Fb	Environmental chemistry	1153	33	43
		SOL	754227	4216098					
		EOL	754403	4216019					
A/203/ENV	200m (S-N) camera transect on isolated feature	SOL	787583	4199232	-	-	1321	37	26
		EOL	787537	4199102					
A/204/ENV	Linked to 17, possible slump	BC	758950	4166435	Fa, Fb	Environmental chemistry	1302	50	27
		SOL	758970	4166483					
		EOL	758020	4166114					
A/205/ENV	500m transect SE-NW, camera only, possible discrete slope failure	SOL	792365	4178244	-	-	1540	12	40
		EOL	792218	4178377					
A/206/ENV	Transect on discrete feature	SOL	776822	4163141	-	-	1530	29	32
		EOL	776881	4163576					
A/207/ENV	Camera transect over discrete 'reef' area	SOL	786707	4209650	-	-	1247	35	27
		EOL	786584	4209771					
A/208/ENV	Geographical coverage	SOL	773650	4228268	-	-	1200	25	40
		EOL	773740	4228376					
A/301/ENV	200m transect NW-SE slope feature, sample on slope	DG/HG	790757	4214853	Fa, Fc	Environmental chemistry	1250	35	29
		SOL	790827	4215011					
		EOL	790806	4214965					
A/302/ENV	Regional sample to be redefined by bathy pinger	DG	804634	4210621	Fa, Fb, Fc	Environmental chemistry	1330	24	22
		SOL	804638	4210663					
		EOL	804617	4210571					
A/303/ENV	200m transect NW/SE to look at slope feature	DG	796137	4211766	Fa, Fb, Fc	Environmental chemistry	1285	31	34
		SOL	796077	4211873					
		EOL	796114	4211842					
A/304/ENV	Regional sample	DG	783354	4221219	Fa, Fb, Fc	Environmental chemistry	1250	18	21
		SOL	783322	4221128					
		EOL	783265	4221188					
A/305/ENV	Regional sample	BC	778056	4210814	Fa, Fb	Environmental chemistry (+ water profile)	1267	19	32
		SOL	778143	4210780					
		EOL	777923	4211004					
A/306/ENV	200m transect across trench feature	HG	796843	4206384	Fa, Fb	Environmental chemistry	1350	32	33
		SOL	796895	4206287					
		EOL	796885	4206287					
A/307/ENV	Regional sample	BC	793230	4187957	Fa, Fb	Environmental chemistry	1400	30	30
		SOL	793335	4187995					
		EOL	793204	4188035					
A/308/ENV	200m transect N-S slump at base of escarpment	BC	784209	4192313	No samples	No samples	1380	26	24
		SOL	784228	4192273					
		EOL	784282	4192427					
A/309/ENV	Transect NW-SE investigate base of trench	BC	790971	4193442	Fa, Fb	Environmental chemistry	1395	20	27
		SOL	791043	4193418					
		EOL	790951	4193618					
A/3010/ENV	Repeat sample of 2011 (8666.1 FOGL Vinson West EBS)	BC	773473	4162976	Fa, Fb	Environmental chemistry	1540	20	27
		SOL	773456	4162973					
		EOL	773586	4163385					

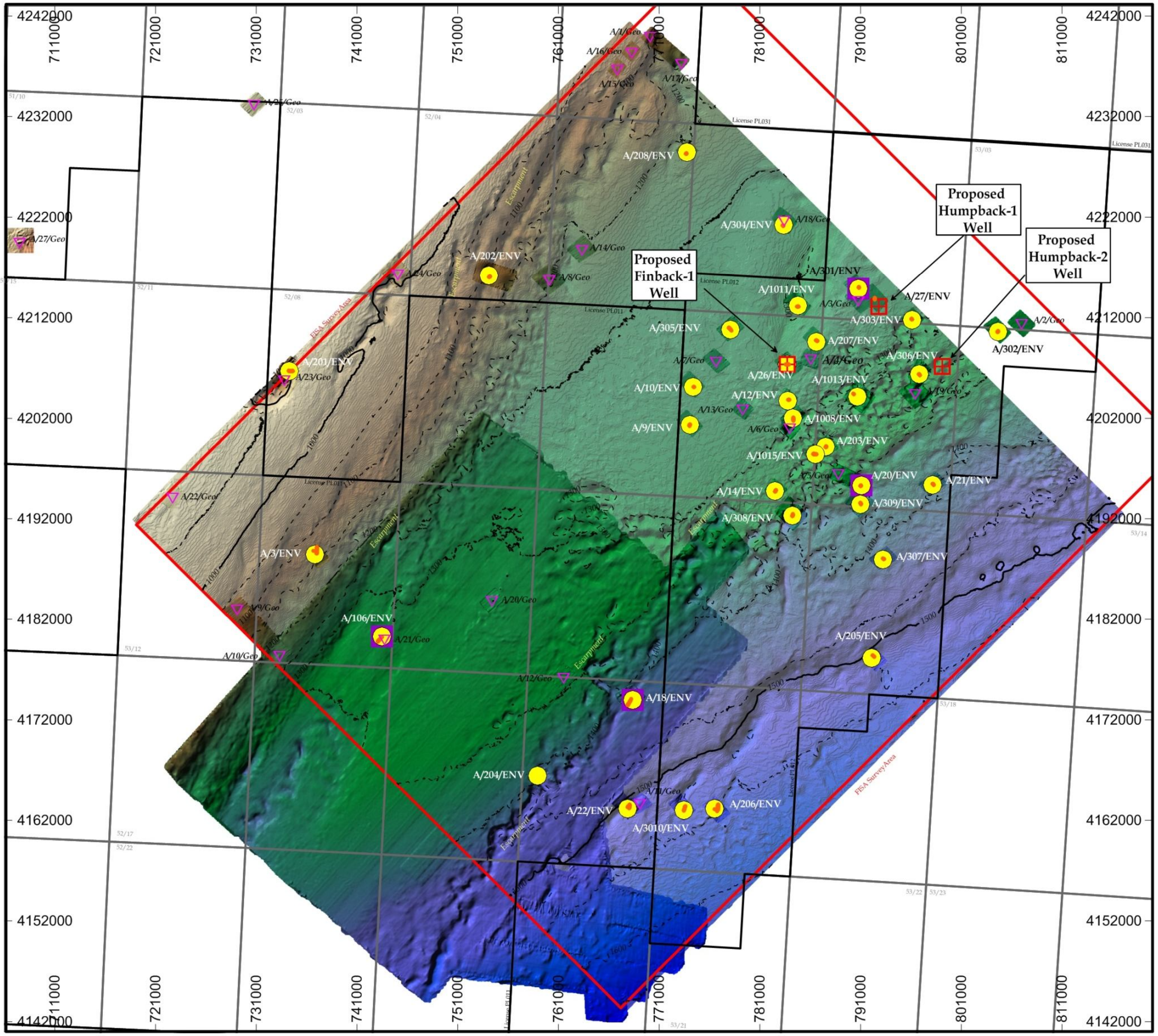
* *Biological replicates Fa - Fc (0.1m^2 macro-invertebrate samples processed over 500µm)*

** *Environmental chemistry - PSA: particle size analysis; TOC: total organic carbon; HM: heavy and trace metals; HC: hydrocarbons (saturates and polycyclic aromatics),*

BC = Box corer sampler; DG = Double grab sampler; HG = Hamon grab sampler; n.a. = not available due to beacon malfunctioning

SOL = camera start of line

EOL – camera end of line



Bathymetry

950 1050 1150 1250 1350 1450 1550 1650

(metres)

Background (3D seismic data), Foreground (This Survey MBES)

Legend

- *Proposed Well Locations*
- *Environmental Sampling Location (Box Corer & Grab)*
- *Geophysical Sampling Location (Gravity Corer)*
- *Seabed Photographic Positions*
- *Water Quality Profiles*

Surface Illumination Horizontal 315° Vertical 45°

Horizontal Scale

0 5000 10000 15000 20000 25000 30000 *(metres)*

Geodesy

Datum WGS84 (EPSG Code 6326), Spheroid WGS84 (EPSG Code 7030)
Projection Transverse Mercator, Central Meridian 60° West

CONTRACTOR

mg3 — Benthic Solutions

Benthic Solutions Limited Elanco Works, Marsh Road, Hoveton, Norfolk NR12 8UH Tel: +44 (0) 1603 784726

CLIENT

noble energy

Figure 1.1 Summary FISA Bathymetry and Sample Locations

Rev	Date	Description	Drawn	Interp	Approved
0	12.08.14	Bathymetry & Sample Locations for FISA	PRS	HL	IW
1	20.08.14	Bathymetry & Sample Locations for FISA	PRS	HL	IW
2	18.09.14	Bathymetry & Sample Locations for FISA	PRS	HL	IW

1.3 Geodetic Parameters

Project Geodesy	
Projection	Transverse Mercator CM 60W
Spheroid	WGS84
Datum	WGS84
Central Meridian	60˚ West of Greenwich
False Easting	500 000m
False Northing	10,000,000m

1.4 Data Comparisons and Historical Datasets

1.4.1 Recent Surveys of Nearby Areas

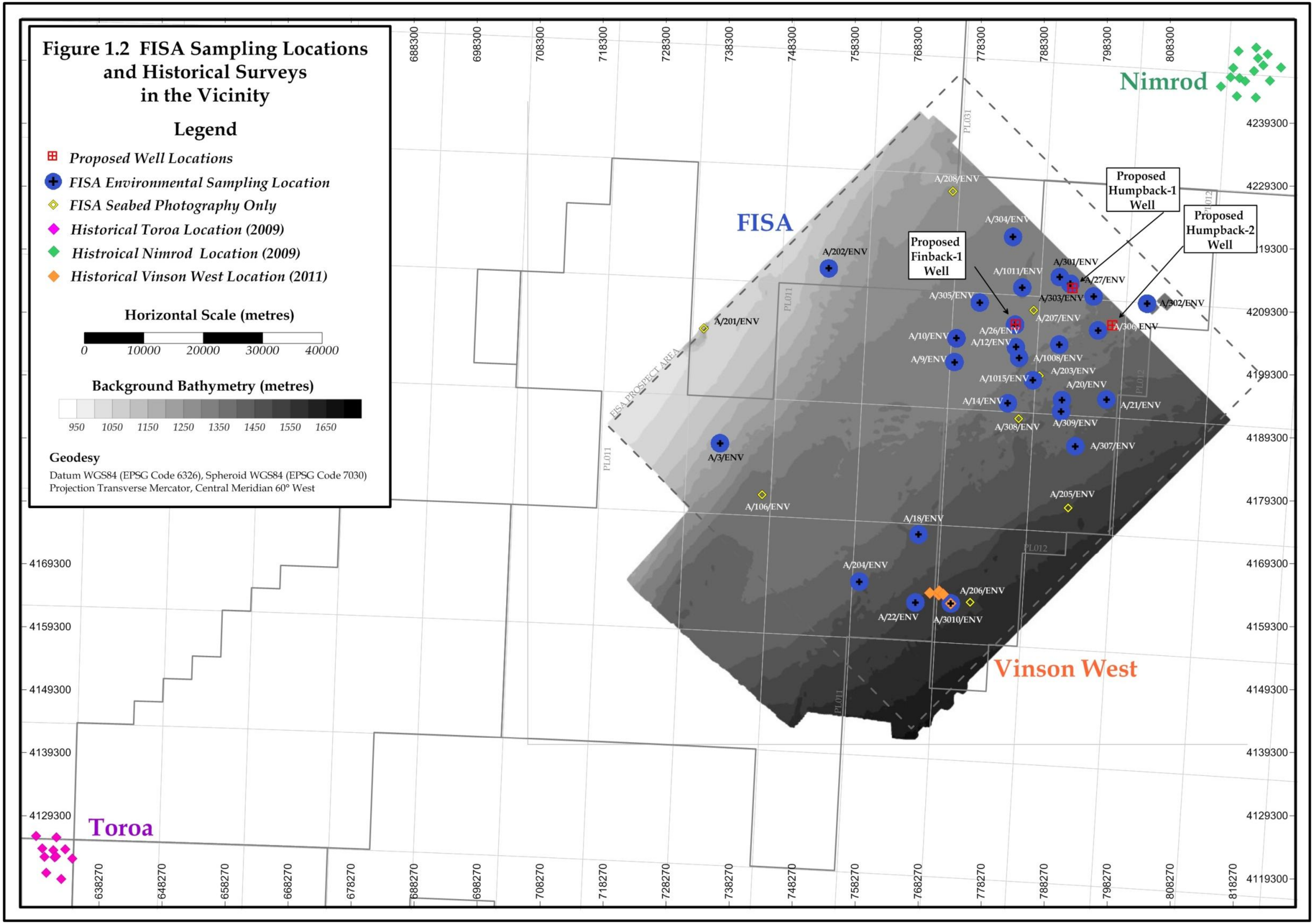
Previous similar datasets have been recorded in earlier baseline surveys around the Falklands, in the North (Gardline, 1998), Eastern (Gardline, 2011a-f; Fugro 2009a-d) and South Falklands Basins (BSL, 2008). For the interpretation at FISA, data comparisons have been made from the previous surveys within the East Falklands Basin (Gardline, 2011b; Fugro 2009a and b). The FISA survey area has been partially surveyed previously and relates to the Vinson West site-survey location (Gardline, 2011b). All historical data acquired during these three earlier studies are displayed for comparison in parameter data tables (Section 2), as applicable (in blue). The station ENV 5 of the Vinson West study was coincidental to station A/3010/ENV of the present study and provides a direct comparison.

Sources used in this comparison are outlined below in Table 1.3 and plotted in Figure 1.2:

Table 1.3 - Historical Datasets Used for Comparison

Source and Year	Reference of the report	Region and Comment
Gardline 2011b	Block 60. Vinson West, Environmental Baseline Reference 8666.1.	Falklands: Vinson West site Inside the survey area
Fugro 2009a	Survey FIDA 61/05 Toroa. Environmental Baseline Reference 9763V3	Falklands: Toroa site South-west of the survey area
Fugro 2009b	Survey FIDA 41/29 Nimrod. Environmental Baseline Reference 9763V5	Falklands: Nimrod site North-east of the survey area

Figure 1.2 FISA Sampling Locations and Historical Surveys in the Vicinity



1.4.2 Regional Standards and Background Information

Details of the legislative background that apply to the Falkland Islands are provided in Volume 2 of this report (MG3, 2014b). This also includes details of the European environmental frameworks that are being applied to the habitats and species found around the islands based on the Oslo Paris (OSPAR) commission for threatened habitats, and the European Habitats Directive (92/43/EEC)). Relevant IUCN Red list species (IUCN, 2013), the regulation of endangered species listed under the Convention on International Trade in Endangered Species (CITES), along with potential sensitive habitats, in particular relating to corals and sponge communities, are also discussed. All identification of Taxonomic Species has followed a review process with Natural History Museum (NHM) to ensure nomenclature and species identification follow a common standard for the region. This is discussed in further detail in Appendix II, Section II.5.2.

1.5 REPORTING STRUCTURE

Final reporting in the FISA area is separated into three volumes as follows:

- Volume 1 FISA Field Report.
- Volume 2 FISA Habitat Assessment Report.
- Volume 3 FISA Environmental Baseline Report (This Report).

2 RESULTS AND DISCUSSIONS

2.1 REGIONAL GEOLOGY AND SEABED FEATURES

The Falkland Islands are situated on an area known as the Falklands Plateau, separated to the north from the Argentine Basin by the Falklands Escarpment. This Falklands Plateau is characterised by a layer of fine to medium sand at the seabed, which may be up to 2m thick (Bastida *et al*., 1992). Some areas are known to have a high percentage of gravel comprising either small pebbles or bioclasts with both gravels and sedimentary concretions recorded in earlier baseline surveys in the North (Gardline, 1998), Eastern (Gardline, 2011a-f; Fugro 2009a-d) and South Falklands Basins (BSL, 2008). The current survey area is located in an area east of the Falkland Islands, and north of the Burdwood Bank in the Falkland Plateau Basin. This Basin has a northeast to southwest trending western margin which is faulted and ends eastwards at the Maurice Ewing Bank which is a bathymetric high ~250km east of the islands (www.fig.gov.fk/minerals). The survey area has been partially surveyed previously, relating to the Vinson West well location (Gardline, 2011b). All of the previous work in the Falklands is available in the public domain from the FIG web site.

The Falkland Plateau Basin is essentially a margin basin that comprises Jurassic and Cretaceous passive margin-type rocks similar to those found in the South Falkland Basin. To the southwest, along the deep water trough known as the Falkland Chasm, the basin merges with the South Falkland Basin. This basin lies beneath 200m to 2500m of water and exhibits numerous major normal faults probably of Jurassic through Early Cretaceous age, contemporaneous with the deposition of sediments in the actively rifting trough. Some of the thrust faults, however, display reactivation into recent times (www.fig.gov.fk/minerals).

The prevalence of surface hard-bottom areas is not accurately known. Features recorded along the edge of several escarpments recorded in the bathymetry and the evidence provided from sampling and photography suggests that an irregular sedimentary material exists over the majority of the site along with some exposures of hard surfaces. Seabed sampling recorded a relatively inconsistent recovery of material and required three types of sampler, sometimes with multiple deployments, to acquire sufficient material for analysis. Whilst the gradient of the seabed was expected to be generally gradual within the survey area, localised bathymetric features such as the escarpments, hummocks, and rock outcrops may be encountered which will exhibit associated minor relief.

2.2 SURVEY BATHYMETRY

Bathymetry for the FISA survey area is summarised in Figure 1.1. This was produced from a combination of data collected during an earlier 3D seismic acquisition campaign (background data in Figure 1.1) and localised survey footprints acquired using multibeam echo sounder during the current survey (foreground data in Figure 1.1). For the most part, the latter dataset provides a more accurate representation of the bathymetry in the area due to removal of processing artefacts, despite its slightly lower resolution.

Water depths have been reduced to Mean Sea Level (MSL). More detailed representations of seabed sample photographs, as well as camera tracks and photographs are presented in Appendix VII.

The water depth for the proposed Finback-1, Humpback-1 and 2 well locations was approximately 1280m, 1270m and 1330m MSL. Depths across the survey area ranged from ~950m in the northwest, decreasing sharply to a maximum depth of ~1650m found in the southeast. The gradient within the well area was generally <2°, but this increased to around 5° along the edge of the escarpment which was found at 1400m depth and a large depression in the shallowest part of the site. Here localised gradients in excess of 45° were recorded and expected to present rock outcrops and areas of near vertical cliff faces.

2.3 SURVEY SURFACE GEOLOGY AND SEABED FEATURES

The seabed was variable throughout the FISA survey area, with the sediment typically comprising of silty SAND with varying levels of gravel, cobbles and boulders. To the northwest and southeast of the survey area, sediments were fine with varying levels of black basalt sands. Running through the centre of the survey area from northeast to southwest was a significant escarpment with associated slumps. Here, coarse material was abundant with exposed cobbles and boulders of glacial origin recorded, often at the base and shoulders of a steep slope. Biological debris was common throughout the escarpment area, especially that of the stony coral *Lophelia* sp. (order Scleractinia) which was found in small, but quite dense mats in discrete areas of the seabed (as evident at stations A/203/ENV, A/308/ENV, A/1008/ENV, A/1013/ENV and A/204/ENV). Station A/204/ENV indicated a *Lophelia* debris-field at the base of the escarpment in the southern part of the survey area. Incidents of live aggregations of hard corals were generally limited to only very small colonies <0.1m in area, with the largest 'thicket' of coral limited to <0.5m in size.

All of the fines observed were light grey to black in colour, whilst the sands were generally black, volcanic (i.e. basalt) in origin. This is generally associated with ice rafted material derived from islands in the Southern Ocean area and has been regularly recorded in sediments on previous surveys in the East Falklands Basin (Gardline, 2011b & d; Fugro 2009d).

Evidence from seabed photography, in particular the video data, shows that the escarpment features are the result of exposure by discordant formations displaying varying rates of erosion. The edge of these escarpments was shown to be capped with harder bedrock which are undercut by currents weathering older and softer substrates, eventually resulting in a collapse. This results in a well-defined escarpment edge in places, and the presence of a boulder field at the base of the slope. These features are discussed in further detail later in this report (Section 2.10.2).

2.4 PARTICLE SIZE DISTRIBUTION

The particle size interpretation of sediments across the survey area were based upon observations made from the acoustic data, seabed photography and the analytical results acquired from the surface sediment at 26 locations (Figure 2.1). Material for PSA analysis was recovered from the surface 5cm.

Sample stations were established at selected sites around the FISA survey area based on bathymetric, geological and spatial preferences as outline in Section 1.2.2. At a general level, the nature of the sediment was predominantly silty SAND with varying levels of gravel, cobbles and boulders.

On average, the sediment composed of these three main fractions:

- Sand: mean 60.31% ± 12.42 SD (standard deviation)
- Fine: mean 32.69% ± 10.74 SD
- Gravel: mean 7.01% ± 6.77 SD

The % proportions of these different sediment types for each station are listed in Table 2.1. These ranged from sandy mud and muddy sand through to gravelly sand, but with the dominant sediment type represented by slightly gravelly muddy sand as denominated by the Folk characterisation (Folk, 1954; Appendix III).

Analytical results were variable around a predominantly sandy seabed. Most distributions were either uni-modal, peaking around the medium SAND to fine SAND with a consistent tail of fines varying through silts and clays, or bi-modal with a slightly elevated proportion of coarse silts, and/or gravels. The mean particle size is outlined in Table 2.1, which ranged from 45µm to 354µm (Figure 2.1), demonstrating the varying proportions of silts, clays and gravels recorded around a consistent sand profile. A comparison of the full particle size distribution is presented in Figure 2.3. The majority of samples indicated similar distributions with representative size classes dominated by medium sands at around 15-20%, gravels below 5% and silts and clays between 4-6%. Outliers to this were stations A/1015/ENV, A/26/ENV, A/12/ENV and A/22/ENV which contained elevated levels of gravel, whilst stations A/3/ENV and A/26/ENV both recorded elevated fines. This particle size variation has also resulted in some variability in the sorting coefficient for the size distributions (Table 2.1), which varied from a poorly sorted 1.97 at A/309/ENV to an extremely poorly sorted 6.08 at A/26/ENV. The majority of stations, however, were generally very poorly sorted ranging from 2.3 to 2.9 based on a uni-modal distribution (albeit with an extended tail of fines).

Table 2.1 - Summary of Surface Particle Size Distribution

Station	Mean Sediment Size		Sorting	Skewness	Kurtosis	% Fines	% Sands	% Gravel
	mm	Phi						
A/304/ENV	0.080	3.65	2.27	0.47	0.86	37.79	60.95	1.26
A/303/ENV	0.125	3.00	2.52	0.57	0.97	29.26	67.01	3.74
A/09/ENV	0.143	2.81	2.80	0.29	1.32	28.73	62.78	8.49
A/204/ENV	0.082	3.61	3.12	0.29	1.04	40.03	52.61	7.36
A/202/ENV	0.088	3.51	2.60	0.47	0.78	40.47	59.38	0.15
A/22/ENV	0.245	2.03	4.06	-0.08	1.78	26.49	55.66	17.85
A/20/ENV	0.131	2.93	2.31	0.59	1.04	26.34	71.91	1.75
A/12/ENV	0.224	2.16	3.61	0.12	1.43	26.47	57.55	15.98
A/21/ENV	0.214	2.23	2.33	0.23	2.30	17.27	73.70	9.03
A/1008/ENV	0.141	2.82	2.56	0.57	0.96	27.87	71.18	0.95
A/1011/ENV	0.117	3.10	2.48	0.46	0.97	30.57	68.27	1.16
A/3/ENV	0.045	4.48	2.68	0.06	0.78	56.11	42.69	1.20
A/307/ENV	0.160	2.65	2.89	0.30	1.44	25.32	62.95	11.73
A/18/ENV	0.149	2.75	2.58	0.45	1.06	27.25	68.93	3.82
A/1013/ENV	0.094	3.41	3.18	0.22	1.12	37.93	49.45	12.62
A/3010/ENV	0.148	2.76	2.39	0.52	1.05	25.87	70.42	3.71
A/301/ENV	0.110	3.18	2.44	0.51	0.96	31.14	66.02	2.84
A/14/ENV	0.144	2.80	2.66	0.43	1.13	27.64	66.69	5.67
A/27/ENV	0.086	3.54	2.47	0.45	0.82	38.52	60.40	1.09
A/306/ENV	0.098	3.36	2.87	0.31	1.19	33.65	59.99	6.36
A/305/ENV	0.073	3.77	2.60	0.31	0.86	42.79	55.44	1.78
A/10/ENV	0.104	3.27	2.88	0.29	1.09	35.77	57.44	6.80
A/309/ENV	0.167	2.58	1.97	0.56	1.65	20.07	78.89	1.05
A/1015/ENV	0.354	1.50	4.13	-0.03	0.80	27.63	45.06	27.30
A/302/ENV	0.177	2.50	2.73	0.27	1.85	22.18	65.88	11.94
A/26/ENV	0.084	3.58	6.08	-0.58	2.62	66.71	16.76	16.53
Mean	**0.14**	**3.00**	**2.89**	**0.31**	**1.23**	**32.69**	**60.31**	**7.01**
StDev	**0.07**	**0.64**	**0.83**	**0.26**	**0.47**	**10.74**	**12.42**	**6.77**
%Variance	**47.7**	**21.3**	**28.6**	**83.3**	**38.3**	**32.7**	**20.6**	**96.7**
Vinson West ENV 5	**0.19**	**2.36**	**-**	**-**	**-**	**17.3**	**80.3**	**2.4**
Vinson West Mean	**0.19**	**2.35**	**-**	**-**	**-**	**18.4**	**76.9**	**4.7**
Vinson West SD	**0.03**	**0.22**	**-**	**-**	**-**	**2.9**	**4.5**	**4.3**
Nimrod Mean	**0.18**	**2.51**	**2.31**	**-**	**-**	**22.6**	**71.3**	**6.2**
Nimrod SD	**0.04**	**0.30**	**0.32**	**-**	**-**	**3.9**	**5.4**	**4.0**
Toroa Mean	**0.31**	**5.00**	**1.54**	**-**	**-**	**77.8**	**22.2**	**0.0**
Toroa SD	**0.02**	**0.08**	**0.01**	**-**	**-**	**1.9**	**1.9**	**0.0**

Historical data are reported in blue

The distribution of coarser gravel sediment sizes (granules above 2mm in size or Phi -1) is presented geographically in Figure 2.3. Coarse sediments were recorded in all samples analysed ranging from 0.15% to 27.3%, with a mean of 7% (Table 2.1 and Figure 2.3). Four of the stations, A/12/ENV, A/22/ENV, A/1015/ENV and A/26/ENV revealed a significantly higher proportion of gravels ranging from 16% to 27.3%, indicative of mixed sediments routinely recorded within the survey area. Most of this material relates to ice-rafted glacial material in the form of drop-stones, although some weathered formations were also present, as described previously.

Figure 2.1 - Particle Size Comparison

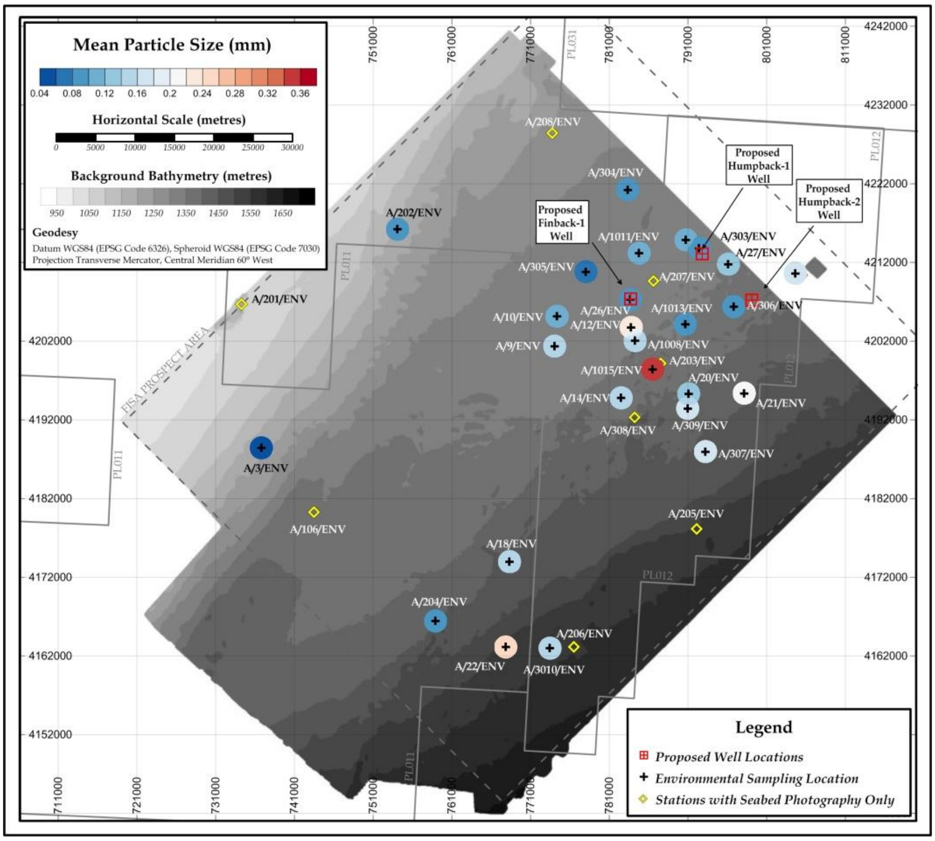
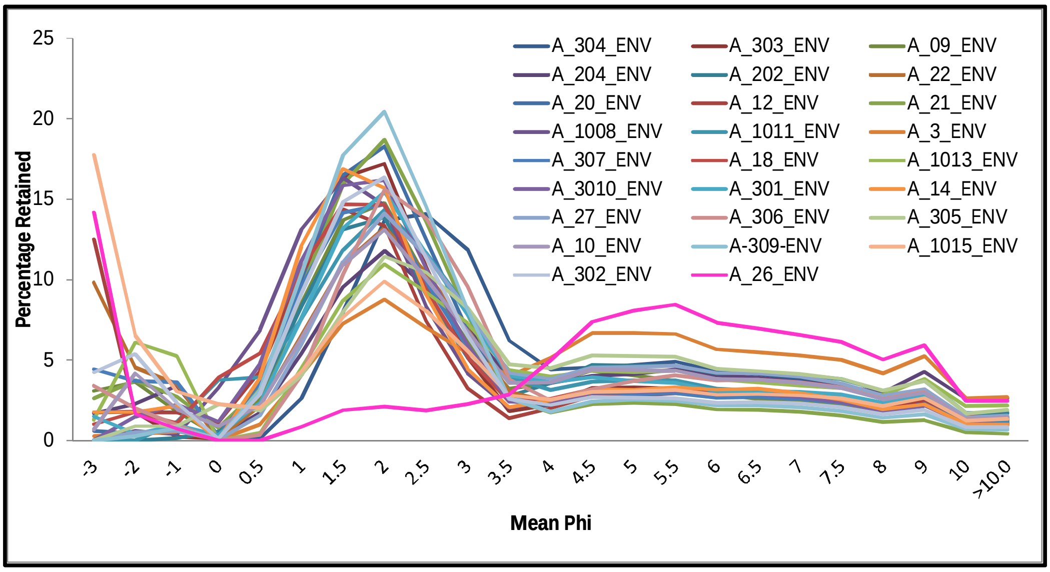


Figure 2.2 - Particle Size Distribution Comparison



Where mixed sediment occurs, the sampling process itself can be biased against coarser material, where only a relatively small sub-sample (approx. 250g) is recovered for analysis or where the efficiency of the sampler may be compromised by coarser sediments. The presence of larger clasts (cobbles and boulders) is well documented for many of the sites from the seabed photography, as is the requirement to use different samplers in order to recover suitable material for subsequent analysis. This means that the data obtained from the particle size analysis should be treated with some caution and should only be used as an indication of the softer granular material populated by the macro-invertebrate communities in these areas, or used in combination with seabed photography where larger gravels are observed. The variability of gravels is readily identified in the residues from biological processing over a 500µm mesh (coarse sand) size and summarised in Appendix VII.

The geographical distribution of sediment fines (i.e. silts and clays <63µm), is shown in Figure 2.4. This shows a broad pattern of distribution with decreasing fines with increasing water depth ($P<0.01$, Appendix XI), with the exception of station A/26/ENV, which indicated a peak 66.7% fines compared to a mean of 32% recorded elsewhere throughout the survey area. This pattern is considered unusual for a deep-water environment where, typically, the deeper waters indicate higher rates of pelagic sedimentation due to decreased water movement. This is clearly not the case at FISA with the majority of softer sedimentary material recorded above the escarpment feature north and west of the proposed well locations. Photographic evidence from sites around the escarpment and to the south and east, recorded rippled bedforms and sediment scour, both indicators of strong seabed currents. Station A/26/ENV indicated a slight aberration to other sediment distributions (Figure 2.2) with a very high proportion of fines, but almost equal proportion of fines and gravels (approximately 16.5%). The reason for this is not known, but must relate to a localised feature of the sediment that was not observed in the seabed photography.

A review of sediment types from the photographic evidence from both baseline and geological sample sites confirmed that the majority of the shallower sediments in the northwest were dominated by a relatively homogeneous and featureless slightly gravelly silty sand, associated with a weak sedimentary environment (i.e. slow sedimentation rate) throughout. The deeper sediments to the southeast were associated with a similar sediment type, but with greater erosion (reduced fines) and a significant gravel component, indicative of residual ice modification from drop stones. Separating these two areas in the central part of the survey area is a complex bathymetry indicative of an irregular escarpment running from the southwest to the northeast. The sediments here have been interpreted as steep sloped exposures of low energy bedrock or a hard underlying formation. The remaining sediment type was represented by an intermediate habitat type, marking the transition from homogeneous sands to the rock outcrops. This is essentially where the homogeneous sand thins to a veneer and is punctuated by occasional to numerous isolated rock outcrops, cobbles and boulders. This is the dominant sediment type along the top of the escarpment and at a depth of 1150m and runs in a northeast-southwest orientation across the length of the survey area. Further information on coarse sediment clasts has been provided from the seabed camera system and presented in Section 2.10.1, with the results of habitat variability presented in Section 2.10.2.

Figure 2.3 - Percentage of Gravel (%)

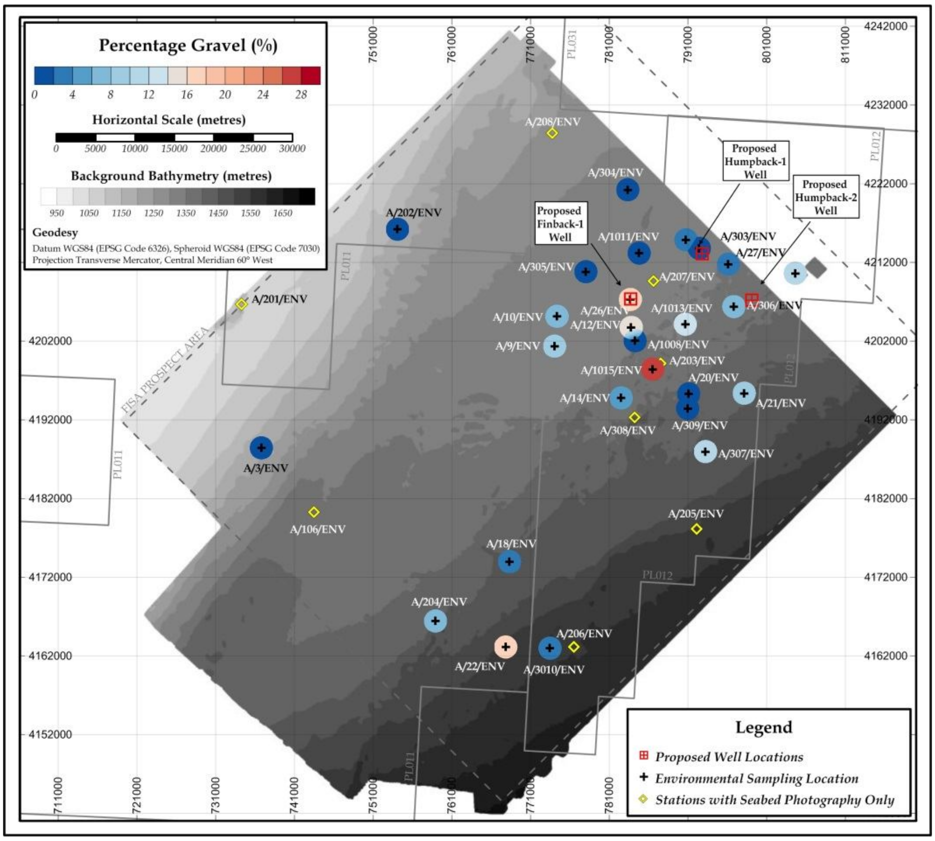
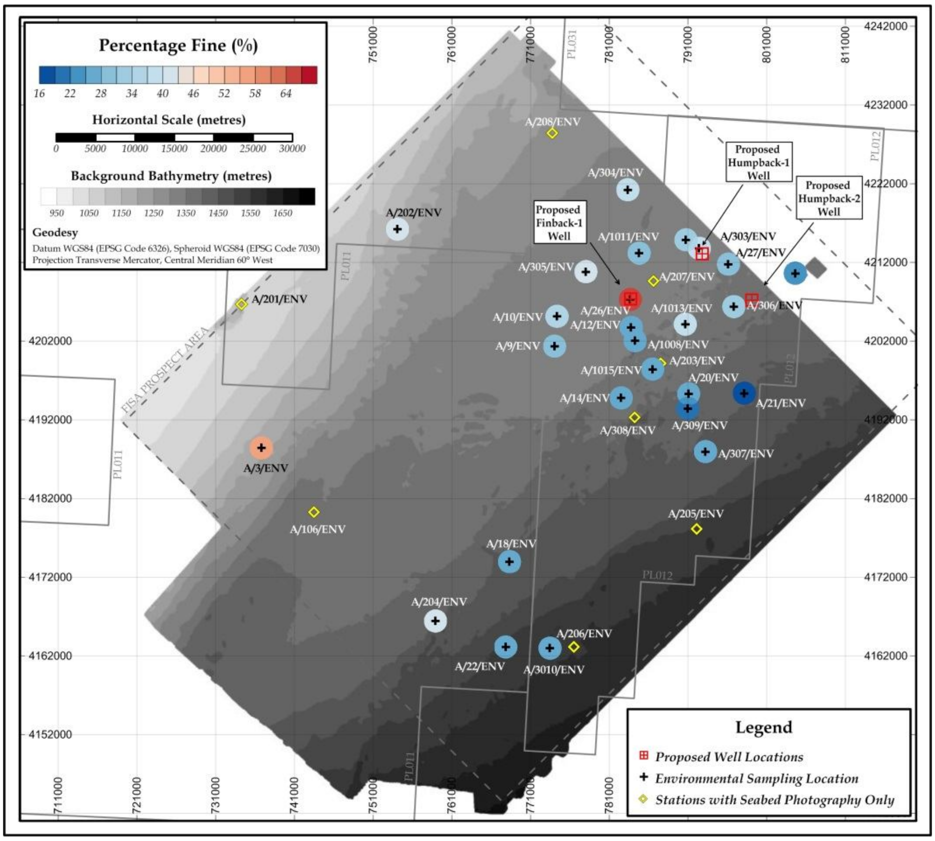


Figure 2.4 - Percentage of Fine (%)

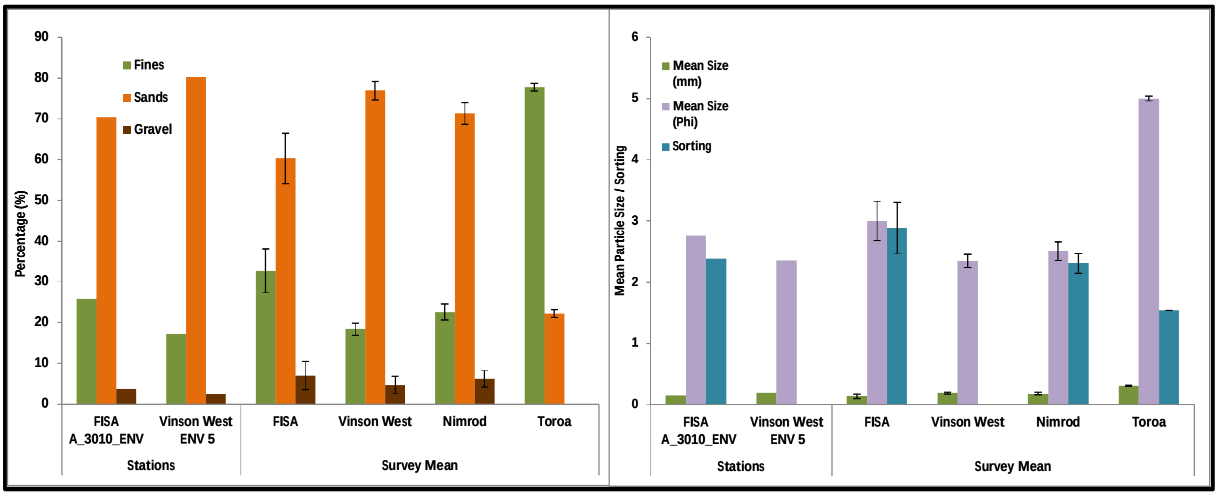


2.4.1 Historical Comparison with Particle Size Distribution

Whilst generally, relatively little is known about the sediments surrounding the Falklands, a number of historical environmental surveys have been undertaken in the South Falklands Basin, indicating similar results to those recorded at FISA. The FISA sample station A/3010/ENV is coincidental to the Vinson West survey (station ENV 5) providing a direct comparison between the two survey years (2009 and 2014). Figure 2.5 showed that both stations recorded approximately the same percentage of fine, sand, gravel and mean particles size (mm and Phi). The same figure also compares the average data with the additional surveys for Nimrod, Toroa as well as Vinson West. From this it is apparent that FISA and Vinson West recorded similar values and gave no significant indication for major changes in regards to particle size between 2009 and 2014.

Previous surface sediments analyses at the Toroa sampling locations, approximately 125km southwest of the present location, showed significantly finer sediments with a higher proportion of silts and clays of around 77.8%, compared to 32.7% recorded in the present study. This variation between sites was underpinned by a regional variation in bathymetry and possibly oceanography. Toroa was located in much shallower waters (approximately 650m) on the upper part of the continental slope and well above the complex bathymetry recorded around the escarpments in the present study (>1350m). The proportion of sands, at 22.2% and absence of coarser admixtures (such as gravels) at Toroa, were both much lower than found at FISA, reflecting the general trend of reduced sedimentation and greater erosion with increased water depth.

Figure 2.5 - Particle Size Comparison with Historical Data



Note sorting coefficient not available for Vinson West.

2.5 TOTAL ORGANIC CARBON

Sediments were analysed for TOC and moisture content and presented in Table 2.2. TOC is less susceptible to interference from other combustible components and represents the proportion of biological material and organic detritus within the substrates. Sometimes it can be recorded using crude combustion techniques, such as total organic matter by loss on ignition. TOC in surface sediments is an important source of food for benthic fauna (Snelgrove and Butman, 1994), although too much can lead to reductions in species richness and abundance due to oxygen depletion. Increases in TOC may also reflect increases in both physical factors (i.e. fines) and common co-varying environmental factor (through elevated sorption on increased sediment surface areas; Thompson and Lowe, 2004).

Table 2.2 - Summary of Moisture and Organic Carbon

Station	Total Organic Carbon (% w/w)	Moisture Content (% w/w)
A/09/ENV	0.11	28.1
A/12/ENV	0.21	21.8
A/14/ENV	0.17	26.9
A/18/ENV	0.23	26.6
A/20/ENV	0.15	23.2
A/202/ENV	0.22	30.0
A/204/ENV	0.15	33.1
A/21/ENV	0.19	21.3
A/22/ENV	0.24	24.2
A/26/ENV	0.40	37.5
A/27/ENV	0.21	25.0
A/3/ENV	0.32	33.5
A/301/ENV	0.24	26.2
A/302/ENV	0.15	22.2
A/304/ENV	0.17	30.8
A/305/ENV	0.17	28.5
A/306/ENV	0.24	23.3
A/307/ENV	0.23	23.4
A/10/ENV	0.32	28.4
A/1008/ENV	0.21	27.0
A/1011/ENV	0.28	29.1
A/1013/ENV	0.27	36.1
A/1015/ENV	0.31	28.6
A/3010/ENV	0.11	27.4
A/303/ENV	0.20	24.5
A/309/ENV	<0.1	20.0
Mean	**0.21**	**27.18**
StDev	**0.07**	**4.47**
%Variance	**34.2**	**16.5**
Vinson West ENV 5	**0.37**	-
Vinson West Mean	**0.41**	-
Vinson West SD	**0.04**	-
Nimrod Mean	**0.27**	-
Nimrod SD	**0.02**	-
Toroa Mean	**0.73**	-
Toroa SD	**0.05**	-

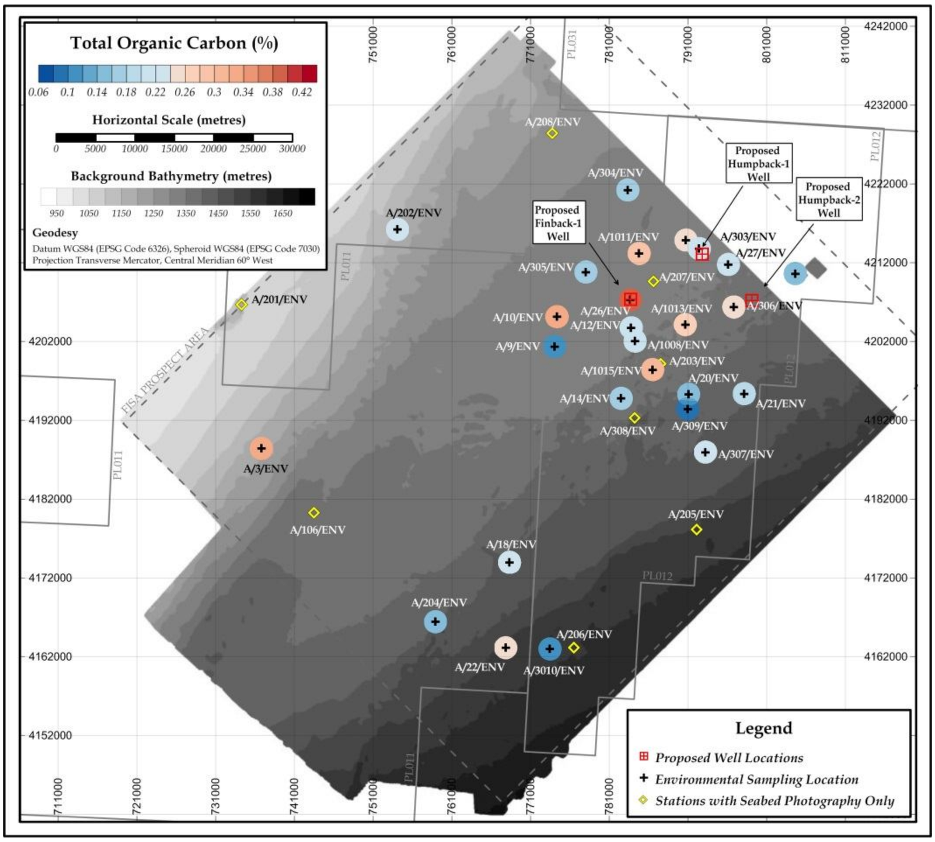
Historical data are reported in blue

The TOC results were low and reasonably consistent (Figure 2.6), ranging from <0.1% to 0.4% (mean 0.21±0.07SD). Overall, these sediments can be considered to be organically poor. The data revealed no spatial pattern of distribution. Station A/26/ENV showed the highest percentage of TOC (0.4%), which also recorded the highest level of %fines (66.7%). This underlined a strong correlation with the proportion of sediment fines (P<0.01, Appendix XI) recorded across the FISA area.

Overall, this level could be considered to be a limiting factor that may influence the distribution and abundance of some infaunal species within the substrates, in particular the deposit feeders within the sediments. TOC is expected to reflect autochthonous material and may give a broad measurement of a low carbon flux in this area due to relatively low nutrient enrichment of the water mass and limited terrestrial influences.

In addition to total organic carbon, the sediments were also analysed for moisture content. The moisture content remained consistent (mean 27.18±4.47SD), indicative of similar texture and consolidation throughout; although slightly higher values were observed at stations A/26/ENV (37.5%) and A/1013/ENV (36.1%).

Figure 2.6 - Total Organic Carbon (TOC)



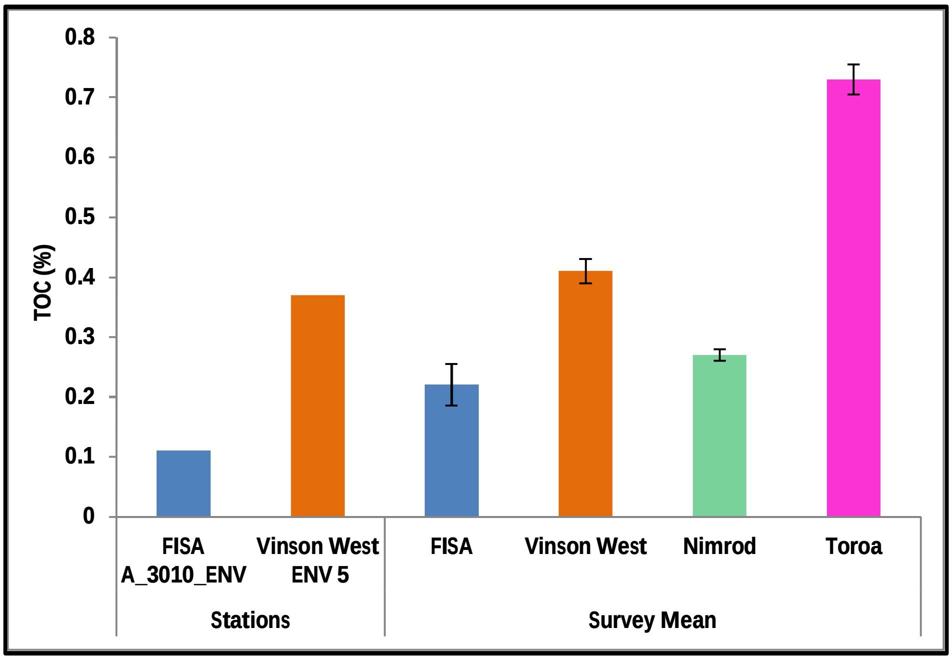
2.5.1 Historical Comparison with Total Organic Carbon

Overall, mean TOC levels in the FISA area can be compared to the data recorded previously in the region during similar baselines surveys at Vinson West (0.41±0.04SD) and Nimrod

(0.27±0.02SD; Figure 2.7). This shows that TOC was slightly variable in this area between 2009 and 2014. The Toroa area revealed a higher mean value of 0.73±0.05SD, corresponding to the finer sediment type previously recorded in this area. This was consistent with the particle size analysis (section above), as the mean percentage of fines (77.8%) at Toroa was about two to three times higher than measured at the other comparison sites.

The trend recorded in mean TOC was further reflected in the direct comparison between station A/3010/ENV on FISA and Vinson West ENV 5 which were also noticeable different (0.11% and 0.37%, respectively). This would suggest that the benthic population and deposition of organic material into the sediments, typically through detrital deposition from the water column (usually from autochthonous sources), varied between survey years. This was slightly lower in the current survey than previously recorded in 2011. As both surveys were undertaken in similar months of the year, the reason for this inconsistency is unclear.

Figure 2.7 - Total Organic Carbon (TOC) with Historical Data

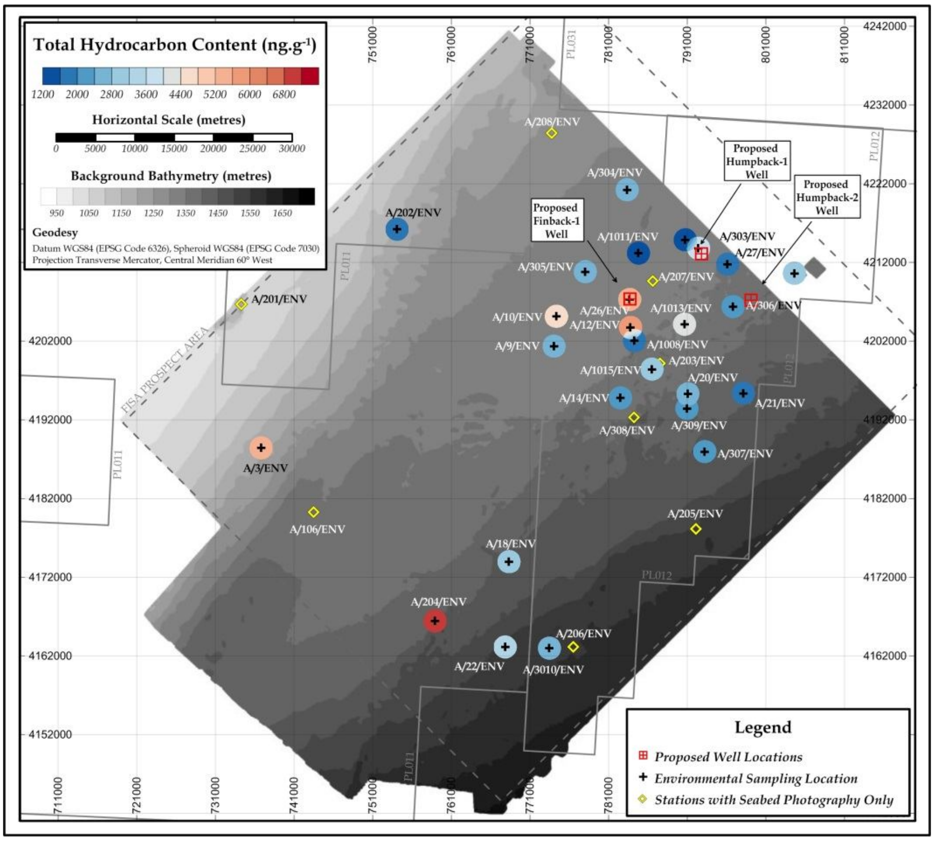


2.6 Sediment Hydrocarbons

2.6.1 Total Hydrocarbons Concentrations

Results for hydrocarbon analysis are summarised and tabulated as total hydrocarbon concentrations, total n-alkane and homologue ratios in Table 2.3, with individual alkanes (nC_{10}-nC_{37}) listed in Table 2.4. An example of a gas chromatogram showing the aliphatic hydrocarbon traces can be seen in Figure 2.11 (with the remaining gas chromatograms presented in Appendix IV for each station), labelled with every fourth n-alkane, the isoprenoid hydrocarbon, pristane and phytane, along with the internal standards hepta-methylnonane (A), deuterated hexadecane (B) and 1-chlorooctadecane, (C).

Figure 2.8 - FISA Sediment Hydrocarbon Content



The THC concentrations of the sediments, measured by integration of all non-polarised components within the GC trace, showed generally low levels but slightly higher concentrations recorded at some stations. The data ranged from 1.23µg.g^{-1} to 7.12µg.g^{-1} (Table 2.3 and Figure 2.8). The mean for the whole of the survey area was 3.10µg.g^{-1} (±1.50SD) but the variability between sites was quite noticeable, with a percentage variance (standard deviation over the mean) of 48%. The highest value of 7.1µg.g^{-1} was recorded at station A/204/ENV which was in close proximity to the escarpment feature. This variability cannot be explained by a geographical pattern of distribution (such as water depth) although THC negatively correlated with the % fines ($P<0.05$, Appendix XI). These can be compared to a mean of 2.9 µg.g^{-1} recorded in similar water depth west of the British Isles (AFEN, 1996).

Table 2.3 - Summary Hydrocarbon Concentrations

Station	THC ($\mu g.g^{-1}$)	Total n-alkanes ($ng.g^{-1}$)	Carbon Preference Index	Pristane/ phytane Ratio	Proportion of Alkanes (%)	Total PAHs ($ng.g^{-1}$)	NPD ($ng.g^{-1}$)
A/09/ENV	2.5	189	1.37	10.3	7.50	53.53	28.96
A/12/ENV	5.8	435	1.24	3.5	7.51	102.85	52.88
A/14/ENV	2.2	208	1.25	11.3	9.47	56.73	29.77
A/18/ENV	3.1	324	1.23	18.7	10.46	88.86	46.42
A/20/ENV	2.6	246	1.25	3.4	9.36	68.09	37.41
A/202/ENV	1.6	155	1.30	5.5	9.46	37.73	22.11
A/204/ENV	7.1	731	1.22	5.7	10.27	207.65	108.08
A/21/ENV	1.8	273	1.48	6.0	15.13	74.94	37.36
A/22/ENV	3.3	306	1.21	5.3	9.32	82.32	40.34
A/26/ENV	5.3	355	1.25	2.3	6.76	105.83	55.93
A/27/ENV	4.0	401	1.34	5.1	10.04	103.85	53.35
A/3/ENV	5.4	510	1.30	3.4	9.44	147.35	80.28
A/301/ENV	1.2	155	1.29	6.3	12.50	35.18	21.02
A/302/ENV	2.9	253	1.31	16.7	8.71	71.06	37.49
A/304/ENV	2.7	230	1.34	16.8	8.47	60.21	31.72
A/305/ENV	2.5	352	1.46	4.4	14.04	91.01	46.03
A/306/ENV	2.1	282	1.42	5.6	14.65	57.21	31.21
A/307/ENV	2.2	241	1.03	18.1	10.97	59.49	32.52
A/10/ENV	4.7	461	1.38	11.2	9.84	138.09	72.24
A/1008/ENV	1.9	234	1.29	8.9	12.27	63.84	33.35
A/1011/ENV	1.4	297	1.45	6.7	12.02	39.88	23.08
A/1013/ENV	4.4	423	1.36	12.7	9.70	118.88	65.76
A/1015/ENV	3.1	393	1.43	13.2	12.79	108.79	57.94
A/3010/ENV	2.4	272	1.16	12.5	11.15	76.12	38.88
A/303/ENV	1.9	179	1.33	9.9	9.19	40.26	22.63
A/309/ENV	2.4	237	1.29	13.2	9.95	62.21	31.96
Mean	**3.10**	**313.14**	**1.30**	**9.38**	**10.13**	**82.77**	**43.80**
StDev	**1.50**	**128.24**	**0.09**	**4.92**	**1.94**	**39.35**	**20.40**
%Variance	**48.3**	**44.4**	**7.3**	**52.4**	**19.2**	**47.5**	**46.6**
AFEN*	**2.90**	**660**	**1.8**	**2.5**	**23.4**	**179**	**72**
Vinson West ENV 5	**3.5**	**228**	**1.4**	**3.6**	**6.51**	**68**	**30**
Vinson West Mean	**3.7**	**162**	**1.5**	**4.3**	**5.21**	**51**	**24**
Vinson West SD	**2.0**	**40**	**0.1**	**0.6**	**2.42**	**10**	**4**
Nimrod Mean	**3.7**	**310**	**0.99**	**3.35**	**8.31**	**70**	**55**
Nimrod SD	**0.3**	**50**	**0.05**	**0.55**	**1.11**	**13**	**12**
Toroa Mean	**8.7**	**650**	**1.12**	**4.27**	**7.55**	**224**	**166**
Toroa SD	**1.1**	**90**	**0.13**	**0.64**	**0.23**	**18**	**19**

Historical data are reported in blue

** Average for deep water sediment (>1000m, AFEN, 1996).*

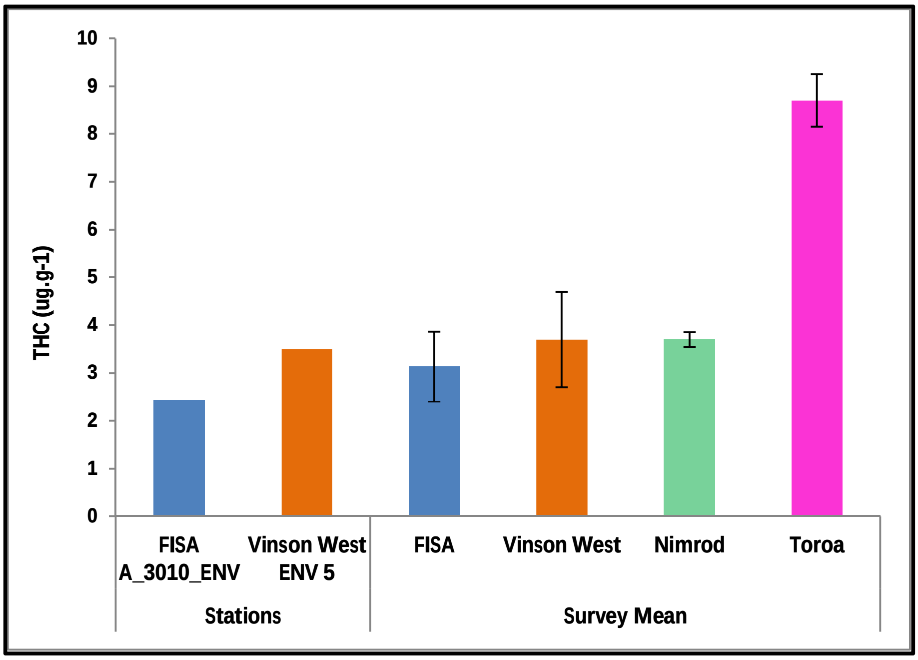
2.6.1.1 Historical Comparison with Total Hydrocarbon Concentration

The historical survey at the Vinson West prospect indicated an insignificantly higher THC value (mean 3.7±2.0SD; Figure 2.9) than recorded at FISA. A further comparison with the Nimrod site showed similar results and is indicative of a generally homogeneous THC level within this sediment type (i.e. gravelly silty sands), albeit that a slightly elevated standard deviation was recorded during these earlier studies. A further direct comparison between Vinson West

ENV5 and A/3010/ENV further revealed a similar elevation during the earlier survey (3.5µg.g^{-1} compared to 2.4µg.g^{-1} respectively). This is a minor change between the two surveys. The total hydrocarbon level for the Toroa survey area was quite different which had a higher mean value of 8.7±1.1µg.g^{-1}. These results were in accordance with the high percentage of fine in this area, indicative of higher sedimentation and stronger assimilation of this hydrocarbon component in the surface sediments. As with TOC, this is likely to be a result of increased sediment fines (77.8%) at this shallower site.

The presence of hydrocarbons in the sediments is due to a range of predominantly natural sources. The likely source of this material is discussed in greater details in Section 2.6.2.

Figure 2.9 - Comparison of Sediment Hydrocarbon Content with Historical Data



2.6.2 Saturate/Aliphatic Hydrocarbons

All of the sample stations were analysed for n-alkanes using gas chromatography with flame ionisation detection (GC-FID). The results are summarised in Table 2.3 and individually listed in Table 2.4, which gives a breakdown of consecutive n-alkane content from nC_{10} through to nC_{37}, together with the isoprenoid hydrocarbons Pristane (Pr) and Phytane (Ph).

Similar to THC, the total n-alkane concentrations were low overall, ranging from 155ng.g^{-1} to 731ng.g^{-1} (mean 313±0.128SD; Figure 2.10). The overall concentration of alkanes typically made up around 10% of the total THC recovered. This is quite low and is expected for uncontaminated marine sediments where background hydrocarbons are continuously being replenished by a low but chronic source of alkanes, usually from allochthonous sources.

Figure 2.10 - Total Saturate Alkanes

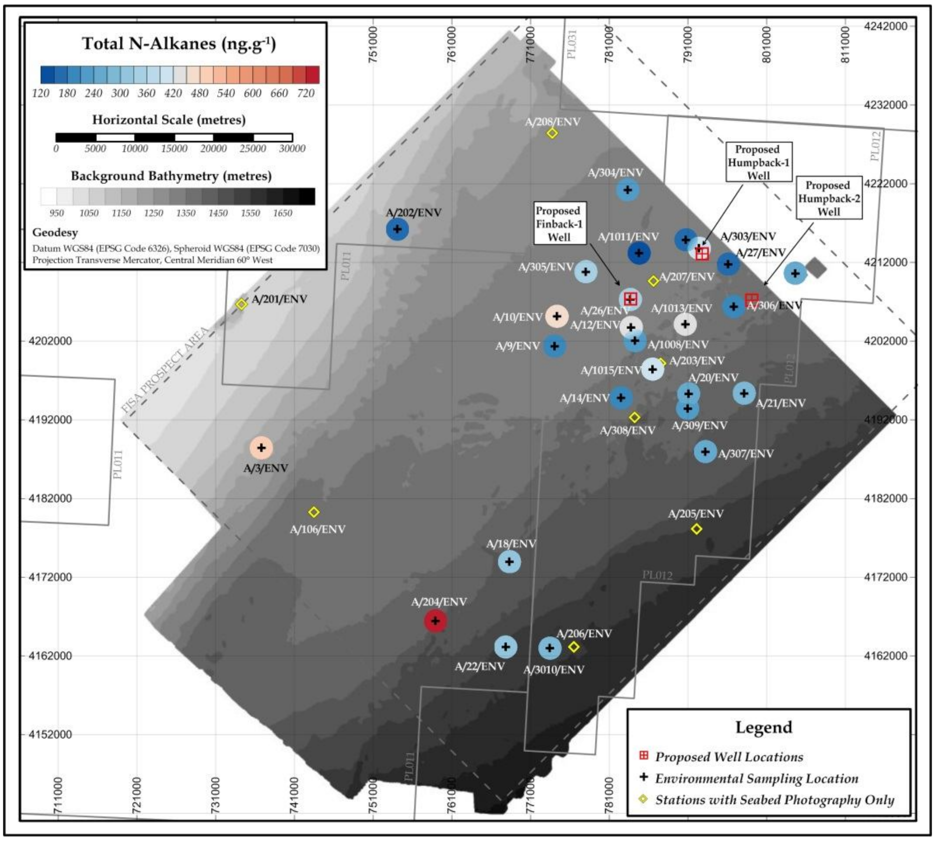
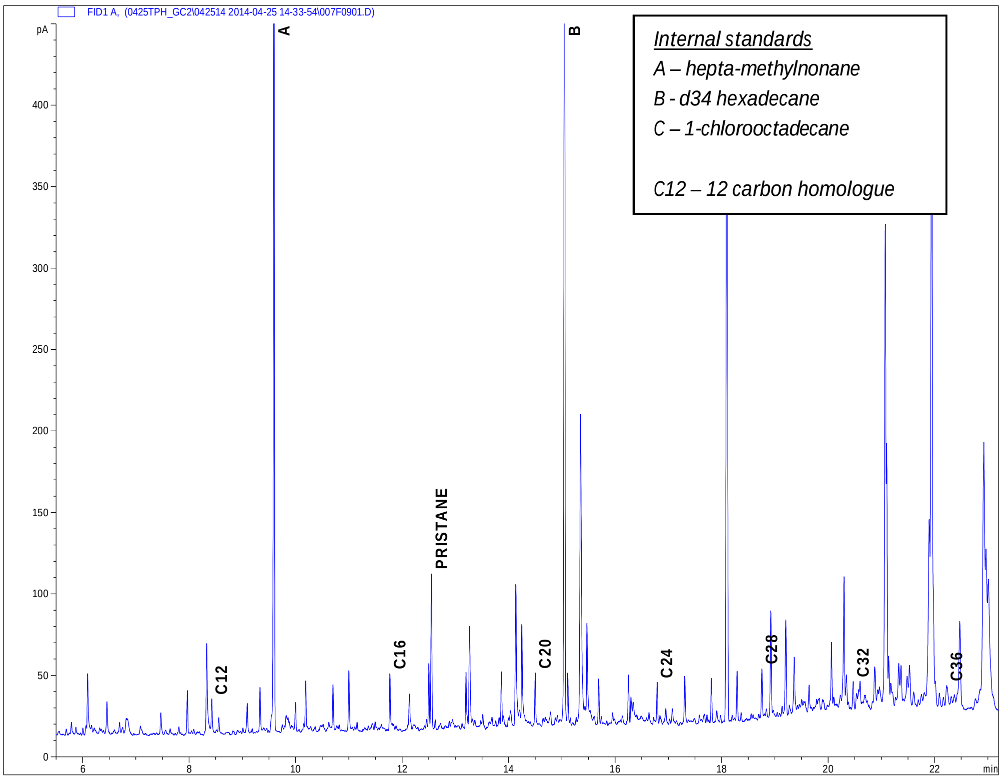


Figure 2.11 - Example Gas Chromatograms for Saturate Hydrocarbons Analysis (A/12/ENV)



Inspection of the individual gas chromatograms at all stations (Figure 2.11 and Appendix IV) indicated similar forms with little or no trends seen, other than those of natural background alkanes recorded in sediments of this type and region. Chromatograms showed a consistent homologous series of saturates throughout the range, but without a significant background "noise", with the exception of station A/12/ENV (Figure 2.11) and A/204/ENV (Appendix IV), albeit at a relatively low level. All stations can be considered as typical examples of this deep water sedimentary environment.

A closer review of the different proportions of n-alkanes recorded can sometimes identify trends within the data or the source from which the different organic components derive. Even though the overall level of saturates is extremely low, the following ratios were further reviewed:

Carbon Preference Index (CPI)

The carbon preference index (CPI), is associated with the preference of biogenic n-alkanes (i.e. that of a preference for odd-carbon numbered homologues, particularly around nC_{27-33}; Sleeter *et al.*, 1980), derived from fatty acids, alcohols, esters and land plant waxes. The CPI was calculated for all stations and was very consistent ranging from 1.03 to 1.48 (mean 1.30±0.09SD) for the full saturate range (nC_{10}- nC_{37}; Table 2.3 and Figure 2.12). Results show only a very small dominance by terrigeneous biogenic compounds although it is not clear if this is all allochthonous in nature. This is expected for an offshore environment where the impacts from terrestrial organic sources and plant matter are extremely limited.

Figure 2.12 - Hydrocarbon Analysis – Carbon Preference Index

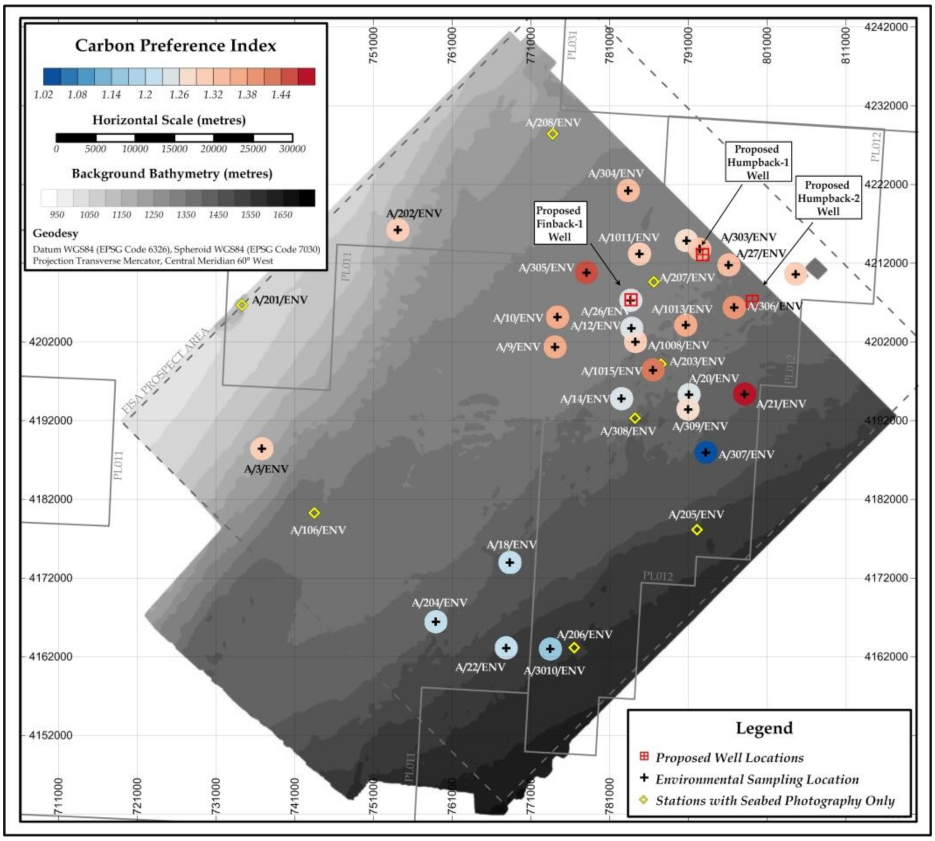


Table 2.4 - Total Aliphatic Concentrations (ng.g^{-1})

Station	A/9/ENV	A/12/ENV	A/14/ENV	A/18/ENV	A/20/ENV	A/202/ENV	A/204/ENV	A/21/ENV	A/22/ENV	A/26/ENV	A/27/ENV	A/3/ENV	A/301/ENV
nC10	<1	1.8	<1	<1	<1	1.1	2.7	<1	<1	<1	<1	1.4	<1
nC11	1.8	10.8	<1	4.9	3.3	1.9	11.3	1.1	3.4	<1	5.3	6.8	<1
nC12	4.1	16.7	3.5	5.5	5.2	4.9	17.6	5.3	4.5	9.3	11.1	12.4	4.4
nC13	6.1	16.0	6.8	10.8	8.7	4.4	22.8	7.8	10.0	10.5	14.0	16.9	4.6
nC14	7.6	16.6	9.8	11.9	9.5	7.0	27.6	11.6	13.2	14.3	15.0	21.6	5.5
nC15	11.9	25.2	12.3	19.9	15.7	8.0	43.7	15.2	17.9	22.7	23.1	33.1	8.0
nC16	10.7	19.4	11.5	18.2	13.7	7.0	40.5	14.4	16.3	23.2	21.9	28.7	7.8
nC17	12.7	24.3	12.9	20.5	16.3	8.6	44.3	17.6	17.8	24.1	24.0	35.9	11.2
pristane	31.2	62.5	34.2	54.3	41.2	20.7	122	49.2	49.2	63.2	57.7	85.3	23.0
nC18	10.9	19.6	13.3	20.0	15.0	8.3	43.5	14.0	17.8	22.0	21.7	31.8	8.2
phytane	3.0	17.7	3.0	2.9	12.0	3.8	21.4	8.2	9.4	27.5	11.3	24.9	3.7
nC19	9.3	17.1	11.6	16.9	13.7	6.8	43.8	16.5	15.2	16.7	21.4	27.2	7.2
nC20	9.6	20.5	10.7	16.7	13.9	7.1	44.7	14.7	16.1	18.7	18.8	26.3	6.9
nC21	7.8	15.6	10.0	15.2	10.8	6.1	37.9	12.4	15.1	16.3	16.0	23.1	6.0
nC22	7.3	14.8	8.5	12.9	9.8	5.7	31.8	9.9	12.2	13.8	14.6	20.7	5.5
nC23	7.3	14.7	8.3	14.4	10.1	6.1	29.5	12.1	13.2	14.2	14.5	22.6	5.8
nC24	7.7	14.0	8.3	19.1	9.3	5.6	30.3	9.4	11.4	12.5	14.4	16.8	5.7
nC25	8.6	14.8	9.5	15.8	9.2	6.5	29.9	10.2	13.7	15.7	16.7	21.0	6.5
nC26	6.5	15.6	7.6	11.0	9.3	5.5	26.6	8.9	10.6	12.8	13.6	19.0	5.5
nC27	9.3	17.6	10.9	15.3	10.9	7.3	36.5	13.5	13.4	17.9	18.7	25.2	7.7
nC28	7.3	18.7	6.9	9.3	9.1	5.6	23.4	6.8	18.6	9.7	12.8	14.1	7.4
nC29	14.1	41.1	19.0	23.2	17.5	14.3	49.8	23.0	29.6	30.8	33.6	37.8	14.8
nC30	3.2	10.5	4.2	7.4	5.1	3.9	15.5	7.9	6.5	5.6	9.7	10.6	4.8
nC31	9.4	19.8	12.1	15.9	10.2	13.6	33.0	20.9	11.9	16.6	23.4	25.8	11.3
nC32	5.1	10.9	5.4	9.0	7.1	4.3	20.4	3.1	8.3	10.8	10.8	13.0	4.6
nC33	8.2	17.2	2.5	5.5	8.9	4.1	19.0	7.7	3.7	9.8	17.0	10.4	3.9
nC34	<1	13.0	<1	2.4	1.1	1.6	3.1	3.1	2.3	2.9	4.8	3.8	1.4
nC35	1.1	3.8	<1	<1	1.5	<1	<1	1.2	2.6	2.4	1.9	2.4	<1
nC36	<1	2.1	3.0	2.0	1.1	<1	2.0	1.1	<1	1.9	2.6	1.1	<1
nC37	1.4	3.0	<1	<1	<1	<1	<1	3.8	<1	<1	<1	<1	<1
Total n-alkanes	**189**	**435**	**208**	**324**	**246**	**155**	**731**	**273**	**306**	**355**	**401**	**510**	**155**

...continuing next page

Table 2.4 - Total Aliphatic Concentrations (ng.g^{-1}) (2 of 2)

Station	A/302/ENV	A303/ENV	A/304/ENV	A/305/ENV	A/306/ENV	A/307/ENV	A/309/ENV	A/10/ENV	A/1008/ENV	A/1011/ENV	A/1013/ENV	A/1015/ENV	A/3010/ENV
nC10	<1	<1	<1	<1	<1	<1	1.3	4.5	<1	<1	3.3	1.1	<1
nC11	3.4	<1	3.1	2.5	2.4	1.9	4.7	6.4	4.6	<1	6.5	4.8	4.5
nC12	6.0	4.8	4.4	7.1	2.7	6.2	3.9	8.0	3.0	2.9	8.5	6.3	5.8
nC13	12.4	6.4	7.2	19.7	6.7	7.4	8.3	18.1	7.5	5.4	14.1	14.7	9.5
nC14	11.1	7.5	9.5	13.2	8.6	10.3	9.8	16.5	10.4	6.6	17.2	14.9	12.7
nC15	16.2	10.4	13.9	15.0	10.8	13.7	17.0	29.7	13.8	7.7	25.9	24.6	16.9
nC16	12.5	8.9	12.1	15.6	9.8	12.7	13.6	24.8	13.1	6.8	22.5	22.8	15.3
nC17	16.5	11.9	15.7	21.3	11.4	14.8	15.7	31.1	16.5	7.8	25.2	25.1	17.7
pristane	41.4	26.6	36.4	51.5	29.7	38.7	40.0	74.4	41.8	19.7	64.6	66.4	47.4
nC18	14.4	8.7	12.8	20.0	9.1	14.8	15.0	22.8	14.7	7.1	18.1	18.2	17.1
phytane	2.5	2.7	2.2	11.7	3.9	2.1	3.0	6.7	4.7	1.7	5.1	5.0	3.8
nC19	11.6	9.1	12.7	17.8	8.7	12.3	12.5	23.9	12.3	5.7	20.2	19.9	14.4
nC20	11.9	8.5	13.4	20.4	8.8	12.0	12.1	23.2	11.9	6.5	23.6	19.0	14.5
nC21	11.5	7.0	10.3	15.1	8.2	9.5	10.9	21.3	10.3	5.5	19.0	17.4	14.5
nC22	13.7	6.5	8.8	13.1	7.1	8.6	9.4	19.5	9.2	5.5	17.6	14.8	11.7
nC23	10.8	6.2	8.9	15.5	7.0	9.6	10.3	19.9	10.1	5.5	17.7	16.7	12.8
nC24	10.0	6.5	7.6	11.2	7.3	25.7	8.7	17.4	8.6	4.9	14.0	14.8	10.6
nC25	12.3	7.9	8.9	15.4	8.1	8.1	10.5	18.6	10.4	6.2	17.1	19.7	15.0
nC26	9.9	6.2	7.5	13.0	6.6	7.8	8.7	15.3	8.1	5.0	14.4	12.7	10.0
nC27	11.5	8.3	10.2	19.4	9.9	9.7	10.7	21.1	10.8	6.8	20.4	18.2	12.5
nC28	8.5	8.7	8.3	10.2	4.9	8.0	7.2	14.3	7.6	4.6	11.8	12.3	9.4
nC29	21.6	16.5	17.6	30.5	16.3	15.9	15.1	37.5	17.8	13.0	38.9	33.5	15.9
nC30	3.5	4.2	5.1	9.2	5.1	5.0	5.7	10.0	6.6	3.0	9.2	8.5	8.9
nC31	9.1	10.4	11.7	26.1	11.3	9.9	12.3	25.9	13.2	9.4	25.5	26.8	9.7
nC32	4.6	5.1	6.4	6.4	5.7	6.8	6.9	14.3	7.8	3.9	14.2	12.2	8.4
nC33	5.5	6.8	9.8	4.9	8.1	8.3	5.2	13.6	4.4	5.5	9.8	8.6	2.7
nC34	1.8	1.3	1.4	2.2	1.7	<1	1.2	1.2	<1	1.6	3.7	2.5	<1
nC35	<1	1.2	1.5	2.2	<1	<1	<1	<1	<1	<1	3.1	1.6	<1
nC36	1.9	<1	1.1	1.6	1.0	1.1	<1	1.8	1.1	2.1	1.3	1.5	1.5
nC37	1.1	<1	<1	3.5	<1	1.3	<1	<1	<1	<1	<1	<1	<1
Total n-alkanes	**253**	**179**	**230**	**352**	**187**	**241**	**237**	**461**	**234**	**139**	**423**	**393**	**272**

Petrogenic/Biogenic or (P/B) Ratio

The P/B ratio compares the lighter, more petrogenic aliphatics with the heavier, and more biogenic aliphatics. Results were calculated for all stations showing a consistent but moderate ratio ranging from 0.69 to 0.93 (mean 0.80±0.06SD) with no clear pattern of distribution. These levels may indicate some minor influence from mixed hydrocarbon source with a possible petrogenic component.

The Pristane/Phytane Ratio

Pristane and phytane are both isoprenoidal alkanes commonly found as constituents within crude oils (Berthou and Friocourt, 1981). However, in biogenic environments, only pristane is commonly found in the marine environment as naturally biosynthesised and a product of phytol moiety of chlorophyll. Phytane is generally absent or only present at low levels in uncontaminated natural systems (Blumer and Snyder, 1965). A presence of both isoprenoids at similar levels is typically taken as an indication of petroleum contamination.

The pristane/phytane ratio ranged from 3.40 to 18.70 (mean 9.38±4.92SD). This would indicate a clear pristane dominance of biogenic origin. This is likely attributed to a significant biogenic influence on the sediments as a result of significant planktonic contribution. This plankton influence could possibly be from the highly productive surrounding surface waters of the Patagonian marine ecosystem. It should be noted that pristane/phytane ratio can often be difficult to interpret due to its erratic nature and should be used mainly to substantiate other interpretations. The use of the ratio in interpretative discourse is open to criticism, mainly owing to the natural occurrence of phytane in some older sediments and the confusing variation of sedimentary pristane, induced by the variability of phytoplankton numbers (Blumer and Snyder, 1965). This may be the case with the current study where high levels of background phytane (petrogenic in origin) are masked by even higher levels of pristane due to significant plankton influence.

2.6.2.1 Historical Comparison with Saturate/Alkanes Hydrocarbons

Previous levels of historical saturates at sites surveyed at the Vinson West, Nimrod and Toroa prospects registered mean total alkanes of 162, 310 and 650ng.g^{-1}, equivalent to 5.2%, 8.3% and 7.6% of the THC, respectively (Figure 2.13). A further direct comparison between Vinson West ENV5 and A/3010/ENV further revealed a similar concentration (228ng.g^{-1} compared to 270ng.g^{-1} respectively).

A general comparison of the saturate chromatograms indicated broad similarities based on uncontaminated hydrocarbon signatures.

For the CPI, the mean value of 1.30 recorded within the current study can be compared to a mean value of 1.50 (±0.10SD) previously recorded at Vinson West, both being slightly higher than 1.12 and 0.99 recorded at Toroa and Nimrod, respectively (Figure 2.14). The values close to unity and the general lack of variance between sites indicates these values are typical for this depth and region of the South Atlantic, located outside of significant influences from terrestrial plants. Terrigenous influence is normally reflected in a higher CPI value which is due to elevated long chain odd numbered alkanes in wax cuticles of higher plants (Eglinton *et al.,* 1962). Further direct comparison between Vinson West ENV5 and A/3010/ENV also revealed a similar result (1.4 compared to 1.16, respectively).

Figure 2.13 - Comparison of Total Saturate Alkanes with Historical Data

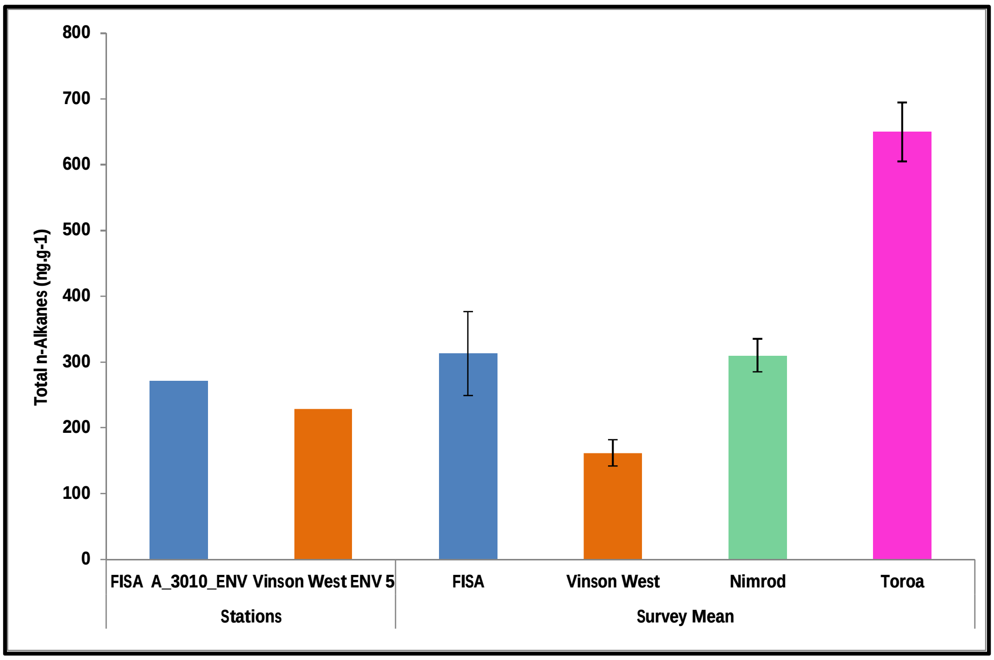
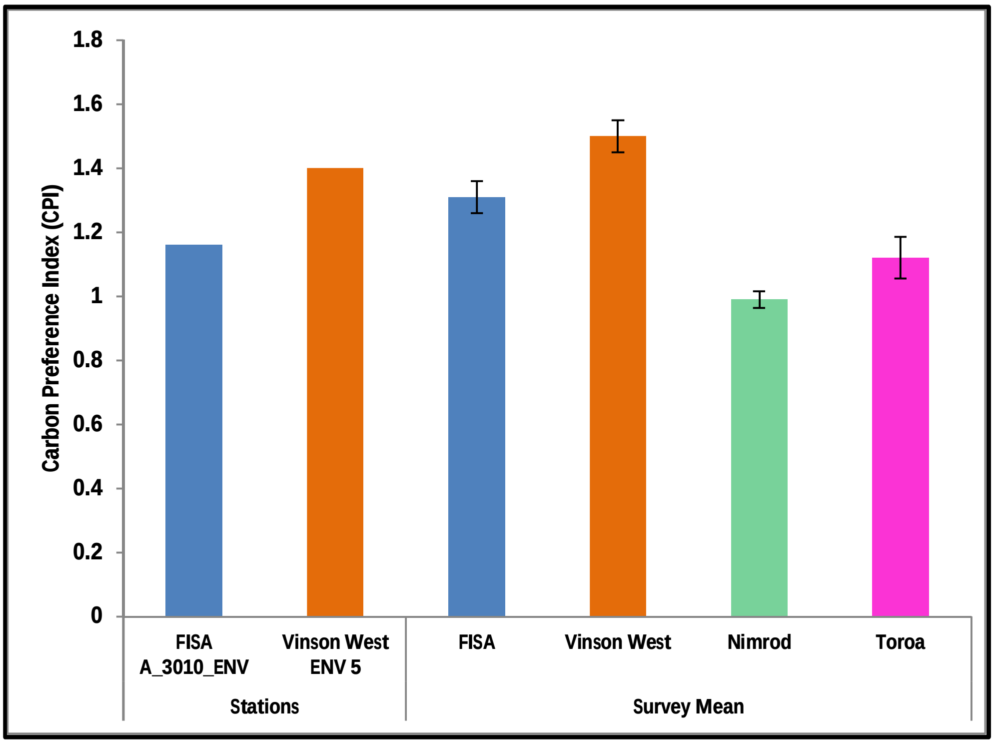


Figure 2.14 - Comparison of Carbon Preference Index with Historical Data



2.6.3 Polycyclic Aromatic Hydrocarbons (PAH)

Quantitative PAHs were analysed at each station using Gas Chromatography-Mass Spectrometry (GC-MS).

Results of the single ion current (SIC) analyses are summarised in Table 2.3, and detailed in Table 2.5, showing concentrations for both parent compounds and their alkyl derivatives. The concentrations of 16 PAH priority pollutants listed by US Environmental Protection Agency (EPA) are listed in Appendix V. The EPA 16 are used globally in assessment of contamination relating to both environmental and human health studies.

PAHs and their alkyl derivatives have been recorded in a wide range of marine sediments (Laflamme and Hites, 1978) with the majority of compounds produced from what is thought to be pyrolytic sources. These are the combustion of organic material such as forest fires (Youngblood and Blumer, 1975), the burning of fossil fuels and, in the case of offshore oilfields, flare stacks, etc. The resulting PAHs, rich in the heavier weight 4-6 ring aromatics, are normally transported to the sediments via atmospheric fallout or river run-off. Another PAH source is petroleum hydrocarbon, often associated with localised drilling activities. These are rich in the lighter, more volatile 2 and 3 ring PAHs (NPD; naphthalene (128), phenanthrene, anthracene (178) and dibenzothiophene (DBT) with their alkyl derivatives).

Total PAH concentrations (2-6 compounds) were moderately low for all sites analysed, ranging from 35.18ng.g^{-1} to 207.65ng.g^{-1} (mean 82.77±39.35SD; Table 2.3, Figure 2.15). Total PAHs indicated no real pattern of distribution within the surface sediments, although an elevated level was measured at station A/204/ENV (207.65ng.g^{-1}), and a weak correlation with % fines recorded throughout ($P<0.05$, Appendix XI).

Figure 2.15 - Total Polycyclic Aromatic Hydrocarbons (2-6 Ring)

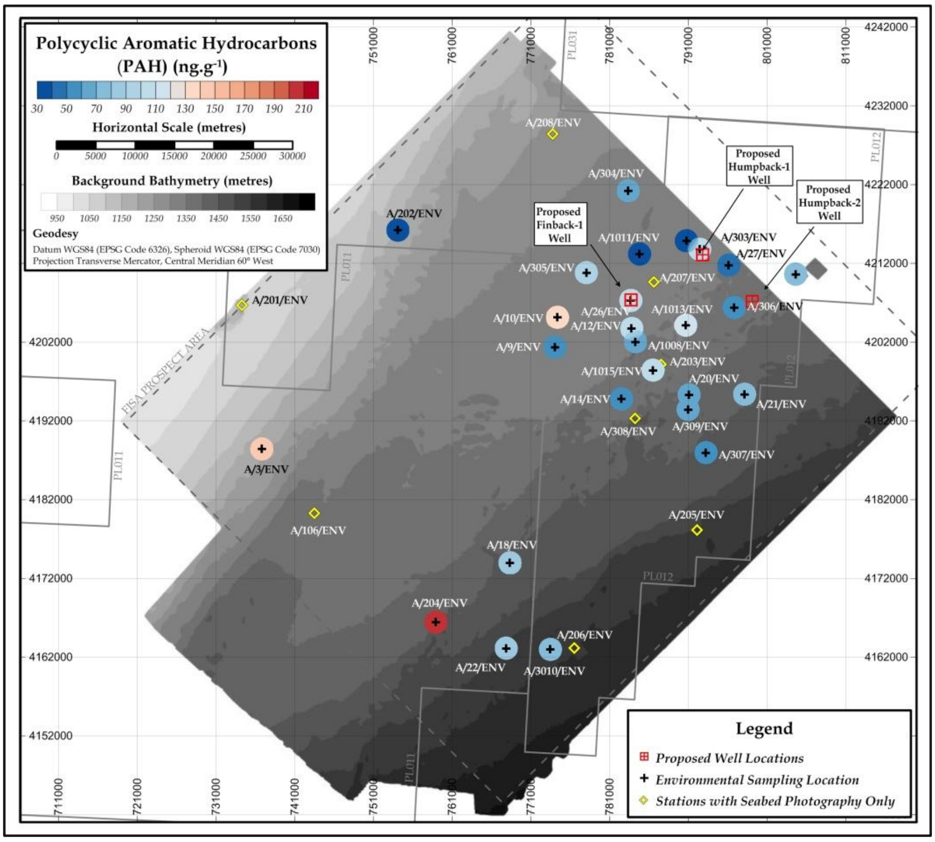


Table 2.5 - Polyaromatic Hydrocarbon Concentrations (Single Ion Currents, $ng.g^{-1}$)

Station	A/9/ENV	A/12/ENV	A/14/ENV	A/18/ENV	A/20/ENV	A/202/ENV	A/204/ENV	A/21/ENV	A/22/ENV	A/26/ENV	A/27/ENV	A/3/ENV	A/301/ENV
Naphthalene	1.0	2.0	<1	1.0	2.5	<1	2.7	<1	<1	1.2	1.3	1.7	<1
C1 Naphthalenes	2.1	3.4	2.1	3.3	2.7	1.7	7.0	2.3	2.5	3.4	3.5	4.7	1.5
C2 Naphthalenes	3.6	5.8	3.7	5.4	4.3	2.9	12.4	4.3	4.6	6.4	6.7	8.9	2.8
C3 Naphthalenes	5.4	7.7	5.9	8.7	6.1	4.2	18.1	7.3	8.3	7.2	10.1	13.6	3.8
C4 Naphthalenes	3.5	5.5	4.2	6.5	4.5	3.0	14.1	5.7	5.4	8.5	6.3	10.2	3.0
Sum Naphthalenes	15.6	24.3	15.8	25.0	20.1	11.7	54.3	19.6	21.0	26.8	27.9	39.1	11.1
Phenanthrene / Anthracene	2.1	4.4	2.3	3.5	3.1	1.7	8.6	2.7	2.9	4.1	3.8	5.9	1.7
C1 178	4.1	8.9	4.4	6.4	5.2	3.1	15.1	5.3	5.8	7.7	7.2	11.2	3.1
C2 178	4.0	7.6	4.1	6.2	4.9	3.0	15.5	5.5	6.2	8.3	7.6	11.4	3.0
C3 178	3.1	6.5	3.2	5.3	4.1	2.5	9.9	4.2	4.4	6.8	5.7	8.4	2.2
Sum 178	13.3	27.4	14.0	21.4	17.3	10.4	49.1	17.7	19.4	26.9	24.3	36.9	9.9
Dibenzthiophene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
C1 Dibenzthiophenes	<1	1.2	<1	<1	<1	<1	1.8	<1	<1	1.3	1.2	1.8	<1
C2 Dibenzthiophenes	<1	<1	<1	<1	<1	<1	1.8	<1	<1	1.0	<1	1.4	<1
C3 Dibenzthiophenes	<1	<1	<1	<1	<1	<1	1.1	<1	<1	<1	<1	1.2	<1
Sum Dibenzthiophenes	0.0	1.2	0.0	0.0	0.0	0.0	4.7	0.0	0.0	2.3	1.2	4.3	0.0
Fluoranthene / pyrene	1.1	2.1	1.1	1.6	1.2	<1	4.5	1.4	1.5	1.9	1.7	3.6	<1
C1 202	2.2	4.1	2.1	3.5	2.6	1.5	7.2	3.0	3.5	3.9	3.8	5.7	1.5
C2 202	2.5	5.4	2.8	4.2	3.4	1.8	10.1	3.9	4.3	5.0	5.2	7.6	2.1
C3 202	2.3	5.3	2.2	4.0	3.0	1.5	8.8	3.0	3.8	4.7	4.6	6.3	1.8
Sum 202	8.1	16.9	8.3	13.3	10.2	4.8	30.6	11.3	13.1	15.4	15.3	23.2	5.4
Benzanthracene / chrysene	1.4	2.7	1.5	2.3	1.8	1.0	6.4	1.8	2.1	2.6	2.5	3.7	<1
C1 228	2.4	4.4	2.4	3.6	2.8	1.9	8.3	3.7	3.7	4.5	4.2	6.0	1.7
C2 228	2.3	5.3	2.6	4.2	3.4	1.7	9.3	3.2	4.4	5.2	4.5	6.3	1.8
Sum 228	6.1	12.4	6.5	10.1	8.0	4.6	24.0	8.8	10.3	12.3	11.2	16.0	3.5
Benzfluoranthenes / benzopyrenes	1.3	4.6	2.6	3.5	2.7	<1	11.0	3.5	3.7	4.1	4.4	6.1	<1
C1 252	3.3	5.6	3.6	5.6	3.7	2.6	10.2	5.3	5.3	6.6	6.5	8.2	2.4
C2 252	2.9	5.3	3.0	5.5	2.9	2.2	11.0	4.7	4.4	5.9	6.5	8.3	1.7
Sum 252	7.5	15.5	9.2	14.6	9.3	4.8	32.2	13.5	13.4	16.6	17.4	22.6	4.1
Aranthanthrenes / indeno- pyrene / benzperylene	1.1	2.6	1.2	1.8	1.3	<1	5.5	1.9	1.9	2.1	2.5	3.0	<1
C1 276	1.7	2.6	1.7	2.6	1.8	1.4	5.3	2.0	2.2	3.4	3.0	1.1	1.2
C2 276	<1	<1	<1	<1	<1	<1	1.9	<1	1.1	<1	1.1	1.2	<1
Sum 276	2.9	5.1	2.9	4.4	3.1	1.4	12.8	3.9	5.2	5.5	6.6	5.3	1.2
Sum of NPD fraction	**29.0**	**52.9**	**29.8**	**46.4**	**37.4**	**22.1**	**108**	**37.4**	**40.3**	**55.9**	**53.4**	**80.3**	**21.0**
% NPD	**54.1**	**51.4**	**52.5**	**52.3**	**54.9**	**58.6**	**52.1**	**49.9**	**49.0**	**52.9**	**51.4**	**54.5**	**59.8**
Parent to derivative ratio	**1.2**	**1.1**	**1.1**	**1.1**	**1.2**	**1.4**	**1.1**	**1.0**	**1.0**	**1.1**	**1.1**	**1.2**	**1.5**

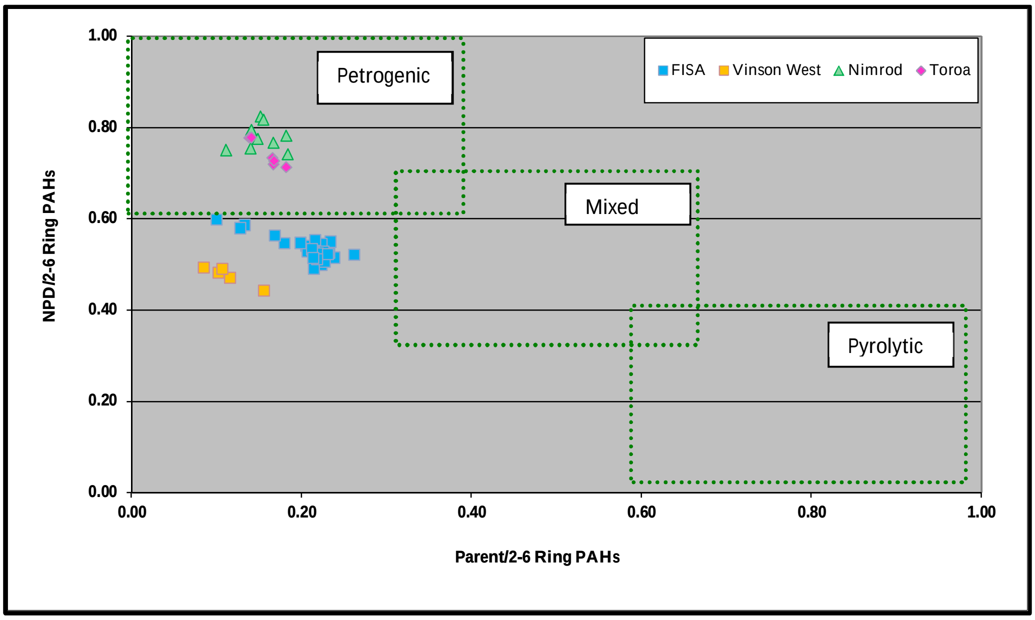
Table 2.5 - Polyaromatic Hydrocarbon Concentrations (Single Ion Currents, $ng.g^{-1}$) (2 of 2)

Station	A/302/ENV	A/304/ENV	A/305/ENV	A/306/ENV	A/307/ENV	A/10/ENV	A/1008/ENV	A/1011/ENV	A/1013/ENV	A/1015/ENV	A/3010/ENV	A/303/ENV	A/309/ENV
Naphthalene	1.2	<1	<1	1.7	1.1	2.3	<1	1.2	2.7	1.8	1.0	<1	1.0
C1 Naphthalenes	2.4	2.1	2.9	2.6	2.2	5.0	2.3	1.6	4.5	3.8	2.2	1.7	2.0
C2 Naphthalenes	4.3	3.9	5.4	3.9	3.7	8.6	4.2	2.7	7.6	6.7	4.7	2.8	3.9
C3 Naphthalenes	6.9	5.7	8.2	5.6	5.8	12.4	6.6	4.3	12.2	10.6	7.5	4.4	5.7
C4 Naphthalenes	5.1	4.5	5.7	3.8	4.3	9.6	4.7	2.7	8.5	6.9	5.3	3.1	4.9
Sum Naphthalenes	19.9	16.2	22.2	17.7	17.2	37.8	17.8	12.5	35.5	29.8	20.8	12.0	17.5
Phenanthrene / Anthracene	3.0	2.3	3.5	2.2	2.5	5.2	2.6	1.8	4.7	4.1	2.9	1.9	2.3
C1 178	5.5	4.7	6.6	3.9	4.8	9.7	4.9	3.3	8.2	7.8	5.5	3.4	4.3
C2 178	5.2	4.8	6.7	4.3	4.7	9.2	4.7	3.1	8.2	7.8	5.6	3.0	4.3
C3 178	3.8	3.8	5.9	3.1	3.4	7.7	3.3	2.3	6.7	6.2	4.1	2.4	3.5
Sum 178	17.6	15.5	22.7	13.5	15.4	31.9	15.6	10.5	27.7	25.9	18.1	10.6	14.5
Dibenzthiophene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
C1 Dibenzthiophenes	<1	<1	1.1	<1	<1	1.4	<1	<1	1.3	1.2	<1	<1	<1
C2 Dibenzthiophenes	<1	<1	<1	<1	<1	1.2	<1	<1	1.2	1.0	<1	<1	<1
C3 Dibenzthiophenes	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Sum Dibenzthiophenes	0.0	0.0	1.1	0.0	0.0	2.5	0.0	0.0	2.5	2.3	0.0	0.0	0.0
Fluoranthene / pyrene	1.4	1.2	1.7	<1	1.1	2.3	1.2	<1	1.9	1.8	1.4	<1	1.1
C1 202	3.0	2.4	3.7	2.3	2.3	5.5	2.6	1.7	4.6	4.3	2.9	1.6	2.4
C2 202	3.2	3.0	4.6	3.0	3.0	6.1	3.2	2.0	5.3	5.3	3.8	2.0	3.3
C3 202	3.0	2.6	3.3	2.7	2.8	6.0	2.8	1.7	4.8	4.6	3.0	1.7	2.9
Sum 202	10.6	9.2	13.3	8.0	9.2	19.9	9.7	5.5	16.6	16.0	11.0	5.3	9.7
Benzanthracene / chrysene	1.8	1.5	2.4	1.4	1.5	3.4	1.7	1.1	2.9	2.7	2.0	1.1	1.6
C1 228	3.1	2.7	4.4	2.5	2.8	5.6	2.7	1.8	4.5	4.5	3.4	1.8	2.7
C2 228	2.9	3.1	4.3	2.6	2.9	6.4	3.8	2.0	4.7	4.9	4.2	1.9	3.4
Sum 228	7.8	7.3	11.0	6.5	7.2	15.4	8.3	5.0	12.1	12.0	9.6	4.9	7.8
Benzfluoranthenes / benzopyrenes	3.0	2.6	4.2	1.3	1.4	5.9	2.8	<1	4.8	4.5	3.4	1.0	2.7
C1 252	5.1	3.4	6.4	4.2	3.3	8.0	3.9	2.8	7.3	6.3	5.0	2.8	3.7
C2 252	3.9	3.2	5.0	3.2	2.9	8.6	2.9	2.0	5.6	5.9	4.2	2.3	3.4
Sum 252	12.0	9.2	15.6	8.8	7.6	22.5	9.6	4.9	17.7	16.7	12.5	6.1	9.8
Aranthanthrenes / indeno- pyrene / benzperylene	1.6	1.0	2.1	1.2	1.2	3.0	1.3	<1	2.4	2.1	1.8	<1	1.2
C1 276	1.6	1.8	2.9	1.6	1.8	4.1	1.6	1.5	3.2	2.6	2.3	1.3	1.7
C2 276	<1	<1	<1	<1	<1	1.0	<1	<1	1.1	1.3	<1	<1	<1
Sum 276	3.1	2.8	5.0	2.8	2.9	8.1	2.9	1.5	6.7	6.1	4.1	1.3	2.9
Sum of NPD fraction	**37.5**	**31.7**	**46.0**	**31.2**	**32.5**	**72.2**	**33.4**	**23.1**	**65.8**	**57.9**	**38.9**	**22.6**	**32.0**
% NPD	**52.8**	**52.7**	**50.6**	**54.6**	**54.7**	**52.3**	**52.2**	**57.9**	**55.3**	**53.3**	**51.1**	**56.2**	**51.4**
Parent to derivative ratio	**1.1**	**1.1**	**1.0**	**1.2**	**1.2**	**1.1**	**1.1**	**1.4**	**1.2**	**1.1**	**1.0**	**1.3**	**1.1**

The NPD fraction, like total PAH, was low ranging from $21ng.g^{-1}$ to $108ng.g^{-1}$ (mean 43.8±20.4SD; Table 2.3), but moderately high and consistent by proportion which ranged from 49.0% to 59.8%. This reflects a low but stable petrogenic influence to the sediments. Like total PAH, the NPD fraction similarly correlated weakly with % fines.

Further information on the source(s) of PAH in the sediment may be obtained from a study of their alkyl homologue distributions (i.e. the degree of methyl, ethyl, substitution of the parent compounds). Pyrolytically derived PAHs are predominantly unalkylated whereas petrogenically derived PAHs are formed at relatively low temperatures (<150°C), and contains mainly alkylated species. The distribution of parent 2-6 ring PAH compounds also reflects whether the source is petrogenic or pyrolytic. The trend is represented graphically in Appendix V. These are three-dimensional plots which show the PAH concentrations, the parent compound distribution and the alkyl homologue distribution of the aromatic material in each of the sediments analysed. Predominantly, mixed to pyrolytic hydrocarbons were recorded within the aromatic materials, with approximately half or more of all PAHs represented by parent compounds. These results, combined with the moderate proportion of more petrogenically derived naphthalenes, phenanthrenes and dibenzothiophenes is demonstrated further in Figure 2.16. This indicates that the PAHs are predominantly petrogenic in origin; although an influence from mixed components was apparent throughout the lighter aliphatics (NPD).

Figure 2.16 - PAH Source Assignment for FISA and Historical Data

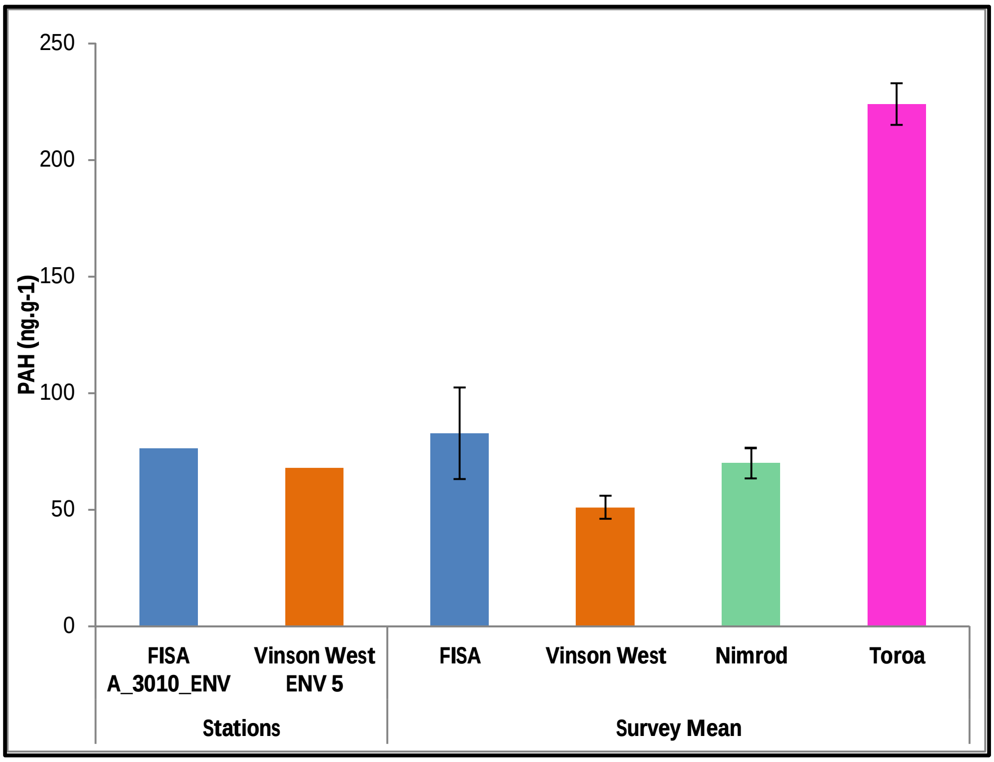


Overall, the amplitude of the hydrocarbon signature within the FISA survey area substrates was low and as generally expected for this region of the South Atlantic. However, the distribution of aromatics components suggests a very limited terrigeneous source of material, with most fractions dominated by petrogenic material with only a minor pyrolytic component. Given the remote location of these sites along with their limited exposure to anthropogenic sources for thermogenic hydrocarbons, the most likely source of this material will be natural hydrocarbon seeps. The low THC and saturates levels suggest that this relates to a low level chronic supply, possibly from a remote origin.

2.6.3.1 Historical Comparison with Aromatic Hydrocarbons

The historical survey at the Vinson West and Nimrod prospects indicated similar or marginally lower concentrations of 51ng.g^{-1} and 70ng.g^{-1}, respectively, compared to 82.8ng.g^{-1} recorded at FISA (Figure 2.17). A further direct comparison between Vinson West ENV5 and A/3010/ENV revealed a similar level during the earlier survey (68ng.g^{-1}). A similar analysis carried out further south at the Toroa site, recorded a higher mean of 224ng.g^{-1} (±18SD). This result is in accordance with the higher percentage of fines recorded in this area (77.8%), indicative of higher sedimentation and stronger assimilation of this hydrocarbon component in the surface sediments. Furthermore, this may also give some geographical indication of the direction from which natural petrogenic material may be transported, with elevated levels recorded towards the south and west.

Figure 2.17 - Comparison of Total Polycyclic Aromatic Hydrocarbons with Historical Data



2.7 HEAVY AND TRACE METAL CONCENTRATIONS

Results for heavy and trace metal analysis are given in Table 2.6 and Figures 2.18 to 2.27. All of the heavy and trace metals analysed (Al, Ba, Sn, As, Fe, Cd, Cr, Cu, Ni, Pb, V and Zn), with the exception of mercury (Hg), underwent a single hydrofluoric (HF) digestion and extraction for total sediment metals. The question of bioavailability of metals to marine organisms is a complex one, as sediment granulometry and the interface between waters and sediment all affect the bioavailability and subsequently toxicity. Therefore, even if a metal is found in higher concentrations it does not necessarily follow that this will have a detrimental effect on the environment, if present in an insoluble state. Historically, several extraction techniques have been applied to metal analysis in the past, with the most common applying to an HF/perchloric extraction for total metals, and a weaker nitric or aqua regia extraction. The latter techniques have shown close correlation to metal burdens in the tissues of benthic organisms (Luoma and Davies, 1983; Bryan and Langston, 1992). However, the overall extent to which a particular digests reflects bioavailability is still not well understood. A further fusion analysis was not considered necessary for Ba due to the unlikely occurrence of insoluble barium typically recorded in areas where previous drilling activities have occurred.

Metals occur naturally in the marine environment, and are widely distributed in both dissolved and sedimentary forms. Some are essential to marine life while others may be toxic to numerous organisms (Paez-Osuna and Ruiz-Fernandez, 1995). Rivers, coastal discharges, and the atmosphere are the principal modes of entry for most metals into the marine environment (Schaule and Patterson, 1983), with anthropogenic inputs occurring primarily as components of industrial and municipal wastes. Historically, several heavy and trace metals are found in elevated concentrations where drilling fluids or produced waters have been discharged by oil and gas installations. These include intentional additives (such as metal based salts and organo-metallic compounds in the fluids) as well as impurities within the drilling mud systems such as clays (e.g. bentonites; a gelling and viscosifying agent) and metal lignosulphates (viscosity controllers; McCourt *et al.*, 1991). Metals most characteristic for offshore contamination of marine sediments are Ba, Cr, Pb and Zn (Neff, 2005), although these may vary greatly dependent upon the constituents used.

Table 2.6 - Total Heavy and Trace Metal Concentrations (µg.g^{-1} or ppm)

	Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Nickel (Ni)	Tin (Sn)	Vanadium (V)	Zinc (Zn)	Aluminium (Al) mg.g^{-1}	Barium (Ba)	Iron (Fe) mg.g^{-1}
A/09/ENV	11	<0.1	136.7	16.8	5.6	0.02	9.8	1.2	77.2	69.8	25.9	306	118
A/12/ENV	10.2	<0.1	133	13.9	6.1	0.01	15.3	1.4	76.2	140	25.4	291	112
A/14/ENV	11.1	<0.1	136.3	14.5	6.2	0.01	10.6	1.1	74.8	70.7	24.5	250	131
A/18/ENV	11.1	<0.1	140.2	15.7	5.9	0.01	10.0	1.3	72.5	74.0	20.7	253	135
A/20/ENV	9.6	<0.1	144.5	19.6	5.9	0.01	13.2	2.1	75.4	83.7	22.8	285	116
A/202/ENV	13.2	<0.1	113.9	16.2	6.1	0.01	9.3	1.5	75.0	70.4	22.4	279	134
A/204/ENV	3.2	<0.1	34.9	17.0	4.2	0.02	10.2	1.5	52.7	43.3	27.2	529	24.7
A/21/ENV	8.9	<0.1	156.8	13.7	6.9	0.01	14.2	1.5	76.3	86.2	28.1	327	117
A/22/ENV	10.1	<0.1	126.1	14.7	6.2	0.01	10.1	1.2	70.0	71.0	22.9	508	122
A/26/ENV	6.4	<0.1	92.4	17.1	5.9	0.02	12.2	1.5	69.4	64.3	32.6	414	49.2
A/27/ENV	10.9	<0.1	110.1	15.8	6.1	0.01	10.5	2.1	74.0	71.5	26.5	313	102
A/3/ENV	12.3	<0.1	89.4	15.5	7.4	0.03	10.1	1.1	72.1	69.6	28.4	415	95
A/301/ENV	7.6	<0.1	127.9	20.1	6.3	0.03	17.6	1.3	71.6	88.0	26.7	321	93.8
A/302/ENV	9.1	<0.1	170.1	17.2	5.2	0.01	14.9	1.4	82.4	84.5	23.5	268	116
A/304/ENV	10.1	<0.1	147.5	14.3	5.2	0.01	10.4	1.6	77.4	72.7	25.5	311	121
A/305/ENV	11.3	<0.1	143.1	11.8	6.6	0.01	10.9	1.4	78.1	75.4	25.9	317	118
A/306/ENV	7.3	<0.1	140.3	18.1	5.8	0.02	20.4	2.3	89.4	85.0	31.5	338	89.5
A/307/ENV	9.9	<0.1	148.9	15.9	6.1	0.01	12.9	1.7	80.9	78.5	25.0	442	128
A/10/ENV	11.1	<0.1	143.2	11.2	4.9	0.01	10.6	1.3	84.1	73.0	27.0	340	10.7
A/1008/ENV	8.6	<0.1	132.3	17.4	5.4	0.01	14.4	1.3	84.0	88.4	25.1	351	93.9
A/1011/ENV	11.4	<0.1	130.3	13.5	6.1	0.02	11.6	1.2	83.8	78.6	25.8	296	104
A/1013/ENV	4.7	<0.1	74.1	15.8	6.7	0.02	12.6	1.2	63.2	57.9	24.3	365	37.8
A/1015/ENV	6.8	<0.1	82.6	19	13.3	0.02	14.9	1.5	80.3	73.2	38.2	338	55.7
A/3010/ENV	12.1	<0.1	158.4	15.6	6.6	0.01	11.1	1.3	84.5	81.8	21.1	233	137
A/303/ENV	10.3	<0.1	130.1	12.8	5.8	0.02	12.0	1.4	85.3	80.8	27.1	290	102
A/309/ENV	10.3	<0.1	185.9	18.3	5.3	0.02	13.9	1.4	87.9	83.9	21.1	245	128
Mean	**9.56**	**<0.1**	**128.0**	**15.8**	**6.22**	**0.02**	**12.5**	**1.45**	**76.9**	**77.5**	**26.0**	**332**	**99.7**
StDev	**2.36**	**-**	**32.15**	**2.27**	**1.59**	**0.01**	**2.67**	**0.30**	**7.96**	**16.2**	**3.79**	**75.7**	**35.3**
%Variance	**24.7**	**-**	**25.1**	**14.3**	**25.5**	**43.2**	**21.5**	**20.8**	**10.4**	**20.8**	**14.6**	**22.8**	**35.4**
ERL*	**8.2**	**1.2**	**81**	**34**	**47**	**0.15**	**21**	**-**	**-**	**150**	**-**	**-**	**-**
AFEN **	**5**	**<1**	**56**	**24**	**8**	**<0.1**	**31**	**-**	**88**	**46**	**6.8**	**320**	**4.2**
Vinson West ENV 5	**12.5**	**0.1**	**157.6**	**20**	**6.9**	**0.02**	**11**	**<0.5**	**82.6**	**96.5**	**19.8**	**199**	**129**
Vinson West Mean	**11.2**	**0.1**	**139**	**17.9**	**6.4**	**0.02**	**10.6**	**<0.5**	**75.3**	**87.1**	**20.0**	**222**	**123**
Vinson West SD	**0.8**	**0**	**11.6**	**4.6**	**0.6**	**0**	**0.5**	**-**	**4.2**	**7.4**	**1.86**	**30**	**5.31**
Nimrod Mean	**5.3**	**0.4**	**136.2**	**10.7**	**6.2**	**<0.1**	**13.3**	**1.1**	**67**	**75.3**	**30.5**	**342**	**98.2**
Nimrod SD	**0.7**	**0.1**	**24.5**	**1.6**	**1.2**	**-**	**1.3**	**0.2**	**2.2**	**6.7**	**7.37**	**93**	**13.5**
Toroa Mean	**1**	**0.9**	**25.8**	**17**	**5.8**	**<0.1**	**10.5**	**1**	**49**	**38.5**	**59.4**	**407**	**22.2**
Toroa SD	**0**	**0.1**	**1.7**	**2.3**	**1.2**	**-**	**0.8**	**0**	**1.3**	**8.7**	**2.54**	**9**	**0.49**

Historical data are reported in blue

**lowest concentration of metal than can produce a harmful affect (Long et.al. 1995)*

*** Average for deep water sediment (>1000m, AFEN, 1996).*

Trace metal contaminants in the marine environment tend to form associations with the non-residual phases of mineral matter, such as iron and manganese oxides and hydroxides, metal sulphides, organics, and carbonates. Metals associated with these non-residual phases are prone to various environmental interactions and transformations (physical, chemical and biological), potentially increasing their biological availability (Tessier *et al.*, 1979). Residual trace metals are defined as those which are part of the silicate matrix of the sediment and that are located mainly in the lattice structures of the component minerals. Non-residual trace metals are not part of the silicate matrix and have been incorporated into the sediment from aqueous solution by processes such as adsorption and organic complexes and may include trace metals originating from sources of pollution. Therefore, in monitoring trace metal contamination of the marine environment, it is important to distinguish these more mobile metals from the residual metals held tightly in the sediment lattice (Chester and Voutsinou, 1981), which are of comparatively little environmental significance. In this study, an analytical procedure involving digestion of sediment in hydrofluoric (HF) acid was employed to analyse the total elemental content of sediments retrieved across the survey area. The results constitute both residual and non-residual heavy metals concentration, much of which may not be available for biological uptake.

Although not directly related to the oil and gas industry, Cd levels consistently gave low concentrations in all samples with a mean concentration of <0.1µg.g^{-1}. There remains some debate as to toxicity of Cd to marine and terrestrial organisms. Some papers describe Cd as "very toxic" (Muniz *et al*., 2004), whilst others consider this metal to have no negative effects (McLeese *et al.*, 1987). Other attempts to quantify the critical level of Cd toxification were carried out by Buchman (1999) and suggested 'probable effect level' of around 4.2µg.g^{-1}.

Mercury (Hg) remained at low concentrations of 0.01µg.g^{-1} to 0.03µg.g^{-1} using ICP-MS at all of sites and depths sampled (mean 0.02±0.01SD).

Lead (Pb) was also recorded at a low level for the current FISA survey, ranging from 4.2µg.g^{-1} to 7.4µg.g^{-1}, with the only relatively elevated values found at A/1015/ENV (13.3µg.g^{-1}; Figure 2.18).

Of particular relevance to the offshore oil and gas industry are metals associated with drilling related discharges. These can contain substantial amounts of barium sulphate (barites) as a weighting agent (NRC, 1983) and Ba is frequently used to detect the deposition of drilling fluids around offshore installations (Chow and Snyder, 1980; Gettleson and Laird, 1980; Tricine and Trefry, 1983). Barites also contain measurable concentrations of heavy metals as impurities, including Cd, Cr, Cu, Pb, Hg, and Zn (NRC, 1983). Heavy metals, either as impurities or additives are also present in other mud components. For this survey, natural Ba levels remained low and relatively consistent throughout the area ranging from 233µg.g^{-1} to 508µg.g^{-1} (mean 331.7µg.g^{-1}±75.7SD; Figure 2.19), with marginally higher levels recorded in the deeper sediments and a slight increase from north to south of the survey area. The majority of Ba is typically insoluble in the form of a non-toxic sulphate (Gerrard *et al*., 1999) - this metal is rarely of toxicological concern to the marine fauna.

Of the other metals, Cr, Ni, Cu, V and Zn all gave relatively low to moderate respective concentration means of 128µg.g^{-1} (Figure 2.20), 12.5µg.g^{-1} (Figure 2.21), 15.8µg.g^{-1} (Figure 2.22), 76.9µg.g^{-1} (Figure 2.23) and 77.5µg.g^{-1} (Figure 2.24). Overall, these metals have relatively low to moderate concentrations compared to other offshore environments (i.e. deep water (>1000m) Northeast Europe (AFEN, 1996, BSL unpublished)). The slightly elevated values recorded for Cr may be due to the occurrence of Tertiary volcanic rocks in the South Atlantic sediments, which are affected through the ice erosion pathways. Vanadium is often associated with the oil and gas industry as it is present in relatively high concentrations in most crude oils (Khalaf *et al*., 1982). Most V enters seawater in suspension or colloidal form, passing quickly out of the water column and into silt deposition (Cole *et al*., 1999). Consequently, as the natural background levels in the Falkland Islands region are relatively low, possible impacts from oil and gas explorations are likely to be detected from future surveys.

The crustal or matrix metal Al gave consistent results with a mean of 25.97mg.g^{-1} (±3.8SD; Figure 2.25) whilst Fe indicated a very variable concentration 99.7mg.g^{-1} (±35.3SD; Figure 2.26). This is equivalent to a respective percentage variance of 15% and 35%, with no clear pattern of distribution (Table 2.6 and Figure 2.29). Aluminium is often used as a normalisation metal in areas (i.e. standardising the proportion of metals against changes in sediment type), where significant changes in sediment parameters can mask relative changes in other metals. As there were no samples indicating significant metal elevations, this was not applied to the results for comparison. The variability of Fe is associated with the deposition of residual ice-rafted volcanic material in the form of granular basalts.

Iron is also an important metal as it is often associated with other elements, such as As to which they adsorb. Consequently, As was similarly variable and relatively moderate in concentration throughout this study (mean 9.56µg.g^{-1} ±2.36SD and a variance of 25%; Figure 2.27). This is above the level recorded for similar depth sediments west of the British Isles (ca. 5 recorded, AFEN, 1996) and also above the ERL levels defined as the lowest concentration of a metal that produces adverse effects in 10% of the data reviewed (Long *et al*. 1995).

Figure 2.18 - Heavy Metal Concentration for Lead (Pb; mg.kg^{-1})

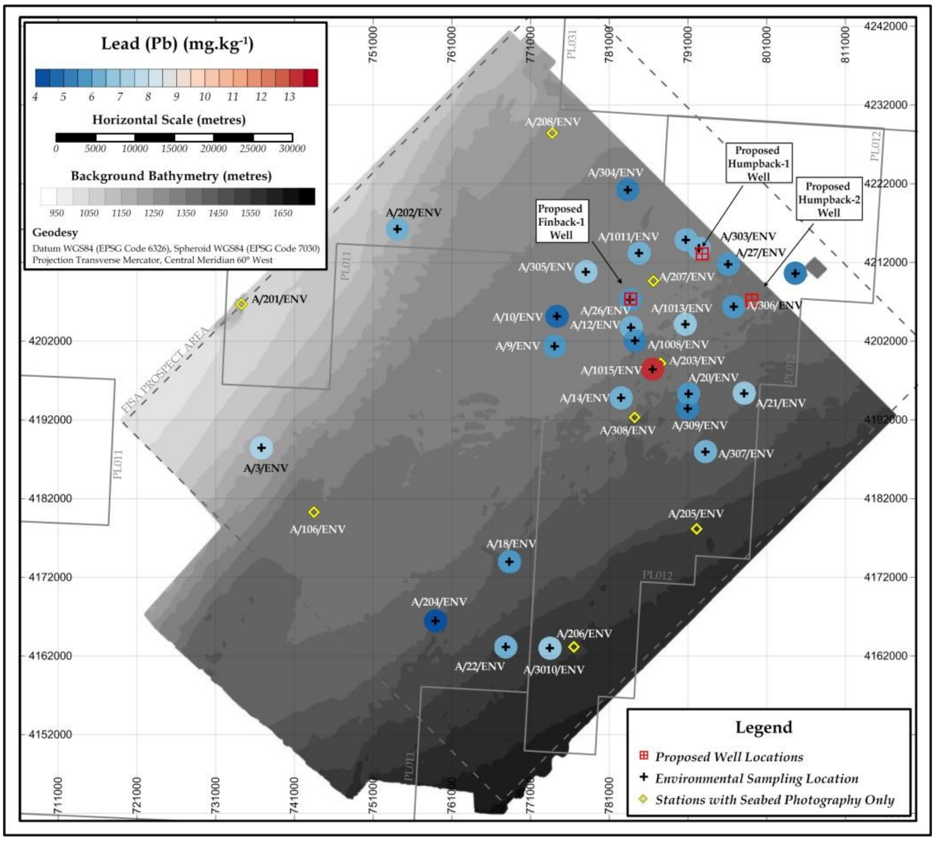


Figure 2.19 - Heavy Metal Concentration for Barium (Ba; mg.kg^{-1})

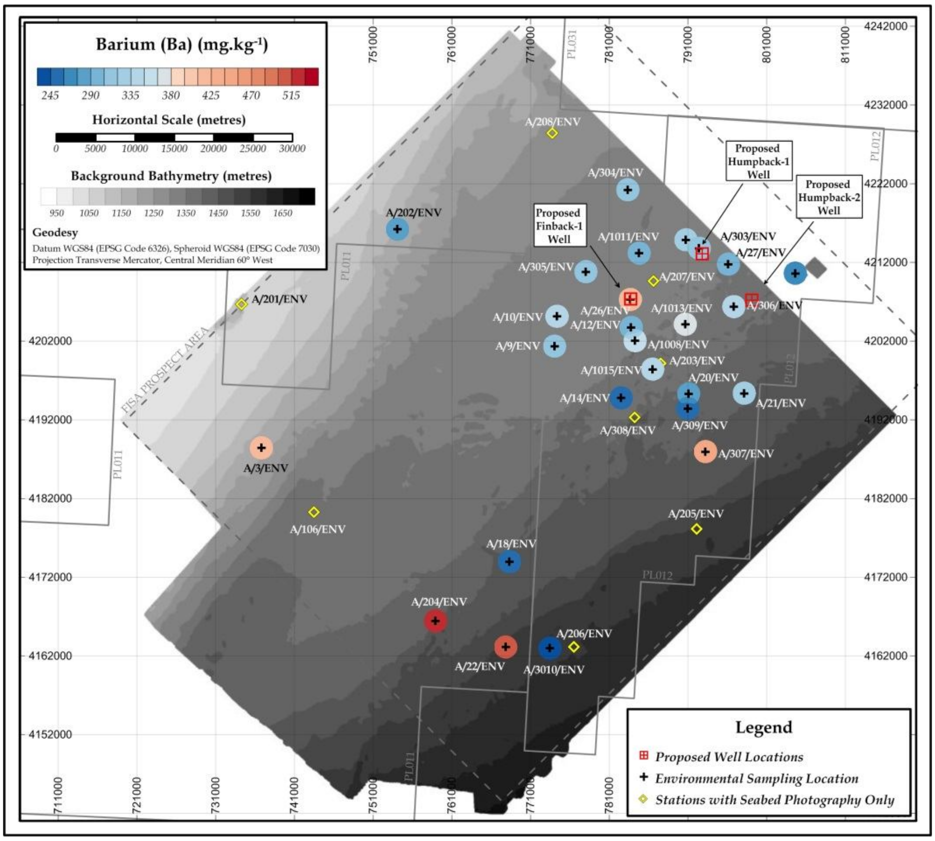


Figure 2.20 - Heavy Metal Concentration for Chromium (Cr; mg.kg^{-1})

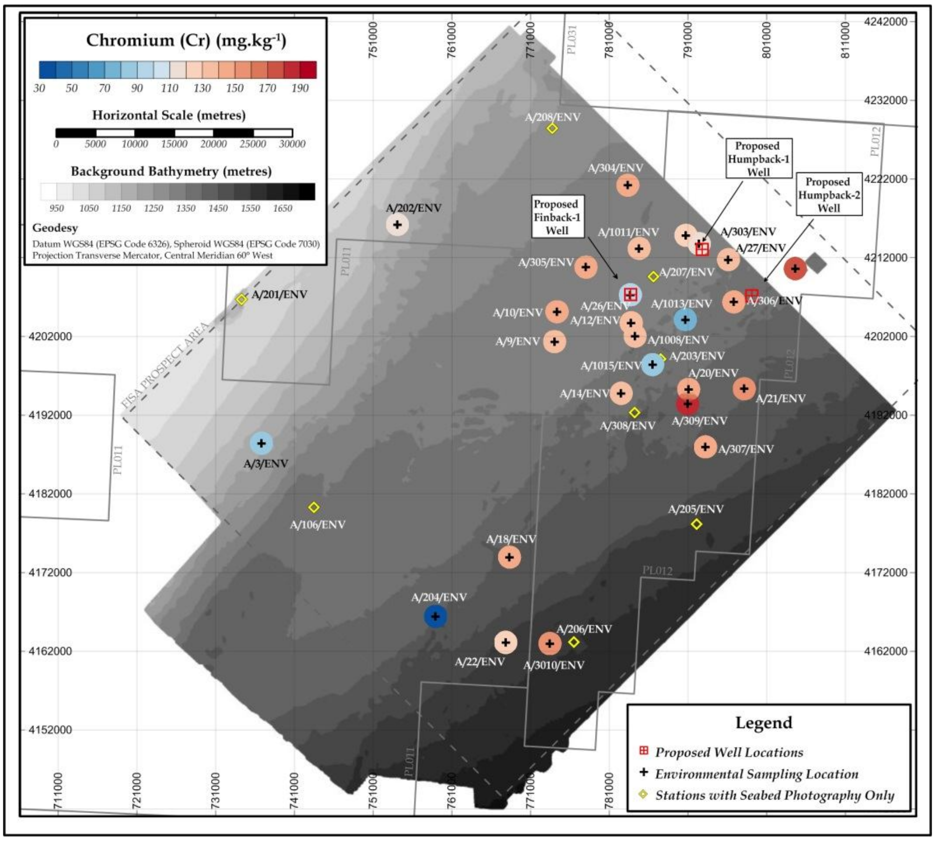


Figure 2.21 - Heavy Metal Concentration for Copper (Cu; mg.kg^{-1})

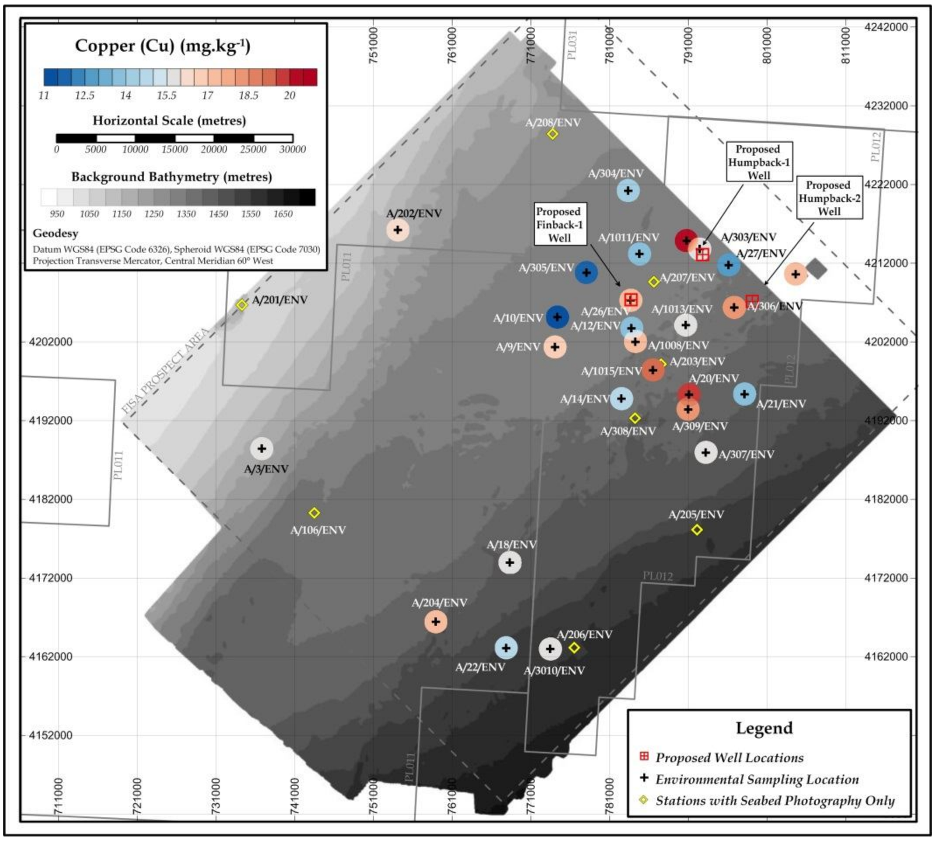


Figure 2.22 - Heavy Metal Concentration for Nickel (Ni; mg.kg^{-1})

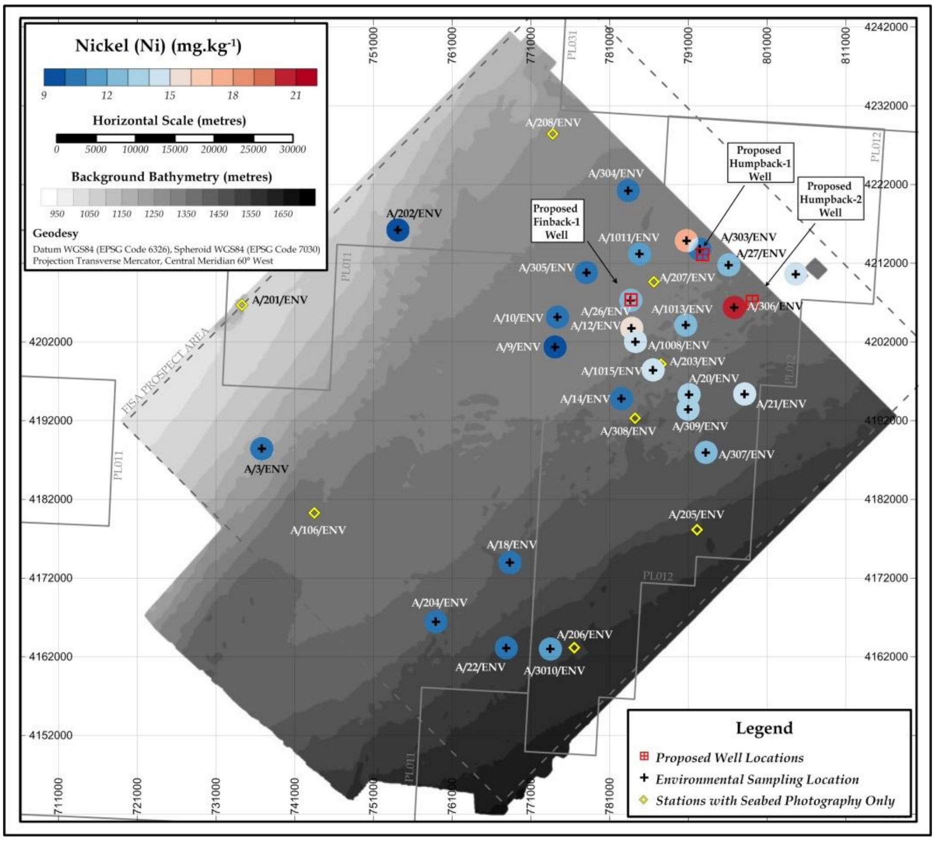


Figure 2.23 - Heavy Metal Concentration for Vanadium (V; mg.kg^{-1})

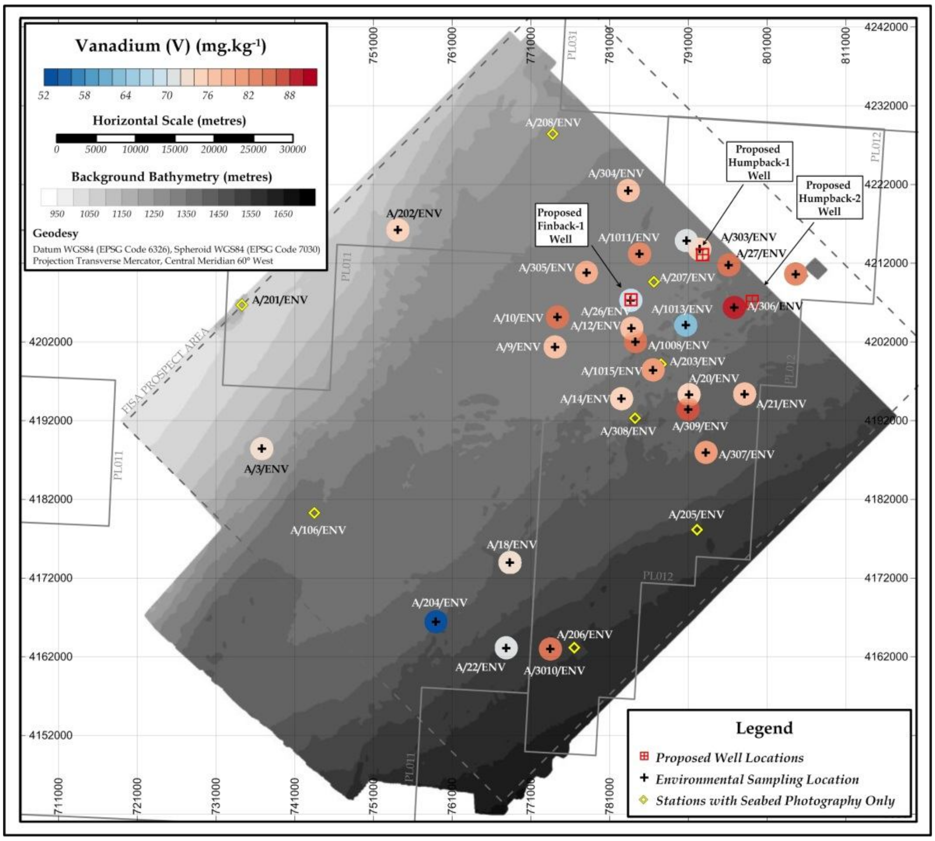


Figure 2.24 - Heavy Metal Concentration for Zinc (Zn; mg.kg^{-1})

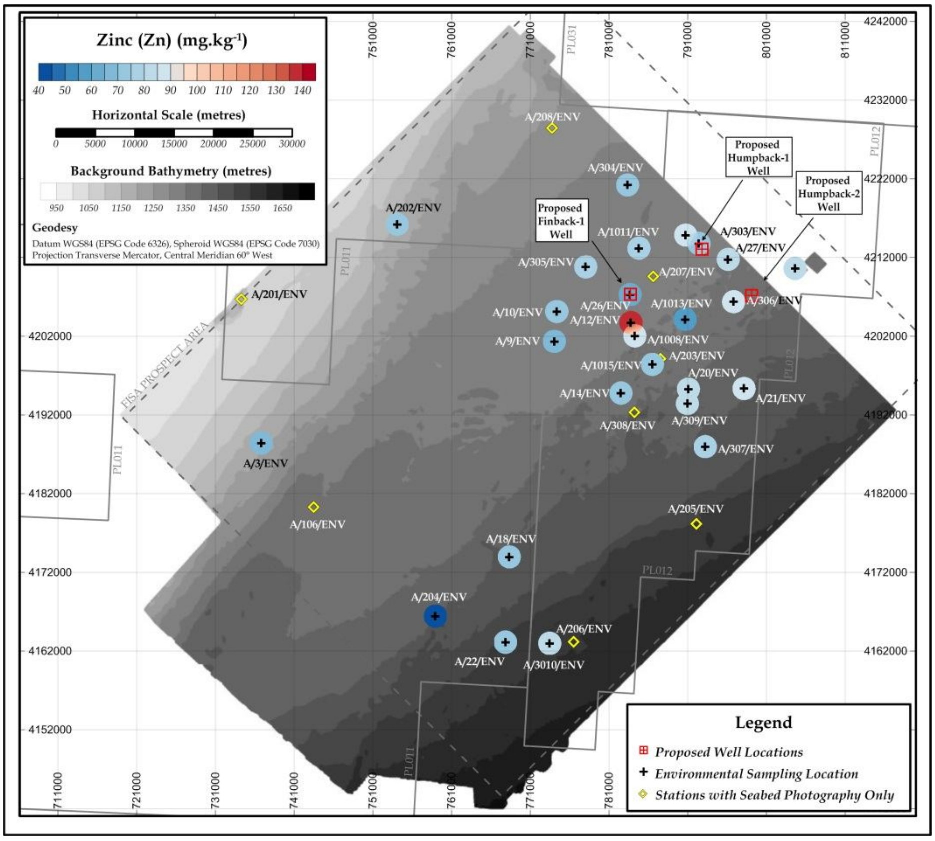


Figure 2.25 - Heavy Metal Concentration for Aluminium (Al; %)

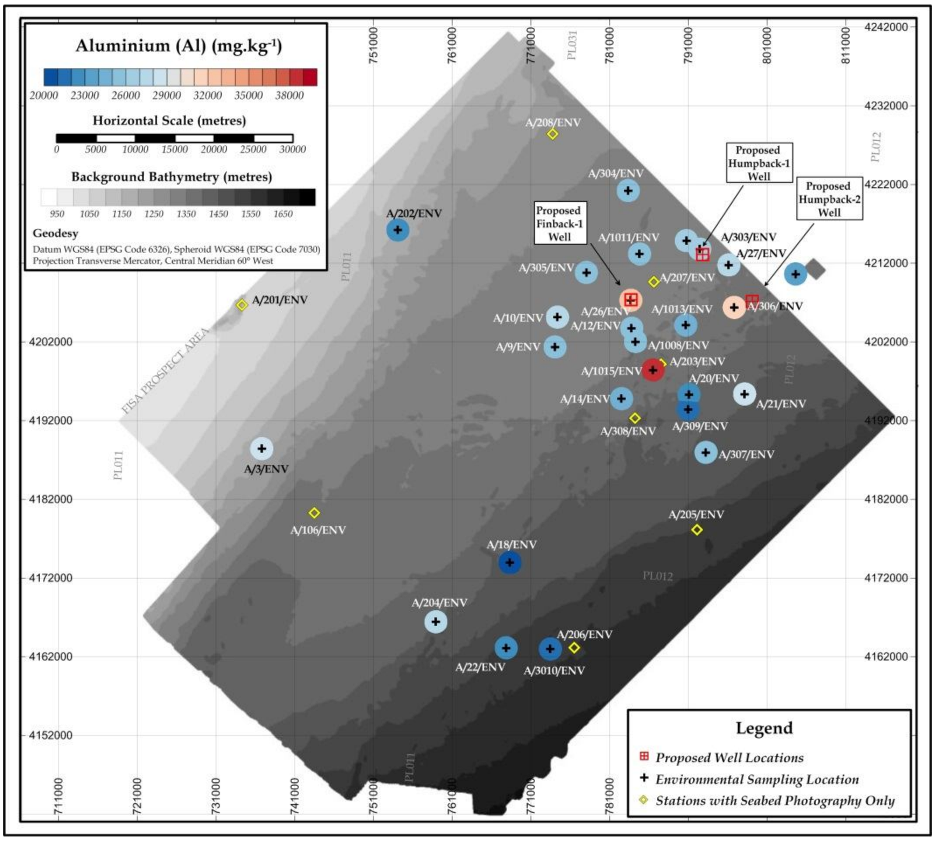


Figure 2.26 - Heavy Metal Concentration for Iron (Fe; %)

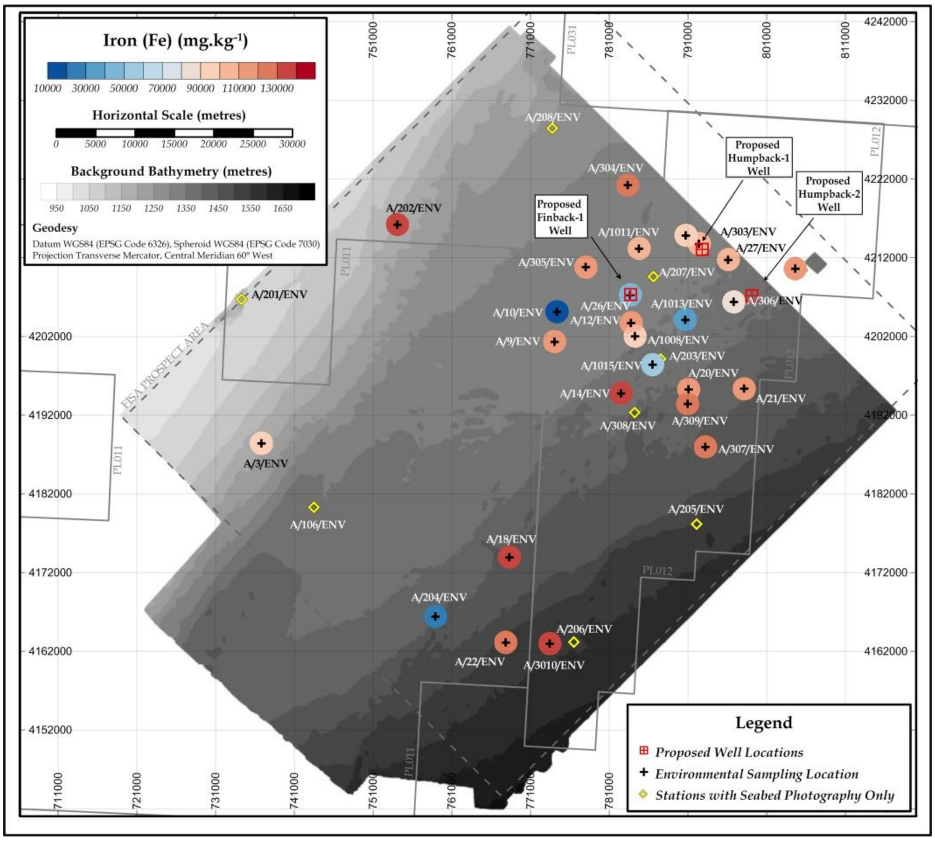
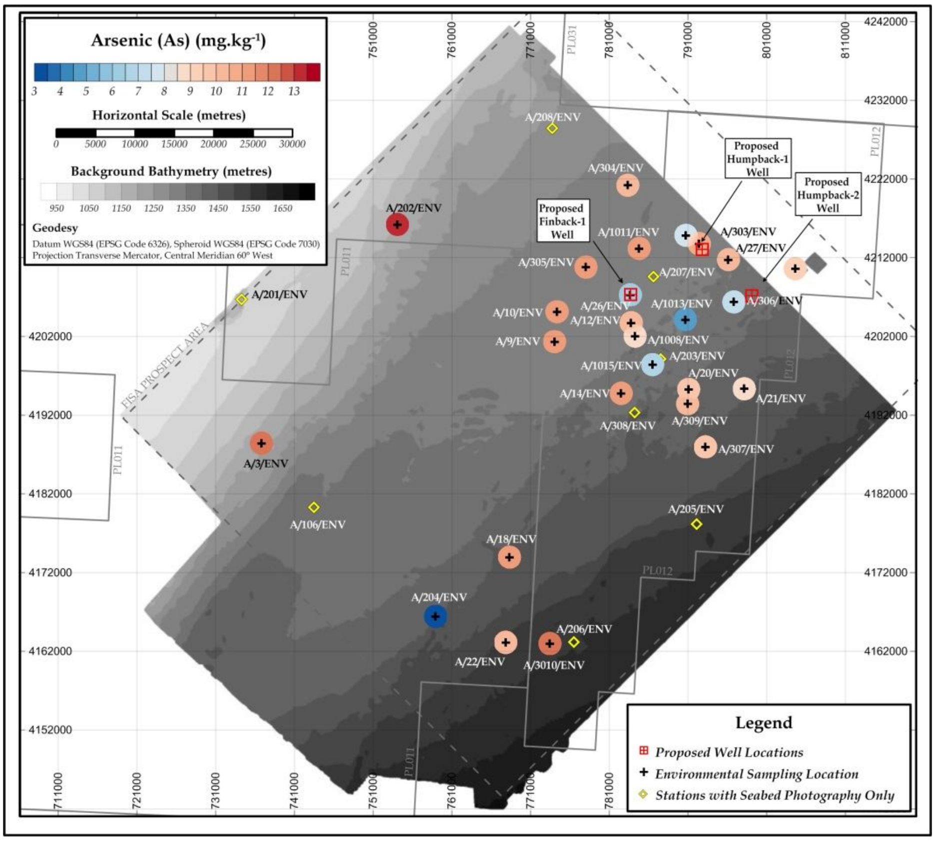


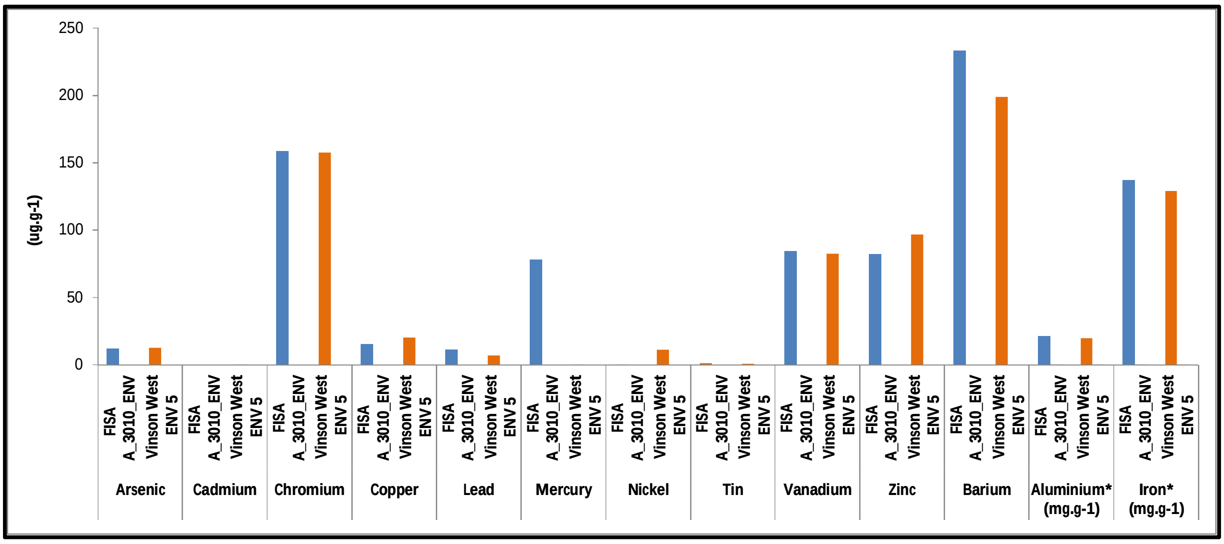
Figure 2.27 - Heavy Metal Concentration for Arsenic (As; mg.kg-1)



2.7.1.1 Historical Comparison with Heavy Metals

A direct comparison was made between the results of station A/3010/ENV from the FISA area and Vinson West ENV5 sampled in 2011. Results are presented in Figure 2.28 which generally showed similar concentrations for all metals. Note that all values are based on µg.g^{-1}, with the exception of the crustal metals Fe and Al, which are presented at mg.g^{-1}.

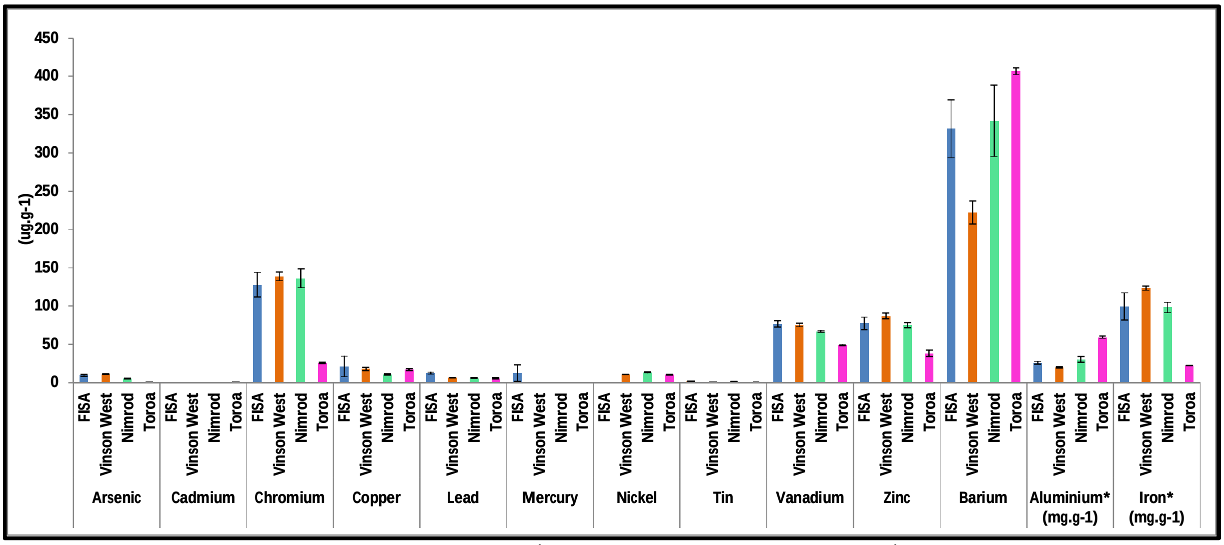
Figure 2.28 - Comparison of Heavy Metal for Stations FISA A/3010/ENV and Vinson West ENV 5



Note that Aluminium and Iron are illustrated as mg.g^{-1}, while other heavy metals are µg.g^{-1}.

A further comparison between the mean values obtained for FISA and those obtained for the historical sites at Vinson West, Nimrod and Toroa Prospects are presented in Figure 2.29. These results are briefly discussed for each metal in Section 2.7.1.

Figure 2.29 - Comparison of Heavy Metal with Historical Data



Note that Aluminium and Iron are illustrated as mg.g^{-1}, while other heavy metals are µg.g^{-1}.

Cadmium levels were similar to that previously recorded at the Vinson West (0.1µg.g^{-1}) but notably lower than levels obtained at Nimrod (0.4µg.g^{-1}) and Toroa (0.9µg.g^{-1}) sites (Table 2.6 and Figure 2.28).

Overall Hg levels were within the range previously recorded within the Vinson West area, which recorded a mean value of 0.02µg.g^{-1} via HF-digestion. Both of the historical sites Toroa and Nimrod displayed values of <0.1µg.g^{-1} with both aqua regia and HF digest procedures (Table 2.6 and Figure 2.29).

With an overall mean value of 6.22µg.g^{-1} the FISA Pb concentrations were very similar to mean concentrations at the historical sites of Vinson West, Nimrod and Toroa, of 6.4µg.g^{-1}, 6.2µg.g^{-1} and 5.8µg.g^{-1}, respectively (Table 2.6 and Figure 2.29).

Previous surveys for Cr, Ni, Cu, V and Zn recorded similar values of 139µg.g^{-1}, 10.9µg.g^{-1}, 17.9µg.g^{-1}, 75.3µg.g^{-1} and 87.1µg.g^{-1} for Vinson West; 136µg.g^{-1}, 13.3µg.g^{-1}, 10.7µg.g^{-1}, 67µg.g^{-1} and 75.3µg.g^{-1} for Nimrod and 25.8µg.g^{-1}, 10.5µg.g^{-1}, 17.0µg.g^{-1}, 49µg.g^{-1} and 38.5µg.g^{-1} for Toroa for the same metals, respectively (Table 2.6 and Figure 2.29).

A comparison with historical sites indicated a relatively high variability in both Fe and Al results. Vinson West and Nimrod displayed relatively similar data to that of FISA for Fe with 123.2mg.g^{-1} and 98.16mg.g^{-1} respectively as well as 18mg.g^{-1} and 30.52mg.g^{-1} for aluminium. In contrast, Toroa exhibited a decrease in Fe (22.38mg.g^{-1}) and an elevation in Al data (59.41mg.g^{-1}). This has been attributed the increased sedimentary regime found at this shallower site, where erosion has not exposed the older granular sediments (Table 2.6 and Figure 2.29).

The concentrations of As found at Vinson West, Nimrod and Toroa were also relatively variable (11.2µg.g^{-1}, 5.3µg.g^{-1} and 1.0µg.g^{-1}) and therefore the result seen at FISA falls within the variability seen in this region (Table 2.6 and Figure 2.29).

2.8 WATER QUALITY

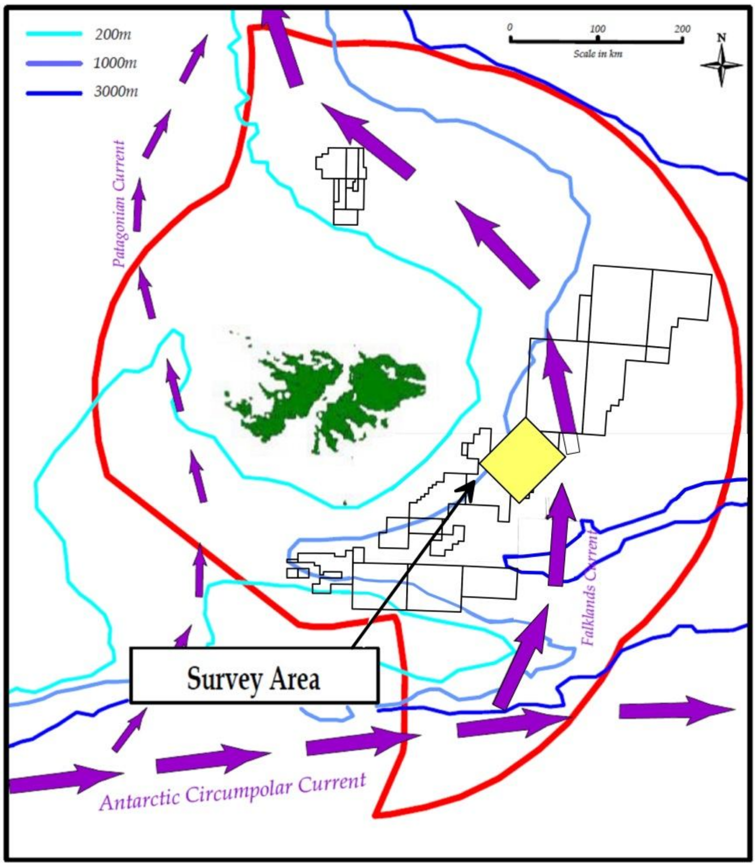
As little is known about the water column in the deeper waters of the proposed prospect area, several water quality profiles were undertaken within the FISA regional survey area. These replicate profiles provide a snapshot of the water column structure for the duration of the survey.

2.8.1 Regional Oceanography

This area is dominated by the temperate Malvinas current that follows the contour of the shelf slope from the south to the north (Falabella *et al.,* 2009). The sea water composition is strongly influenced by the sub-Antarctic waters and continental fresh waters (Acha *et al*., 2004). With this sub-Antarctic water impact, the water columns in the Falkland Island Basin are usually cold, low in salinity and with a high dissolved oxygen and nutrient concentrations (Piola, 2008). The sea surface water temperature also follows a seasonal fluctuation resulting from a combination of multiple factors such as solar radiation, winds and cloud cover. The average sea water temperature in the summer (January-March) is around 10˚C and the annual salinity average in this area is around 33.7 psu (Palma *et al.,* 2008).

The general water circulation in the survey area is dominated by the Antarctic Circumpolar Current (ACC), which is located to the south of the Falklands in the Antarctic Polar Front or Antarctic Convergence where surface waters to the south meet warmer surface waters from the north. Travelling from west to east, the ACC passes around Cape Horn and then splits into two weaker current passing either side of the Falklands. These two northern components (collectively called the Malvinas current) are separated by the eastern flow following the southern edge of the Burdwood Bank before turning north to follow the eastern Falklands Continental Margin (Figure 2.30). The water masses influencing this site are therefore a result of this deviation of the ACC northwards, although it is unknown exactly how the current will affect the survey area within the South Falkland Basin, slightly west of this deviation. Evidence from the survey showed that softer deposited material only occurred in the shallower west, whilst elsewhere the seabed was either actively eroded or indicated were non-depositional sediments. This would suggest that stronger currents exist in the deeper waters to the east of the survey area. The presence on a non-zero bottom currents was directly verified by Harkema and Weatherly (1989, as cited in Garzoli, 1993). Their bottom current meters measured velocities of up to 10cm/s (Garzoli, 1993). Based on hydrographic data, it is believed that the Malvinas Current has a strong barotropic component and that it is well-mixed (Vivier and Provost 1999). A residual flow of water is expected to be from the south and west. This is supported by admiralty charts which show a surface flow east-north-east across the basin at velocities of up to 1.5 knots.

Figure 2.30 - General Current Circulation at the Proposed Survey Area



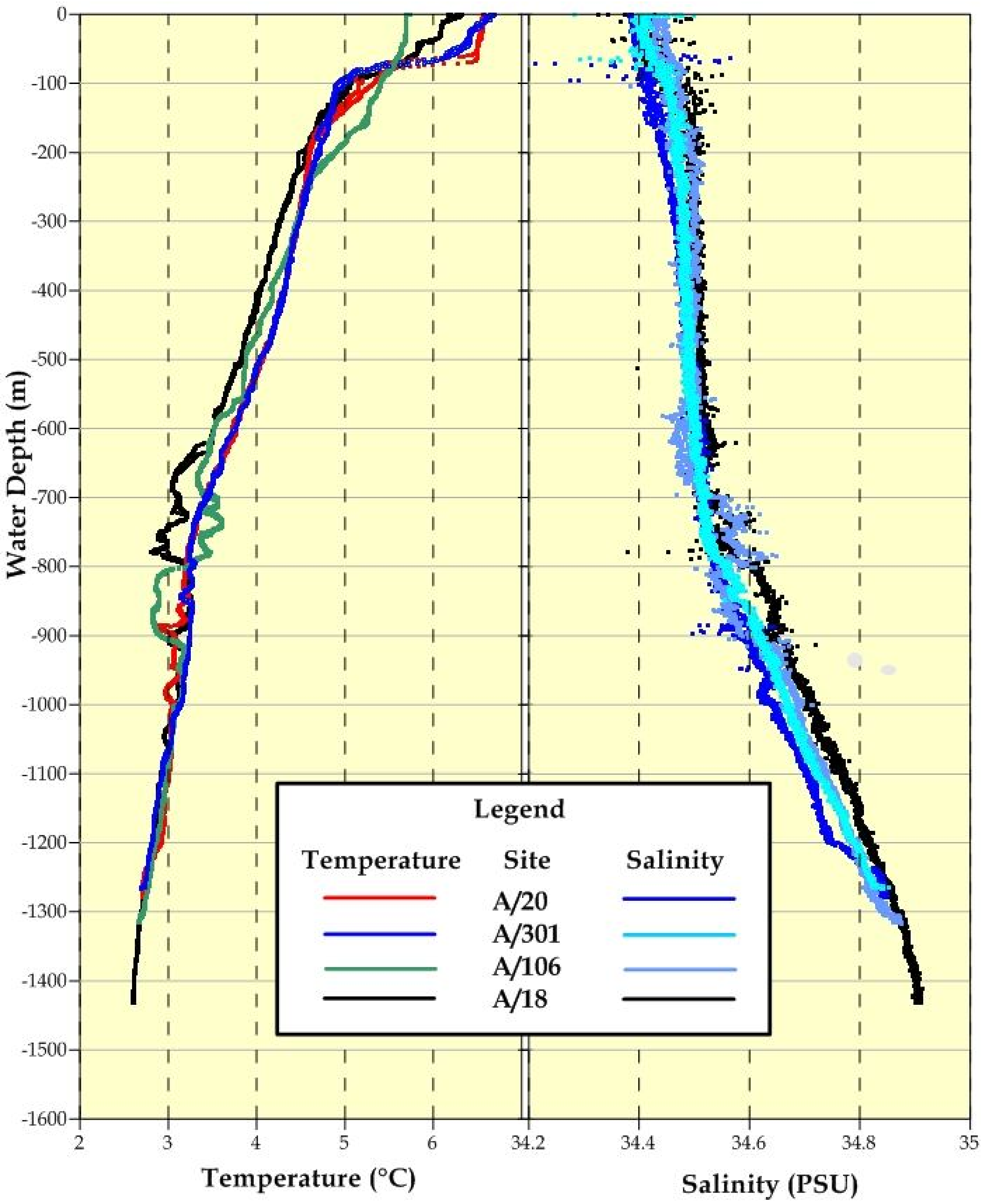
2.8.2 CTD Profiling (Conductivity-Temperature-Depth)

The structure of the water column within the FISA area was surveyed using a CTD probe with temperature and salinity sensors. A total of four profiles were recorded during the survey with the results presented in Figure 2.31, and the data extremes listed in Table 2.7. These datasets have been overlaid to show the consistency of the profile over depth and over a survey period of just over 1 month.

Table 2.7 - Water Quality Profile Extremes

Profile	File name	Max Depth (m)	Date	Easting	Northing	Temp °C (Max/Min)	Salinity psu (Max/Min)
A/20/ENV	FILE116	1055	03.01.14	791099	4195292	6.56/2.92	34.67/33.33
A/301/ENV	FILE122	1267	08.01.14	790756	4214853	6.70/2.69	34.85/34.28
A/106/ENV	FILE125	1317	16.01.14	743490	4180280	5.73/2.66	33.91/31.53
A/18/ENV	FILE113	1432	01.02.14	768352	4173956	6.32/2.60	34.91/34.14

Figure 2.31 CTD Water Quality Profiles



Water profiles obtained from stations A/20/ENV, A/301/ENV, A/106/ENV and A/18/ENV all indicated similar and consistent profiles. Surface water temperature varied slightly from 5.73°C to 6.70°C with a small thermocline developing in the surface 80m. With increasing depth, water temperature continued to decline at a relatively consistent rate to around 2.60°C recorded at the deepest point (1432m). All profiles indicated a small area of mixed waters between 620m and 950m (Figure 2.31).

The salinity profiles for the same sites indicated a similar pattern, although the variability in salinity was limited to only 0.5psu throughout the whole water column. Whilst a subtle halocline was just perceptible in the surface 80m, the upper 600m of the water column remained relatively consistent, increasing in salinity by only 0.1psu. A slightly mixed zone was then encountered between 620m and 950m, with a slightly greater increase in salinity recorded thereafter throughout the lower water column by around 0.4psu.

No significant differences were recorded between the four stations, indicative of one regional water column for this area and survey period.

2.8.2.1 Historical Comparison with Water quality data

Overall, a comparison with historical data from Vinson West, Nimrod and Toroa revealed similar results in regards to water temperature and salinity. Water temperature at the FISA site (~6˚C) was lower than at the other three survey areas which recorded approx. 9˚C at the surface. This could be due to a combination of seasonal effect and different water currents/masses mixing the surface layers. However, water temperature at the seabed was consistent throughout, recording values of ~2.6 ˚C. Higher seabed water temperature was measured at the Toroa site (~4.4˚C) which is explained by the shallower bathymetry (~730m) at the seabed as opposed to around 1300-1600m in the other survey areas.

As with the temperature profiles, salinity profiles were relatively consistent throughout with no significant variations between survey areas. A negative correlation with temperature was observed in all profiles with the highest salinity encountered close to the seabed giving values of approximately 34.5psu.

2.8.3 Water Chemistry

Water quality at the proposed prospect area was good, as expected for an open 'blue-water' environment. Water samples were acquired at different water depths at two locations. Methods and analytical techniques are outlined in Appendix I and II with results presented in Table 2.8.

Table 2.8 - Water Quality Measurements for A/03/ENV

Description	Detection limit (mg/l)	A/03/ ENV (1m)	A/03/ ENV (50m)	A/03/ ENV (400m)	A/03/ ENV (1134m)	A/23/ ENV (1m)	A/23/ ENV (50m)	A/23/ ENV (500m)	A/23/ ENV (1110m)
Barium as Ba (Total)	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phosphorus as P (Total)	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Silicon as Si (Total)	0.1	0.2	0.3	0.4	1	0.4	0.4	0.6	0.5
Total Sulphur as SO4 (Dissolved)	3	2320	2600	2040	2560	4796	4593	4222	4296
Arsenic as As (Total)	0.001	0.010	0.012	0.008	0.011	0.023	0.024	0.024	0.027
Cadmium as Cd (Total)	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium as Cr (Total)	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper as Cu (Total)	0.001	0.003	0.003	0.002	0.003	0.007	0.008	0.007	0.007
Lead as Pb (Total)	0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.001	0.001	<0.001
Mercury as Hg (Total)	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0004	0.0004	0.0003	0.0003
Nickel as Ni (Total)	0.001	0.002	0.002	0.001	0.002	0.006	0.005	0.004	0.004
Zinc as Zn (Total)	0.002	0.023	0.01	0.008	0.038	0.029	0.041	0.048	0.035
Suspended Solids w	5	<5	9	5	<5	<5	<5	<5	<5
Total Alkalinity as CaCO3	2	116	116	124	126	112	114	114	120
Total Acidity as CaCO3	2	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Nitrite as N	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Total Oxidised Nitrogen as N	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Sulphide as S	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Total Organic Carbon	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Kjeldahl Nitrogen as N	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Nitrogen as N	1	<1	<1	<1	<1	<1	<1	<1	<1
Dissolved Organic Carbon	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Total Oil (µg/l)	0.001	0.010	0.082	0.078	0.011	0.012	0.0095	0.0094	0.0096
Total n alkanes	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Pristane	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Phytane	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Note: All values are shown in mg/l (excluding alkanes)

All results showed very low levels or non-detectable concentration for all tests. As the water mass seems to be the same in the area (correlate with CTD casts), we can presume that these low values are representative of the entire FISA region.

2.9 MACROFAUNAL ANALYSIS

A macrofaunal analysis was carried out on all 59 replicates obtained at the 26 key baseline sediment sites, sampled within the FISA survey area with a particular concentration of stations around the proposed Finback-1 and Humpback-1 well locations. The sediments throughout the survey area generally conformed to silty SAND although gravel exposures and occasional drop stones were common, as identified in the seabed photography as well as sample residues. Macrofaunal samples were processed in the field using a 500µm mesh size. Subsequent macrofaunal taxonomy of all recovered fauna identified a total of 2,874 individuals (infauna and epifauna) from the 59 samples analysed. Faunal data for each sample are listed in Appendix VII, whilst univariate analyses are summarised in Tables 2.10 and 2.11. Of the 254 species recorded, 188 were infaunal, consisting of 69 annelid species and accounting for 48.4% of the total individuals. The molluscs were represented by 32 species (6.4% of total individuals), the crustaceans by 62 species (42.1%) and the echinoderms by only 13 species (and only 2.6% of total individuals), while all other groups (Cnidaria, Nemertea, Nematoda, Sipuncula, Echiurida, Turbellaria, Brachiopoda and Chaetognatha) accounted for the remaining 8.5%, or 12 species. A distribution of the different taxa is presented in Figures 2.32 and 2.33 by sample replicate, or Figure 2.34 by station.

With the exception of species that have been intentionally grouped into higher taxonomic levels (e.g. Nematoda, Nemertea, etc.), the majority of adult specimens were identified to genus level, or higher. This was approximately 88% of specimens (excluding juveniles and fragmented species) 18% of which were identified to species level. Only three juvenile specimens (Asteroidea, Holothurioidea and Isopoda) were recorded throughout the survey area (possibly reflecting the mid-summer timing of the sampling). Conversely, the polyp stage of Scyphozoa was recorded in reasonably high numbers, accounting for approximately 16% of all individuals recorded. The scyphozoan polyp stage is significantly suppressed within their life cycle, and can be classed as a juvenile form until the adult medusa stage is achieved. Juveniles are often excluded from community analyses (in accordance with OSPAR commission guidelines, 2004) due to having high mortality prior to reaching maturity, as well as difficulties in distinguishing species of the same genus and different life cycle stages. Consequently, they tend to induce a recruitment spike at certain times of the year due to rapid settlement and colonisation, but are essentially an ephemeral part of the population masking the underlying trends within the mature adults. Therefore, the two juveniles were excluded from the multivariate analyses.

Figure 2.32 Proportion of Individual Abundance by Main Group and Replicate

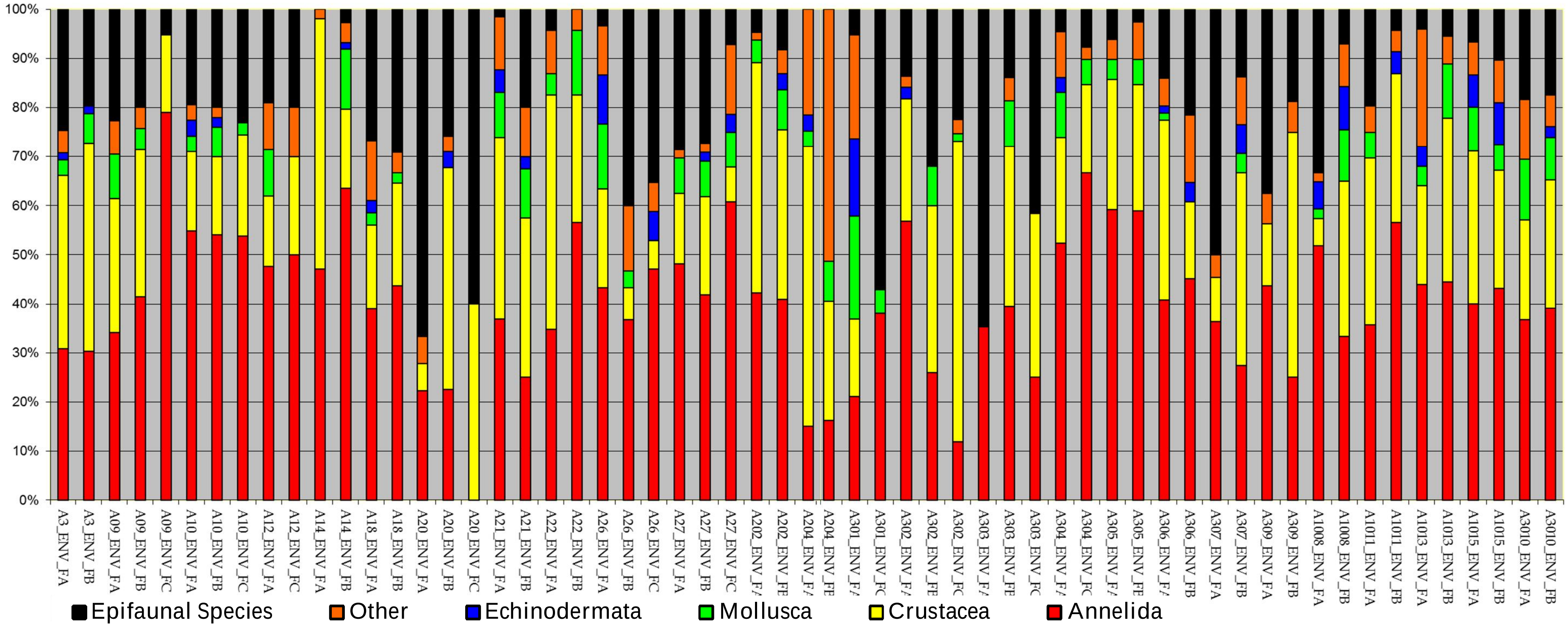


Figure 2.33 Proportion of Species Richness by Main Group and Replicate

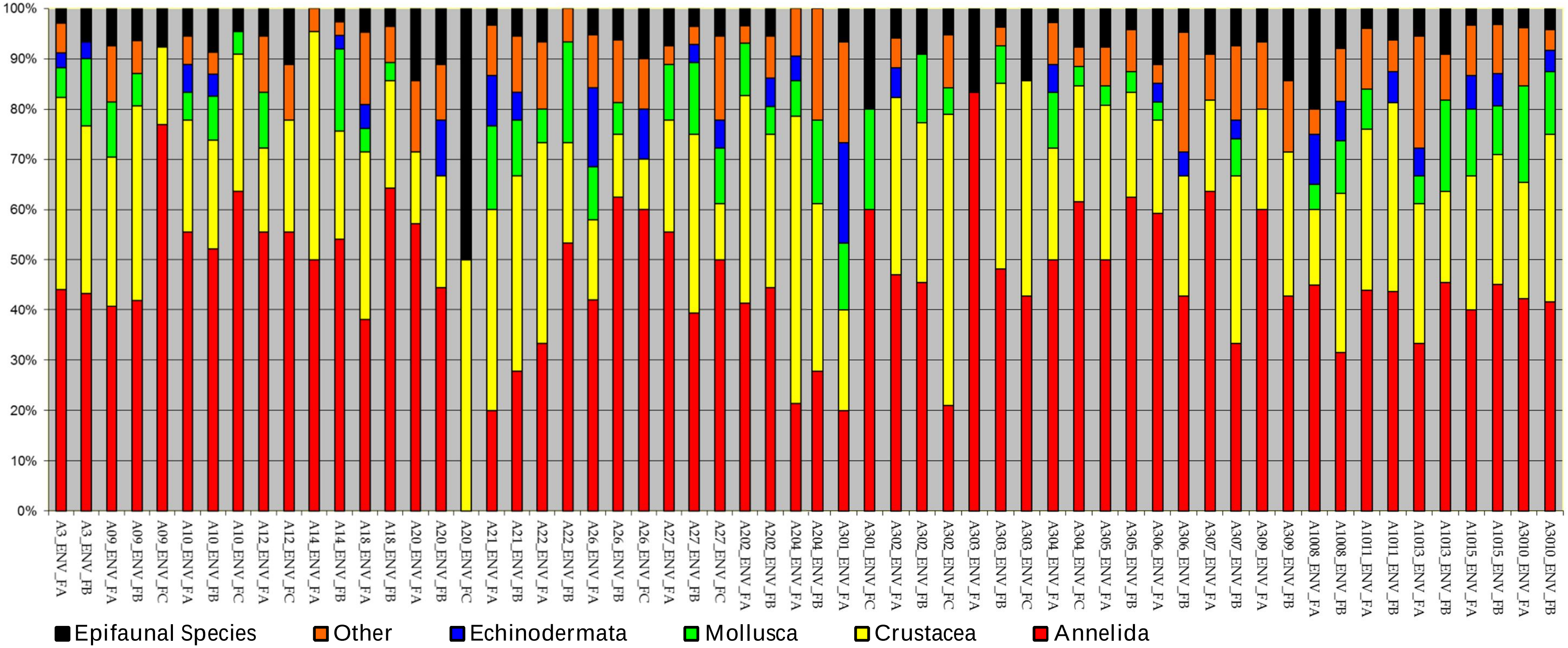
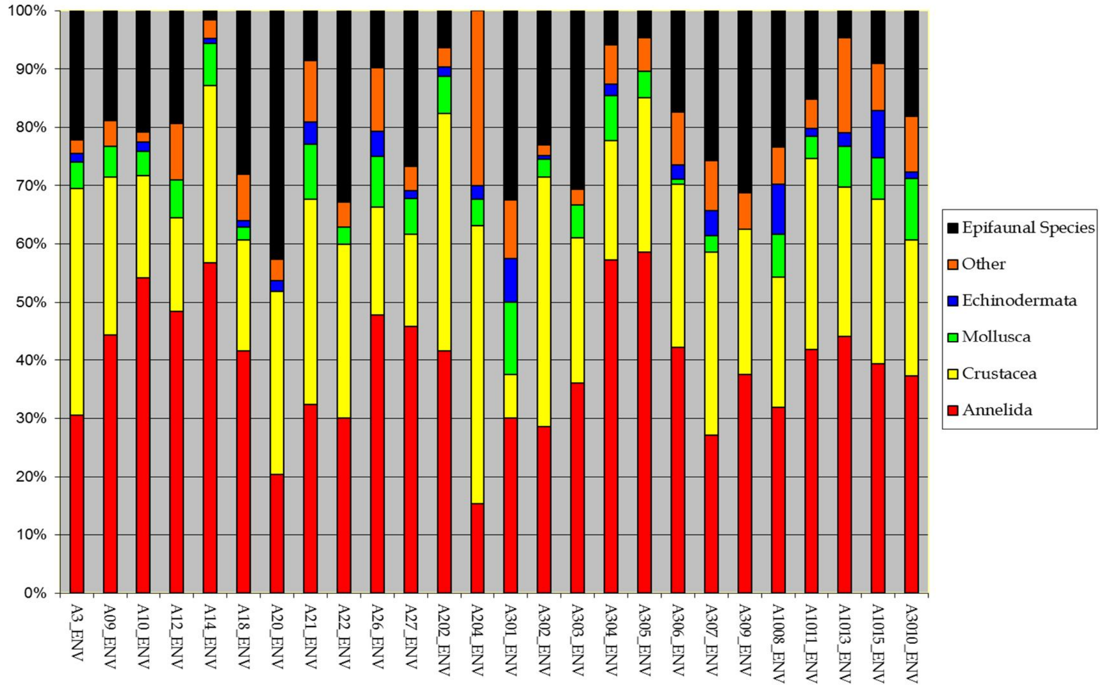
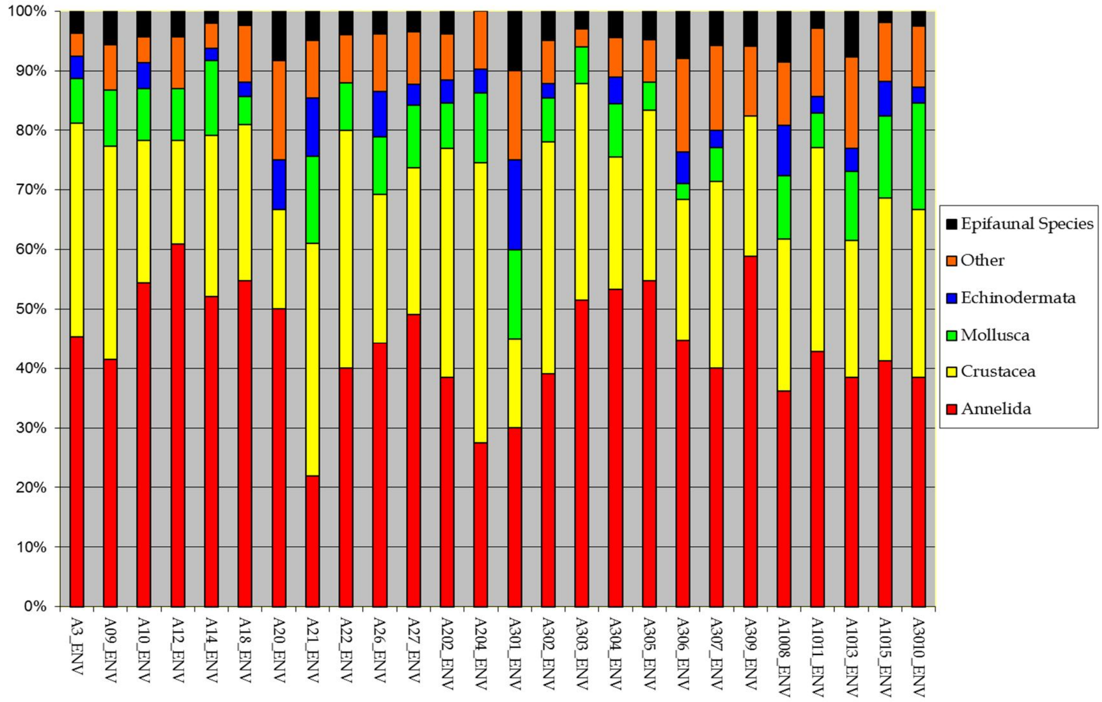


Figure 2.34 Proportion of Individual Abundance and Richness by Main Group and Station

(a) Individual Abundance



(b) Species Richness



Fragments of one species were also recorded accounting for only one specimen or 0.04% of the community recorded. This has also been excluded from the multivariate analyses as it is not often possible to differentiate the number of animals from which fragments are derived. The juveniles and fragmented species have been listed separately in Appendix VII.

2.9.1 Infaunal trends

The macrofauna for the FISA site was as expected for the South Falklands Basin of this sediment type and water depth. Unlike most deep-water low energy environments, the seabed exhibited a varied seabed with a mixed soft and granular sediment community generally dominated by small polychaetes. This dominance was shown in both abundance and richness, with six polychaetes recorded in the top ten numerically ranked species. This dominance was closely followed by crustaceans which were also well represented, having three species in the in the top ten numerically ranked taxa. In overall rank order, the key dominant species across the area were the Polychaete *Rhamphobrachium (Spinigerium) ehlersi*, the crustaceans *Ampelisca* and a Copepoda, separated by the polychaete *Gymnonereis fauveli* and followed by *Apistobranchus* sp I. A Sipuncula worm *Nephasoma (Nephasoma) diaphanes* was ranked 6th followed by the crustacean *Urothoe*. The polychaetes *Caulleriella*, Maldanidae and *Euchone pallida* were ranked 8th, 9th and 10th, respectively.

Table 2.9 - Overall Species Ranking (Top 15 Species)

Overall Top 15 Rank	Species/Taxon	Total rank score (out of 590)	Numerical Abundance (59 replicates)	Numerical Top 15 rank
1	*Rhamphobrachium (Spinigerium) ehlersi*	465	247	1
2	*Ampelisca sp. A*	186	60	4
3	*Gymnonereis fauveli*	183	63	3
4	Copepoda	183	106	2
5	*Apistobranchus sp I*	176	56	5
6	*Nephasoma (Nephasoma) diaphanes*	166	54	7
7	*Urothoe*	162	56	5
8	*Caulleriella*	154	51	8
9	Maldanidae	127	40	11
10	*Euchone pallida*	124	38	13
11	*Leptognathia*	122	42	10
12	*Spiochaetopterus typicus*	111	32	16
13	*Melinna cristata*	107	33	15
14	Nematoda	90	26	20
15	*Eunoe*	86	23	23

A measure of the overall dominance pattern in the sampling area was achieved by ranking the top species per sample replicate according to abundance, giving a rank score of 10 to the most abundant species, decreasing to 1 for the tenth most abundant species, and summing these scores for all 59 samples to provide an overall dominance score (Eleftheriou and Basford, 1989) for each species. The top 15 species are shown in Table 2.9. This ranking varied only slightly from that of the numerical ranking for the species overall with 12 out of the 15 species recorded in both ranks, further highlighting the general homogeneous yet broad nature of the community between sample replicates. Despite slight variations in order, the same top five species were recorded in both lists. The most dominant ranked species, the polychaete *R. ehlersi* recorded a score of 465 out of 590, identifying this species as the most dominant species throughout the replicates acquired. Generally all phyla identified were typical for this deep sea region. While the species richness was high, individual counts were typically low, demonstrating a diverse benthic community.

Within the processed samples, residues consisted of black sand (of basaltic origin) with a varying amount of gravel and pebbles, mostly volcanic with many very rounded and polished by glacial transport. Many of these pebbles carried epifauna mostly consisting of sponges and Bryozoa and are discussed in Section 2.9.5. Biological residue was scarce or non-existent, with only very rare empty shells and on some stations dead *Lophelia* and Stylasteridae (Hydrozoa) remains. A discussion on the recovered faunal groups is discussed below. As a general comment, a bipolar distribution is quite common in deep sea fauna, especially in the polychaeta, with morphologically identical species found at both poles. Whether this morphological similarity extends towards the genetic material, is yet unproven. However a very wide to (in some cases) cosmopolitan distribution is a common feature of deep sea fauna.

Further comments relating to the macrofaunal population and their separate phylogenetic groups are presented below with example images of some specimens shown in Figure 2.25a-f:

Brachiopoda: Three species of Brachiopoda were recorded. An example species includes *Pelagodiscus atlanticus* which resembles a limpet, and has a virtually cosmopolitan distribution.

Sipunculids: Two species of Sipuncula were recorded. *Nephasoma diaphanes* (Figure 2.35g) is widespread in the deeper waters of the North and South Atlantic. *Golfingia margaretacea* ranges from the shallow waters of Europe to the Antarctic.

Polychaeta: This phylum provides the bulk of the infauna, with many common genera. Most prominent was the quill worm *Rhamphobrachium ehlersi* (Figure 2.35a), with frequently large number of specimens recorded in the samples, many of which reaching a good size. A couple of observations would point towards this species actually brooding its young. One specimen was found within a tube with juveniles tightly packed together. Another tube contained an adult followed by a chain of eggs/embryos filling the space behind. This brooding is found in many Antarctic species. The second most abundant polychaete was represented by *Apistobranchus* sp. I followed by *Gymnonereis fauveli* (Figure 2.35c).

Nothria conchylega is another quill worm with a bipolar distribution. Quill worms are predators, as are *Nephtys*, *Aaglaophamus* and *Lumbrineris* spp.. *Euphrosine* spp. are short bodied polychaetes which feed on sponges. This genus is generally rarely recorded but *Euphrosine cirrata* is a species common to the North and South Atlantic.

Most non-errantia polychaete species are sediment feeders, e.g. Cirratulidae (*Tharix*, *Caulleriella*, *Cirriformia* and *Cirratulus* spp.) and Maldanidae. Filter feeders included members of the family Sabellidae, of which the commonest was *Euchone pallida.*

Two Terebellid species should be mentioned here, *Terebellides stroemi* and *Melinna cristata.* These are further examples of species common to both hemispheres.

Crustacea: Crustacea is one of the most common and diverse phyla recorded in the Antarctic and sub-Antarctic.

Amongst the barnacles, several specimens of a *Scalpellum* species (stalked or goose barnacle) were recorded. Another barnacle was *Altiverruca*, an asymmetrical raised species commonly found on *Lophelia* debris in the FISA area.

Amphipoda were very common; however notoriously difficult to identify to species level. It proved however possible to place a high proportion into genera or phyla, and to distinguish different species by characterising features. Common were *Ampelisca* (Figure 2.35b), *Urothoe* and Phoxocephalidae spp.. Some notably conspicuous specimens belonged to the Genus *Eusira*. While *Ampelisca* is known as a filtration feeder, most others are likely to feed on debris.

The Isopoda are very well represented by all the common deep sea genera, e.g. *Desmosoma, Haploniscus, Ischnomesus,* etc.. Most of the species are without eyes, given lack of light in this habitat. Despite comparatively recent keys it was not possible to go further than to genus level for this group; with some estimations quoting five out of six species as undescribed. Little is known about their life history and style.

The family Serolidae, typical of Antarctic and sub Antarctic waters, was not found although this species was recorded in a number of the seabed photographs acquired during the survey. An example image is shown in Section 2.10.1 in Figure 2.51 (poss. *Acutiserolis neaera*).

Tanaidacea were common in the samples, often very small specimens, with bigger specimens belonging to the genera *Apseudes* and similar *Pseudospyrapus*, the latter lacking an antennal scale.

Cumacea were somewhat scarce, but nevertheless a number of species could be identified to species level. They are suspension feeders burrowed in the upper layers of the sediment. The genera have a very wide distribution, and can be found at varying water depth.

Mollusca: This group proved fairly diverse, with some interesting material. The most interesting find is of a Monoplacophoran, likely *Neopilina* (Figure 2.35e). This group was thought to be extinct for 400 million years until the Danish zoologist Henning Lemche discovered and described living specimens from the deep sea, obtained during the Galathea expedition. These are acceptably placed on a side branch of evolution and thought to be related to the chitons. These animals are very rare, and so far only about 150 specimens have ever been found worldwide, belonging to about 25 species. Only one specimen was found at station A/21/ENV, which is about 20km away from the proposed well locations.

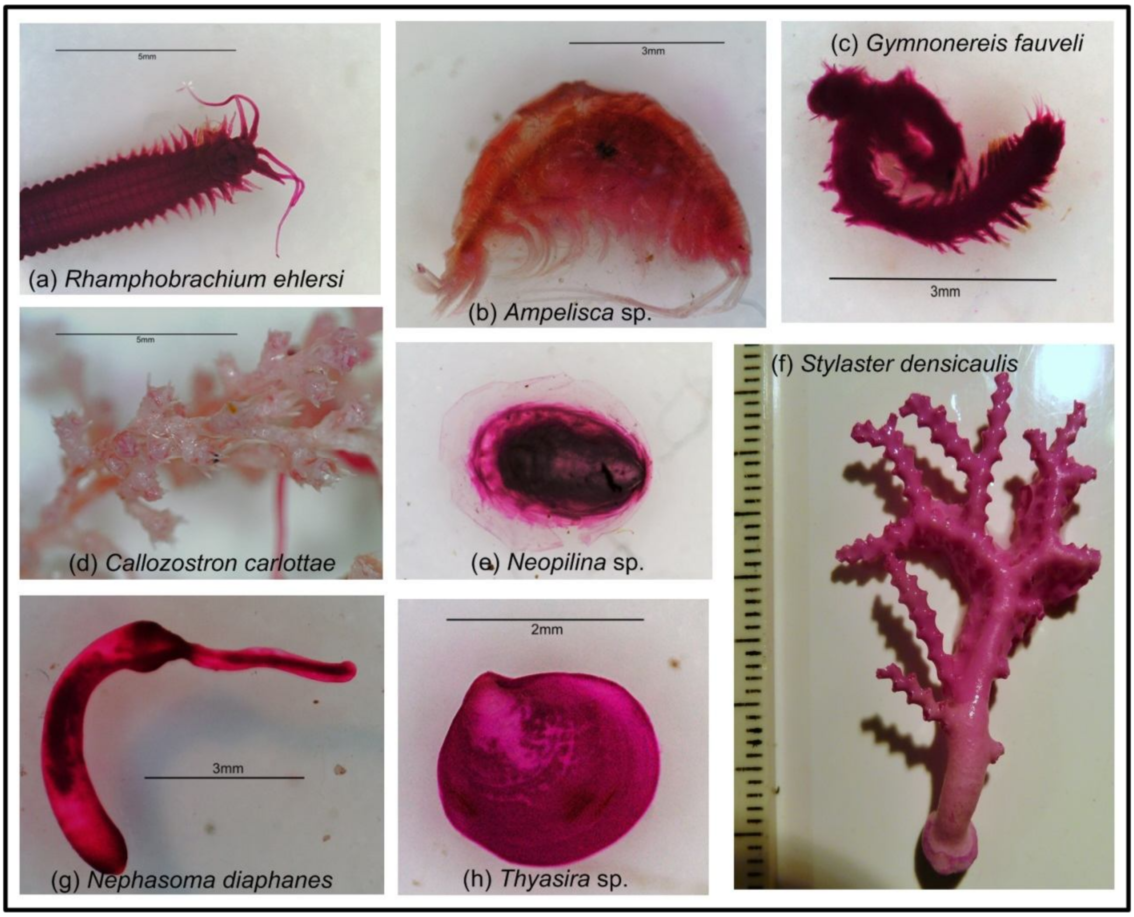
The species of Mollusca recorded are typical members of deep sea or deep water fauna, e.g. *Thyasira* (Figure 2.35h) *Skenea, Limopsis, Dacrydium, Limatula, Nuculana* and *Lyonsiella* etc. The fauna of this zoogeographical area known as the Magellanic region is poorly known.

Echinodermata: As expected, Ophiuroidea are the most common, in this case *Amphiura belgica* (named after a research vessel). A number of other species were recorded, most common of these was *Ophiozonella falklandica.*

Typical of deep sea fauna are very small holothurians, *Myriotrochus* sp. (with wheel like spicules in the dermis) and another species entirely without any calcareous bodies. These species are extremely small, with complete specimens rarely more than one mm in length.

Overall, the benthic community is of a typical Deep Sea habitat, with diverse species, low numbers and high variation between samples, with many species typical of bathyal and abyssal depth.

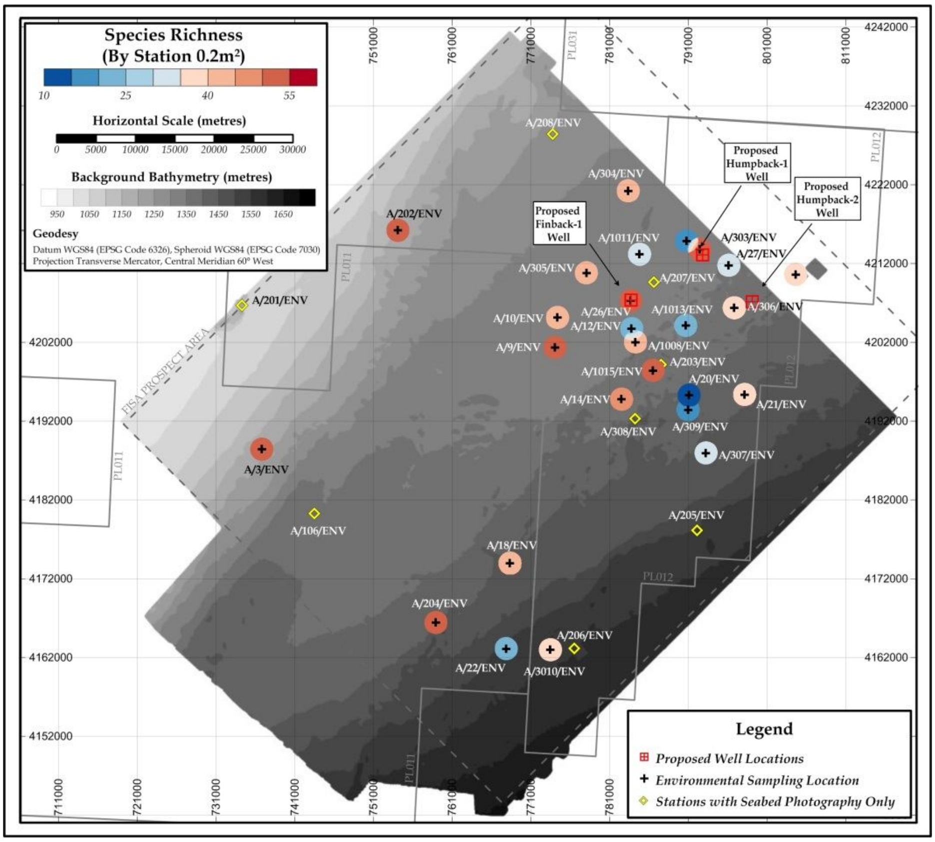
Figure 2.35 Example Macro-invertebrate Specimens Recorded during the Survey



2.9.2 Univariate Parameters

The primary and univariate parameters are listed for individual macrofaunal replicates, together with aggregated stations in Tables 2.10 (by replicates) and Table 2.11 (by stations), respectively. The average number of species per 0.1m^2 replicate for the FISA survey area is 20 (±9SD), these are comparative to the other surveys performed in the South Falklands Basin which ranged from an average of 20 to 29 species per 0.1m^2 (Figures 2.36 and 2.37). The abundance of individuals recorded during this study, per m^2, was generally as expected at 351 (±185SD), comparative to historical sites in the South Falklands Basin. This varied between 305, 407 and 417 per m^2 for Nimrod, Toroa and Vinson West, respectively (Figures 2.38 and 2.39).

Figure 2.36 Macrofauna – Species Richness (per $0.1m^2$)



The 2011 Vinson West survey area appears to have a marginally higher mean species abundance and richness than the current survey, although remained very similar compared to Nimrod and Toroa. This may be due to the large variability of habitats recorded during the FISA study, not encountered during the earlier surveys which were limited to a much smaller area. This is supported by the larger variance in standard deviation (shown as an error bars on Figure 2.37). As a direct comparison sites A/3010/ENV and Vinson West ENV 5 have a closer similarity in species abundance of 78 and 85 and richness of 39 and 45 per $0.2m^2$, respectively. This equates to only a marginally lower survey mean of around 13.3% for abundance and 8.3% richness, for the current survey overall. The relationship between the number of taxa and the individuals is shown in Figure2.40.

Figure 2.37 Macrofauna – Species Richness Comparison (per 0.1m²)

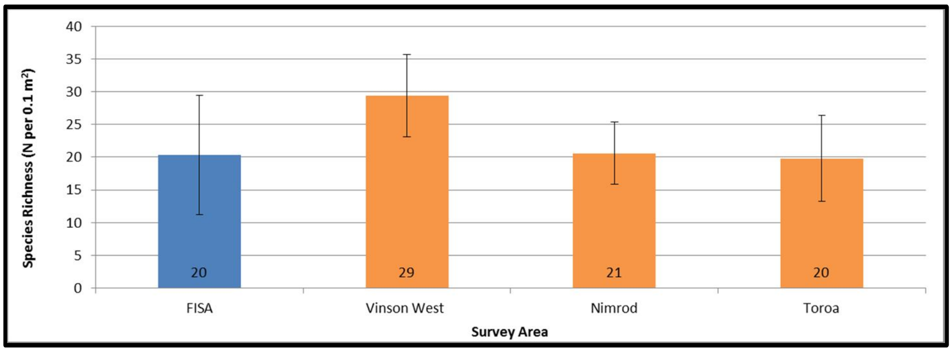


Figure 2.38 Macrofauna – Species Abundance (per m²)

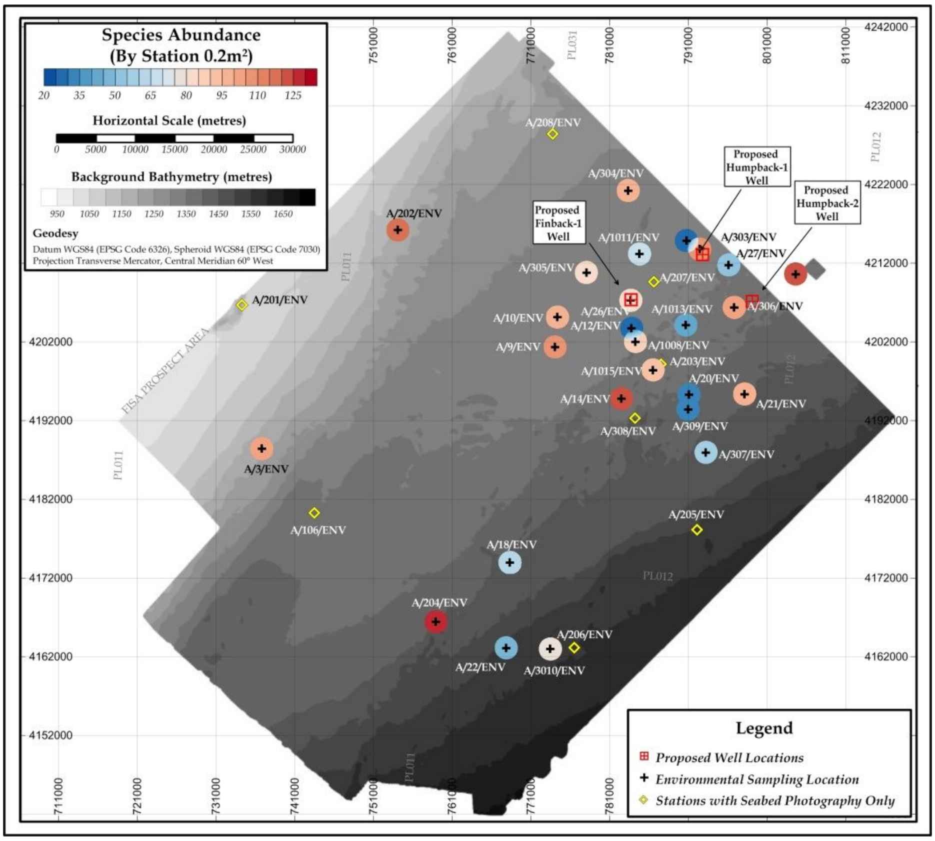


Figure 2.39 Macrofauna – Species Abundance Comparison (per m^2)

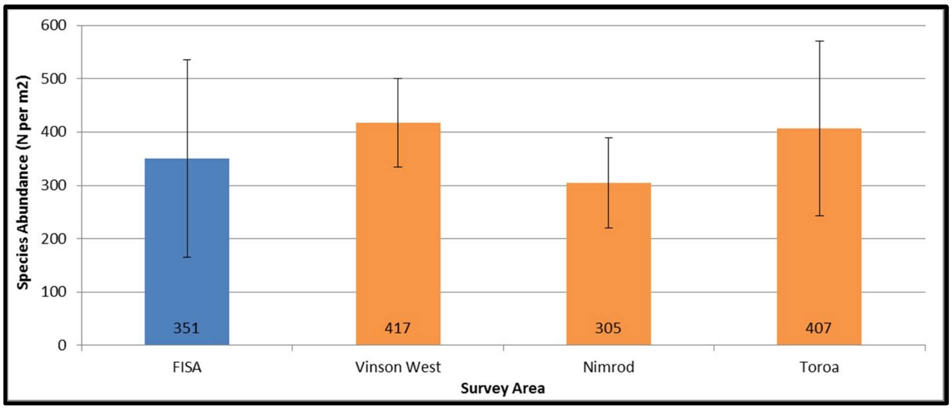
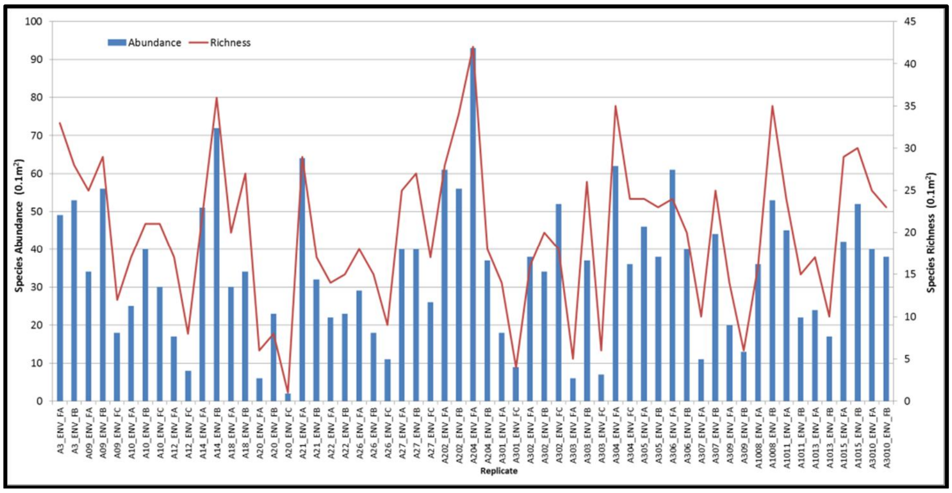
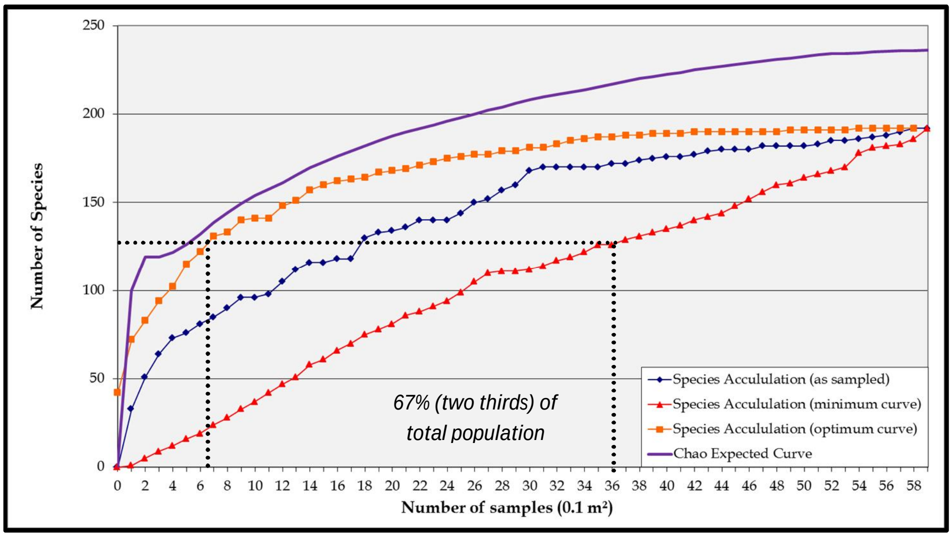


Figure 2.40 Species Abundance and Richness by Replicate (0.1m^2)



The consistent accumulation of taxa with each replicate is demonstrated in a bioaccumulation curve shown in Figure 2.41. The minimum curves in this figure demonstrate the slow incremental increase in species accumulation, as additional replicates were acquired. This suggests that the population is quite diverse and representative of different habitats with a consistent but relatively low species richness being recorded in every new sample. By interpolation, this shows that between 6.5 and 36 x 0.1m^2 replicates are required to recover a representative proportion (i.e. 67% or 129 species) of the overall population.

Figure 2.41 Bioaccumulation Curve of the FISA Survey Area



By further interpolation, the theoretical total species populations and accrual by replicates was assessed using Chao-1 analysis (see Appendix II). This analysis estimates the maximum species accumulation for FISA site to be 236, compared to the actual 188 infaunal species recorded during the survey. This large degree of variability is due to the relatively low species richness recovered throughout the survey, requiring a significant number of samples to achieve asymptote.

The Shannon-Wiener Diversity remained at a relatively high mean level by replicate at 3.801 and slightly variable with a 24.7% variance (i.e. the proportion of standard deviation against the mean). By station, this mean increased to 4.64 and a variance of 13.8% (Figure 2.42). The Pielou's Equitability by station was low with a mean of 0.899 (±0.05SD or 6.5% variance) indicating only a weak species dominance across the sampling template. Margalef's Index (Species Richness) by station recorded a mean of 8.45 (±2.7SD or 26.62% variance) whilst Simpson's dominance illustrated a quite diverse community and low dominance at 0.945 (±0.05SD or 5.6% variance; Figure 4.39). All results conclude a relative low richness suggestive of a broad community with no particularly dominant species.

Figure 2.42 Macrofauna – Shannon-Wiener Diversity (H(s))

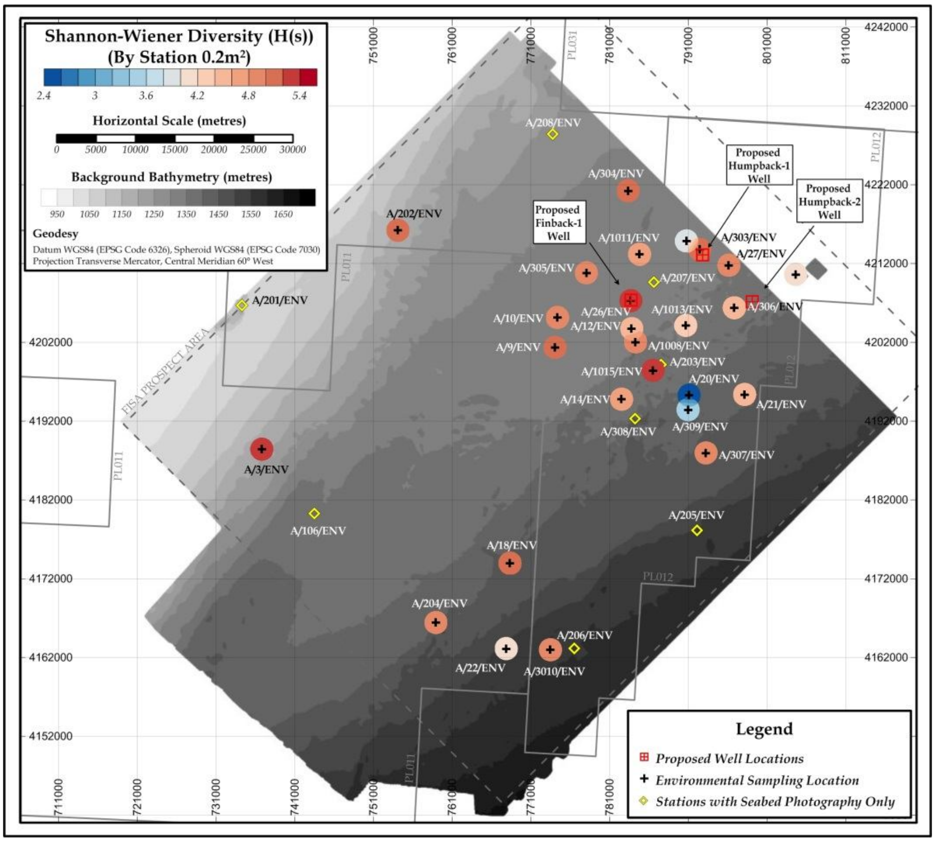
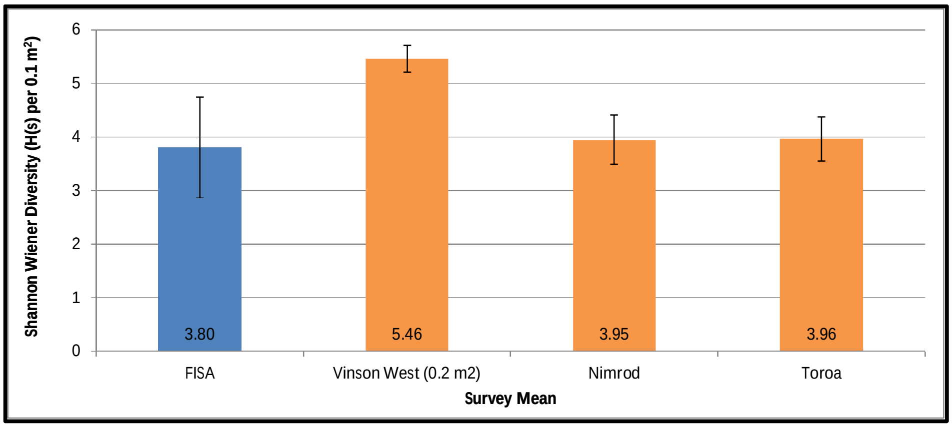


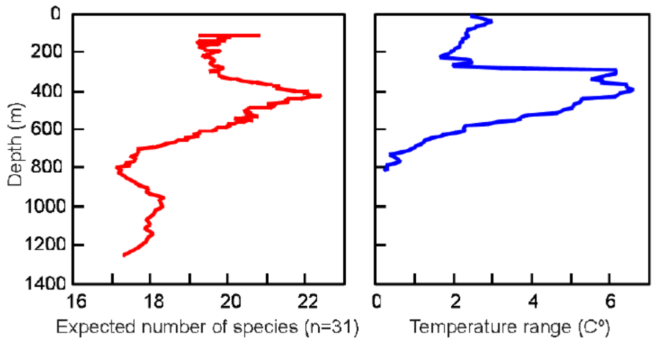
Figure 2.43 Macrofauna – Shannon-Wiener Diversity (H(s)) Comparison



The large diversity within the FISA area, containing a relatively high species richness compared with abundance is typical of deep sea benthic community in this region and remains within the mean abundance and richness of the previous surveys completed in the region at Vinson West, Toroa and Nimrod.

The Atlantic Frontier Environmental Network or AFEN surveys (2000) showed that there was a general decline in diversity (or increase in dominance) with depth, consistent with the low diversity of Arctic and Norwegian Basin deep-sea benthos. A close link between the hydrography was shown to exist within the macrobenthos for intermediate depths within the Faroe-Shetland Channel (Figure 2.44). Diversity was shown to be enhanced in the region of maximal temperature variation (~400m and 6˚C), where the mixing of water masses supports both sets of fauna, increased niche availability and biotic interaction over well-developed epifaunal communities. Based on this model, where the depths of the survey area are recorded (~1000 – 1300m), we would expect a species richness of around 17 to 18 taxon/0.1m^2, indicating the average of 20 taxon/0.1m^2 observed in this survey to be higher than that observed at a similar bi-polar depths.

Figure 2.44 Illustration of correlation between diversity and water temperature, west of Shetlands



This relatively high diversity reflects the high number of species relative to generally low numbers of individuals recorded for many of those species. The most dominant species was represented by the polychaete *Rhamphobrachium (Spinigerium) ehlersi*, which was recorded in 52 of the 59 samples acquired at an average density of 42 per 1m^2, throughout the FISA survey area. This was followed by an amphipod *Ampelisca* sp. A and polychaete *Gymnonereis fauveli* which were present in 29 and 25 of the samples with an average density of 10.2 and 10.6 individuals per 1m^2, respectively. To further highlight the low dominance recorded throughout the survey only four taxa (*R. ehlsersi, A.* sp. A*, G. fauveli* and a copepod), were recorded during the survey with an average density of more than one individual per sample (0.1m^2), with 44 of the 188 infaunal taxa recorded represented by only a single specimen for the entire survey.

Table 2.10 - Univariate Faunal Parameters (0.1m^2 replicates)

Station	Number of Species per 0.1m^2 (S)	Number of Individuals per 0.1m^2 (N)	Shannon-Wiener Diversity	Simpsons Diversity (1-Lambda')	Evenness (Pielou's Evenness)	Richness (Margalef)
A/3/ENV FA	33	49	4.89	0.9821	0.9694	8.222
A/3/ENV FB	28	53	4.175	0.9267	0.8686	6.801
A/09/ENV FA	25	34	4.43	0.9715	0.9539	6.806
A/09/ENV FB	29	56	4.543	0.9604	0.9352	6.956
A/09/ENV FC	12	18	3.303	0.9216	0.9213	3.806
A/10/ENV FA	17	25	3.894	0.96	0.9526	4.971
A/10/ENV FB	21	40	4.015	0.941	0.9142	5.422
A/10/ENV FC	21	30	4.215	0.9701	0.9596	5.88
A/12/ENV FA	17	17	4.087	1	1	5.647
A/12/ENV FC	8	8	3	1	1	3.366
A/14/ENV FA	22	51	3.694	0.8894	0.8283	5.341
A/14/ENV FB	36	72	4.679	0.9476	0.905	8.184
A/18/ENV FA	20	30	4.006	0.9494	0.927	5.586
A/18/ENV FB	28	35	4.672	0.9832	0.9719	7.594
A/20/ENV FA	6	6	2.585	1	1	2.791
A/20/ENV FB	8	23	2.084	0.668	0.6947	2.233
A/20/ENV FC	1	2	0	0	****	0
A/21/ENV FA	29	64	4.142	0.9092	0.8526	6.733
A/21/ENV FB	17	32	3.929	0.9577	0.9613	4.617
A/22/ENV FA	14	22	3.629	0.9524	0.9532	4.206
A/22/ENV FB	16	25	3.764	0.95	0.941	4.66
A/26/ENV FA	32	48	4.756	0.9743	0.9513	8.008
A/26/ENV FB	21	25	4.294	0.9833	0.9775	6.213
A/26/ENV FC	8	10	2.922	0.9556	0.974	3.04
A/27/ENV FA	27	41	4.439	0.961	0.9336	7.001
A/27/ENV FB	28	41	4.399	0.9488	0.9151	7.271
A/27/ENV FC	17	26	3.714	0.9262	0.9086	4.911
A/202/ENV FA	28	61	4.261	0.9355	0.8863	6.568
A/202/ENV FB	34	56	4.807	0.974	0.9449	8.198
A/204/ENV FA	43	94	4.827	0.9508	0.8896	9.244
A/204/ENV FB	18	37	3.424	0.8529	0.8211	4.708
A/301/ENV FA	14	18	3.684	0.9673	0.9675	4.498
A/301/ENV FC	4	9	1.447	0.5833	0.7233	1.365
A/302/ENV FA	16	38	3.43	0.8876	0.8576	4.124
A/302/ENV FB	20	34	4.146	0.9643	0.9594	5.388
A/302/ENV FC	18	52	2.639	0.6659	0.6328	4.302
A/303/ENV FA	5	6	2.252	0.9333	0.9697	2.232
A/303/ENV FB	26	37	4.574	0.9805	0.9731	6.923
A/303/ENV FC	6	7	2.522	0.9524	0.9755	2.569
A/304/ENV FA	35	62	4.865	0.972	0.9485	8.238
A/304/ENV FC	24	36	4.44	0.9762	0.9685	6.418
A/305/ENV FA	24	46	4.229	0.9478	0.9224	6.007
A/305/ENV FB	23	38	4.353	0.9701	0.9623	6.048
A/306/ENV FA	24	61	3.816	0.8923	0.8324	5.595
A/306/ENV FB	20	40	4.015	0.9436	0.9291	5.151
A/307/ENV FA	10	11	3.278	0.9818	0.9867	3.753
A/307/ENV FB	25	44	4.37	0.9609	0.9411	6.342
A/309/ENV FA	14	20	3.622	0.9526	0.9513	4.34
A/309/ENV FB	6	13	2.035	0.7179	0.7872	1.949
A/1008/ENV FA	16	36	3.224	0.8381	0.806	4.186
A/1008/ENV FB	35	53	4.963	0.9826	0.9676	8.564
A/1011/ENV FA	24	45	4.356	0.9646	0.95	6.042
A/1011/ENV FB	15	22	3.698	0.9524	0.9465	4.529
A/1013/ENV FA	17	24	3.887	0.9601	0.9509	5.035
A/1013/ENV FB	10	17	3.052	0.9044	0.9186	3.177
A/1015/ENV FA	29	42	4.576	0.9686	0.9421	7.491

A/1015/ENV FB	30	52	4.695	0.9744	0.9569	7.339
A/3010/ENV FA	25	40	4.463	0.9718	0.961	6.506
A/3010/ENV FB	23	38	4.217	0.9545	0.9323	6.048
Mean	20.4	35.1	3.804	0.916	0.920	5.409
St Dev	9.2	18.7	0.941	0.146	0.074	1.959
% Variation	45.3%	53.1%	24.7%	16.0%	8.1%	36.2%
Nimrod Mean	**19.8**	**30.5**	**3.95**	**0.942**	**0.924**	**5.5**
Nimrod SD	**4.8**	**8.5**	**0.46**	**0.04**	**0.044**	**1.1**
Toroa Mean	**20.7**	**40.7**	**3.96**	**0.946**	**0.923**	**5.34**
Toroa SD	**6.6**	**16.4**	**0.41**	**0.024**	**0.037**	**1.27**

Historical comparisons are in blue. Note: No historical data available for Vinson West

Table 2.11 - Univariate Faunal Parameters (for 0.2m^2 station)

Station	Number of Species per 0.2m^2 (S)	Number of Individuals per 0.2m^2 (N)	Shannon-Wiener Diversity	Simpsons Diversity (1-Lambda')	Evenness (Pielou's Evenness)	Richness (Margalef)
A/3/ENV	51	102	5.224	0.9703	0.9209	10.81
A/09/ENV*	50	108	5.081	0.9619	0.9002	10.47
A/10/ENV*	44	95	4.851	0.953	0.8885	9.443
A/12/ENV	22	25	4.404	0.99	0.9875	6.524
A/14/ENV	47	123	4.744	0.9351	0.854	9.559
A/18/ENV	42	65	5.04	0.9731	0.9346	9.822
A/20/ENV*	11	31	2.451	0.7183	0.7084	2.912
A/21/ENV	39	96	4.594	0.9366	0.8692	8.325
A/22/ENV	24	47	4.187	0.9482	0.9132	5.974
A/26/ENV*	50	83	5.359	0.9797	0.9496	11.09
A/27/ENV*	56	108	5.152	0.9486	0.8871	11.75
A/202/ENV	50	117	5.052	0.963	0.8951	10.29
A/204/ENV	52	131	4.868	0.9372	0.854	10.46
A/301/ENV	18	27	3.856	0.943	0.9248	5.158
A/302/ENV*	39	124	4.092	0.8752	0.7743	7.883
A/303/ENV*	32	50	4.823	0.9796	0.9647	7.924
A/304/ENV	44	98	5.119	0.9726	0.9377	9.378
A/305/ENV	41	84	4.922	0.9621	0.9186	9.028
A/306/ENV	36	101	4.471	0.936	0.8648	7.584
A/307/ENV	34	55	4.801	0.9717	0.9437	8.235
A/309/ENV	16	33	3.467	0.8958	0.8669	4.29
A/1008/ENV	44	89	4.907	0.9533	0.8988	9.58
A/1011/ENV	34	67	4.708	0.9643	0.9254	7.848
A/1013/ENV	24	41	4.211	0.9512	0.9184	6.193
A/1015/ENV	51	94	5.343	0.979	0.9418	11.01
A/3010/ENV	39	78	4.932	0.9657	0.9332	8.722
Mean	**38.1**	**79.7**	**4.641**	**0.945**	**0.899**	**8.472**
St Dev	**12.4**	**32.5**	**0.643**	**0.053**	**0.058**	**2.224**
% Variation	**32.5%**	**40.7%**	**13.9%**	**5.6%**	**6.5%**	**26.3%**
Vinson West ENV 5	**45**	**83**	**5.17**	**0.96**	**0.94**	**-**
Vinson West Mean	**53**	**39**	**5.46**	**0.97**	**0.95**	**-**
Vinson West SD	**8**	**12**	**0.25**	**0.01**	**0.01**	**-**
Nimrod Mean	**32.4**	**61.7**	**4.49**	**0.942**	**0.897**	**7.62**
Nimrod SD	**5.7**	**12.3**	**0.41**	**0.031**	**0.042**	**1.12**
Toroa Mean	**35.3**	**81.3**	**4.56**	**0.949**	**0.892**	**7.84**
Toroa SD	**7.9**	**23.6**	**0.41**	**0.023**	**0.046**	**1.48**

** 3 replicates present (0.3m^2)*

Historical comparisons are in blue

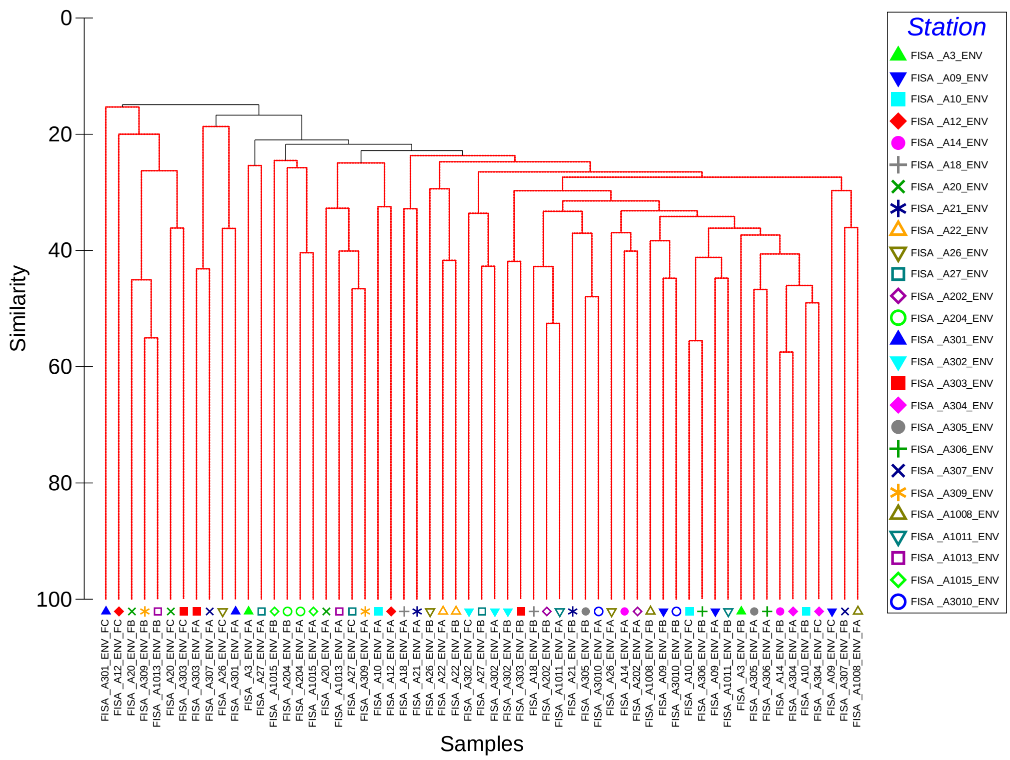
2.9.3 Multivariate Analyses

To provide a more thorough examination of the macrofaunal community, multivariate analyses was performed upon the data for both the replicate and aggregated stations using Plymouth Routines in Multivariate Ecological Research software (PRIMER; Clarke and Warwick 1994) to illustrate data trends. Unlike univariate parameters, multivariate analyses preserve the identity of the different species by assigning a similarity or dissimilarity between the samples. The analyses were undertaken on appropriately transformed data, relating to square-root for both replicates and stations.

2.9.3.1 Dendrogram – Group Average Method

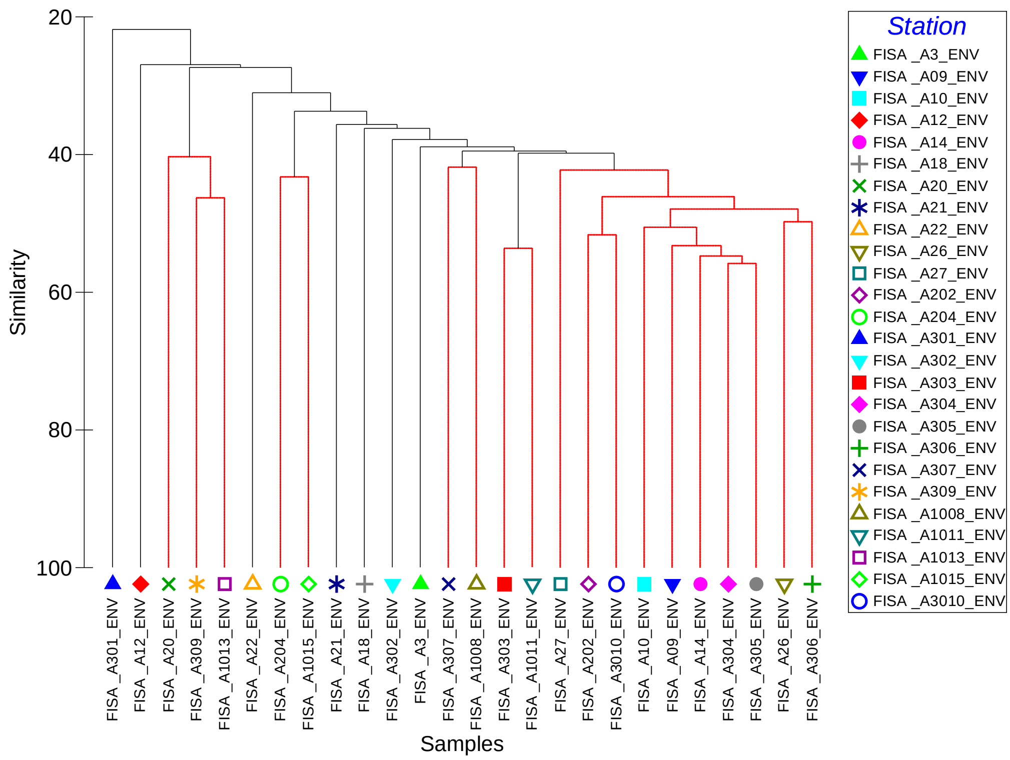
The similarity dendrogram is given for all replicates in Figure 2.45. This diagram shows that both inter-station and intra-station relationships are relatively weak and largely variable, despite this several sites showed stronger intra-station relationships by replicates of the same station clustering together. The SIMPROF test showed six significant structural groupings in the data (black branches) at between 15% to 23% similarity. Within these SIMPROF groupings all replicates had branched out at the 60% similarity mark. The lack of clustering within and between stations indicates a reasonably large degree of overlapping of species assemblages between replicates and stations, highlighting a broad homogeneous macro-invertebrate community. Given the large scale of this regional survey it is likely to encompass numerous variations of the same extensive habitat.

Figure 2.45 Dendrogram of Macrofaunal Replicates



This is further supported in Figure 2.46, which shows a similarity dendrogram by station made up of combined sites based on the two to three replicates (total surface area of 0.2m^2 - 0.3m^2). Results indicate a slightly higher and narrower similarity range, with most sites branching off within the similarity range of 35%-55%. The SIMPROF routine concluded that there were 12 statistically significant differences between the 26 stations, with seven of these groups consisting just one station. Consequently, this plot shows that when lists are combined at a station level there appears to be more significant differences within the macro-invertebrate community.

Figure 2.46 Dendrogram of Macrofaunal Stations



2.9.3.2 MDS Ordination Plot

The replicate similarities were presented in a 2-dimensional representation with two axes of similarity. This multi-dimensional scaling (MDS) ordination is presented in Figure 2.47 for all 59 replicates and shows a general "cloud" of sample replicates, with the sites/groups that showed significant SIMPROF separation on the outskirts of the main cloud, particularly replicates of station A/20/ENV show the largest separation A/20/ENV/FC, which had only one infaunal individual (copepod).

However, the MDS plot is only of limited use due to its high stress level of 0.277, which provides an ordination that should be treated with scepticism, with points close to being arbitrarily placed in the 2-D plot (see Appendix II, Table G). In this instance the 3-D plot was examined for clarifications on ordinations, which indicated a lower stress level of 0.211, yet showed a similar distribution.

Figure 2.47 MDS Ordination Plot by Replicate

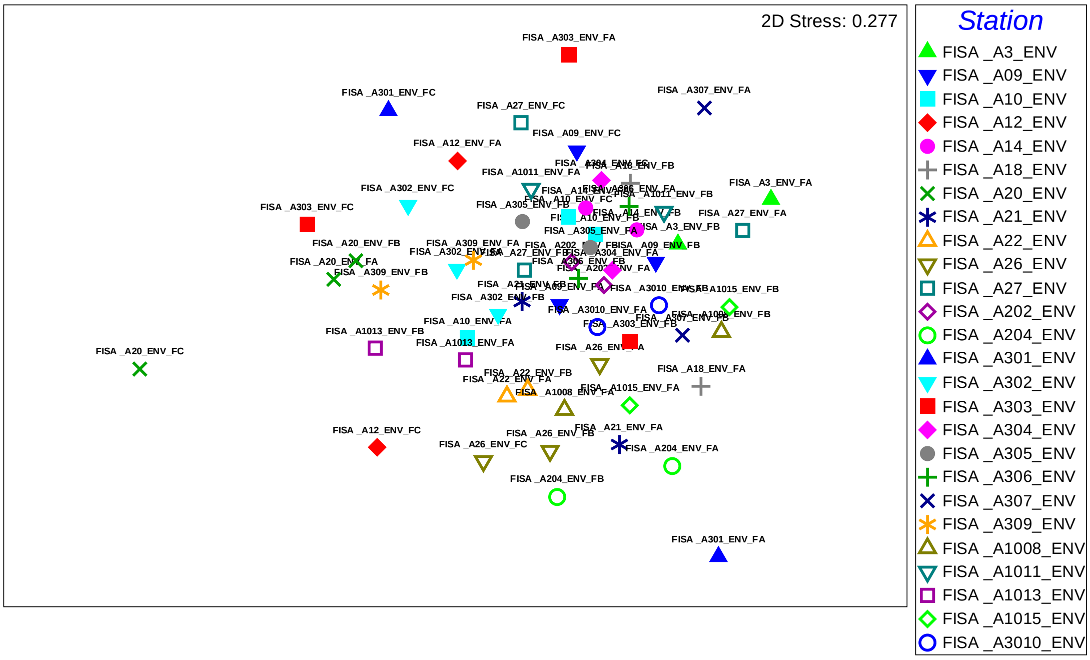
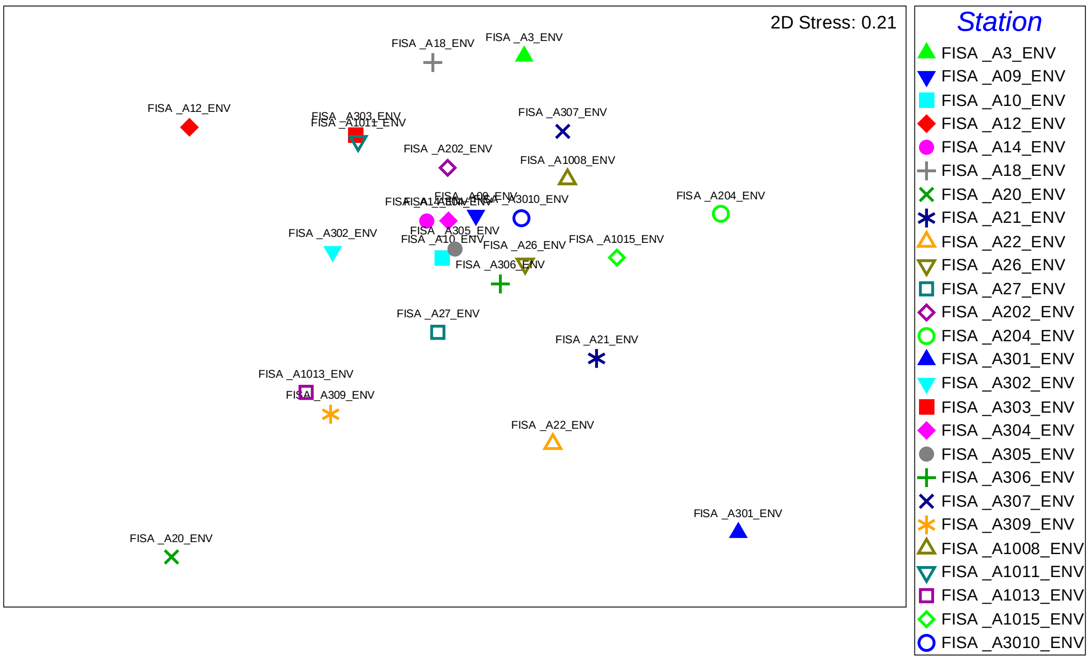


Figure 2.48 MDS Ordination Plot by Station



The MDS 2D ordination of samples by stations (Figure 2.48) indicated a similarly low stress score of 0.21, which means that the plot should be treated with some scepticism. Consequently, this plot has been interpreted with the use of the 3D plot which has a reduced stress level of 0.156 providing a more useful demonstration of the separation between station similarities. There is no particular trend to the data observed here however the sites that show significant SIMPROF structure show the greatest distance from the main cluster. In order to see the magnitude of the differences between the different SIMPROF groups an ANOSIM (analysis of similarity) test was performed, which showed a similarity R Value of 0.928 ($p<0.01$), indicating a high degree of difference between the SIMPROF groups. From the data there appears to be no trend based on geographical location, with geographically close stations remaining biologically separated.

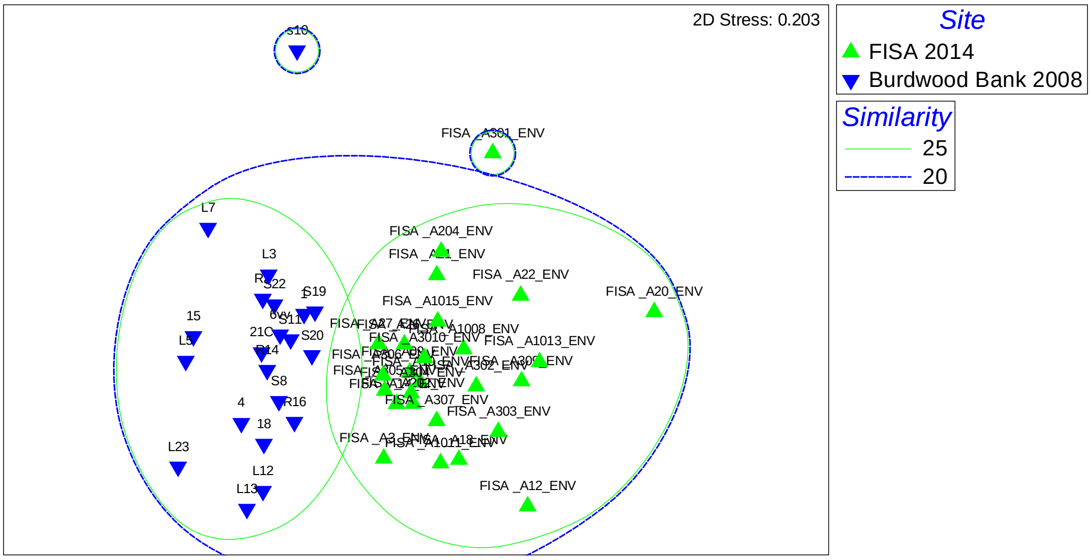
The most likely explanation for these differences is sediment type, however subsequent principle components analysis (PCA) and RELATE tests have failed to yield any significant correlation between particle size and biological community, with the exception of sites A/12/ENV, A/22/ENV and A/1015/ENV, which seemed to have the most Euclidean distance from the other sites using mean Phi particle size. The general lack or correlation here is likely due to the particle size analysis (PSA) itself. Although an industry standard, only a small proportion of the grab is sub-sampled for analysis, therefore often larger sized pebbles and gravels can be misrepresented. An unrepresentative proportion of larger sized sediments appears to be the case for some of the stations based on observation from the seabed photography. For instance the grab data for station A/20/ENV, clearly shows the presence of larger pebbles within the samples, that will not only reduce the grab volume but also a proportion of sediment suitable for infaunal inhabitation.

Due to the large amount of data and broad transition of sediment types identified, varying from sandy muds, through to gravelly sands, it appears that this may have created an underlying gradient of change in order to assign discrete biological communities. This results in a large amorphous grouping of station similarities, indicative of a single but broad macrofaunal assemblage.

In order to place this biological information into a regional context, the results have been included into a regional comparison: where samples from a BSL survey at Burdwood Bank, performed in 2008, have been ordinated in a MDS plot to assess any similarities/differences between the stations (Figure 2.49. BSL, 2009). The 2008 Burdwood Bank survey area is located approximately 250km southwest of the centre of the FISA survey area and exhibiting similar sediment properties to that of the FISA location. Multivariate analysis of the biology from Vinson West, Toroa and Nimrod have not been used as these were analysed at different laboratories (i.e. Fugro Survey and the Natural History Museum) without any consistency being applied to putative species nomenclature.

The resulting MDS plot (Figure 2.49) also indicated a relatively high stress value of 0.203, meaning that the plot should be interpreted with some scepticism, and therefore had to be assessed using the 3D MDS plot, providing a lower stress value of 0.153. The figure shows that the stations form one main cluster at a 20% similarity but with a separation of the two datasets at a 25% similarity level, and the two further outlier sites FISA location A/301/ENV and the Burdwood Bank location s10 showing a large degree of separation. Due to the typical lack of temporal variation in benthic communities at this depth, the differences observed are difficult to interpret and may simply relate to zoogeographical zonation.

Figure 2.49 MDS Ordination Plot of Survey Areas



The general, the separation of the two datasets is due to the intra-station relationships remaining stronger than the inter-station relationships. The macrofauna within the FISA cluster had a similarity of 35.5%, while the Burdwood Bank cluster had a similarity of 34.3%, These are generally quite low owing to the mixed sediment types surveyed. The dissimilarity between the two clusters is 75.2%, this appears to be due to more subtle variances in abundances of same or similar species, as 45% of the recorded species were present in both survey areas and surveys.

A RELATE test was performed between the two main clusters biology and their PSA data to see if the macrofaunal community structure can be explained by the particle size analysed. This permuted a significant coefficient value of 0.388 ($p<0.01$), highlighting a correlation between the two datasets, albeit a weak one. This could largely be attributed to the coarse silts that were frequently sampled at Burdwood Bank, amongst other mixed sediment, yet sandy mud (silt) was only classified at site A/03/ENV.

The SIMPER calculations for the different clusters identifying the top five contributory species are presented in Table 4.11 along with their contribution percentages.

Table 2.12 - SIMPER analysis of the four different cluster formations and top Five contributing species and percentages

	FISA 2014		FISA A/301		BB/s10	
Burdwood Bank	Dissimilarity Percentage 75.21%		Dissimilarity Percentage 85.19%		Dissimilarity Percentage 85.47%	
	Nematoda	2.11%	Nematoda	3.29%	Nematoda	3.16%
	Ostracoda	2.09%	*Urothoe*	2.26%	Ostracoda	2.89%
	Rhamphobrachium	1.88%	Phoxocephalidae	2.18%	*Rhamphobrachium*	2.8%
	Aricidea oculata	1.52%	*Rhamphobrachium ehlersi*	2%	Pardaliscidae	2.64%
	Copepoda	1.5%	Ostracoda	1.85%	*Urothoe*	2.16%
FISA 2014			Dissimilarity Percentage 78.18		Dissimilarity Percentage 88.51%	
			Copepoda	2.84%	Pardaliscidae	3.53%
			Dacrydium	2.73%	*Rhamphobrachium*	2.78%
			Brachiopoda	2.57%	Copepoda	2.36%
			Nephasoma diaphanes	2.35%	*Similipecten*	2.06%
			Ampelisca	2.13%	*Psolus*	2.02%
FISA A/301					Dissimilarity Percentage 82.41%	
					Pardaliscidae	5.96%
					Rhamphobrachium	3.87%
					Nemertea	3.77%
					Eunoe	3.77%
					Similipecten	3.77%

The differences observed at the Burdwood Bank and FISA cluster are due to the higher abundance of nematodes, ostracods, *Rhamphobrachium ehlersi* and *Aricidea oculata* at Burdwood Bank, however there were slightly higher counts of copepods at FISA. All these species were present in both surveys to some degree. The separation of A/301/ENV from the other clusters are generally attributed to the absence of copepods, nematodes, *Urothoe*, Phoxocephalidae and Pardaliscidae and generally low counts of Brachiopoda and *Dacrydium* with the prevalence of Copepoda, *Nephasoma diaphanes and Ampelisca*, amplified by the overall low species richness and abundance here. The differences observed at Burdwood Bank s10 were attributed to the relative high abundance of the crustacean Pardaliscidae which was either absent or had low counts in the other clusters, and the absence of *Eunoe*, Nematoda, *Urothoe* and Ostracoda combined with the relatively low counts of *Rhamphobrachium ehlersi* yet prevalence of *Similipecten* all contributed to this locations biological separation. As this station only had one fauna sample this is sure to have exaggerated these differences in species counts.

The differences observed between the two main clusters appear to be an accumulation of subtle differences in species counts, mainly of the dominant species identified, which the RELATE test showed could partially be explained by the PSA data. The two outlying sites had low species richness's either attributed to the coarse substrate (A/301/ENV) or only having one faunal replicate (BB/s10), which seems to have amplified any differences observed.

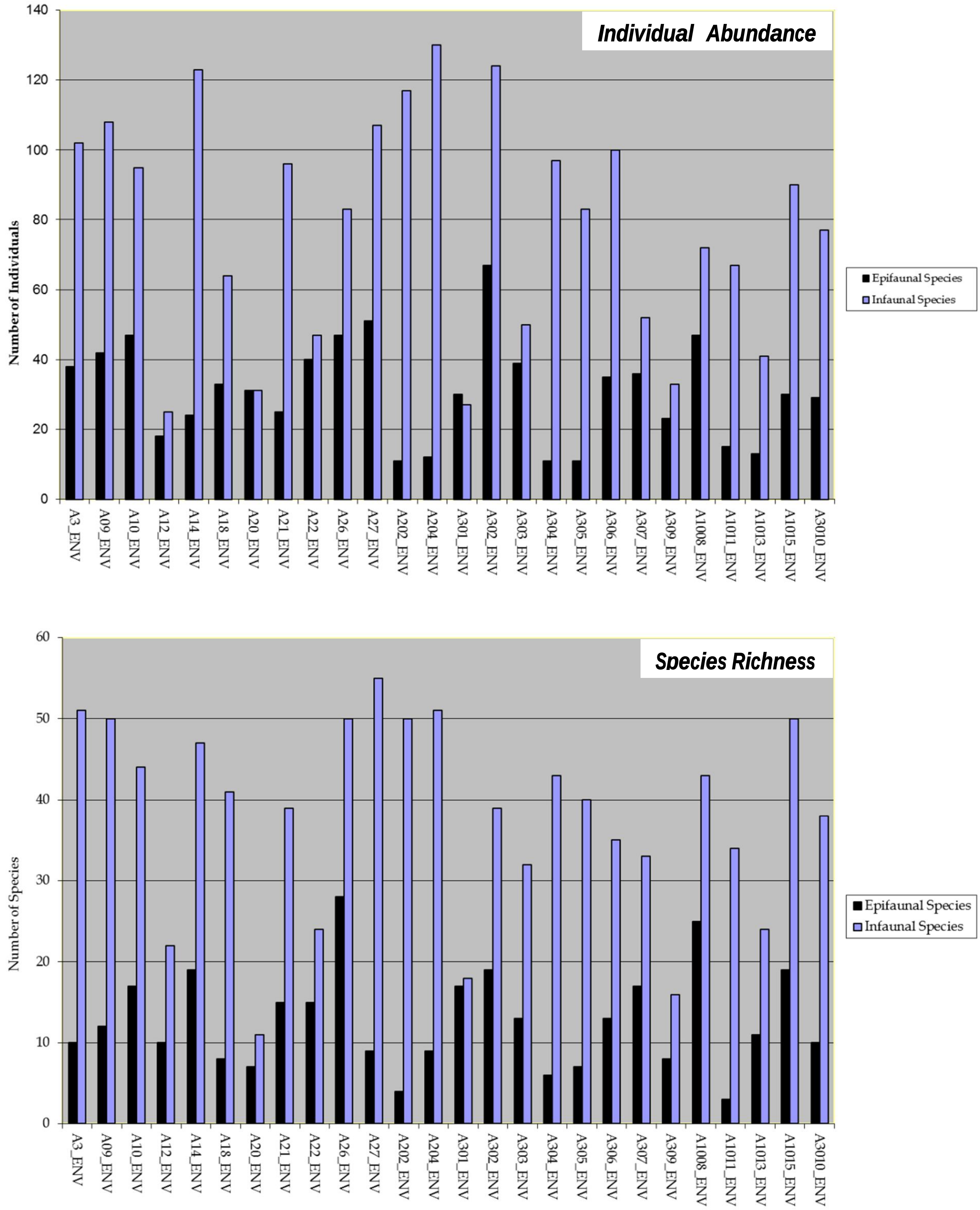
2.9.4 Environmental Variables

In order to assess whether any relationships between the biological community and chemical variables were present and whether these differences were significant, numerous principle components analyses and RELATE tests were performed. However no meaningful trends or conclusions were reached. Depending on the test, different stations showed differing separations. For instance, station A/1015/ENV, A/306/ENV, A/301/ENV and A/26/ENV, all showed separation from the other sites according to Ni, Zn and V, whereas station A/12/ENV and again A/26/ENV, separated from the other sites by % NPD. These individual variances are often not present when viewed from a different principle component dimension, and are therefore only weak relationships that lay in a particular category when forced into a PCA ordination. Subsequent RELATE tests have not shown any significant relationships of these environmental variables with biological separations. In addition to this a Pearson's correlation has been permuted of the macrofauna diversity indices with physico-chemical parameters. There are few significant weak correlations relating % fines and several of the metals with species richness, Shannon-Wiener diversity and Simpsons diversity (all $P<0.05$), but no strong correlations were recorded (Appendix XI). Although such correlations can be regarded as negligible due to their co-incidence nature, % fines and Al both relate to the sediment parameters of particle size and may bare some relevance to the faunal distribution.

2.9.5 Epifaunal and other Biological Groups

All of the macrofaunal samples recorded the presence of invertebrate species that are generally considered to be epifaunal and are not statistically assessed within the infauna. Whilst the underwater photography showed that some habitats within the survey area are heterogeneous due to the intermittent exposures of underlying bedrock and sporadic drop-stones caused by ice modification (see Sections 2.3); the benthic sampling indicated varying quantities of these coarser admixtures. The consistency and importance of the epifaunal assemblages is demonstrated in Figure 2.50, highlighting the general proportion of infaunal and epifaunal species. Due to the presence/absence scale to which a lot of epifaunal species are identified, for the purpose of this chart and to highlight both the epifaunal abundance and richness, where epifaunal species have been recorded as present this has been given the numerical value of "1" only to represent the colony. Infauna and epifauna species are listed separately in Appendix VII.

Figure 2.50 Epifaunal Abundance and Richness versus Infauna (by Station)



Sessile epifauna were prevalent throughout the FISA macro-invertebrate samples. Some of the key groups are discussed below.

Porifera: The Class Hexactinellida was relatively well represented by many fragments, not sufficient for determination. In addition embryos in the form of little spheres were common in every sample. This is a feature of most deep water and deep sea sediments.

A single specimen of a *Sycon* species represented the Class Calcarea, with the rest made up of Demospongia, with siliceous spicules and varying amounts of spongin.

Most common were *Eurypon* spp., encrusting species with the spicules standing on the substrate giving a hairy appearance. These sponges are belonging to the order Hadromerida which have an extended planktonic larval life which allows for wide geographical dispersion. Most of the genera are typical for deeper water (e.g. *Hymedesmia* spp., *Crella* and *Lissodendoryx*). Many of the species inhabit a wide distribution in the Atlantic or are often cosmopolitan; in addition many species are only represented by a couple of specimens or small colonies.

Cnidaria: This group was regularly represented. Nine genera of thecate and athecate Hydrozoa and two genera of Stylasteridae were recorded. Live Stylasteridae were not infrequent, and the species *Stylaster densicaulis* (Figure 2.35f) was the most common, with the second species *Lepidopora* sp*.* only of sporadic occurrence. Stylasteridae are a group of Hydrozoa with a calcified skeleton resembling corals. The other Hydrozoa are common genera in the Atlantic but their species status could not be determined.

Scyphozoa were represented by their sessile polyp stage, likely of the order Coronatae (Deep Sea Medusae). These are trumpet shaped with very distinct annulation, and are known as voracious feeders and predators. They are very common in the deep water samples.

While some of the samples contained dead *Lophelia* and *Lophelia* debris, no live material was found. The material looked very weathered. The live solitary corals belong to the species *Flabellum curvatum.*

Several species of Octocorallia were found. Several specimens of Pennatulidae were too small to identify. Two species of Gorgonacea were not infrequent, *Callozostron carlottae* (Figure 2.35d) and the more common *Fannyella rossi*. The latter is a common and widespread species.

Bryozoa: This group was a common constituent on pebbles and stones, with many species endemic. While most specimens were encrusting, there are a number of upright forms, e.g. *Cornucopina*, *Isosecuriflustra* and *Notoplites*.

Other epibenthic taxa: *Rhabdopleura* is commonly found in polar waters both in the North and South Atlantic.

Further photographic examples of epifaunal species are given in Figure 4.49.

2.10 VIDEO/PHOTOGRAPHIC SURVEY OF SEDIMENT HABITATS

2.10.1 Video/Photographic survey

In addition to the analysis and interpretation of the benthic samples, additional photographic ground truthing data was also obtained at eight additional locations (total 34 stations) within the FISA survey area. These were selected based upon areas of bathymetric interest or on sediments representative of typical habitats encountered for the area to provide a more regional context. The bathymetric dataset indicated a generally habitat of silty sand, some areas targeted relate to features created by historical ice modifications. Occasional examples of larger clasts, such as boulders, were also frequently recorded. A list of the ground truthed sites and their location is given in Table 2.2 and summary photo pages in (Appendix VIII).

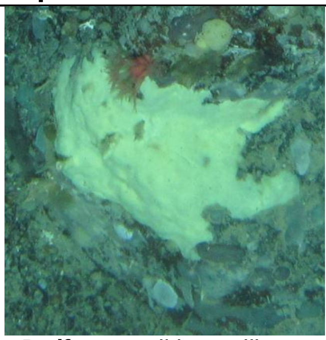
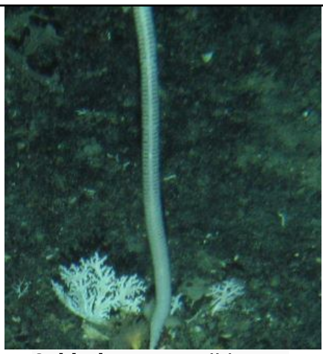
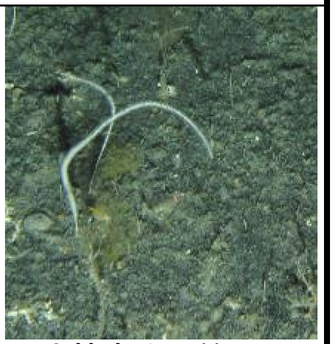
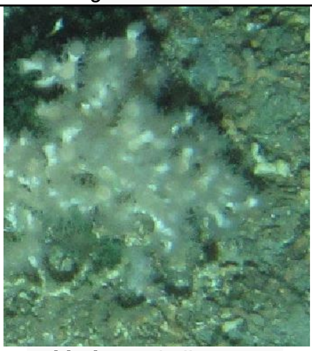
No environmentally sensitive habitats or benthic communities were recorded at or surrounding the proposed Finback-1 and Humpback well locations or within the FISA Block. This includes the absence of potential Annex I habitats such as gas escape feature, biogenic reefs or geological reefs, currently protected under the European Habitats Directive. Dead *Lophelia* fragments were identified within the fauna samples, and live *Lophelia* specimens were located in the photographs at several stations A/1008/ENV, A/205/ENV, A/206/ENV, A/301/ENV, A/303/ENV (Humpback -1, well location), A/304/ENV, and A/308/ENV. However where present, these were only as small sporadic colonies and do not represent the complex well developed structures that constitute reef status under the Annex I of the European Habitats Directive. Despite this lack of size or proliferations across the area, coral reefs, where found are classified by OSPAR as under threat and there may be instances along the edge of escarpment where larger aggregations may exist and should be protected from physical damage. The majority of evidence for the presence of this species relates to extensive areas of debris relating to relic residue populations located on the edge of the escarpment drop-off approximately 4.7km southeast of the proposed Finback-1, 2km southeast of Humpback-1 and approximately 5.7km northwest of the proposed Humpback-2 well locations.

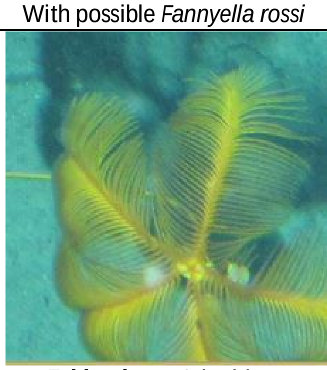
Survey operations were carried out using a combined digital video and still camera system deployed in a drop-down frame (see Section 2). Results for each of the 34 ground truthing locations are summarised in Appendix VIII for the dominant habitats encountered, or Figure 4.49 for the common and/or conspicuous faunal groups encountered.

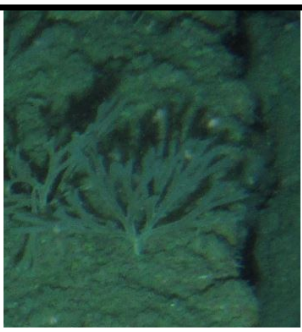
These photographs confirmed expectations acquired during the regional habitat assessment and observed on the bathymetric dataset (see Section 4.1). The seabed photography revealed evidence of ice modification mainly relating to cobbles and drop-stones sporadically placed throughout the survey area, as well as bedrock exposure also observed on escarpment outcrops. An assessment of the epifaunal assemblages shown within the seabed photographs, confirmed a relatively well populated community of species overall, with healthy aggregations colonising occasional drop-stones as well as

Lophelia debris, where present and some rooted into the sediment. Many of the species recorded are associated with deep water and/or cold water environments. A summary of the main taxa recorded, along with some example photographs is given in Figure 2.51.

Figure 2.51 Examples of Epifaunal and Megafauna Species Recorded at the FISA Site

Species Examples from Seabed Photography		
 **Porifera:** Possible Demospongiae sp.	 **Porifera:** Possible *Myxilla* sp.	 **Porifera:** Possible *Mycale* sp.
 **Cnidaria:** *Anthoptilum grandiflorum*	 **Cnidaria:** Pennatulidae sp.	 **Cnidaria:** Sea whip sp.
 **Cnidaria:** *Lophelia pertusa*	 **Cnidaria:** *Lophelia* debris	 **Cnidaria:** Possible Stylasteridae sp.
 **Cnidaria:** Gorgonian sp.	 **Cnidaria:** Pennatulidae sp.	 **Cnidaria:** Gorgonian sp. (Octocorallia)

 **Cnidaria:** Gorgonian sp. (Octocorallia)	 **Cnidaria:** Hydroid sp. (Surrounded by Porifera sp. and possible Bryozoan)	 **Cnidarian sp.**
 **Cnidaria sp.**	 **Actiniaria sp.**	 **Actiniaria:** Possible *Bolocera* sp.
 **Actiniaria:** Possible *Actinoscyphia aurelia*	 **Cnidaria:** Alcyonium sp. With possible *Fannyella rossi*	 **Poss Cnidarian sp.**
 **Cnidaria:** Possible *Flabellum* sp.	 **Echinoderm:** Crinoidea.	 **Echinoderm:** Crinoidea.

 **Bryozoan sp.**	 **Echinoid:** Possible *Eucidaris* sp.	 **Ophiuroidea:** probably *Astrotoma agassizii.*
 **Ophiuroidea sp.**	 **Asteroidea sp.**	 **Asteroidea:** Possible *Culcita* sp.
 **Holothuroidea sp.**	 **Holothuroidea sp.**	 **Isopoda:** Possible *Acutiserolis neaera*
 **Decapoda:** Caridea sp.	 **Decapoda:** Possible Galatheidae sp	 **Decapoda:** Nephropidae sp. probably *Thymops birsteini.*
 **Decapoda:** Lithodoidea sp probably *Paralomis sp.*	 **Moridae sp.**	***No used***

Overall, the phylogenetic make-up of the conspicuous megafauna observed was dominated by the cnidarians, with octocorals and Pennatulidae remaining prevalent throughout. Echinoderms were better represented in the seabed photography than the grab samples with ophiuroids, crinoids, asteroids and holothurians present. Where drop-stones were present, encrusting sponges were common along with anthozoans. Often rooted into soft sediments bryozoans and hydroids were observed as sparse tufts. There were also numerous burrows likely to be associated with crustacean and holothurian activity. Free-swimming megafauna included the demersal teleosts: Macrouridae, Grenadier, hake and batoids.

Previous assessments of the epifaunal component from seabed photographic records taken at the Vinson West, Nimrod and Toroa similar epifaunal communities, where recorded. One main difference recorded would be that of the tube-dwelling onuphid worms, *Onuphis pseudoirirescens*, and *Kinbergonuphis oligobranchiata* which were dominant within the Toroa and Nimrod surveys but absent from this survey, with occasional *K. oligobranchiata* specimens observed at Vinson West. Due to the large area covered by this FISA survey, with seabed photography undertaken at 34 stations, the epifaunal species are more extensive than previous surveys undertaken in the region. This is due the numerous colonised hard substrates identified, compared with that of Toroa and Nimrod which didn't undertake seabed photography. Toroa especially had poor representations of epifauna due to the survey area being comprised of softer sandy silt. The stations surveyed at Vinson West also observed only limited footage of boulders.

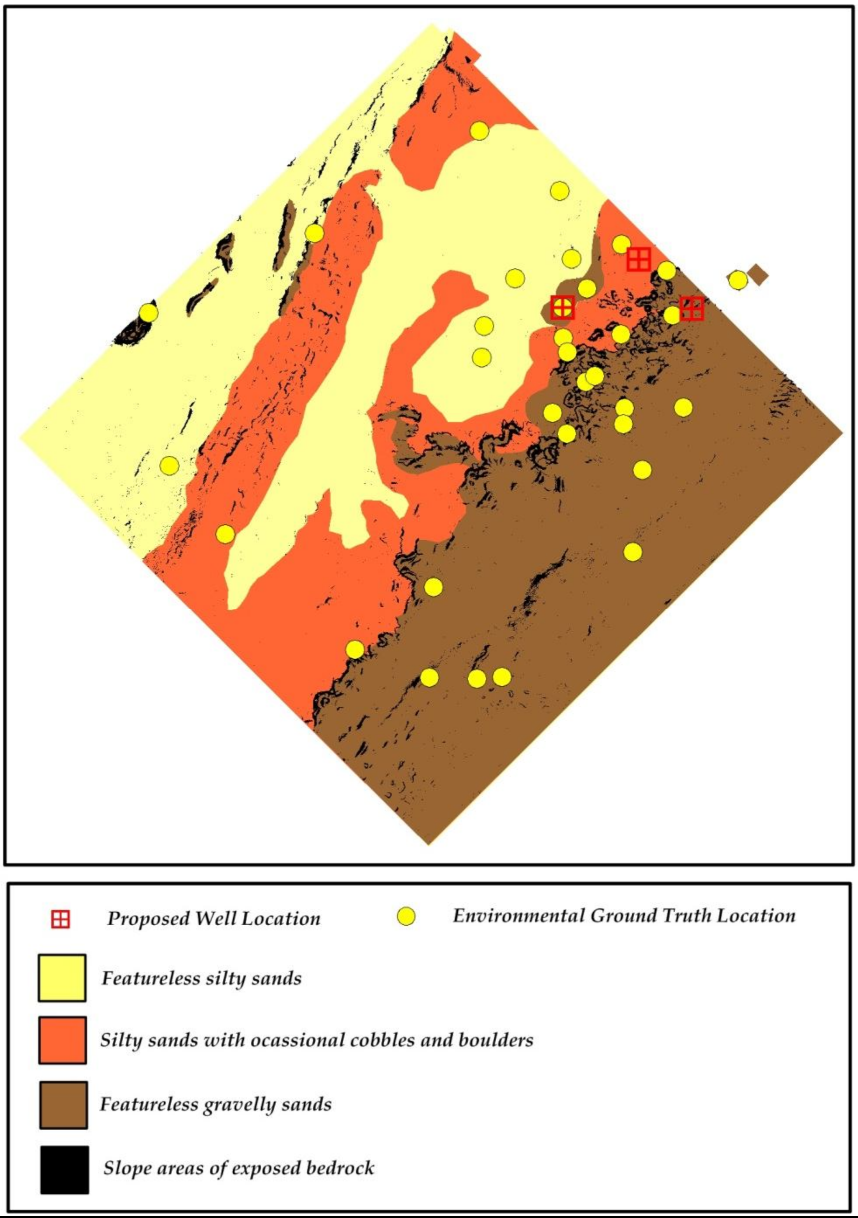
The remainder sites of the current survey area did not yield any evidence of particularly sensitive habitats, especially within the immediate vicinity of the proposed exploration wells. The habitats in these areas were considered to be homogenous, gravelly or slightly gravelly silty sands with limited sensitivity to the proposed operations. A review of both stills and video footage indicate that some potential CITES Appendix II coral species (such as *Flabellum* sp.) were observed.

2.10.2 Environmental Habitats

Within the survey area, the majority of the shallower sediments were dominated by a relatively homogeneous and featureless slightly gravelly silty sand, associated with a weak sedimentary environment throughout. The deeper sediments to the south and east were associated with a similar sediment type, but with greater erosion and significant gravel component, indicative of ice modification from drop stones throughout. The central part of the survey area is represented by a complex bathymetry indicative of a number of underlying geological structures forming an irregular escarpment running from the southwest to the northeast. These have been interpreted as steep sloped exposures of bedrock or a hard underlying formation (such as a concretion) revealing a low energy rock exposure. In the shallower, northwestern part of the survey area, this underlying formation appears to have either collapsed or has been eroded leaving steep sided depressions at a number of locations leaving slump material (boulder field) at its base.

Separating the shallower slightly gravelly silty sands from the deeper gravelly sands is the rocky escarpment along with an intermediate habitat type which marks the transition from homogeneous sands to the rock outcrops. This is interpreted as generally homogeneous sand punctuated by occasional to numerous isolated rock outcrops and boulders. This area is the dominant sediment type along the top of the escarpment and over a sub-cropping geological feature, observed in the bathymetry, running at a depth of 1150m along the length of the survey area in a northeast-southwest orientation. Here the sands thin to a veneer.

Figure 2.52 - Summary Habitat Classifications



Whilst the homogeneous sands showed relatively few conspicuous species, the diversity of fauna increased slightly in the deeper gravelly sediments to the southeast and significantly on the intermittent or escarpment bedrock exposures. On this hard substrate, the dominant fauna consists mostly of suspension feeding anthozoans, in particular both soft and hard corals, although communities were generally small in size. Present within these areas was the reef-building coral *Lophelia pertusa*, although live examples were only found in small colonies, not sufficient to constitute an Annex I reef, as designated under the European Habitats Directive. However, the skeletal debris from this species was also found in relatively high concentrations in small isolated patches on flat rocky areas and along the top and on the escarpment slope, presumed to be of historical residues and the aggregation of eroded material produced over a significant period of time. The base of the escarpment is marked by slump deposits from the escarpment erosion in the form of a boulder field. The surrounded granular sediments with this area indicate the influence from currents in the form of localised scour and some sand rippling.

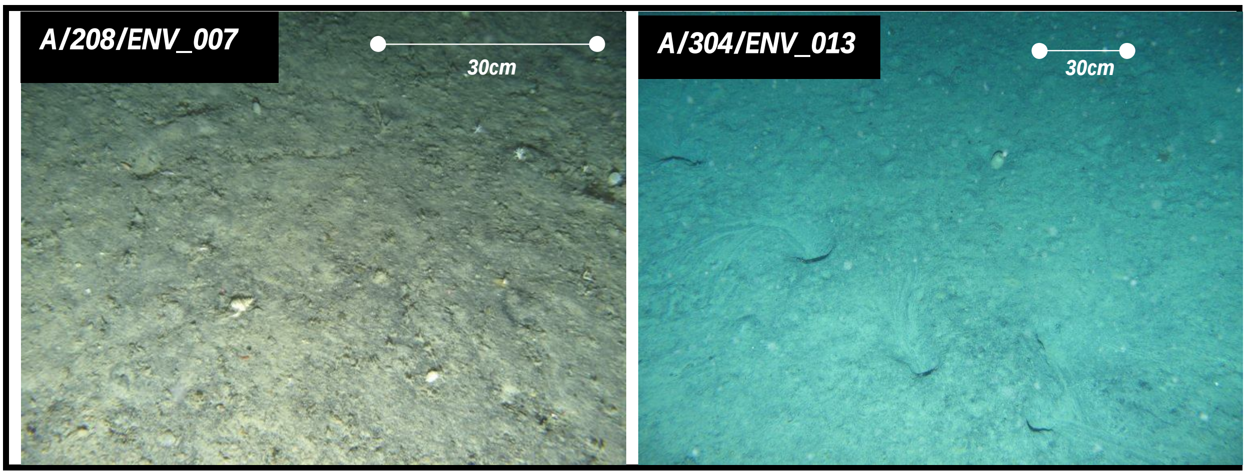
Environmental ground-truthing using both cameras and seabed sampling confirmed the presence of these sediment changes although the boundaries of these main areas are estimated based on the coverage by the ground truth stations or interpretation from the regional bathymetry.

A summary of the key habitat variations recorded during ground truthing within the FISA Survey area are outlined below in Figure 2.52 (and Appendix VIII). Greater detail regarding the habitat variations are presented in Volume 2 of this report (MG3, 2014b).

2.10.2.1 Habitat: Holocene Sedimentary Slightly Gravelly Silty Sand:

The majority of the seabed is described as featureless slightly gravelly silty sand. This is broadly similar to an offshore circalittoral sand (SS.SSa.OSa; Connor *et al.,* 2004). This material will be related to granular Holocene sedimentary material and granular Pleistocene residues (i.e. drop-stones, recorded during faunal sieving). Seabed photography recorded a presence of bioturbation in the form of burrows from various crustaceans, as well as other “lebensspuren” (animal tracks and furrows) likely to be produced by echinoderms (in particular spatangoids) observed in both the grab sampling and seabed imagery. An example of this habitat type is shown in Figure 2.53.

Figure 2.53 - Example Images of Slightly Gravelly Silty Sand Habitat



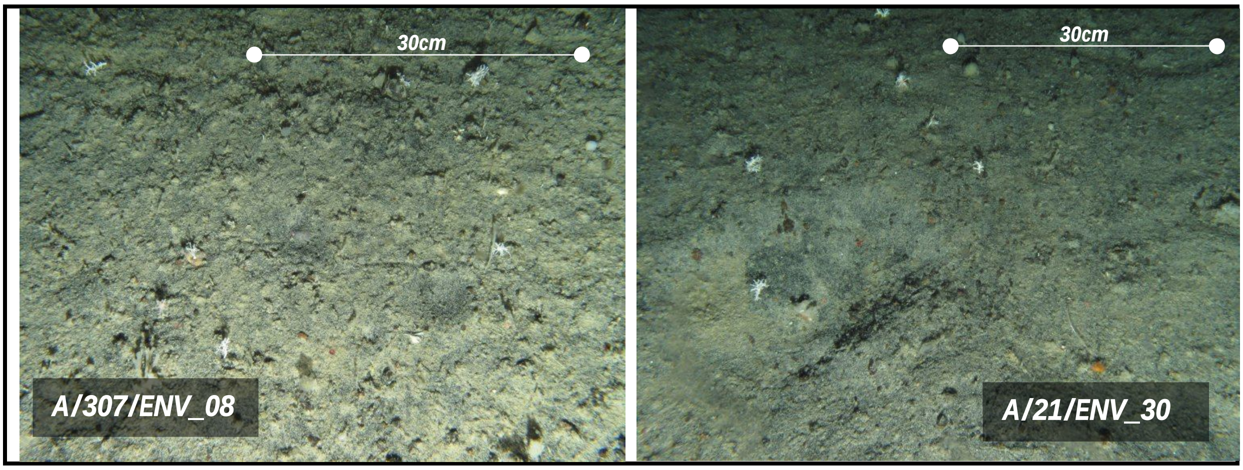
Relatively few conspicuous fauna were recorded in this habitat by seabed photography, although the presence of some bioturbation would signify a relatively rich infaunal community. The seabed was generally featureless with an absence of current related bedforms indicative of a sedimentary regime and limited hydrodynamic reworking of sediments. Conspicuous fauna observed included the isopod Serolidae (possibly the deep water species *Acutiserolis neaera*), occasional ophiuroids, the potential CITES Appendix II solitary cup coral (*Flabellum* sp.) and the striped shrimp (*Nauticaris* sp.).

2.10.2.2 Habitat: Featureless Gravelly Silty Sands:

The seabed to the southeast of the escarpment indicated a similar featureless, slightly mixed seabed to that described in Section 2.10.2.1, with the exception that coarser gravel admixtures were recorded on the surface of the seabed (as observed by seabed photography).

As with the shallower sediments this is broadly similar to an offshore circalittoral sand (SS.SSa.OSa; Connor *et al.,* 2004), but with the addition of fine gravels, although not sufficient to alter the general habitat to an offshore circalittoral mixed sediment (SS.SMx.OMx; Connor *et al.,* 2004). Nevertheless, the presence of fine pebbles at the surface has introduced a small epifaunal community of small isolated stone coral-like Hydrozoa *Stylaster* sp., usually in the form of a single branched 'sprig' only a few centimetres high. Other species recorded were echinoderms (a cushion star, the pencil urchin (*Cidaris* sp.) and a burrowing holothurian) and the same Serolidae isopod as recorded elsewhere on the FISA site (possibly *A. neaera*). The small pebble surfaces also support the occasional foliose bryozoan, ascidians and solitary sponge (*Suberites* sp.), although the solitary cup corals (*Flabellum* sp.) previously recorded on the Holocene slightly gravelly silty sands, appeared to be absent.

Figure 2.54 - Example Images of Gravelly Silty Sand



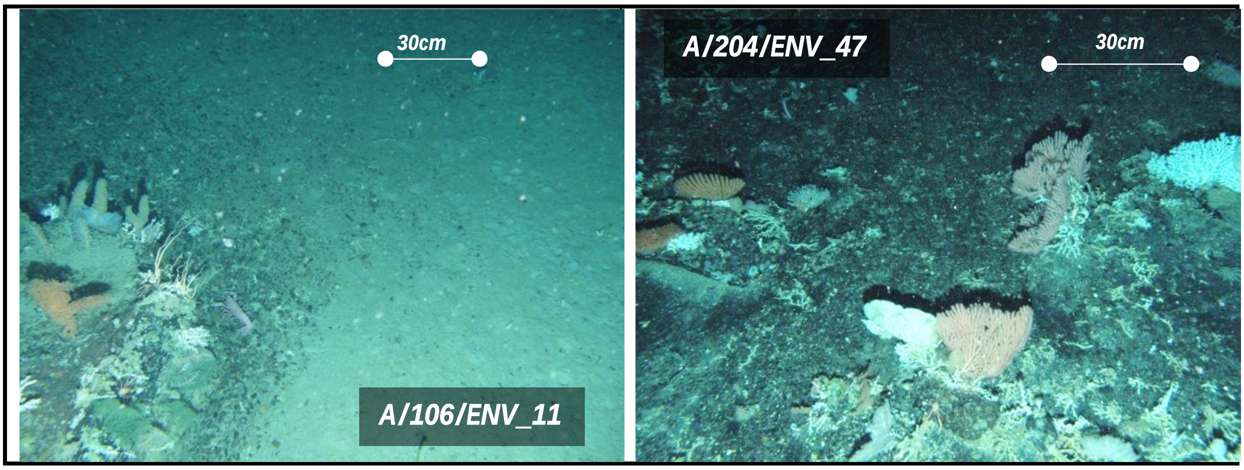
This sediment will be related to granular Holocene sedimentary material and coarser granular Pleistocene residues (drop-stones observed at the surface and during faunal sieving). Seabed photography indicated a presence of bioturbation in the form of spatangoid furrows and surface “lebensspuren” (animal tracks). An example of this habitat type is shown in Figure 2.54.

The Finback-1 and Humpback-2 proposed well location is located in this sediment type.

2.10.2.3 Habitat: Silty Sands with Occasional Cobbles and Boulders:

This habitat type is recorded in areas where underlying hard geology pinches out close to the surface and along the peripheral edges of the bedrock exposures where the surface granular sediments thin to a veneer. This creates a mixed habitat of featureless sands punctuated by rock outcrops, large cobbles and boulders all populated with small but conspicuous epifaunal communities, all associated with the hard substrate. An example of this habitat type is shown in Figure 2.55.

Figure 2.55 - Example Images of Silty Sands with Cobble and Boulder Outcrops



As with the previous habitat, this sediment is broadly similar to an offshore circalittoral sand (SS.SSa.OSa; Connor *et al.*, 2004), but with localised outcrops of circalittoral low energy rock (CR.LCR; Connor *et al.*, 2004). These isolated hard substrates are well populated by developed epifaunal communities based on both hard and soft corals. Examples of species recorded include the hard branched stone coral-like Hydrozoa *Stylaster* sp., occasionally developed into fan shaped morphology of 20-30cm in diameter. Other corals include soft octocorals (similar to *Callogorgia* sp.), and solitary cup corals, solitary sponges (Suberites sp.), and some foliose bryozoans. Living around these rocks are a number of echinoderms, including ophiuroids spread amongst the corals, the pencil urchin (*Cidaris* sp.), whilst several examples of larger boulders observed a resident small lobster as well as several small squat lobsters (*Munida* sp.).

Some of these boulders indicated the presence of current scour including localised areas of ripples indicative of turbulence around the feature and the subsequent reworking of the sediments by the seabed water movements.

The Humpback-1 proposed well location (A/27/ENV) is located in this sediment type.

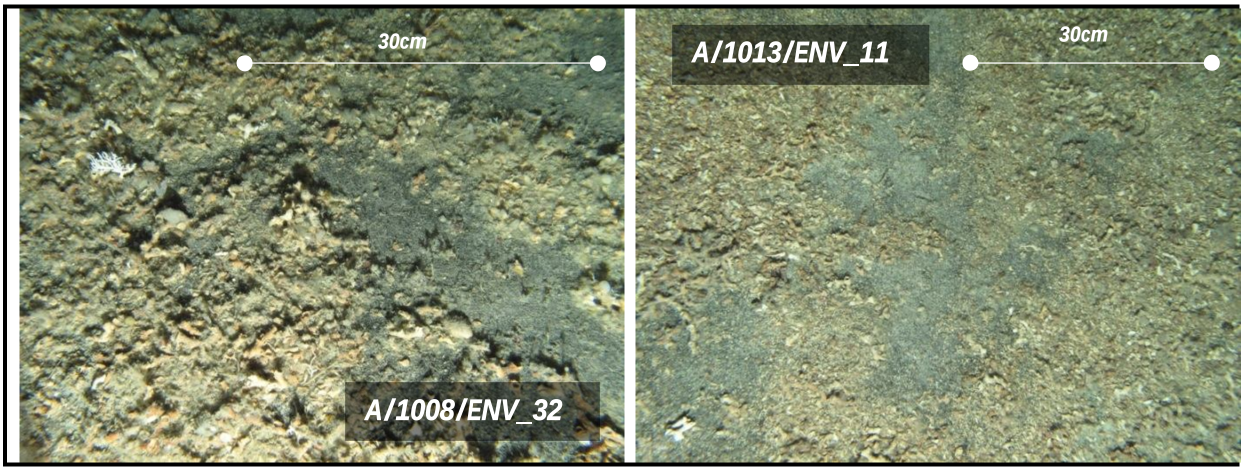
2.10.2.4 Bedrock Exposure and Localised Patches of Relic Coral Debris

Several exposures of bedrock were recorded within the FISA survey area, predominantly associated with the steeper slopes of the central escarpment and on the edges of collapsed depressions in the northwest. For the most part, the epifaunal coverage of exposed bedrock, including the areas of slumped boulders found at the base of most steep sloped areas, was limited to a low lying faunal turf of bryozoans, hydroids and the occasional soft coral. Some larger examples of well-developed *Stylaster* sp. hydrozoans were also recorded, but these were low in number. However, the most dominant species recorded in these areas was that of the reef-building stone coral *Lophelia pertusa*. This was in localised areas of high density, associated with the sides of boulders at the base of the escarpment, or low level coverage at the top of the escarpment, at the edge of the drop-off. Both areas are likely to be associated with the strongest water movement in the area.

Generally, the coverage by *L. persusa* was predominantly made up of relic debris of whole and fragmented material no larger than 10cm in length. Relatively few examples of live material were recorded and these were all less than a few decimetres in diameter. This would suggest that larger reefs created by *L. pertusa* are absent from the area. A low ambient seabed water temperature of approximately 2.5°C is thought to inhibit the growth rate and development of *Lophelia*, restricting its size and proliferation in the polar regions (Zibrowius, 1980; Cairns, 1994). Corals preferred temperature range is thought to be between 6°C and 8°C (Frederiksen *et al*., 1992; Freiwald, 1998).

The extensive coverage of *Lophelia* debris appears to be a relic feature of considerable age. An example of this habitat type is shown in Figure 2.56. As the area of proliferation is localised and limited to a rocky, non-sedimentary environment, the residues of earlier colonies are not incorporated within a carbonate mound or bioherm. Consequently, the presence of *Lophelia* (live or dead) in these areas is not thought to be of major significance to the local biodiversity in the region and therefore are not thought to be of notable conservational importance. These corals are generally considered to be vulnerable due to their sensitivity to trawling damage and their slow growth rate. The FISA area is not currently impacted by trawlers at the depth of this populations (1300m to 1400m), and the closest populations are expected to be around 3.8km south of the nearest proposed well (Humpback-1).

Figure 2.56 - Example Images of Coral Debris from *Lophelia pertusa* (Scleractinia)



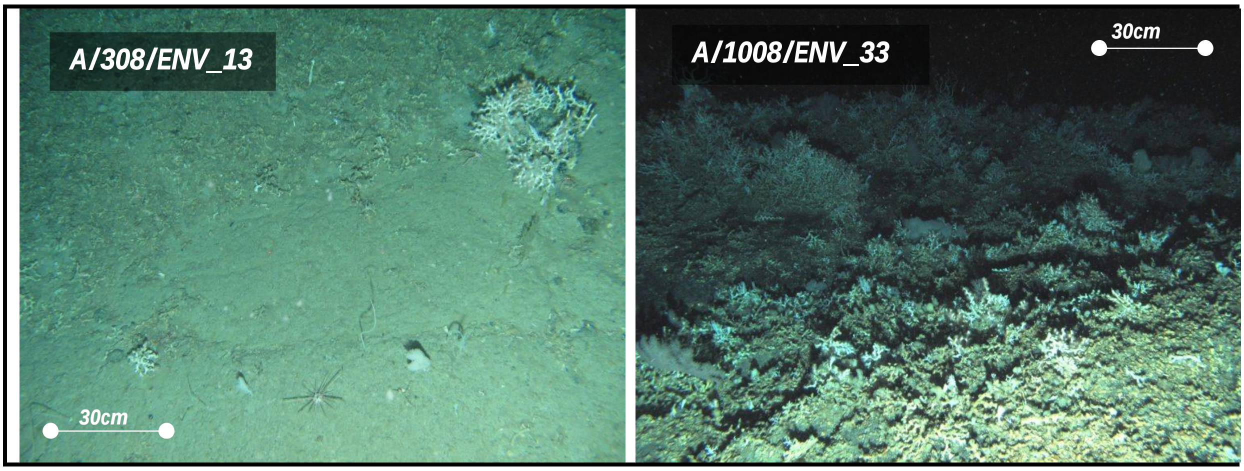
2.10.2.5 Potential Annex I Habitats and Other Sensitive Habitats

The majority of evidence for the presence of *L. pertusa* relates to extensive areas of debris relating to relic residue populations located on the edge of the escarpment drop-off approximately 3.8km southeast of Humpback-1 and approximately 5.7km northwest of the proposed Humpback-2 well locations. Examples of live populations are presented in Figure 2.36. These mostly show localised 'sprigs' of *Lophelia* (a few decimetres in length) recorded on the edges of prominent boulders or at the very edge of the escarpment drop-off where the current movements are greatest. No 'thickets' (aggregations large than 1m) of *L. pertusa* were recorded during the survey.

Despite the lack of size or proliferations across the area, whilst the recorded aggregations of live *Lophelia* are not generally classified as Annex I habitats, there may be instances along the edge of escarpment where larger aggregations may exist and should be protected from physical damage. However, as these areas are located several kilometres from the proposed well locations, they are not expected to be impacted by drilling related discharges from either of the two proposed well sites. Should the final well locations move, then these should not be brought within 500m from the edge of the escarpment.

The remainder of the survey area did not yield any evidence of particularly sensitive habitats, particularly within the immediate vicinity of the proposed exploration wells. The habitats in these areas were considered to be homogenous, gravelly or slightly gravelly silty sands with limited sensitivity to the proposed operations. A review of both stills and video footage indicate that some potential CITES Appendix II coral species (such as *Flabellum* sp.) were observed.

Figure 2.57 - Example Images of Live *Lophelia pertusa* Corals (Scleractinia) Found in the FISA Survey Area



3 CONCLUSION

The bathymetry and geology of the surveyed area showed a deep water environment with low sedimentation rate and a seabed of gravelly silty sands with historical influences from glacial activity in the form of some coarser sediment admixtures. The bathymetry indicated a shallower seabed to the northwest with the gradient in this area punctuated by a number of well-defined escarpments where the slope of the seabed increased from <2 ° to in excess of 45°, indicative of almost vertical rock faces. The base of these features was marked by slump deposits of boulders eroded from the escarpment. Ground truthing of sediments across the site indicates relatively homogenous slightly gravelly silty sand throughout. Below the escarpment to the southeast of the survey area, the proportion of surface gravels increased slightly, whilst intermediate sediments at the top of the escarpment were represented by a thin veneer of silty sands punctuated by regular large cobbles, rock outcrops and boulders.

The main habitats recorded related to an offshore circalittoral sand which was separated into two areas of greater or lesser surface gravels (a result of historical glacial deposits in the area). The deeper waters indicate a lower depositional rate. The proposed well locations of Finback-1, Humpback-1 and 2 were all located within the gravelly sands, with sediments at Humpback-1 proposed well location also comprising localised exposures of cobbles or boulders.

Environmental baseline sampling undertaken within the FISA regional survey area acquired physico-chemical and biological macro-invertebrate samples from 26 stations and further seabed photography from 34 stations. Observations for each of the key parameters are summarised as follows:

In line with the general habitat variations recorded across the survey area, the particle size analysis indicated some variation in the different proportions of sands, fines (below 63µm) and gravels (>2mm) which indicated some variability across the survey area. The average for the sediment composition each of the three main size fractions was sand (60.3%), fines (32.7%) and gravels (7.0%). The proportion of these different sizes ranged from a sandy mud and muddy sand through to a gravelly sand, but with the dominant sediment type representative of a slightly gravelly muddy sand as denominated by the Folk characterisation (Folk, 1954).

Analytical results mostly indicated a uni-modal distributions peaking around the medium sand to fine sand with a consistent tail of fines varying through silts and clays, or occasionally a bi-modal distribution with a slightly elevated proportion of coarse silts, and/or gravels. The mean particle size ranged from 45µm to 354µm, demonstrating the slightly elevated proportions of silts and clays at two sites and gravels at four sites. With the exception of these sites, the sorting coefficient generally ranged from 2.3 to 2.9 based on poorly sorted slightly gravelly muddy sand. The mean proportion of gravels was typically around 7%, but elevated levels between 16% to 27.3% were recorded at the four stations. However, where mixed sediment occurs, the sampling process itself can be biased against coarser material due to a small sub-sampling procedures or the inability to sample mixed sediments by the samplers themselves. In these cases, coarser clasts are likely to be underestimated, with cobbles and boulders frequently recorded by the seabed photography.

Only two locations indicated proportion of fines greater than 50%, with a peak 66.7% recorded at station A/26/ENV at the same location as the Humpback well prospect. The mean proportion of sediment fines was 32%. The distribution of fines indicated a pattern of distribution with fewer fines in the deeper sediments. This pattern is considered unusual for a deep-water environment where, typically, the deeper waters indicates a higher rates of pelagic sedimentation due to decreased water movement. In FISA the majority of softer sedimentary are recorded above the escarpment feature north and west of the proposed well locations and follows a similar trend identified with the neighbouring sites of Toroa and Nimrod which indicated softer sedimentary material on the continental slope, but heavily eroded and non-depositional bedrocks and glacial sands below. This may be a combination of the East Falklands current coupled with the rugose seabed created by discordant or irregular formation erosion rates. This has been observed in some of the video footage on this and other neighbouring sites (i.e. FINA).

Some of the chemical parameters surveyed followed patterns observed within the particle size analysis. Total organic carbon (TOC), total hydrocarbon content (THC) and saturates all indicated relatively low background concentrations with a subtle pattern of distribution relative to the mean particle size or the proportion of fines. This relates to the increased surface area provided by silts and clays which sorbs and adsorbs organic and some inorganic components within the sediments.

The total hydrocarbon content (THC) concentrations gave a mean of 3.1µg.g$^{-1,}$ whilst alkanes indicated a mean of 313ng.g^{-1}, approximately 10% of the total THC recovered. Inspection of the individual gas chromatograms at all stations revealed no background fingerprints throughout with no specific envelopes or peaks relating to anthropogenic or petrogenic. Whilst a review of the alkanes showed that terrestrial influences to the saturates were also minimal at the site, indicative of an offshore site influenced by Antarctic water masses, and a relatively low pyrolytic polycyclic aromatic hydrocarbon influence, the presence of 2 and 3 ring PAHs (naphthalene, phenanthrene and dibenzothiophene or NPD) and the high incident of alkylated PAHs suggests a clear and chromic input from petrogenic sources, albeit at a trace level. This is likely to be from natural hydrocarbon seeps previously recorded within the region. Historical datasets on the Burdwood Bank (BSL, 2008) and surveys at Toroa have similarly recorded background petrogenic influences to the surface environmental samples with a suggestion that the source are south and west of the FISA location. Total PAH concentrations (2-6 compounds) recorded a mean of 82.8 ng.g^{-1} whilst the mean of the NPD fraction 43.8 ng.g^{-1}.

The concentrations of heavy and trace metals were consistent with historical surveys within the area. The distribution of the metals often correlated with themselves and occasionally other sediment factors. The most obvious of these was that of aluminium which indicated a strong correlation with % gravels and sorting coefficient. Several other metals indicated auto-correlations with each other (that is to say that they followed similar trends relating to the same parameter but not necessarily each other). One clear correlation between metal was recorded between iron and arsenic. Iron indicated a huge variability across the survey area ranging from 10.7 to 135mg.g^{-1}. This has been interpreted as a function of the variability of the residual glacial materials recorded at some sites, in particular the black basalt sands reworked by the currents in some areas. Arsenic, which is often adsorbed onto iron, indicated modest but quite variable concentrations ranging from 3.2 to 12.3 µg.g^{-1}. All metals were processed for total content using a hydrofluoric acid digestion. Results recorded trace levels of cadmium and mercury, whilst the means of lead (6.2µg.g^{-1}), barium (331.7µg.g^{-1}), chromium (128µg.g^{-1}), nickel (12.5µg.g^{-1}), copper (15.8µg.g^{-1}), vanadium (76.9µg.g^{-1}) and zinc (77.5µg.g^{-1}) all gave background concentrations.

Multiple water column profiles taken over a time period of a calendar month indicated a consistent water column with a weak thermocline in the surface 80m followed by a slow cooling to the seabed from 5.73 to 6.70°C at the surface to around 2.60°C at 1432m. All profiles indicated a small area of mixed waters between 620m and 950m. The salinity only varied by 0.5psu throughout the whole water column, showing similar structure to that of the thermocline but an increase from 34.4 to 34.9psu with depth. Water chemistry, recorded at four depths at two sites, indicated trace or undetectable concentrations expected for open 'blue-water' environment.

A macrofaunal analysis was carried out on all 59 replicates obtained at 26 baseline sediment sites, sampled within the FISA survey and processed in the field using a 500µm mesh size. Subsequent macrofaunal taxonomy of all recovered fauna identified a total of 2,874 individuals. Of the 254 species recorded, 188 were infaunal dominated by small polychaetes. This dominance was by both abundance and richness, with six polychaetes recorded in the top ten numerically ranked species. This dominance was closely followed by crustaceans which were also well represented, having three species in the in the top ten numerically ranked taxa. In overall rank order, the top 5 key dominant species across the area were the Polychaete *Rhamphobrachium (Spinigerium) ehlersi* the crustaceans *Ampelisca* and a Copepoda, separated by the polychaete *Gymnonereis fauveli* and followed by another polychaete *Apistobranchus* sp I. The species list was very diverse due to the number of sites, with around 88% of specimens identified to genus or species. Several undescribed species were recorded, but around 45% of the species list was similar to the population recorded on the Burdwood Bank in 2009 on similar sediment type (BSL, 2008). Whilst the deep water coral *Lophelia pertusa* was recorded in the samples, all incidents were of relic debris with no live animals recovered. Camera operations, however, did identify small examples of this species, but of a morphology insufficient to be considered as an Annex I habitat under the European Habitats Directive, or the OSPAR list of threatened habitats. Also of note from the macrofaunal samples was one group of solitary corals (*Flabellum* sp.) and a very rare mollusc of the group Monoplacophora *(Neopilina).* This group was thought to be extinct for 400 million years until a recent discovery of a living specimen from the deep sea. These animals are very rare, and so far only about 150 specimens have ever been found worldwide, belonging to about 25 species.

Univariate analysis of the data indicated that the species richness and abundance were similar to previous surveys in the area by surface area. This was 20 species for $0.1m^2$ and a mean of 351 individuals per m^2, although the variability of the sediments has shown significant variability between samples. The mean Shannon-Weiner diversity was 4.64 for the station ($0.2m^2$). The bioaccumulation curves indicated that the potential number of species calculated from asymptote was estimated to be 236 species (using Chao-1 analysis).

Multivariate analysis indicated no clearly separated faunal populations, although results showing clustered stations at the 35%-55% similarity range producing 12 statistically distinct groups within the population, seven of which represented by a single station. An ordination of these results failed to produce a clear 2D plot due to high stress within the calculation, but a 3D representation indicated no significant trend based on geographical location, sediment type or other environmental factors.

Due to the large amount of data and broad transition of sediment types identified, varying from sandy muds, though to gravelly sands, it appears that this may have created an underlying gradient of change from to assign discrete biological communities. This results in a large amorphous grouping of station similarities, indicative of a single but broad macrofaunal assemblage. A multivariate comparison with a similar dataset acquired at the Burdwood Bank showed significant separation in the populations despite the similar species list. A review of these differences using the software showed that differences observed between the two main clusters appear to be a subtle accumulation of differences in species counts within the dominant species identified, rather than any fundamental population change.

In addition to the infaunal community the qualitative presence of the epifaunal community was reviewed from the seabed samples, and provided a rich faunal assemblage, especially in areas where drop-stones were common. Key faunal groups were the sponges, class Hexactinellida, Calcarea and Demospongia; many of the genera were typical for deeper water (e.g. *Hymedesmia* spp., *Crella* and *Lissodendoryx)*, with a wide and sometime cosmopolitan distribution. The Cnidaria were represented by nine genera of thecate and athecate Hydrozoa and two genera of Stylasteridae. In particular *Stylaster densicaulis* which was also recorded in the photography. The live solitary coral belonging to the species *Flabellum curvatum* (a potential CITES Appendix II coral species) was also recorded. Several Octocorallia were found, including the sea pens Pennatulidae (generally too small to identify) and two species of Gorgonacea. Bryozoa were also very common constituent on pebbles and stones, with many species endemic.

A further assessment of the epifaunal assemblages shown within the seabed photographs, confirmed a relatively well populated community of species overall, with healthy aggregations colonising occasional drop-stones as well as *Lophelia* debris, where present and some rooted into the sediment. Many of the species recorded were associated with deep water and/or cold water environments. Overall, the phylogenetic make-up of the conspicuous megafauna observed was dominated by the cnidarians, with octocorals and Pennatulidae remaining prevalent throughout. Echinoderms were better represented in the seabed photography than the grab samples with ophiuroids, crinoids, asteroids and holothurians present. Where drop-stones were present, encrusting sponges were common along with anthozoans. Often rooted into soft sediments bryozoans and hydroids were observed as sparse tufts. There were also numerous burrows likely to be associated with crustacean and holothurian activity. Free-swimming megafauna included the demersal teleosts: Macrouridae, Grenadier, hake and batoids.

The remainder of the survey area did not yield any evidence of particularly sensitive habitats, especially within the immediate vicinity of the proposed exploration wells. The habitats in these areas were considered to be homogenous, gravelly or slightly gravelly silty sands with limited sensitivity to the proposed operations. A review of both stills and video footage indicate that some

4 BIBLIOGRAPHY

AFEN, 1996. Atlantuic Frontier Environmental Network . Field data. Survey Cruise 1996.

Acha, M., Mianzan H., Guerrero R., Favero M., Bava J., 2004, Marine fronts at the continental shelves of austral South America, Physical and ecological processes, Journal of marine systems, 44: 83 – 105, doi:10.1016/j.jmarsys.2003.09.005.

Bastida, R., Roux, A., & Martinez, D.E., 1992. Benthic Communities of the Argentine Continental Shelf. Oceanologica Acta, 15 (6), 687-698.

Berthou, F. & Friocourt, M. P., 1981. Gas Chromatographic Separation of Diastereometric Isoprenoids as Molecular Markers of Oil Pollution. *Journal of Chromatography* **219:** 393-402.

Bett, B.J. and Rice, A.L., 1992. The influence of hexactinellid sponge (*Pheronema carpenteri*) spicules on the patchy distribution of macrobenthos in the Porcupine Seabight (bathyal NE Atlantic). Ophelia, 36: 217–226. Blacker, 1957.

Blumer, M. & Snyder, W. D., 1965. Isoprenoid hydrocarbons in recent sediments: presence of pristane and probably absence of phytane, *Science* 150, 1588.

Bryan G.W. and Langston W.J., 1992. Bioavailability, accumulation and effects of heavy metals in sediments with special reference to United Kingdom estuaries: A review. Environmental Pollution, 76: 89-131.

BSL, 2008. Regional benthic environmental survey of the Burdwood Bank, South Falkland Basin. Report for Borders and Southern. Benthic Solutions Limited Report 0811.

Buchman, M. F., 1999. NOAA screening Quick Reference Tables. NOAA HAZMAT Report 99-1. Seattle, WA. Coastal Protection and Restoration Division. National Oceanic and Atmospheric Administration, 12pp.

Cairns, S. D., 1994. Scleractinia of the Temperate North Pacific. Smiths. Contrib. Zool. 557. 150 pp.

Chester, R. & Voutsinou, F. G., 1981. The Initial Assessment of Trace Metal Pollution in Coastal Sediments. Mar Pol Bull 12: 84-91.

Chow, T. J. & Snyder, C. G., 1980. Barium in the Marine Environment: A Potential Indicator of Drilling Contamination. In Symposium Proceedings: Research on environmental fate and effects of drilling fluids and cuttings. Lake Buena Vista, Florida, 2: 723-736.

Cole, S., Codling, I. D., Parr, W. and Zabel, T., 1999. Guidelines for managing water quality impacts with European marine sites. Report prepared for the UK Marine SACs project. October 1999, Swindon WRc.

Connor D. W., Allen J. H., Golding N., Howell K. L., Lieberknecht L. M., Northen K. O., Reker J. B. 2004. The Marine Habitat Classification for Britain and Ireland Version 04.05 JNCC, Peterborough.

Eglinton, G., Gonzalez, A. G., Hamilton, R. J. and Raphael, R. A., 1962. Hydrocarbon constituents of the wax coatings of plant leaves; a taxonomic survey. Phytochemistry 1:89-102.

Eleftheriou, A. & Basford, D.J., 1989. The macrobenthic infauna of the offshore northern North Sea. J.Mar. Biol.Ass. UK., 69: 123-143.

Falabella, V., Campagna, C., and Croxall, J. (Eds)., 2009, Atlas of the Patagonian Sea. Species and Spaces, Buenos Aires, Wildlife Conservation Society and BirdLife International, http://www.atlas-marpatagonico.org

FCO, 2005. Foreign and Commonwealth Office Country Profiles - Falkland Islands; www.fco.gov.uk

Frederiksen, R., A. Jensen & H. Westerberg, 1992. The distribution of the scleractinian coral Lophelia pertusa around the Faroe islands and the relation to internal mixing. Sarsia 77: 157–171.

Freiwald, A., 1998. Geobiology of *Lophelia pertusa* (Scleractinia) reefs in the north Atlantic. Habilitation thesis, Univ. Bremen, 116 pp.

Fugro, 2009a. BHP Billiton Petroleum Falklands Corporation. Rig Site Survey FIDA 61/05 Toroa. Environmental Baseline Survey, Report Reference 9763V3. Fugro Survey Ltd, Great Yarmouth, UK.

Fugro, 2009b. BHP Billiton Petroleum Falklands Corporation. Rig Site Survey FIDA 41/29 Nimrod. Environmental Baseline Survey, Report Reference 9763V5. Fugro Survey Ltd, Great Yarmouth, UK.

Fugro, 2009c. BHP Billiton Petroleum Falklands Corporation. Rig Site Survey FIDA 30/17, 18,22 and 23 Enveadour. Environmental Baseline Survey, Report Reference 9763V4. Fugro Survey Ltd, Great Yarmouth, UK.

Fugro, 2009d. BHP Billiton Petroleum Falklands Corporation. Rig Site Survey FIDA 42/02 Loligo. Environmental Baseline Survey, Report Reference 9763V0. Fugro Survey Ltd, Great Yarmouth, UK.

Gardline,**1998.** Benthic Environmental Baseline Survey of the Sediments around the exploration FI 14/24 "Braela" Well (March 1998), Gardline Surveys Limited.

Gardline, 2011a. Falkland Oil and Gas Ltd. Falklands Block 60/15 and 60/20. Inflexible Site Survey. February 2011. Survey Report. Gardline Report Reference 8665. Gardline Geosurvey Ltd, Great Yarmouth, UK.

Gardline, 2011b. Falkland Oil and Gas Ltd. Falklands Blocks 53/16. Vinson West Site Survey. Environmental Baseline Report. Gardline Report Reference 8666.1. Gardline Environmental Ltd, Great Yarmouth, UK.

Gardline, 2011c. Falkland Oil and Gas Ltd. Falklands Blocks 42/01. Loligo NW Site Survey. Environmental Baseline Report. Gardline Report Reference 8751.1. Gardline Environmental Ltd, Great Yarmouth, UK.

Gardline, 2011d. Falkland Oil and Gas Ltd. Falklands Block 31/18. Hero Site Survey. Environmental Baseline Report. Gardline Report Reference 8667.1. Gardline Environmental Ltd, Great Yarmouth, UK.

Gardline, 2011e. Falkland Oil and Gas Ltd, Falklands Block 31/13. Scotia East Site Survey. Environmental Baseline Report. Gardline Report Reference 8668.1. Gardline Environmental Ltd, Great Yarmouth, UK.

Gardline, 2011f. Falkland Oil and Gas Ltd, Falklands Block 60/15 and 60/20. Inflexible Site Survey. Environmental Baseline Report. Gardline Report Reference 8665.1. Gardline Environmental Ltd, Great Yarmouth, UK.

Garzoli, S.L., 1993. Geostrophic velocity and transport variability in the Brazil-Malvinas confluence. Deep Sea Research, 40, 1379-1403.

Gerrard, S., Grant, A., March, R. and London, C., 1999. Drill Cuttings Piles in the North Sea. Management options during Platform Decommissioning. Centre for Environmental Risk Report No 31. University of East Anglia.

Gettleson, D. A. & Laird, C. E., 1980. Benthic Barium Levels in the Vicinity of Six Drill Sites on the Gulf of Mexico. In Symposium Proceedings: Research on Environmental Fate and Effects of Drilling Fluids and Cuttings. Lake Buena Vista, Florida, 2: 739-785.

Harkema, R. and G.L. Weatherly, 1989. A compilation of moored current meter data in the Argentine Basin: April 25 1987 - March 14 1988. Technical Report CMF- 89-01. Florida State University, 64 pp.

ICES. 2003. Environmental status of the European Seas. A quality status report prepared by the International Council for the Exploration of the Sea, Copenhagen.

Kålås, J.A., Viken, Å., Henriksen, S. og Skjelseth, S. (eds.) 2010. Norsk rødliste for arter 2010. Artsdatabanken, Norge.

Khalaf, F., Literathy, V. and Anderlini, V., 1982. Vanadium as a tracer of oil pollution in the sediments of Kuwait. Hydrobiologia 91-92:147-154.

Laflamme, R. E. & Hites, R. A., 1978. The global distribution of polycyclic aromatic hydrocarbons in recent sediments. *Geochim Cosmochim Acta* 42: 289-303.

Long, E. R., MacDonald, D. D., Smith, S. L. and Calder, F. D., 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuary sediments. Environmental Management 19: 81-97.

Luoma, S.N. and Davis J.A., 1983. Requirements for modelling trace metal portioning in oxidised estuarine sediments. Marine Chemistry, 12: 159-181.

McCourt, C. B., Price, R. J., John, S. D., Penny, D. M. and Clarke, L.J., 1991. Environmental Applications of Plasma Spectrometries within the Oil Industry. SPE, Proceedings First International Conference on Health, Safety and Environment, The Hague, The Netherlands 10 - 14 November 1991, SPE 23349, 301-309.

McLeese, D. W., Sprague, J. B., and Ray, S., 1987. Effects of cadmium on marine biota. p. 171-198. In: Nriagu, J.O. and J.B. Sprague (eds.). Cadmium in the Aquatic Environment. Advances in Environmental Science and Technology, Volume 19. John Wiley & Sons, New York. 272 pp.

MG3, 2014a. Regional field results report South Falklands Basin – FISA Geochemical Phase. Report Number 1334.3. Report for Noble Energy Falklands via MG3 Survey Limited. Volume 1.

MG3, 2014b. Regional Environmental Baseline Survey (EBS) South Falklands Basin – FISA Report Number 1334.3. Report for Noble Energy Falklands via MG3 Survey Limited. Volume 3.

MG3, 2014c. Habitat Assessment Survey (HAS) Report South Falklands Basin – FIST Report Number 1334.2. Report for Noble Energy Falklands via MG3 Survey Limited. Volume 2.

MG3, 2014. Wreck Search Survey Report. Report for Noble Energy Falklands Volume 5.

Muniz, P. Danulat, E., Yannicelli, B., Garcia-Alonso, J. and Bicego, M.C., 2004. Assessment of contamination by heavy metals and petroleum hydrocarbons in sediments of Montevideo harbour (Uraguay). Environmental International. 29: 1019-1028.

National Research Council (NRC), 1983. Drilling Discharges in the Marine Environment. National Academy Press, Washington DC. 180 pp.

Neff, J. M., 2005. Bioaccumulation in marine organisms. Effects of contaminants from oil well produced water. Elsevier, Oxford, UK.

NOAA,2013. Endangered and Threatened Marine Species. From: http:// www.nmfs.noaa.gov/pr/species/esa/ [Accessed June 2013].

OSPAR Commission, 2004. OSPAR guidelines for monitoring the environmental impact of offshore oil and gas activities. Meeting of the OSPAR Offshore Industries Committee (OIC), 15 – 19 March, 2004.

OSPAR, 2008-6. List of Threatened and/or Declining Species and Habitats.

OSPAR, 2008-7. Descriptions of habitats on the OSPAR list of threatened and/or declining species and habitats.

OSPAR 10/23/1-E, Annex 31. OSPAR Recommendation 2010/9 on furthering the protection and restoration of coral gardens in the OSPAR Maritime Area.

OSPAR 10/23/1-E, Annex 32. OSPAR Recommendation 2010/10 on furthering the protection and restoration of deep-sea sponge aggregations in the OSPAR Maritime Area.

OSPAR. 2010a. Background document for *Lophelia pertusa* reefs. Biodiversity Series P00423.

OSPAR. 2010b. Background document for coral gardens. Biodiversity Series P00486.

OSPAR. 2010c. Background document for deep-sea sponge aggregations. Biodiversity Series P00485.

Otley H, Munro G, Clausen A and Ingham B. 2008. Falkland Islands State of the Environment Report 2008. Falkland Islands Government and Falklands Conservation, Stanley.

Paez-Osuna, F. & Ruiz-Fernandez, C., 1995. Comparative Bioaccumulation of Trace Metals in *Penaneus Stylirostris* in Estuarine and Coastal Environments. *Estuarine, Coastal and Shelf Science* 40**:** 35-44.

Palma, E. D., Matano, R. P., and Piola, A. R., 2008. A numerical study of the Southwestern Atlantic Shelf circulation: Stratified ocean response to local and offshore forcing, Journal of Geophysics Research, 113, C11010, doi:10.1029/2007JC004720.

Piola, A., 2008. Synthesis of the Conservation Status of the Patagonian Sea and Areas of Influence Centro Argentino de Datos Oceanográficos, information contributed by (SHN-UBA-CONICET, Argentina).

Roberts, J.M., Wheeler, A.J. and Freiwald, A. 2009. Reefs of the Deep: The Biology and Geology of Cold-Water Coral Ecosystems. Science, 312, 543 – 547.

Schaule, B. K. & Patterson, C. C., 1983. Perturbations of the Natural Lead Depth Profile in the Sargasso Sea by Industrial Lead. In: *Trace Metals in Seawater*. Plenum Press, New York.

Sleeter, T. D., Butler, J. N. and Barbash, J. E., 1980. Hydrocarbons in the Sediment of the Bermuda Region: Lagoonal to Abyssal Depths. Pp 267-288 In: Petrakis, L. and Weiss, F.T. (Eds.). Petroleum in the Marine Environment. Chem Soc., Washington, D.C.

Snelgrove PVR, Butman CA., 1994. Animal–sediment relationships revisited: cause versus effect. Oceanogr Mar Biol Annu Rev 32:111–177

Tessier, A, Campbell, P. G. C. and Bisson, M., 1979. Sequel Extraction Procedure for the Speciation of Particulate Trace Metals. Analytical Chemistry 51: 844 - 851.

Thompson B, Lowe S., 2004. Assessment of macrobenthos response to sediment contamination in the San Francisco estuary, California, USA. Environ Toxicol Chem 23: 2178–2187

Tricine, R. P. & Trefry, J. H., 1983. Particulate Metal Tracers of Petroleum Drilling Mud Dispersion in the Marine Environment. Environ Sci Technol 17: 507 - 512.

Vivier, F. and C. Provost, 1999. Direct velocity measurements in the Malvinas Current. Journal of Geophysical Research, 104, 21083-21103.

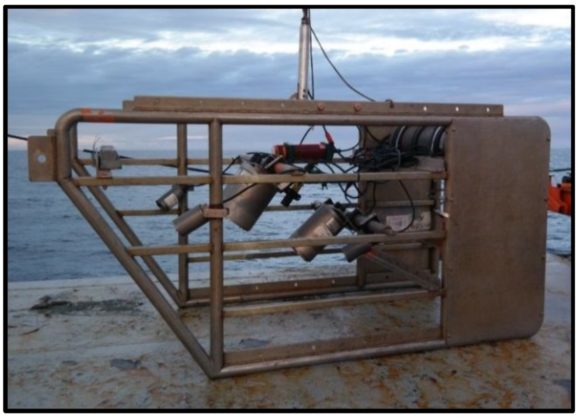
Youngblood, W. W. & Blumer, M., 1975. Plycyclic aromatic hydrocarbons in the environment: homologues series in soils and recent marine sediments. *Geochim Cosmochim Acta* 39:1303-1314.

Zibrowius, H., 1980. Les Scléractiniaires de la Méditerranée et de l'Atlantique nord-oriental. Mem. Inst. Oceanog. No 11, 226 pp.

APPENDIX I – FIELD OPERATIONS AND SURVEY METHODS

I.1 Seabed Photography and Video

Seabed photography was undertaken using a "Sea Bug" system developed by Subsea Technology and Rentals (STR). The system is based on a housed G10 Canon Camera which can output up to a 14.7megapixel quality (five megapixel used for the current project to reduce operational upload time). The system is mounted in a fish with a skid and drop-down frame which can be towed as a sled on, or just above the seabed for the camera. The output from the camera is controlled from the surface using a video stream supplied from the camera and number of function controls operated through a multiplexer system and armoured 3km sonar cable. Once on the seabed, the system was towed for at least 100m and a minimum of 5 digital stills photographs acquired at each site.



Camera system configuration

The key acquisition parameters of the system used are as follows:

Standard Features	Comment
Image Resolution	5 to 14.7 megapixel (up to 4,416 x 3,312 pixels)
Light Sensitivity setting	ISO 60-1600 Auto/Manual Selected
Sensor Type	1 / 1.8" format high density CCD sensor
Light source	6 x 1000lumen controllable LED lamps Stills strobe TTL controller
Typical settings on this survey	Aperture priority at F8, Shutter speed typically 1/125th second, Auto flash mode (TTL)
Framing Video Used	320 Line / 50 Hz PAL
Control System	STR Multiport DTS
Other sensors	Roll, Pitch, Heading and Altimeter

The system was deployed from the stern of the vessel using the vertical drop-down frame technique and lowered to the seabed using the inbuilt altimeter. The online video was used to control the frames height and attitude once at the seabed. The seabed was surveyed using a combination of video and digital still photographs (minimum of 5 shots per site).

Positioning of the system was maintained throughout by using a USBL positioning beacon attached to the cable above the camera frame. The vessel maintained this positioning or followed a target transect using its dynamic positioning (DP) and was allowed to move at a tow speed of approximately 0.5 - 1 knot (< 0.5m/sec). As no environmentally sensitive sites (such as biogenic reefs or sponges), were encountered within the main survey area, evasive measures to prevent contact with the seabed were not necessary. Operations over the area of hard corals were carried out at a controlled height just off the seabed where possible. The frame was also fitted with a laser scale set to a 30cm separation.

Stills images have been reviewed for larger and obvious mega-fauna and epifaunal species to assist in diagnosing sediment changes across the sites and to assist in the macrofaunal interpretation. The camera system is a particularly useful tool in recording larger contacts, hard substrates or occasionally seabed features impossible to sample using the Box corer or grab samplers.

I.2 Benthic Environmental Sampling

A combination of benthic sampling devices were mobilised to allow for the varied surface geological conditions, as previously encountered at neighbouring sites throughout the South Falklands Basin (BSL, 2008). The unusual and variable nature of the surface geology encountered at the site necessitated a flexible approach to sample recovery, without which little or no material would have been recovered at many of the locations. MG3mobilised a 0.25m² USNEL box corer as the primary seabed sampler. Additional sample acquisition contingency measures were in place in the form of alternative sampling devices, in the event that unsuitable geology was encountered by the primary seabed sampler. A unique double Van Veen grab sampler was mobilised (designed for operation in very soft sediments and compacted sands), along with a 0.1m^2 Hamon grab sampler (for operation in mixed sediments) as contingency devices. In the event, all three devices had to be utilised in order to recover material in the compacted and sometimes gravelly sediments encountered within the FISA survey area. Details of the sampling equipment and associated operations are as follows:

I.2.1 Box Corer Operations

The primary seabed sampler was a 0.25m^2 USNEL type box corer, requiring a single deployment at each of the proposed locations. Pre-deployment procedures included cleaning of the inner stainless steel box, cable and blocks to be generally grease free. A record of the samplers touch down at deployment depth was monitored by means of a load cell (within the winch) which recorded tension on the cable. Samples were subject to quality control on retrieval and were retained in the following circumstances:

- Water above sample was undisturbed;
- Spade closure complete allowing no sediment washout;
- Penetration of the box was sufficient to maintain a seal at the base of the core but not over penetrated and allowing water to remain above the sample when recovered;
- Sampler was retrieved perfectly upright and had not fouled in any way;
- Inspection/access doors had closed properly enclosing the sample;
- No disruption of the sample through striking the side of the vessel;
- Sample were taken inside the acceptable target range; and
- The sample was acceptable to the principle scientist.

For each sample, the whole core was inspected, described and sub-sampled for two 0.1m^2 replicates before being photographed, and then processed onboard using a Wilson Auto-Siever over a 500µm aperture mesh. [Key observations from samples were colour, sediment classification, layering (including RDLs), smell (including the presence of H_2S), obvious fauna and evidence of bioturbation]. The separation of the macrofaunal samples was undertaken following area segregation and siphoning the supernatant surface waters prior to sediment extractions down to a depth of 20cm. The remainder of the core sample (0.05m^2) was surface sub-sampled for physico-chemistry. An additional hand core (89mm id) was also taken to preserve the surface structure of the samples for possible later geotechnical analysis. This was pushed into the full penetration of the box core, and complete core extracted and stored upright.

Pre-deployment procedures included the cleaning of the inner stainless Box corer buckets, cable and blocks so that they were generally grease-free. On retrieval, the whole sample was inspected, described and photographed prior to processing. Key observations from samples were colour, sediment classification, layering (including RDLs), smell (including the presence of H_2S), obvious fauna and evidence of bioturbation and evidence of anthropogenic debris. To obtain sufficient replication, this device was deployed a total of four times to recover a suitable surface area for both macro-invertebrate and an additional sample for sediment physico-chemistry.

I.2 2 Double Van Veen Operations

Where box corer penetration failed (usually in compacted sands limiting penetration) the double grab sampler was employed. This device has two samplers in a ballasted frame and acquires a seabed sample area of 2 x 0.1m^2 on each deployment. Pre-deployment procedures included the cleaning of the inner stainless grab buckets, cable and blocks so that they were generally grease free. Samples were subject to quality control on retrieval and were retained in the following circumstances:

- Water above sample was undisturbed;
- Bucket closure complete allowing no sediment washout;
- Penetration of the grab was sufficient to maintain a seal at the base;
- Sampler was retrieved perfectly upright and had not fouled in any way;
- Sampler access doors had closed properly enclosing the sample;
- No disruption of the sample through striking the side of the vessel;
- Sample was taken within the acceptable target range; and
- The sample was acceptable to the principle scientist.

I.2.3 Hamon Grab Operations

If ground truthing revealed mixed coarse sediment, a 0.1m^2 Hamon grab was used to recover sediments including; gravels, pebbles and cobbles. This device has a single 0.1m^2 scoop attached to a pivoting arm, and allows retention of a sample even if the grab is not completely closed. While requiring a minimum of three deployments for this survey and recovering a relatively disturbed sample, it does however have a high success rate in sampling mixed coarse sediments where other samplers would fail. Pre-deployment procedures included the cleaning of the inner stainless grab bucket, cable and blocks so that they were generally grease free. Samples were subject to quality control on retrieval and were retained in the following circumstances.

- Water above sample was undisturbed;
- Penetration of the grab was sufficient to maintain a seal at the base;
- Sampler was retrieved perfectly upright and had not fouled in any way;
- Sampler access doors had closed properly enclosing the sample;
- No disruption of the sample through striking the side of the vessel;
- Sample was taken within the acceptable target range; and
- The sample was acceptable to the principle scientist.

On recovery, the whole sample was inspected, described and photographed prior to processing. A minimum of three 0.1m^2 replicates were required per sample location to acquire enough material for two fauna replicates and sub-sampling of physico-chemistry. Faunal replicates were processed onboard using a Wilson Auto-Siever over a 500µm aperture mesh. Key observations from samples were colour, sediment classification, layering (including RDLs), smell (including the presence of H_2S), obvious fauna and evidence of bioturbation and any anthropogenic debris. The remaining sample (0.1m^2) was sub-sampled for physico-chemistry.

I.2.4 Sample Processing

Sub-sampling of physico-chemistry was undertaken from the sampler with the following material retrieved from the surface 2cm:

- Hydrocarbon analysis (collected with stainless steel scoop or directly in a prewashed foil capped glass jar);
- Heavy and trace metals (collected with plastic scoop and stored in doubled lined ziplock plastic bag);
- Particle Size Analysis (PSA) (collected with plastic/stainless steel scoop and stored in doubled lined ziplock plastic bag);
- Total organic matter and total organic carbon (TOM & TOC)(collected with plastic scoop and stored in doubled lined ziplock plastic bag); and
- Duplicate samples from all of the above.

The preservation of materials was undertaken using standard techniques. All physico-chemical samples were stored in appropriate containers (i.e. glass for hydrocarbons, and plastics for metals and PSA) and immediately frozen and stored (<-18^{o}C) for later transportation (frozen) to the laboratory on demobilisation. Faunal samples were processed onsite using a Wilson Auto-Siever over a 500µm aperture mesh, with all residues retained, fixed and stained in 5% buffered formalin and a vital stain (Rose Bengal) for storage and transportation. This material was later transferred to IMS. All biological samples were double-labelled, with internal tags. For samples that retained minor amounts of clays a small amount of additional di-sodium hexametaphosphate was included within the fixative onboard to induce clay separation during storage. Photographs from the field sampling operations are given in the final environmental baseline report.

I.2.5 Water Sampling using the Niskin Bottle

Water samples were taken at four different depths – at the surface, thermocline, mid-depth and at the seabed to obtain a representative vertical profile. Pre-deployment procedures included a thorough check of the sampling device and all rubber seals, the firm attachment of the Niskin Bottle to the water sampling wire as well as correct setup and function of all mechanisms.

I.2.6 Sample Processing

On recovery, samples were sampled for the following material and stored appropriately depending on the analysis:

- 1 x glass bottle for hydrocarbons analysis;
- 1 x plastic bottle for heavy metals analysis;
- 1 x plastic bottle for nutrients analysis; and
- 1 x plastic bottle as a spare.

APPENDIX II – LABORATORY ANALYSES AND STATISTICAL ANALYSES

II.1 PARTICLE SIZE DISTRIBUTION

The samples recovered from each site were analysed by Benthic Solutions Limited which is accredited under the National Marine Biological Association Quality Control scheme (NMBAQC) for PSA analysis.

The sample was homogenised and split into a small sub-sample for laser diffraction and the remaining material was sieved through stainless steel sieves with mesh apertures of 8000µm, 4000µm and 2000µm. In most cases almost the entire sample would pass through the sieve stack, but any material retained on the sieve, such as small shells, shell fragments and stones were removed and the weight was recorded.

The smaller sub-sample was wet screened through a 2000µm and determined using a Malvern Mastersizer 2000 particle sizer according to Standard Operating Procedures (SOP). The results obtained by a laser sizer have been previously validated by comparison with independent assessment by wet sieving (Hart, 1996). The range of sieve sizes, together with their Wentworth classifications, is given in Table A. For additional quality control, all datasets were run through the mastersizer in triplicate and the variations in sediment distributions assessed to be within the 95% percentile.

The separate assessments of the fractions above and below 2000µm were combined using a computer programme. This followed a manual input of the sieve results for fractions 16-8mm, 8-4mm and 4-2mm fractions and the electronic data captured by the Mastersizer below 2000µm.

This method defines the particle size distributions in terms of Phi mean, median, fraction percentages (i.e. coarse sediments, sands and fines), sorting (mixture of sediment sizes) and skewness (weighting of sediment fractions above and below the mean sediment size; Folk 1954).

Formulae and classifications for particle calculations made are given below:

- **Graphic Mean (M)** - a very valuable measure of average particle size in Phi units (Folk and Ward, 1957).

$$M = \frac{\o 16 + \o 50 + \o 84}{3}$$

Where *M = The graphic mean particle size in Phi*
ø = the Phi size of the 16^{th}, 50^{th} and 84^{th} percentile of the sample

Table A - Phi and Sieve Apertures with Wentworth Classifications

Aperture in microns	Aperture in Phi Unit	Sediment Description	
2000	-1	Granule	Gravel
1400	-0.5	Very Coarse Sand	Sands
1000	0		
710	0.5	Coarse Sand	
500	1		
355	1.5	Medium Sand	
250	2		
180	2.5	Fine Sand	
125	3		
90	3.5	Very Fine Sand	
63	4		
44	4.5	Coarse Silt	Fines (Silts)
31.5	5		
22	5.5	Medium Silt	
15.6	6		
11	6.5	Fine Silt	
7.8	7		
5.5	7.5	Very Fine Silt	
3.9	8		
2	9	Clay	Fines (Clays)
1	10		

- **Sorting (D)** – the inclusive graphic standard deviation of the sample is a measure of the degree of sorting (Table B).

$$D = \frac{\o 84 + \o 16}{4} + \frac{\o 95 + \o 5}{6.6}$$

where *D = the inclusive graphic standard deviation*
ø = the Phi size of the 84^{th}, 16^{th}, 95^{th} and 5^{th} percentile of the sample

Table B - Sorting Classifications

Sorting Coefficient (Graphical Standard Deviation)	Sorting Classifications
0.00 < 0.35	Very well sorted
0.35 < 0.50	Well sorted
0.50 < 0.71	Moderately well sorted
0.71 < 1.00	Moderately sorted
1.00 < 2.00	Poorly sorted
2.00 < 4.00	Very poorly sorted
4.00 +	Extremely poorly sorted

- **Skewness (S)** – the degree of asymmetry of a frequency or cumulative curve (Table C).

$$S = \frac{ø84 + ø16 - (ø50)}{2(ø84 - ø16)} + \frac{ø95 + ø5 - 2(ø50)}{2(ø95 - ø5)}$$

where *S = the skewness of the sample*
ø = the Phi size of the 84th, 16th, 50th, 95th and 5th percentile of the sample

Table C - Skewness Classifications

Skewness Coefficient	Mathematical Skewness	Graphical Skewness
+1.00 > +0.30	Strongly positive	Strongly coarse skewed
+0.30 > +0.10	Positive	Coarse skewed
+0.10 > -0.10	Near symmetrical	Symmetrical
-0.10 > -0.30	Negative	Fine skewed
-0.30 > -1.00	Strongly negative	Strongly fine skewed

- **Graphic Kurtosis (K) –** The degree of peakedness or departure from the 'normal' frequency or cumulative curve (Table D).

$$K = \frac{ø95 - ø5}{2.44(ø75 - ø25)}$$

Where *K = Kurtosis*
ø = the Phi size of the 95th, 5th, 75th and 25th percentile of the sample

Table D - Kurtosis Classifications

Kurtosis Coefficient	Kurtosis Classification	Graphical meaning
0.41 < 0.67	Very Platykurtic	Flat-peaked; the ends are better sorted than the centre
0.67 < 0.90	Platykurtic	
0.90 < 1.10	Mesokurtic	Normal; bell shaped curve
1.11 < 1.50	Leptokurtic	Curves are excessively peaked; the centre is better sorted than the ends.
1.50 < 3.00	Very Leptokurtic	
3.00 +	Extremely Leptokurtic	

II.2 Sediment Total Organic Carbon (TOC)

Organic and carbon sediments are analysed using a combination of tests. These include Total Carbon (TC), analysed using a known weight of dried soil and combusted at 1300° C and the amount of Carbon determined by Infra-Red detection, and Total Organic Carbon (TOC; see below). In addition to the standard accreditation as outlined below, additional analytical quality control (AQC), is carried out with every batch where a soil of known value is determined (every batch of 20 samples or part thereof). Blank determinations are also carried out routinely where required.

Total Inorganic Carbon (TIC) is determined by calculation: TC –TOC = TIC

TOC was analysed using an Eltra combustion method. This method is used for total carbon analysis of dried, crushed rock powder and environmental soil samples. The samples are previously treated with 10% HCl to remove inorganic carbon (Carbonates) before washing to remove residual acids and further dried. The Carbon Analyser heats the sample in a flow of oxygen and any carbon present is converted to carbon dioxide which is measured by infra-red absorption. The percentage carbon is then calculated with respect to the original sample weight. The range for the method is 0.01 - 100%. The method is current being evaluated under the UKAS accreditation scheme.

II.3 Hydrocarbon Concentrations (Total hydrocarbon Concentrations and Aliphatics)

II.3.1 General Precautions

High purity solvents were used throughout the analyses. Solvent purity was assessed by evaporating an appropriate volume to 1ml and analysing the concentrate by GC for general hydrocarbons, target n-alkanes and aromatics. All glassware and extraction sundries were cleaned prior to use by thorough rinsing with hydrocarbon-free deionised water followed by two rinses with dichloromethane. All glassware was heated in a high temperature oven at 450^{o}C for 6 hours.

II.3.2 Extraction Procedure for Hydrocarbons

Each analytical sample (15±0.1g) was spiked with an internal standard solution containing the following components: aliphatics - heptamethylnonane, 1-chlorooctadecane and squalane. The sample was then wet vortex extracted using three successive aliquots of DCM/Methanol. The extracts were combined and water partitioned to remove the methanol and any excess water from the sample.

Solvent extracts were chemically dried and then reduced to approximately 1ml using a Kuderna Danish evaporator with micro Snyder.

II.3.3 Column fractionation for Aliphatic and Aromatic Fractions

The concentrated extract was transferred to a pre-conditioned flash chromatography column containing approximately 1g of activated Silica gel. The compounds were eluted with 3ml of Pentane/DCM (2:1). An aliquot of the extract was then taken and analysed for total hydrocarbon (THC) content and individual n-alkanes by large volume injection GC-FID.

II.3.4 Quality Control Samples

The following quality control samples were prepared with the batches of sediment samples:

- A method blank comprising 15±0.1g of baked anhydrous sodium sulphate (organic free) treated as a sample.
- A matrix matched standard sample consisting of 15±0.1g baked sand spiked with Florida mix and treated as sample.
- A sample duplicate - any one sample from the batch, dependent upon available sample mass, analysed in duplicate.

II.3.5 Hydrocarbon Analysis

Analysis of total hydrocarbons and aliphatics was performed by using an Agilent 6890 with an FID detector. Appropriate column and GC conditions were used to provide sufficient chromatographic separation of all analytes and the required sensitivity.

II.3.5.1 Carbon Preference Index

The carbon preference index is calculated as follows:

$$CPI = \frac{\text{odd homologues } (nC_{11} \text{ to } nC_{35})}{\text{even homologues } (nC_{10} \text{ to } nC_{34})}$$

II.3.5.2 Petrogenic/Biogenic or (P/B) Ratio

The Petrogenic/Biogenic Ratio is calculated as follows:

$$P/B\ \text{Ratio} = \frac{P = \text{sum of } nC_{10} \text{ to } nC_{20}}{B = \text{sum of } nC_{21} \text{ to } nC_{35}}$$

II.3.6 Calibration and Calculation

GC techniques require the use of internal standards in order to obtain quantitative results. The technique requires addition of non-naturally occurring compounds to the sample, allowing correction for varying recovery.

Target analytes concentrations were calculated by comparison with the nearest eluting internal standards. A relative response factor was applied to correct the data for the differing responses of target analytes and internal standards. Response factors were established prior to running samples, from solutions containing USEPA(16) PAHs + Dibenzothiophene for the GCMS, Florida mix (even n-Alkanes nC10-nC40) for individual GCFID targets and a Diesel/Mineral Oil mix for total oil determination.

The mean detection limits used for the sediment total hydrocarbons and n-alkanes were:

1. n-alkane - 1ng.g^{-1} (ppb)
2. Total Hydrocarbons - 100ng.g^{-1} (ppb)

II.4 Heavy and Trace Metal Concentrations

Sediment samples were homogenised and a 50g portion of each sample was air dried at room temperature. Each sample was then ground down to a fine powder (<100µm) by hand using a metal free mortar and pestle. A clean sand sample was hand ground prior to preparation of the field samples as a blank.

II.4.1 Sample Digestion Procedure

Total Metals by ICPOES (Hydrofluoric /Boric acid Extractable Metals - Fe, Ba, Sr & Al)

Approximately 0.20g of the sediment sample was accurately weighed and placed in a PTFE bottle and 2.5mls of hydrofluoric acid was added. The bottle was then placed in an oven at 105±5°C for approximately 30 minutes and then allowed to air cool in a fume cupboard. A further 65mls of 4% boric acid was then added to the bottle and the contents were then mixed thoroughly and placed in a polypropylene flask. The solution was then made up to 100ml with deionised water and analysed by ICP-OES.

Total Metals by ICPMS (Hydrofluoric /Nitric acid Extractable Metals - Cr, Cu, Ni, Zn, As, Pb, Sn, V & Cd).

Approximately 0.10g of the sediment sample was accurately weighed and placed in a PTFE bottle. Approximately 1ml of hydrofluoric acid, 1ml of nitric acid and 1ml of water were added and the bottle placed in an oven at 105±5°C for approximately 60 minutes. The bottle was then allowed to air cool in a fume cupboard. The extract was transferred to a plastic beaker and evaporated to dryness. The residue was then cooled and dissolved in 2ml of nitric acid. This was transferred to a 100ml volumetric flask and made up to volume with deionised water. The metals concentrations in the extract were determined by ICP-MS.

The mean detection limits are given in Table E for acid leachable (AL) and hydrofluoric acid (HF) digestions.

Table E - Heavy Metals - Mean Detection Limits (MDL)

Analyte	Unit	MDL
Ni	$\mu g.g^{-1}$	5
V	$\mu g.g^{-1}$	5
Al	$\mu g.g^{-1}$	10
Zn	$\mu g.g^{-1}$	5
Fe	$\mu g.g^{-1}$	10
Cu	$\mu g.g^{-1}$	5
Ba	$\mu g.g^{-1}$	5
Cr	$\mu g.g^{-1}$	5
As	$\mu g.g^{-1}$	1
Cd	$\mu g.g^{-1}$	1
Pb	$\mu g.g^{-1}$	1
Sn	$\mu g.g^{-1}$	0.5
Hg	$\mu g.g^{-1}$	0.01

ICPMS	ICPOES	TMMS

II.4.2. Mercury Digestion Procedure

Approximately 1g of the sediment was accurately weighed and transferred to a beaker. Hydrogen peroxide (10ml of 30 volumes) was added, and the covered sample left to digest for 0.5 hour in the fume cupboard. 10ml of nitric acid was added and the sample placed on the hotplate for 1 hour.

After digestion, the sample was filtered through a Whatman 542 filter paper into a 100ml standard flask. The watch-glass and beaker were rinsed thoroughly, transferring the washings to the filter paper. The filter paper was rinsed until the volume was approximately 90ml. Subsequently, the filter funnel was rinsed into the flask and then the flask was made up to 100ml volume and mixed well. The filtrate was then analysed by ICP-MS.

II.4.3 Analytical Methodology

Inductively Coupled Plasma Optical Emission Spectrometry

The instrument is calibrated using dilutions of the 1ml (=10mg) spectroscopic solutions. The final calibration solutions are matrix matched with the relevant acids. The calibration line consists of five standards.

Inductively Coupled Plasma- Mass Spectrometry

The instrument is calibrated using dilutions of the 1ml (=10mg) spectroscopic solutions. The calibration line consists of seven standards.

The analytes are scaled against internal standards to take account of changes in plasma conditions as a result of matrix differences for standards and samples. The internal standards have a similar mass and ionisation properties to the target metals.

II.5 Macro-Invertebrate Analysis

II.5.1 Methodology

All macrofaunal determination was carried by MG3 subcontractor BSL using a specialist taxonomist. This senior taxonomist has a wealth of experience in macrofaunal identification in temperate deep water environments (such as Ireland, Scotland, Faroes and sub-Antarctic waters).

Benthic sediment samples were thoroughly washed with freshwater on a 500µm sieve to remove traces of formalin, placed in gridded, white trays and then hand sorted by eye followed by binocular microscope, to remove all fauna. Sorted organisms were preserved in 70% IMS and 5% glycerol. Where possible, all organisms were identified to species level according to appropriate keys for the region. Colonial and encrusting organisms were recorded by presence alone and, where colonies could be identified as a single example, these were also recorded, although these datasets have not been considered in the overall statistical analysis of the material. The presence of anthropogenic components was also recorded where relevant.

All taxa were distinguished to species level and identified to at least family level where possible, although information is limited for the area, many of the species that could not be fully identified were separated putatively. Whilst some of the groups were only partially separated in this document, ongoing analysis with further site-specific well sites will increase our knowledge of the area and a more definitive faunal matrix will be provided at a later point in time. Nomenclature for species names were allocated either when identity was confirmed, allocated as "cf." when apparently identifying to a known species but confirmation was not possible (for example, incomplete specimens or descriptions), or allocated as "aff." when close to but distinct from a described species. The terms "indet." refers to being unable to identify to a lower taxon and "juv" as a juvenile to that species, genus or family. Species lists for the twenty six stations (56 samples (typically 2 replicates per station)), together with univariate parameters for both sample replicates and stations, are given within Section 2.9.2 and Appendix VII.

II.5.2 Quality Assurance

Benthic Solutions is committed to total quality control from the start of a project to its completion. All samples taken or received by the company were given a unique identification number. All analytical methods were carried out according to recognised standards for marine analyses. All taxonomic staff are fully qualified to post-doctorate level. Documentation is maintained that indicates the stage of analysis that each sample has reached. A full reference collection of all specimens has been retained for further clarification of putative species groups where/if required. BSL is a participant in the National Marine Biological Association Quality Control (NMBAQC) quality assurance scheme.

Furthermore, as requested by the Noble Energy Falklands, a reconciliation process has been applied on the macrofaunal species collected by verifying identified species with specimens curated at the NHM in London. This was carried out at the NHM on 13th to 15th August 2014, with taxonomists from BSL and NHM participating and RPS overseeing the reconciliation process. The results of this process confirmed that the standard of taxonomy undertaken for the FISA site was very high. A statement from the NHM confirmed that 'both teams (BSL and NHM) were working to the same standards and arriving at similar identification levels (i.e. the same species were being recognised by both team). There was also a useful exchange of experience and literature used in the identification process. For the most part, identifications were similar and so there is comparability between the different studies in that the diversity of the fauna is being captured' (email from Gordon Patterson to RPS 9th Sept 2014).

Where previous putative species have previously been assigned to species, the nomenclature for this has been included in the faunal matrix for future continuity and to aid curation of the reference material. One consistent observation made by the NHM taxonomists during the workshop was of the excellent condition of the material available. This is anticipated to be due to a combination of the following:

- Experienced and well-trained staff in the field;
- Use of the Wilson Auto-siever during field processing;
- Control and buffering of preservation fluids; and
- Sample sorting techniques by very experienced personnel.

Further analytical quality control on the sorting efficiency of macrofaunal samples was carried out by Aquatic Environments with a certificate provided in Appendix VIII.

Digital datasets are kept for all sites in the form of excel spreadsheets (by sample and by station) on MG3 archive and within the BSL's archive. This system is duplicated onto a second archive drive in case of electronic failure. These datasets will be stored in this way for a minimum of three years, or transferred to storage disk (data CD or DVD).

II.5.3 Data Standardisation and Analyses

In accordance to OSPAR Commission (2004) guidelines, all species falling into juvenile, colonial, planktonic of meiofaunal taxa are excluded from the full analyses within the dataset (this is discussed further within the text of Section 2.9). This helps to reduce the variability of data undertaken during different periods within the year, or where minor changes may occur or where some groups may only be included in a non-quantitative fashion, such as presence/absence. Certain taxa, such as the Nematoda, normally associated with meiofauna, were included where individuals greater than 10mm were recorded. The following primary and univariate parameters were calculated for each all data by stations and sample (Table F).

Table F - Primary and Univariate Parameter Calculations

Variable	Parameter	Formula	Description
Total Species	S	Number of species recorded	Species richness
Total Individuals	N	Number of individuals recorded	Sample abundance
Shannon-Wiener Index	H(s)	$H(s) = -\sum_{i=1}^{s} (Pi)(\log_2 Pi)$ where s = number of species & Pi = proportion of total sample belonging to *i*th species.	Diversity: using both richness and equitability, recorded in log 2.
Simpsons Diversity	1-Lambda	$Lambda = \sum \left(\frac{ni(ni-1)}{N(N-1)} \right)$ where ni = number of individuals in the *i*th species & N = total number of individuals	Evenness, related to dominance of most common species (Simpson, 1949)
Pielou's Equitability	J	$J = \frac{H(s)}{(\log S)}$ where s = number of species & H(s) = Shannon-Wiener diversity index.	Evenness or distribution between species (Pielou, 1969)
Margalefs Richness	D_{Mg}	$D_{Mg} = \frac{(S-1)}{(\log N)}$ where s = number of species & N = number of individuals.	Richness derived from number of species and total number of individuals (Clifford and Stevenson, 1975)

In addition to univariate methods of analysis, data for both sample replicates and stations were analysed using multivariate techniques. These serve to reduce complex species-site data to a form that is visually interpretable. A multivariate analyse was based on transformed data (double square root) to detect any improved relationships when effects of dominance were reduced. The basis for multivariate analyses was based upon the software PRIMER (Plymouth Routines In Multivariate Ecological Research).

Similarity Matrices and Hierarchical Agglomerative Clustering

A similarity matrix is used to compare every individual sample replicate and/or stations with each other. The coefficient used in this process is based upon Bray Curtis (Bray and Curtis, 1957), considered to be the most suitable for community data. These are subsequently assigned into groups of replicates and/or stations according to their level of similarity and clustered together based upon a Group Average Method into a dendrogram of similarity.

Non-Metric Multidimensional Scaling (nMDS): nMDS is currently widely used in the analysis of spatial and temporal change in benthic communities (e.g. Warwick and Clarke, 1991). The recorded observations from data were exposed to computation of triangular matrices of similarities between all pairs of samples. The similarity of every pair of sites was computed using the Bray-Curtis index on transformed data. Clustering was by a hierarchical agglomerative method using group average sorting, and the results are presented as a dendrogram and as a two-dimensional ordination plot. The degree of distortion involved in producing an ordination gives an indication of the adequacy of the nMDS representation and is recorded as a stress value as outline in Table G.

Table G - Inference from nMDS Stress Values

nMDS Stress	Adequacy of Representation for Two-Dimensional Plot
≤0.05	Excellent representation with no prospect of misinterpretation.
>0.05 to 0.1	Good ordination with no real prospect of a misleading interpretation.
>0.1 to 0.2	Potentially useful 2-d plot, though for values at the upper end of this range too much reliance should not be placed on plot detail; superimposition of clusters should be undertaken to verify conclusions.
>0.2 to 0.3	Ordination should be treated with scepticism. Clusters may be superimposed to verify conclusions, but ordinations with stress values >2.5 should be discarded. A 3-d ordination may be more appropriate.
>0.3	Ordination is unreliable with points close to being arbitrarily placed in the 2-d plot. A 3-d ordination should be examined.

SIMPER: the nMDS clustering program is used to analyse differences between sites. SIMPER enables those species responsible for differences to be identified by examining the contribution of individual species to the similarity measure. As all sites grouped within a single cluster, this program was subsequently not used.

Bioaccumulation Curve Estimates are undertaken using **Chao-1 (S^*_1)**. This is a formula that estimates how many additional species would be needed to sample all of the asymptotic species richness of a region, based on the samples acquired. It calculates this by comparing the number of species that occur in one sample with those that occur in two samples where;

$$S^*_1 = S_{obs} + (a^2/2b)$$

S_{obs} is the number of species observed
a is the number of species observed just once
b is the number of species observed just twice

RELATE – Is non-parametric Mantel test that looks at the relationship between 2 matrices (often biotic and environmental). This shows the degree of seriation, an alternative to cluster analysis, which looks for a sequential pattern in community change. The test computes Spearman's rank correlation coefficient (ρ) between the corresponding elements of each pair of matrices to produce a correlation statistic present between the two datasets, the significance of the correlation determined by a permutation procedure (Clarke and Gorley, 2006).

ANOSIM (Analysis of Similarity) – Non parametric, multivariate test often used in community ecology that calculates Bray-Curtis coefficient (for biological data) or Euclidean distance (for environmental data) based on permutations of ranked data. It produces an *R* value which is an effect level on a scale of 0-1, *R*=1 where all differences between sites are greater than any differences within site, *R*=0 when there is no separation between groups. *P* value (<5%) is the likelihood of arriving at that *R* value by chance, this significance value is determined by a permutation procedure (Clarke and Gorley, 2006).

SIMPROF (similarity profile) test - analyses data for significant clusters that show evidence of a multivariate pattern in data that are *a priori* unstructured, i.e. single samples from each site, this differs from the ANOSIM tests which permutes data based on a grouping factor such as 'site' or 'year'. The test works by comparing samples which have been ranked and ordered by resemblance against an expected profile which is obtained by permuting random species (variables) across the set of samples, a mean of 1000 permutations is taken to produce an expected result for null structure with rare and common species displaying the same pattern. If the actual data deviates outside the 95% limits of the expected profile then there is evidence for significant structure and vice versa. The 'significant structure' is well represented on a dendrogram which will also show the clusters containing that lack significant differentiation (null structure), (Clarke and Gorley, 2006).

II.6 Water Quality

Water profiles were collected using a Valeport CTD continuous reading water quality profiler depth rated to 3000m. This was fitted with sensors to record measurements throughout the water column from sea surface down to the seabed. The probe was pre-programmed and set to recording mode and lowered at an approximate rate of ca. 65m/min. This was a sufficient time to allow the onboard sensors (conductivity, temperature and pressure) to equilibrate to ambient conditions during the cast. The sampling frequency of the instrument was set to 1 reading per second. Data was recorded during both down and up casts. A total of nine data casts were acquired throughout the FISA survey area.

Profile sensors and derived parameters are as follows:

- Conductivity: mS/cm
- Temperature: ^{o} C
- Depth: Metres
- Density: g/cm3 calculated
- Sound Velocity: m/sec calculated
- Salinity: ppt calculated

To accompany these profiles, water samples were recovered using a Niskin bottle at four depth strata. Samples were collected at the surface, thermocline, mid-depth and at the seabed. Due to the 'blue water' nature of the survey area, spatial variation of water samples was deemed to be negligible. Therefore two full sets of water samples were acquired from the approximate centre of the survey area with temporal separation of approximately 10 days.

II.7 BIBLIOGRAPHY

Bray, J. R. & Curtis, J. T., 1957. An ordination of the upland forest communities of Southern Wisconsin. Ecol. Monogr. 27: 325-349.

Clarke K. R., Gorley, R. N., 2001 & 2006 PRIMER v5 (& v6): User manual/tutorial, PRIMER-E, Plymouth UK, 91pp (& 192pp).

Clifford, H. T. & Stephenson, W., 1975. An Introduction to numerical classification. Academic Press, London.

Folk, 1954. The destinction between grain size and mineral composition in sedimentary rock neomenclature. Journal of Geology 62: 344-349.

Folk, R. L & Ward, W. C., 1957. Brazos River Bar: A Study in the Significance of Grain Size Parameters. Journal of Sedimentary Research 27:3-26.

Hart, B., 1996. Ecological Monitoring Unit - Confirmation of the reproducibility of the Malvern Mastersizer Microplus Laser Sizer and comparison of its output with the Malvern 3600E sizer. Brixham Environmental Laboratory report BL2806/B.

OSPAR Commission, 2004. OSPAR guidelines for monitoring the environmental impact of offshore oil and gas activities. Meeting of the OSPAR Offshore Industries Committee (OIC), 15 – 19 March, 2004

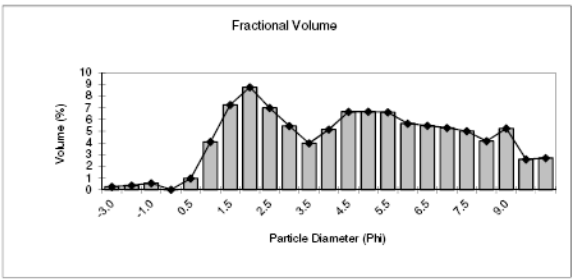
Pielou, E. C., 1969. An introduction to mathematical ecology. Wiley, New York.

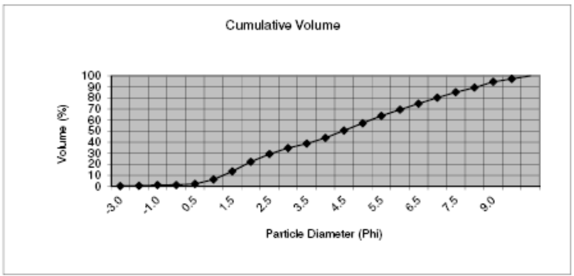
Simpson, E. H. (1949) Measurement of diversity. Nature, 163, 688.

Warwick, R. M. & Clarke, K. R., 1991. A comparison of some methods for analysing changes in benthic community structure. J. mar. biol. Ass. U.K. 71: 225-244.

APPENDIX III - PARTICLE SIZE DISTRIBUTION

Sample No.:	A_3_ENV	Operator	PaulSil
Source Data:	Nobel Energy	Date&Time:	29/05/2014 12:37

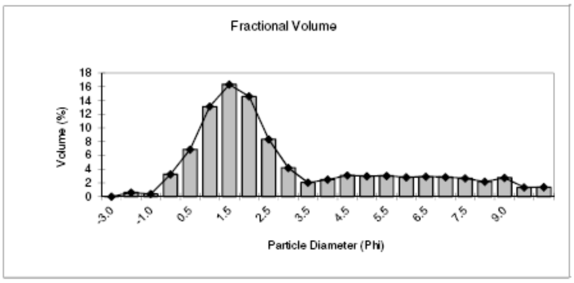


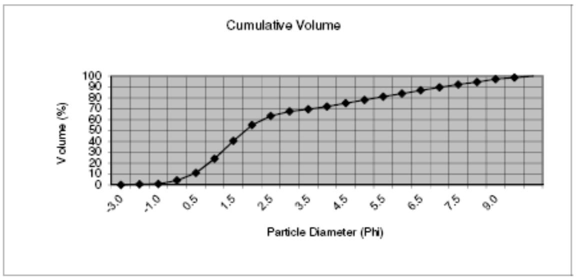


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	0.27	0.3	Pebble
4.000	-2.0	0.37	0.6	
2.000	-1.0	0.57	1.2	Granule
1.000	0.0	0.02	1.2	V.Coarse Sand
0.710	0.5	0.98	2.2	Coarse Sand
0.500	1.0	4.09	6.3	
0.355	1.5	7.26	13.5	Medium Sand
0.250	2.0	8.76	22.3	
0.180	2.5	7.00	29.3	Fine Sand
0.125	3.0	5.45	34.8	
0.900	3.5	3.97	38.7	V.Fine Sand
0.063	4.0	5.16	43.9	
0.044	4.5	6.66	50.6	Coarse Silt
0.032	5.0	6.68	57.2	
0.022	5.5	6.62	63.8	Medium Silt
0.016	6.0	5.66	69.5	
0.011	6.5	5.48	75.0	Fine silt
0.008	7.0	5.29	80.3	
0.006	7.5	5.01	85.3	V.Fine Silt
0.004	8.0	4.16	89.4	
0.002	9.0	5.24	94.7	Coarse Clay
0.001	10.0	2.61	97.3	Medium Clay
<0.001	>10.0	2.71	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.045	0.216	4.48
Median	0.046		4.46
Sorting	**Value**	**Inference**	
Coefficient	2.68	Very Poorly Sorted	
Skewness	0.06	Symmetrical	
Kurtosis	0.78	Platykurtic	
% Fines	56.11%	Coarse Silt	
% Sands	42.69%		
% Gravel	1.20%		

Sample No.:	A_1008_ENV	Operator	PaulSil
Source Data:	Nobel Energy	Date&Time:	29/05/2014 12:03

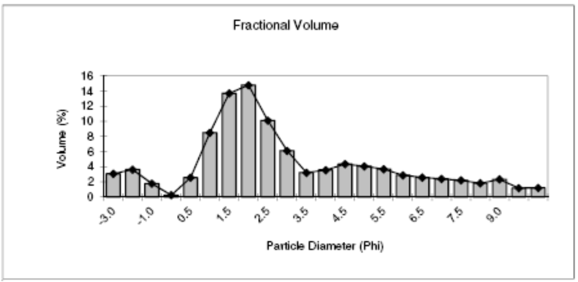


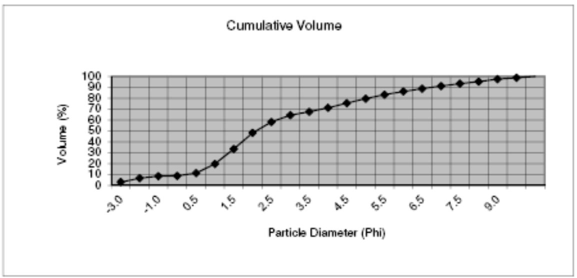


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	0.00	0.0	Pebble
4.000	-2.0	0.58	0.6	
2.000	-1.0	0.36	0.9	Granule
1.000	0.0	3.24	4.2	V.Coarse Sand
0.710	0.5	6.86	11.0	Coarse Sand
0.500	1.0	13.12	24.2	
0.355	1.5	16.33	40.5	Medium Sand
0.250	2.0	14.60	55.1	
0.180	2.5	8.35	63.4	Fine Sand
0.125	3.0	4.18	67.6	
0.900	3.5	2.04	69.7	V.Fine Sand
0.063	4.0	2.47	72.1	
0.044	4.5	3.08	75.2	Coarse Silt
0.032	5.0	2.98	78.2	
0.022	5.5	3.02	81.2	Medium Silt
0.016	6.0	2.81	84.0	
0.011	6.5	2.90	86.9	Fine silt
0.008	7.0	2.84	89.8	
0.006	7.5	2.65	92.4	V.Fine Silt
0.004	8.0	2.17	94.6	
0.002	9.0	2.73	97.3	Coarse Clay
0.001	10.0	1.34	98.6	Medium Clay
<0.001	>10.0	1.36	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.141	0.369	2.82
Median	0.287		1.80
Sorting	**Value**	**Inference**	
Coefficient	2.56	Very Poorly Sorted	
Skewness	0.57	Very Positive (Coarse)	
Kurtosis	0.96	Mesokurtic	
% Fines	27.87%	Fine Sand	
% Sands	71.18%		
% Gravel	0.95%		

Sample No.:	A_09_ENV	Operator	PaulSil
Source Data:	Nobel Energy	Date&Time:	29/05/2014 10:35

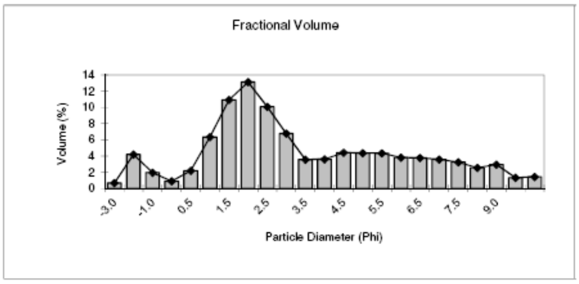


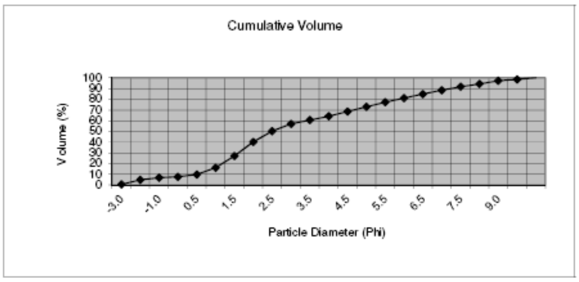


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	3.08	3.1	Pebble
4.000	-2.0	3.63	6.7	
2.000	-1.0	1.78	8.5	Granule
1.000	0.0	0.25	8.7	V.Coarse Sand
0.710	0.5	2.56	11.3	Coarse Sand
0.500	1.0	8.49	19.8	
0.355	1.5	13.69	33.5	Medium Sand
0.250	2.0	14.78	48.3	
0.180	2.5	10.10	58.4	Fine Sand
0.125	3.0	6.11	64.5	
0.900	3.5	3.22	67.7	V.Fine Sand
0.063	4.0	3.57	71.3	
0.044	4.5	4.35	75.6	Coarse Silt
0.032	5.0	4.07	79.7	
0.022	5.5	3.69	83.4	Medium Silt
0.016	6.0	2.88	86.3	
0.011	6.5	2.59	88.9	Fine silt
0.008	7.0	2.39	91.2	
0.006	7.5	2.21	93.5	V.Fine Silt
0.004	8.0	1.82	95.3	
0.002	9.0	2.34	97.6	Coarse Clay
0.001	10.0	1.18	98.8	Medium Clay
<0.001	>10.0	1.21	100.0	Fine Clay

Graphical		mm	StDev (mm)	Phi
Mean (MZ)		0.143	1.894	2.81
Median		0.238		2.07
Sorting Coefficient		Value 2.80	Inference Very Poorly Sorted	
Skewness		0.29	Positive(Coarse)	
Kurtosis		1.32	Leptokurtic	
% Fines		28.73%	Fine Sand	
% Sands		62.78%		
% Gravel		8.49%		

Sample No.:	A_10_ENV	Operator	PaulSil
Source Data:	Nobel Energy	Date&Time:	29/05/2014 15:22

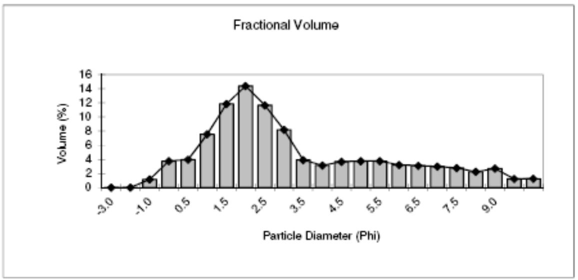


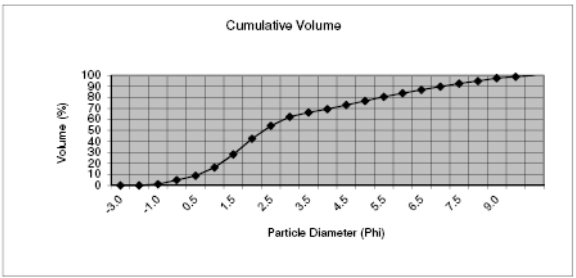


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	0.67	0.7	Pebble
4.000	-2.0	4.18	4.8	
2.000	-1.0	1.95	6.8	Granule
1.000	0.0	0.89	7.7	V.Coarse Sand
0.710	0.5	2.19	9.9	Coarse Sand
0.500	1.0	6.34	16.2	
0.355	1.5	10.91	27.1	Medium Sand
0.250	2.0	13.11	40.2	
0.180	2.5	10.07	50.3	Fine Sand
0.125	3.0	6.77	57.1	
0.900	3.5	3.56	60.6	V.Fine Sand
0.063	4.0	3.61	64.2	
0.044	4.5	4.41	68.6	Coarse Silt
0.032	5.0	4.37	73.0	
0.022	5.5	4.34	77.4	Medium Silt
0.016	6.0	3.81	81.2	
0.011	6.5	3.76	84.9	Fine silt
0.008	7.0	3.58	88.5	
0.006	7.5	3.24	91.7	V.Fine Silt
0.004	8.0	2.55	94.3	
0.002	9.0	2.96	97.2	Coarse Clay
0.001	10.0	1.32	98.6	Medium Clay
<0.001	>10.0	1.43	100.0	Fine Clay

Graphical		mm	StDev (mm)	Phi
Mean (MZ)		0.104	1.232	3.27
Median		0.182		2.46
Sorting Coefficient		Value 2.88	Inference Very Poorly Sorted	
Skewness		0.29	Positive(Coarse)	
Kurtosis		1.09	Mesokurtic	
% Fines		35.77%	V.Fine Sands	
% Sands		57.44%		
% Gravel		6.80%		

Sample No.:	A_1011_ENV	Operator	PaulSil
Source Data:	Nobel Energy	Date&Time:	29/05/2014 12:24

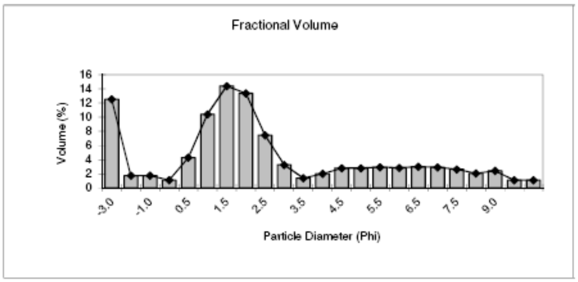


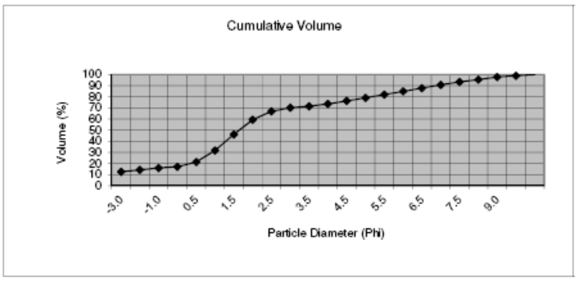


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	0.00	0.0	Pebble
4.000	-2.0	0.00	0.0	
2.000	-1.0	1.16	1.2	Granule
1.000	0.0	3.74	4.9	V.Coarse Sand
0.710	0.5	3.95	8.9	Coarse Sand
0.500	1.0	7.54	16.4	
0.355	1.5	11.82	28.2	Medium Sand
0.250	2.0	14.36	42.6	
0.180	2.5	11.64	54.2	Fine Sand
0.125	3.0	8.17	62.4	
0.900	3.5	3.90	66.3	V.Fine Sand
0.063	4.0	3.13	69.4	
0.044	4.5	3.65	73.1	Coarse Silt
0.032	5.0	3.74	76.8	
0.022	5.5	3.75	80.6	Medium Silt
0.016	6.0	3.20	83.8	
0.011	6.5	3.10	86.9	Fine silt
0.008	7.0	2.97	89.8	
0.006	7.5	2.76	92.6	V.Fine Silt
0.004	8.0	2.24	94.8	
0.002	9.0	2.69	97.5	Coarse Clay
0.001	10.0	1.22	98.8	Medium Clay
<0.001	>10.0	1.25	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.117	0.355	3.10
Median	0.205		2.28
Sorting	Value	Inference	
Coefficient	2.48	Very Poorly Sorted	
Skewness	0.46	Very Positive (Coarse)	
Kurtosis	0.97	Mesokurtic	
% Fines	30.57%	V.Fine Sands	
% Sands	68.27%		
% Gravel	1.16%		

Sample No.:	A_12_ENV	Operator	PaulSil
Source Data:	Nobel Energy	Date&Time:	29/05/2014 11:27

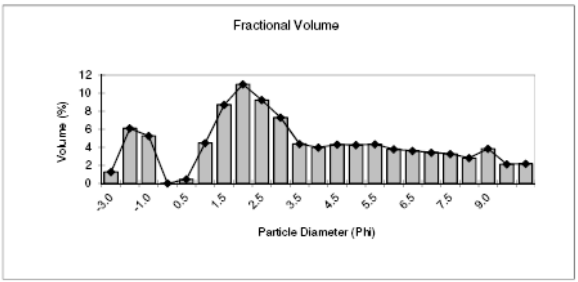


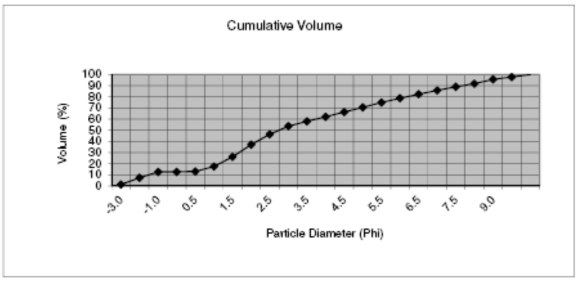


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	12.52	12.5	Pebble
4.000	-2.0	1.73	14.2	
2.000	-1.0	1.73	16.0	Granule
1.000	0.0	1.09	17.1	V.Coarse Sand
0.710	0.5	4.28	21.4	Coarse Sand
0.500	1.0	10.40	31.8	
0.355	1.5	14.37	46.1	Medium Sand
0.250	2.0	13.34	59.5	
0.180	2.5	7.43	66.9	Fine Sand
0.125	3.0	3.25	70.2	
0.900	3.5	1.37	71.5	V.Fine Sand
0.063	4.0	2.00	73.5	
0.044	4.5	2.78	76.3	Coarse Silt
0.032	5.0	2.78	79.1	
0.022	5.5	2.92	82.0	Medium Silt
0.016	6.0	2.83	84.9	
0.011	6.5	3.00	87.8	Fine silt
0.008	7.0	2.91	90.8	
0.006	7.5	2.62	93.4	V.Fine Silt
0.004	8.0	2.05	95.4	
0.002	9.0	2.41	97.8	Coarse Clay
0.001	10.0	1.08	98.9	Medium Clay
<0.001	>10.0	1.08	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.224	8.943	2.16
Median	0.325		1.62
Sorting	Value	Inference	
Coefficient	3.61	Very Poorly Sorted	
Skewness	0.12	Positive(Coarse)	
Kurtosis	1.43	Leptokurtic	
% Fines	26.47%	Fine Sand	
% Sands	57.55%		
% Gravel	15.98%		

Sample No.:	A_1013_ENV	**Operator**	PaulSil
Source Data:	Nobel Energy	**Date&Time:**	29/05/2014 13:43

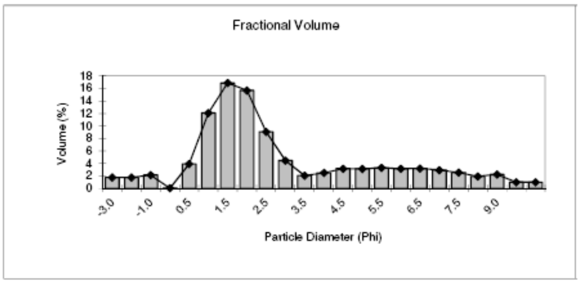


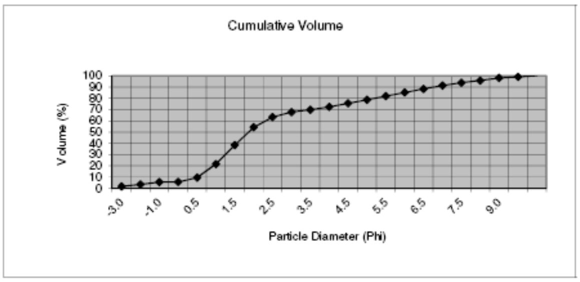


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	1.27	1.3	Pebble
4.000	-2.0	6.10	7.4	
2.000	-1.0	5.25	12.6	Granule
1.000	0.0	0.00	12.6	V.Coarse Sand
0.710	0.5	0.46	13.1	Coarse Sand
0.500	1.0	4.47	17.5	
0.355	1.5	8.69	26.2	Medium Sand
0.250	2.0	10.97	37.2	
0.180	2.5	9.23	46.4	Fine Sand
0.125	3.0	7.29	53.7	
0.900	3.5	4.37	58.1	V.Fine Sand
0.063	4.0	3.98	62.1	
0.044	4.5	4.31	66.4	Coarse Silt
0.032	5.0	4.25	70.6	
0.022	5.5	4.34	75.0	Medium Silt
0.016	6.0	3.78	78.8	
0.011	6.5	3.61	82.4	Fine silt
0.008	7.0	3.42	85.8	
0.006	7.5	3.26	89.0	V.Fine Silt
0.004	8.0	2.81	91.9	
0.002	9.0	3.84	95.7	Coarse Clay
0.001	10.0	2.12	97.8	Medium Clay
<0.001	>10.0	2.18	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.094	1.933	3.41
Median	0.153		2.71
Sorting	**Value**	**Inference**	
Coefficient	3.18	Very Poorly Sorted	
Skewness	0.22	Positive(Coarse)	
Kurtosis	1.12	Leptokurtic	
% Fines	37.93%	v.Fine Sands	
% Sands	49.45%		
% Gravel	12.62%		

Sample No.:	A_14_ENV	**Operator**	PaulSil
Source Data:	Nobel Energy	**Date&Time:**	29/05/2014 14:31

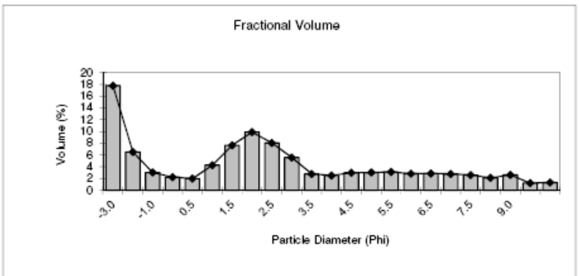


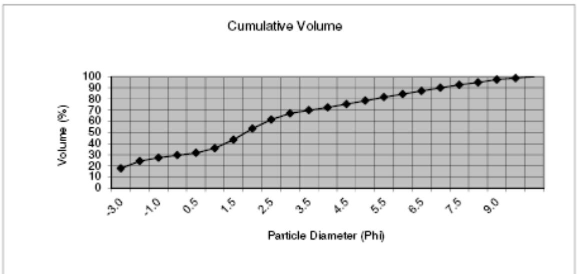


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	1.76	1.8	Pebble
4.000	-2.0	1.76	3.5	
2.000	-1.0	2.14	5.7	Granule
1.000	0.0	0.04	5.7	V.Coarse Sand
0.710	0.5	3.92	9.6	Coarse Sand
0.500	1.0	12.08	21.7	
0.355	1.5	16.88	38.6	Medium Sand
0.250	2.0	15.69	54.3	
0.180	2.5	9.07	63.3	Fine Sand
0.125	3.0	4.46	67.8	
0.900	3.5	2.06	69.9	V.Fine Sand
0.063	4.0	2.49	72.4	
0.044	4.5	3.18	75.5	Coarse Silt
0.032	5.0	3.13	78.7	
0.022	5.5	3.30	82.0	Medium Silt
0.016	6.0	3.16	85.1	
0.011	6.5	3.20	88.3	Fine silt
0.008	7.0	2.95	91.3	
0.006	7.5	2.54	93.8	V.Fine Silt
0.004	8.0	1.93	95.8	
0.002	9.0	2.24	98.0	Coarse Clay
0.001	10.0	1.00	99.0	Medium Clay
<0.001	>10.0	1.00	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.144	0.832	2.80
Median	0.279		1.84
Sorting	**Value**	**Inference**	
Coefficient	2.66	Very Poorly Sorted	
Skewness	0.43	Very Positive (Coarse)	
Kurtosis	1.13	Leptokurtic	
% Fines	27.64%	Fine Sand	
% Sands	66.69%		
% Gravel	5.67%		

Sample No.:	A_1015_ENV	Operator	PaulSil
Source Data:	Nobel Energy	Date&Time:	29/05/2014 15:50

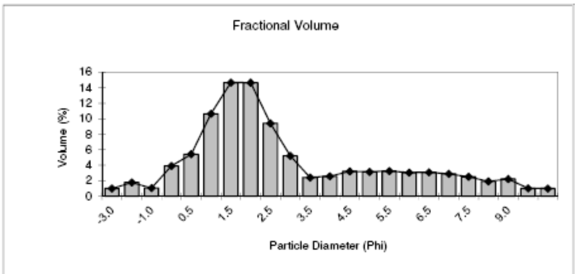


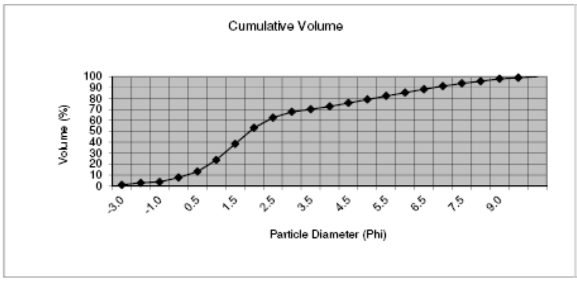


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	17.75	17.7	Pebble
4.000	-2.0	6.52	24.3	
2.000	-1.0	3.04	27.3	Granule
1.000	0.0	2.25	29.6	V.Coarse Sand
0.710	0.5	2.01	31.6	Coarse Sand
0.500	1.0	4.28	35.8	
0.355	1.5	7.67	43.5	Medium Sand
0.250	2.0	9.90	53.4	
0.180	2.5	8.05	61.5	Fine Sand
0.125	3.0	5.58	67.0	
0.900	3.5	2.80	69.8	V.Fine Sand
0.063	4.0	2.53	72.4	
0.044	4.5	3.00	75.4	Coarse Silt
0.032	5.0	3.04	78.4	
0.022	5.5	3.12	81.5	Medium Silt
0.016	6.0	2.83	84.4	
0.011	6.5	2.87	87.2	Fine silt
0.008	7.0	2.80	90.0	
0.006	7.5	2.62	92.7	V.Fine Silt
0.004	8.0	2.14	94.8	
0.002	9.0	2.64	97.4	Coarse Clay
0.001	10.0	1.24	98.7	Medium Clay
<0.001	>10.0	1.34	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.354	6.612	1.50
Median	0.286		1.81
Sorting	Value	Inference	
Coefficient	4.13	Extremely Poorly Sorted	
Skewness	-0.03	Symmetrical	
Kurtosis	0.80	Platykurtic	
% Fines	27.63%	Medium Sand	
% Sands	45.06%		
% Gravel	27.30%		

Sample No.:	A_18_ENV	Operator	PaulSil
Source Data:	Nobel Energy	Date&Time:	29/05/2014 13:21

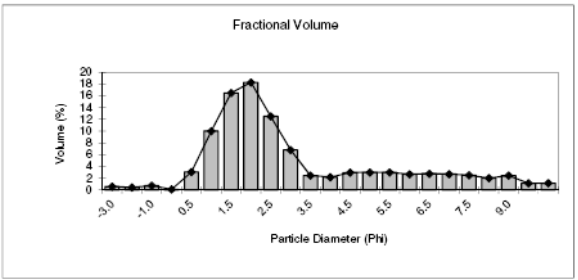


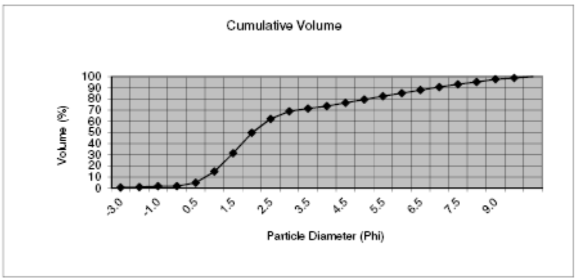


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	1.00	1.0	Pebble
4.000	-2.0	1.76	2.8	
2.000	-1.0	1.06	3.8	Granule
1.000	0.0	3.91	7.7	V.Coarse Sand
0.710	0.5	5.42	13.2	Coarse Sand
0.500	1.0	10.65	23.8	
0.355	1.5	14.67	38.5	Medium Sand
0.250	2.0	14.65	53.1	
0.180	2.5	9.41	62.5	Fine Sand
0.125	3.0	5.22	67.8	
0.900	3.5	2.42	70.2	V.Fine Sand
0.063	4.0	2.58	72.8	
0.044	4.5	3.20	75.9	Coarse Silt
0.032	5.0	3.14	79.1	
0.022	5.5	3.24	82.3	Medium Silt
0.016	6.0	3.04	85.4	
0.011	6.5	3.09	88.5	Fine silt
0.008	7.0	2.88	91.3	
0.006	7.5	2.51	93.8	V.Fine Silt
0.004	8.0	1.91	95.8	
0.002	9.0	2.23	98.0	Coarse Clay
0.001	10.0	1.02	99.0	Medium Clay
<0.001	>10.0	1.00	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.149	0.565	2.75
Median	0.272		1.88
Sorting	Value	Inference	
Coefficient	2.58	Very Poorly Sorted	
Skewness	0.45	Very Positive (Coarse)	
Kurtosis	1.06	Mesokurtic	
% Fines	27.25%	Fine Sand	
% Sands	68.93%		
% Gravel	3.82%		

Sample No.:	A_20_ENV	Operator	PaulSil
Source Data:	Nobel Energy	Date&Time:	29/05/2014 11:17

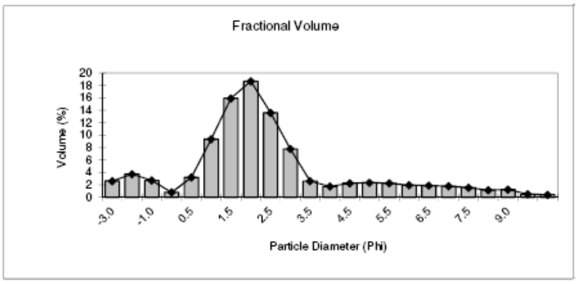


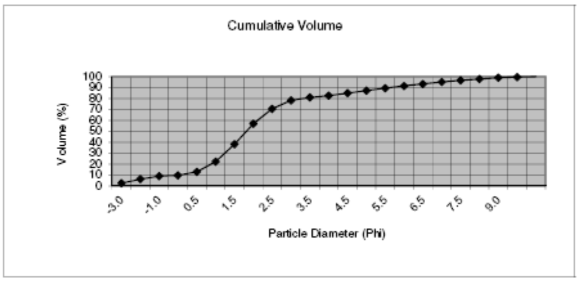


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	0.58	0.6	Pebble
4.000	-2.0	0.44	1.0	
2.000	-1.0	0.73	1.8	Granule
1.000	0.0	0.11	1.9	V.Coarse Sand
0.710	0.5	3.06	4.9	Coarse Sand
0.500	1.0	10.00	14.9	
0.355	1.5	16.48	31.4	Medium Sand
0.250	2.0	18.28	49.7	
0.180	2.5	12.51	62.2	Fine Sand
0.125	3.0	6.81	69.0	
0.900	3.5	2.46	71.5	V.Fine Sand
0.063	4.0	2.19	73.7	
0.044	4.5	2.95	76.6	Coarse Silt
0.032	5.0	3.00	79.6	
0.022	5.5	2.98	82.6	Medium Silt
0.016	6.0	2.68	85.3	
0.011	6.5	2.75	88.0	Fine silt
0.008	7.0	2.71	90.7	
0.006	7.5	2.51	93.2	V.Fine Silt
0.004	8.0	2.02	95.3	
0.002	9.0	2.45	97.7	Coarse Clay
0.001	10.0	1.14	98.9	Medium Clay
<0.001	>10.0	1.14	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.131	0.278	2.93
Median	0.248		2.01
Sorting Coefficient	Value: 2.31	Inference: Very Poorly Sorted	
Skewness	0.59	Very Positive (Coarse)	
Kurtosis	1.04	Mesokurtic	
% Fines	26.34%	Fine Sand	
% Sands	71.91%		
% Gravel	1.75%		

Sample No.:	A_21_ENV	Operator	PaulSil
Source Data:	Nobel Energy	Date&Time:	29/05/2014 11:47

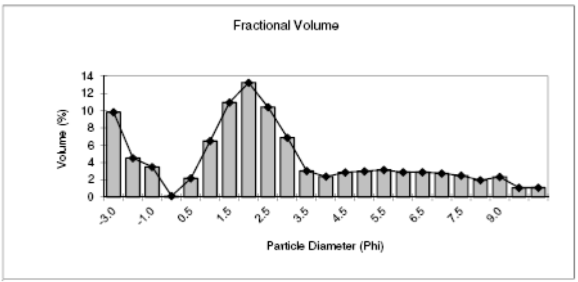


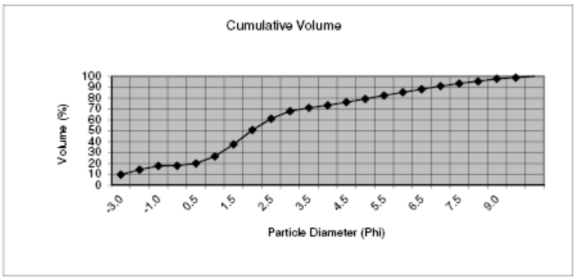


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	2.61	2.6	Pebble
4.000	-2.0	3.72	6.3	
2.000	-1.0	2.70	9.0	Granule
1.000	0.0	0.78	9.8	V.Coarse Sand
0.710	0.5	3.20	13.0	Coarse Sand
0.500	1.0	9.36	22.4	
0.355	1.5	15.94	38.3	Medium Sand
0.250	2.0	18.70	57.0	
0.180	2.5	13.60	70.6	Fine Sand
0.125	3.0	7.78	78.4	
0.900	3.5	2.60	81.0	V.Fine Sand
0.063	4.0	1.73	82.7	
0.044	4.5	2.26	85.0	Coarse Silt
0.032	5.0	2.34	87.3	
0.022	5.5	2.26	89.6	Medium Silt
0.016	6.0	1.92	91.5	
0.011	6.5	1.89	93.4	Fine silt
0.008	7.0	1.77	95.2	
0.006	7.5	1.54	96.7	V.Fine Silt
0.004	8.0	1.15	97.9	
0.002	9.0	1.24	99.1	Coarse Clay
0.001	10.0	0.50	99.6	Medium Clay
<0.001	>10.0	0.40	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.214	1.732	2.23
Median	0.289		1.79
Sorting Coefficient	Value: 2.33	Inference: Very Poorly Sorted	
Skewness	0.23	Positive(Coarse)	
Kurtosis	2.30	Very Leptokurtic	
% Fines	17.27%	Fine Sand	
% Sands	73.70%		
% Gravel	9.03%		

Sample No.:	A_22_ENV	**Operator**	PaulSil
Source Data:	Nobel Energy	**Date&Time:**	29/05/2014 11:08

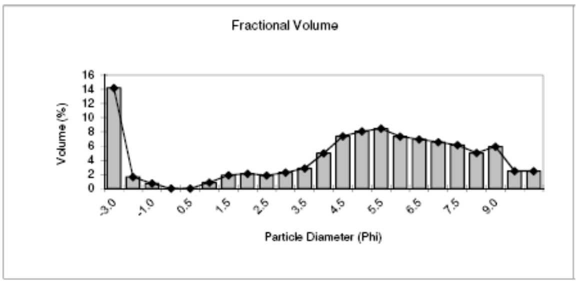


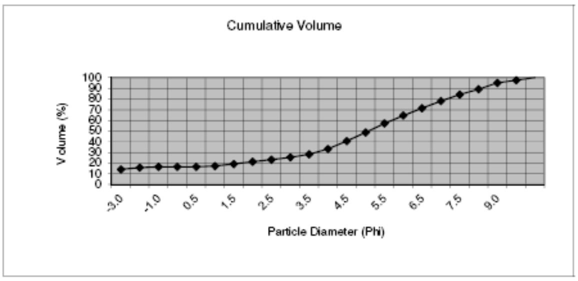


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	9.83	9.8	Pebble
4.000	-2.0	4.53	14.4	
2.000	-1.0	3.49	17.9	Granule
1.000	0.0	0.12	18.0	V.Coarse Sand
0.710	0.5	2.16	20.1	Coarse Sand
0.500	1.0	6.48	26.6	
0.355	1.5	10.95	37.6	Medium Sand
0.250	2.0	13.24	50.8	
0.180	2.5	10.40	61.2	Fine Sand
0.125	3.0	6.89	68.1	
0.900	3.5	3.03	71.1	V.Fine Sand
0.063	4.0	2.38	73.5	
0.044	4.5	2.86	76.4	Coarse Silt
0.032	5.0	3.00	79.4	
0.022	5.5	3.15	82.5	Medium Silt
0.016	6.0	2.88	85.4	
0.011	6.5	2.89	88.3	Fine silt
0.008	7.0	2.75	91.0	
0.006	7.5	2.48	93.5	V.Fine Silt
0.004	8.0	1.96	95.5	
0.002	9.0	2.34	97.8	Coarse Clay
0.001	10.0	1.09	98.9	Medium Clay
<0.001	>10.0	1.09	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.245	36.424	2.03
Median	0.256		1.96
Sorting Coefficient	Value: 4.06	Inference: Extremely Poorly Sorted	
Skewness	-0.08	Symmetrical	
Kurtosis	1.78	Very Leptokurtic	
% Fines	26.49%	Fine Sand	
% Sands	55.66%		
% Gravel	17.85%		

Sample No.:	A_26_ENV	**Operator**	PaulSil
Source Data:	Nobel Energy	**Date&Time:**	29/05/2014 16:16

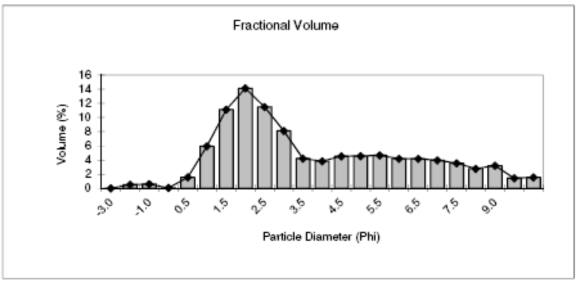


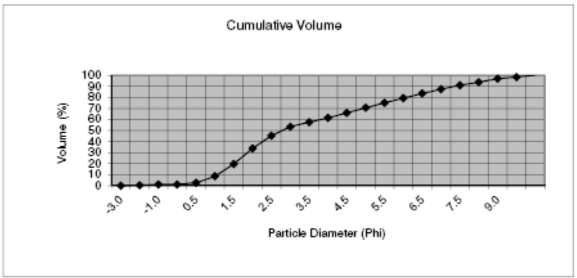


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	14.18	14.2	Pebble
4.000	-2.0	1.64	15.8	
2.000	-1.0	0.71	16.5	Granule
1.000	0.0	0.00	16.5	V.Coarse Sand
0.710	0.5	0.00	16.5	Coarse Sand
0.500	1.0	0.85	17.4	
0.355	1.5	1.88	19.3	Medium Sand
0.250	2.0	2.10	21.4	
0.180	2.5	1.85	23.2	Fine Sand
0.125	3.0	2.26	25.5	
0.900	3.5	2.86	28.3	V.Fine Sand
0.063	4.0	4.97	33.3	
0.044	4.5	7.38	40.7	Coarse Silt
0.032	5.0	8.07	48.7	
0.022	5.5	8.45	57.2	Medium Silt
0.016	6.0	7.33	64.5	
0.011	6.5	6.95	71.5	Fine silt
0.008	7.0	6.55	78.0	
0.006	7.5	6.13	84.1	V.Fine Silt
0.004	8.0	5.02	89.2	
0.002	9.0	5.91	95.1	Coarse Clay
0.001	10.0	2.46	97.5	Medium Clay
<0.001	>10.0	2.46	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.084	20874.306	3.58
Median	0.030		5.06
Sorting Coefficient	Value: 6.08	Inference: Extremely Poorly Sorted	
Skewness	-0.58	Very Negative(fine)	
Kurtosis	2.62	Very Leptokurtic	
% Fines	66.71%	V.Fine Sands	
% Sands	16.76%		
% Gravel	16.53%		

Sample No.:	A_27_ENV	Operator	PaulSil
Source Data:	Nobel Energy	Date&Time:	29/05/2014 14:51

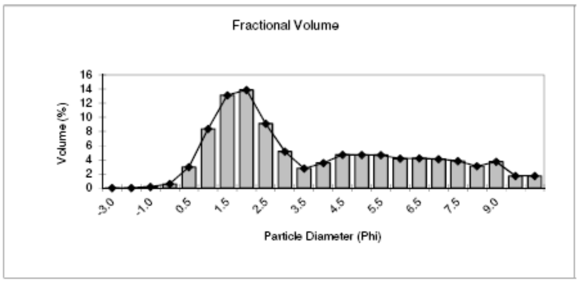


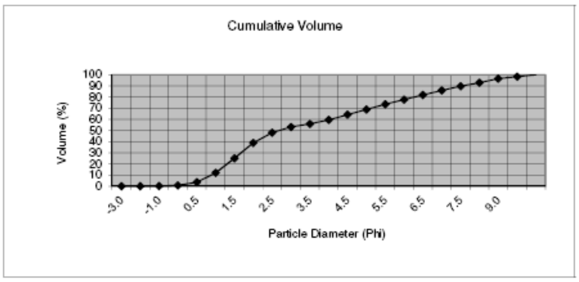


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	0.00	0.0	Pebble
4.000	-2.0	0.50	0.5	
2.000	-1.0	0.59	1.1	Granule
1.000	0.0	0.06	1.2	V.Coarse Sand
0.710	0.5	1.55	2.7	Coarse Sand
0.500	1.0	5.95	8.7	
0.355	1.5	11.10	19.8	Medium Sand
0.250	2.0	14.11	33.9	
0.180	2.5	11.48	45.3	Fine Sand
0.125	3.0	8.12	53.5	
0.900	3.5	4.19	57.7	V.Fine Sand
0.063	4.0	3.83	61.5	
0.044	4.5	4.52	66.0	Coarse Silt
0.032	5.0	4.55	70.6	
0.022	5.5	4.65	75.2	Medium Silt
0.016	6.0	4.18	79.4	
0.011	6.5	4.17	83.6	Fine silt
0.008	7.0	3.95	87.5	
0.006	7.5	3.55	91.1	V.Fine Silt
0.004	8.0	2.77	93.8	
0.002	9.0	3.20	97.0	Coarse Clay
0.001	10.0	1.43	98.5	Medium Clay
<0.001	>10.0	1.54	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.086	0.240	3.54
Median	0.148		2.75
Sorting	Value	Inference	
Coefficient	2.47	Very Poorly Sorted	
Skewness	0.45	Very Positive (Coarse)	
Kurtosis	0.82	Platykurtic	
% Fines	38.52%	V.Fine Sands	
% Sands	60.40%		
% Gravel	1.09%		

Sample No.:	A_202_ENV	Operator	PaulSil
Source Data:	Nobel Energy	Date&Time:	29/05/2014 10:56

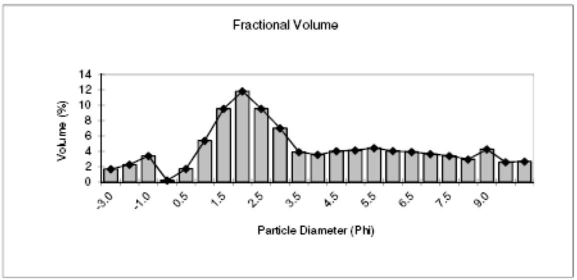


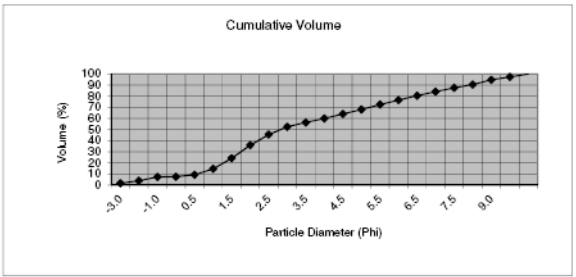


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	0.00	0.0	Pebble
4.000	-2.0	0.00	0.0	
2.000	-1.0	0.15	0.2	Granule
1.000	0.0	0.57	0.7	V.Coarse Sand
0.710	0.5	2.96	3.7	Coarse Sand
0.500	1.0	8.34	12.0	
0.355	1.5	13.12	25.1	Medium Sand
0.250	2.0	13.85	39.0	
0.180	2.5	9.08	48.1	Fine Sand
0.125	3.0	5.15	53.2	
0.900	3.5	2.76	56.0	V.Fine Sand
0.063	4.0	3.54	59.5	
0.044	4.5	4.70	64.2	Coarse Silt
0.032	5.0	4.67	68.9	
0.022	5.5	4.65	73.6	Medium Silt
0.016	6.0	4.15	77.7	
0.011	6.5	4.20	81.9	Fine silt
0.008	7.0	4.09	86.0	
0.006	7.5	3.81	89.8	V.Fine Silt
0.004	8.0	3.08	92.9	
0.002	9.0	3.71	96.6	Coarse Clay
0.001	10.0	1.70	98.3	Medium Clay
<0.001	>10.0	1.71	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.088	0.266	3.51
Median	0.160		2.65
Sorting	Value	Inference	
Coefficient	2.60	Very Poorly Sorted	
Skewness	0.47	Very Positive (Coarse)	
Kurtosis	0.78	Platykurtic	
% Fines	40.47%	V.Fine Sands	
% Sands	59.38%		
% Gravel	0.15%		

Sample No.:	A_204_ENV	Operator	PaulSil
Source Data:	Nobel Energy	Date&Time:	29/05/2014 10:49

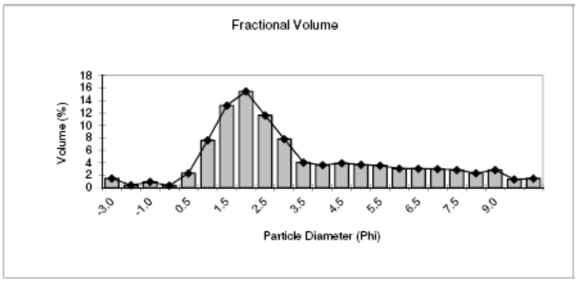


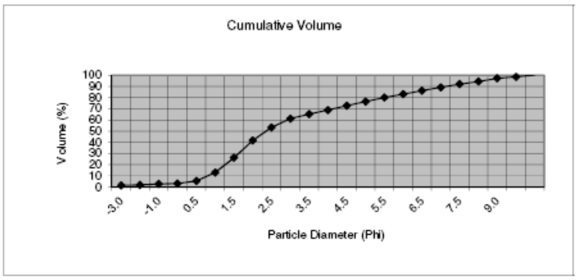


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	1.69	1.7	Pebble
4.000	-2.0	2.27	4.0	
2.000	-1.0	3.41	7.4	Granule
1.000	0.0	0.20	7.6	V.Coarse Sand
0.710	0.5	1.72	9.3	Coarse Sand
0.500	1.0	5.39	14.7	
0.355	1.5	9.53	24.2	Medium Sand
0.250	2.0	11.79	36.0	
0.180	2.5	9.53	45.5	Fine Sand
0.125	3.0	7.00	52.5	
0.900	3.5	3.90	56.4	V.Fine Sand
0.063	4.0	3.56	60.0	
0.044	4.5	4.01	64.0	Coarse Silt
0.032	5.0	4.12	68.1	
0.022	5.5	4.43	72.5	Medium Silt
0.016	6.0	4.04	76.6	
0.011	6.5	3.91	80.5	Fine silt
0.008	7.0	3.64	84.1	
0.006	7.5	3.41	87.5	V.Fine Silt
0.004	8.0	2.95	90.5	
0.002	9.0	4.26	94.8	Coarse Clay
0.001	10.0	2.58	97.3	Medium Clay
<0.001	>10.0	2.67	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.082	1.087	3.61
Median	0.145		2.79
Sorting	Value	Inference	
Coefficient	3.12	Very Poorly Sorted	
Skewness	0.29	Positive(Coarse)	
Kurtosis	1.04	Mesokurtic	
% Fines	40.03%	v.Fine Sands	
% Sands	52.61%		
% Gravel	7.36%		

Sample No.:	A_301_ENV	Operator	PaulSil
Source Data:	Nobel Energy	Date&Time:	29/05/2014 14:10

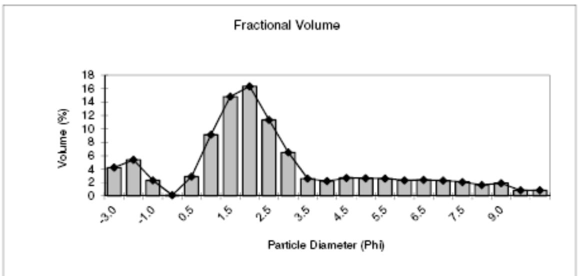


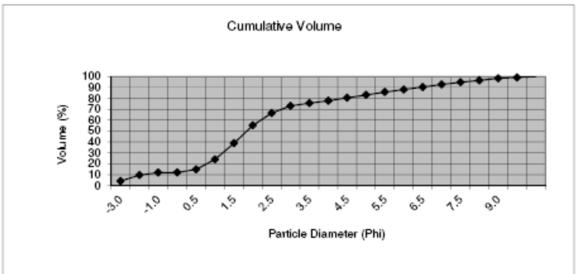


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	1.49	1.5	Pebble
4.000	-2.0	0.41	1.9	
2.000	-1.0	0.95	2.8	Granule
1.000	0.0	0.34	3.2	V.Coarse Sand
0.710	0.5	2.33	5.5	Coarse Sand
0.500	1.0	7.61	13.1	
0.355	1.5	13.19	26.3	Medium Sand
0.250	2.0	15.45	41.8	
0.180	2.5	11.61	53.4	Fine Sand
0.125	3.0	7.82	61.2	
0.900	3.5	4.06	65.2	V.Fine Sand
0.063	4.0	3.63	68.9	
0.044	4.5	3.94	72.8	Coarse Silt
0.032	5.0	3.69	76.5	
0.022	5.5	3.55	80.0	Medium Silt
0.016	6.0	3.07	83.1	
0.011	6.5	3.06	86.2	Fine silt
0.008	7.0	3.01	89.2	
0.006	7.5	2.85	92.0	V.Fine Silt
0.004	8.0	2.34	94.4	
0.002	9.0	2.85	97.2	Coarse Clay
0.001	10.0	1.33	98.5	Medium Clay
<0.001	>10.0	1.47	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.110	0.289	3.18
Median	0.200		2.32
Sorting	Value	Inference	
Coefficient	2.44	Very Poorly Sorted	
Skewness	0.51	Very Positive (Coarse)	
Kurtosis	0.96	Mesokurtic	
% Fines	31.14%	V.Fine Sands	
% Sands	66.02%		
% Gravel	2.84%		

Sample No.:	A_302_ENV	Operator	PaulSil
Source Data:	Nobel Energy	Date&Time:	29/05/2014 16:02

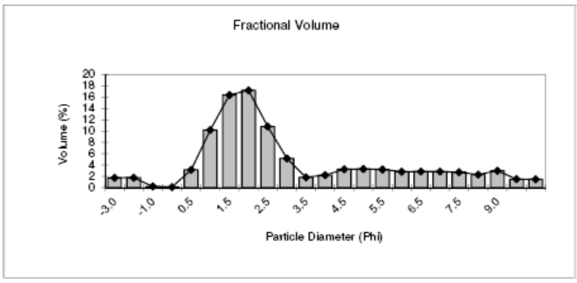


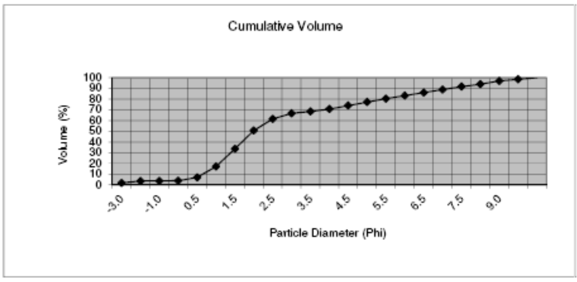


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	4.24	4.2	Pebble
4.000	-2.0	5.37	9.6	
2.000	-1.0	2.33	11.9	Granule
1.000	0.0	0.11	12.0	V.Coarse Sand
0.710	0.5	2.87	14.9	Coarse Sand
0.500	1.0	9.13	24.0	
0.355	1.5	14.80	38.9	Medium Sand
0.250	2.0	16.35	55.2	
0.180	2.5	11.35	66.5	Fine Sand
0.125	3.0	6.49	73.0	
0.900	3.5	2.58	75.6	V.Fine Sand
0.063	4.0	2.20	77.8	
0.044	4.5	2.69	80.5	Coarse Silt
0.032	5.0	2.64	83.1	
0.022	5.5	2.60	85.7	Medium Silt
0.016	6.0	2.33	88.1	
0.011	6.5	2.38	90.4	Fine silt
0.008	7.0	2.30	92.7	
0.006	7.5	2.08	94.8	V.Fine Silt
0.004	8.0	1.63	96.4	
0.002	9.0	1.90	98.3	Coarse Clay
0.001	10.0	0.82	99.2	Medium Clay
<0.001	>10.0	0.83	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.177	2.539	2.50
Median	0.283		1.82
Sorting	Value	Inference	
Coefficient	2.73	Very Poorly Sorted	
Skewness	0.27	Positive(Coarse)	
Kurtosis	1.85	Very Leptokurtic	
% Fines	22.18%	Fine Sand	
% Sands	65.88%		
% Gravel	11.94%		

Sample No.:	A_303_ENV	Operator	PaulSil
Source Data:	Nobel Energy	Date&Time:	29/05/2014 10:24

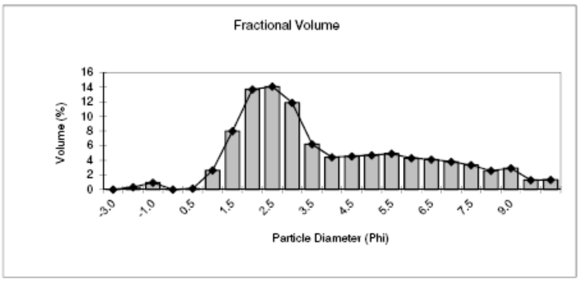


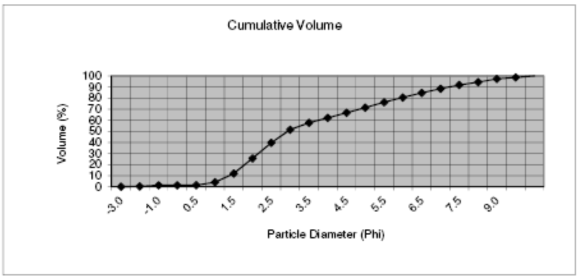


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	1.75	1.7	Pebble
4.000	-2.0	1.78	3.5	
2.000	-1.0	0.21	3.7	Granule
1.000	0.0	0.12	3.9	V.Coarse Sand
0.710	0.5	3.16	7.0	Coarse Sand
0.500	1.0	10.18	17.2	
0.355	1.5	16.35	33.5	Medium Sand
0.250	2.0	17.19	50.7	
0.180	2.5	10.79	61.5	Fine Sand
0.125	3.0	5.18	66.7	
0.900	3.5	1.83	68.5	V.Fine Sand
0.063	4.0	2.21	70.7	
0.044	4.5	3.25	74.0	Coarse Silt
0.032	5.0	3.29	77.3	
0.022	5.5	3.22	80.5	Medium Silt
0.016	6.0	2.82	83.3	
0.011	6.5	2.84	86.2	Fine silt
0.008	7.0	2.83	89.0	
0.006	7.5	2.73	91.7	V.Fine Silt
0.004	8.0	2.31	94.0	
0.002	9.0	3.01	97.0	Coarse Clay
0.001	10.0	1.49	98.5	Medium Clay
<0.001	>10.0	1.47	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.125	0.329	3.00
Median	0.255		1.97
Sorting	Value	Inference	
Coefficient	2.52	Very Poorly Sorted	
Skewness	0.57	Very Positive (Coarse)	
Kurtosis	0.97	Mesokurtic	
% Fines	29.26%	V.Fine Sands	
% Sands	67.01%		
% Gravel	3.74%		

Sample No.:	A_304_ENV	Operator	PaulSil
Source Data:	Nobel Energy	Date&Time:	29/05/2014 10:13

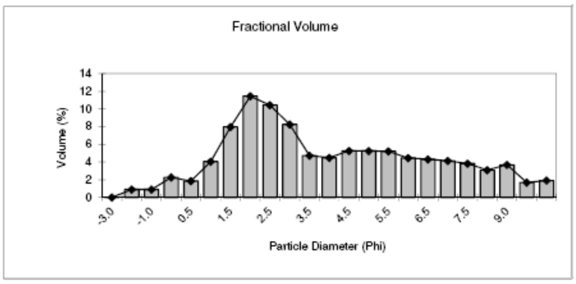


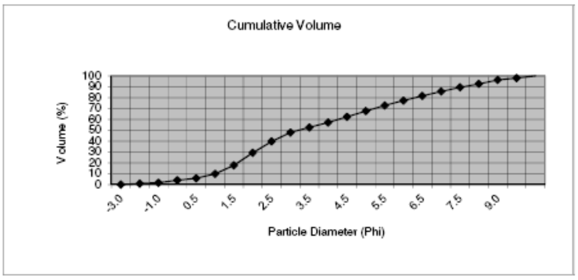


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	0.00	0.0	Pebble
4.000	-2.0	0.31	0.3	
2.000	-1.0	0.94	1.3	Granule
1.000	0.0	0.00	1.3	V.Coarse Sand
0.710	0.5	0.12	1.4	Coarse Sand
0.500	1.0	2.62	4.0	
0.355	1.5	7.99	12.0	Medium Sand
0.250	2.0	13.68	25.7	
0.180	2.5	14.07	39.7	Fine Sand
0.125	3.0	11.86	51.6	
0.900	3.5	6.21	57.8	V.Fine Sand
0.063	4.0	4.41	62.2	
0.044	4.5	4.55	66.8	Coarse Silt
0.032	5.0	4.70	71.5	
0.022	5.5	4.89	76.4	Medium Silt
0.016	6.0	4.29	80.6	
0.011	6.5	4.11	84.8	Fine silt
0.008	7.0	3.79	88.5	
0.006	7.5	3.35	91.9	V.Fine Silt
0.004	8.0	2.57	94.5	
0.002	9.0	2.92	97.4	Coarse Clay
0.001	10.0	1.29	98.7	Medium Clay
<0.001	>10.0	1.33	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.080	0.186	3.65
Median	0.132		2.92
Sorting	Value	Inference	
Coefficient	2.27	Very Poorly Sorted	
Skewness	0.47	Very Positive (Coarse)	
Kurtosis	0.86	Platykurtic	
% Fines	37.79%	V.Fine Sands	
% Sands	60.95%		
% Gravel	1.26%		

Sample No.:	A_305_ENV	Operator	PaulSil
Source Data:	Nobel Energy	Date&Time:	29/05/2014 15:11

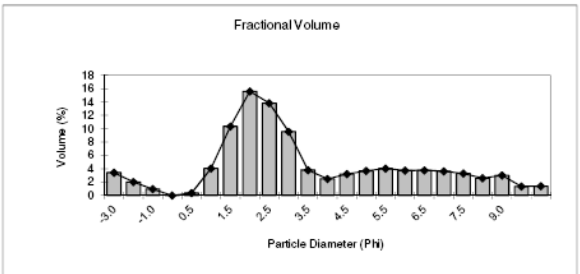


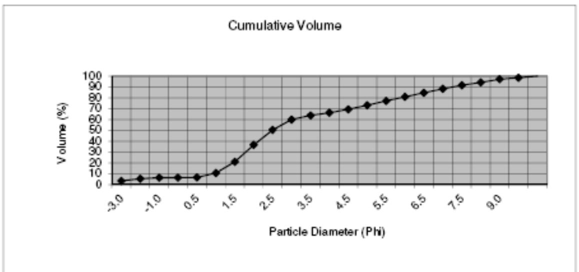


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	0.00	0.0	Pebble
4.000	-2.0	0.89	0.9	
2.000	-1.0	0.89	1.8	Granule
1.000	0.0	2.26	4.0	V.Coarse Sand
0.710	0.5	1.84	5.9	Coarse Sand
0.500	1.0	4.05	9.9	
0.355	1.5	7.97	17.9	Medium Sand
0.250	2.0	11.44	29.3	
0.180	2.5	10.44	39.8	Fine Sand
0.125	3.0	8.24	48.0	
0.900	3.5	4.72	52.7	V.Fine Sand
0.063	4.0	4.48	57.2	
0.044	4.5	5.27	62.5	Coarse Silt
0.032	5.0	5.25	67.7	
0.022	5.5	5.20	72.9	Medium Silt
0.016	6.0	4.45	77.4	
0.011	6.5	4.31	81.7	Fine silt
0.008	7.0	4.13	85.8	
0.006	7.5	3.83	89.7	V.Fine Silt
0.004	8.0	3.09	92.7	
0.002	9.0	3.68	96.4	Coarse Clay
0.001	10.0	1.68	98.1	Medium Clay
<0.001	>10.0	1.90	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.073	0.294	3.77
Median	0.110		3.18
Sorting	Value	Inference	
Coefficient	2.60	Very Poorly Sorted	
Skewness	0.31	Very Positive (Coarse)	
Kurtosis	0.86	Platykurtic	
% Fines	42.79%	V.Fine Sands	
% Sands	55.44%		
% Gravel	1.78%		

Sample No.:	A_306_ENV	Operator	PaulSil
Source Data:	Nobel Energy	Date&Time:	29/05/2014 15:00

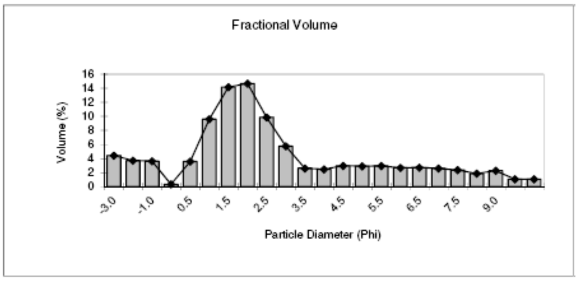


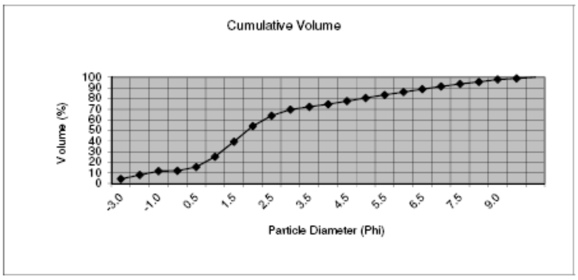


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	3.40	3.4	Pebble
4.000	-2.0	2.01	5.4	
2.000	-1.0	0.95	6.4	Granule
1.000	0.0	0.00	6.4	V.Coarse Sand
0.710	0.5	0.36	6.7	Coarse Sand
0.500	1.0	4.05	10.8	
0.355	1.5	10.33	21.1	Medium Sand
0.250	2.0	15.59	36.7	
0.180	2.5	13.83	50.5	Fine Sand
0.125	3.0	9.55	60.1	
0.900	3.5	3.80	63.9	V.Fine Sand
0.063	4.0	2.48	66.4	
0.044	4.5	3.20	69.6	Coarse Silt
0.032	5.0	3.69	73.2	
0.022	5.5	4.04	77.3	Medium Silt
0.016	6.0	3.73	81.0	
0.011	6.5	3.76	84.8	Fine silt
0.008	7.0	3.62	88.4	
0.006	7.5	3.29	91.7	V.Fine Silt
0.004	8.0	2.58	94.3	
0.002	9.0	3.00	97.3	Coarse Clay
0.001	10.0	1.34	98.6	Medium Clay
<0.001	>10.0	1.40	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.098	1.557	3.36
Median	0.183		2.45
Sorting	**Value**	**Inference**	
Coefficient	2.87	Very Poorly Sorted	
Skewness	0.31	Very Positive (Coarse)	
Kurtosis	1.19	Leptokurtic	
% Fines	33.65%	V.Fine Sands	
% Sands	59.99%		
% Gravel	6.36%		

Sample No.:	A_307_ENV	Operator	PaulSil
Source Data:	Nobel Energy	Date&Time:	29/05/2014 13:01

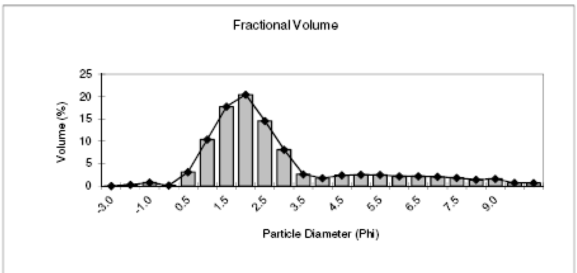


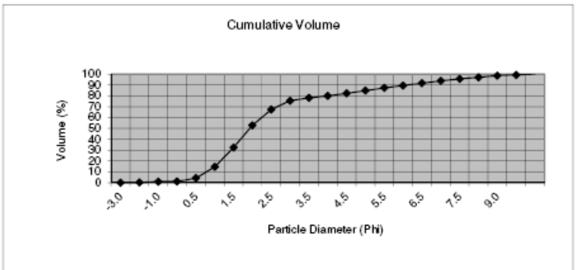


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	4.42	4.4	Pebble
4.000	-2.0	3.70	8.1	
2.000	-1.0	3.61	11.7	Granule
1.000	0.0	0.33	12.1	V.Coarse Sand
0.710	0.5	3.56	15.6	Coarse Sand
0.500	1.0	9.58	25.2	
0.355	1.5	14.15	39.4	Medium Sand
0.250	2.0	14.66	54.0	
0.180	2.5	9.85	63.9	Fine Sand
0.125	3.0	5.75	69.6	
0.900	3.5	2.60	72.2	V.Fine Sand
0.063	4.0	2.46	74.7	
0.044	4.5	2.96	77.6	Coarse Silt
0.032	5.0	2.90	80.5	
0.022	5.5	2.93	83.5	Medium Silt
0.016	6.0	2.67	86.1	
0.011	6.5	2.70	88.9	Fine silt
0.008	7.0	2.59	91.4	
0.006	7.5	2.34	93.8	V.Fine Silt
0.004	8.0	1.86	95.6	
0.002	9.0	2.25	97.9	Coarse Clay
0.001	10.0	1.06	98.9	Medium Clay
<0.001	>10.0	1.06	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.160	2.452	2.65
Median	0.279		1.84
Sorting	**Value**	**Inference**	
Coefficient	2.89	Very Poorly Sorted	
Skewness	0.30	Positive(Coarse)	
Kurtosis	1.44	Leptokurtic	
% Fines	25.32%	Fine Sand	
% Sands	62.95%		
% Gravel	11.73%		

Sample No.:	A-309-ENV	**Operator**	PaulSil
Source Data:	Nobel Energy	**Date&Time:**	29/05/2014 15:34



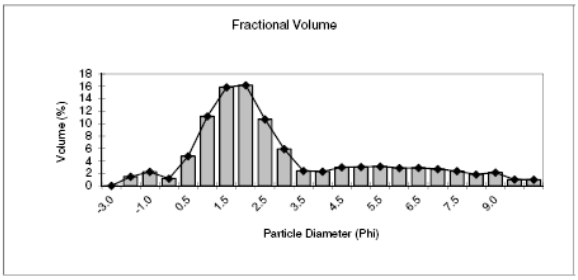


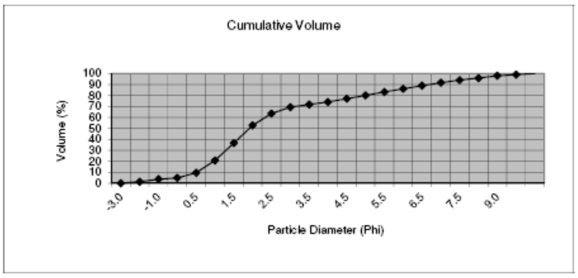
Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	0.00	0.0	Pebble
4.000	-2.0	0.26	0.3	
2.000	-1.0	0.79	1.0	Granule
1.000	0.0	0.13	1.2	V.Coarse Sand
0.710	0.5	3.13	4.3	Coarse Sand
0.500	1.0	10.40	14.7	
0.355	1.5	17.74	32.4	Medium Sand
0.250	2.0	20.43	52.9	
0.180	2.5	14.55	67.4	Fine Sand
0.125	3.0	8.12	75.5	
0.900	3.5	2.62	78.2	V.Fine Sand
0.063	4.0	1.77	79.9	
0.044	4.5	2.41	82.3	Coarse Silt
0.032	5.0	2.52	84.9	
0.022	5.5	2.48	87.4	Medium Silt
0.016	6.0	2.17	89.5	
0.011	6.5	2.18	91.7	Fine silt
0.008	7.0	2.07	93.8	
0.006	7.5	1.83	95.6	V.Fine Silt
0.004	8.0	1.40	97.0	
0.002	9.0	1.62	98.6	Coarse Clay
0.001	10.0	0.70	99.3	Medium Clay
<0.001	>10.0	0.68	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.167	0.265	2.58
Median	0.265		1.92

Sorting	Value	Inference
Coefficient	1.97	Poorly Sorted
Skewness	0.56	Very Positive (Coarse)
Kurtosis	1.65	Very Leptokurtic
% Fines	20.07%	Fine Sand
% Sands	78.89%	
% Gravel	1.05%	

Sample No.:	A_3010_ENV	**Operator**	PaulSil
Source Data:	Nobel Energy	**Date&Time:**	29/05/2014 13:56



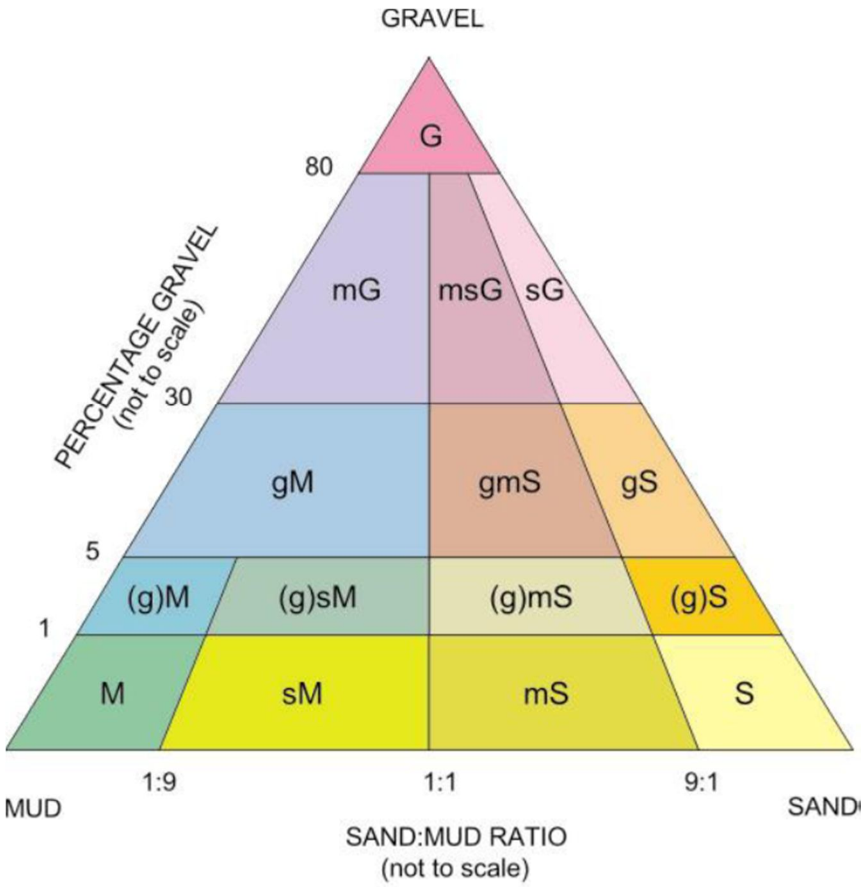


Aperture (µm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.000	-3.0	0.00	0.0	Pebble
4.000	-2.0	1.47	1.5	
2.000	-1.0	2.24	3.7	Granule
1.000	0.0	1.16	4.9	V.Coarse Sand
0.710	0.5	4.77	9.6	Coarse Sand
0.500	1.0	11.17	20.8	
0.355	1.5	15.85	36.7	Medium Sand
0.250	2.0	16.18	52.8	
0.180	2.5	10.69	63.5	Fine Sand
0.125	3.0	5.92	69.4	
0.900	3.5	2.39	71.8	V.Fine Sand
0.063	4.0	2.29	74.1	
0.044	4.5	2.99	77.1	Coarse Silt
0.032	5.0	3.03	80.1	
0.022	5.5	3.11	83.3	Medium Silt
0.016	6.0	2.86	86.1	
0.011	6.5	2.88	89.0	Fine silt
0.008	7.0	2.69	91.7	
0.006	7.5	2.37	94.1	V.Fine Silt
0.004	8.0	1.83	95.9	
0.002	9.0	2.15	98.0	Coarse Clay
0.001	10.0	1.00	99.0	Medium Clay
<0.001	>10.0	0.98	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.148	0.361	2.76
Median	0.268		1.90

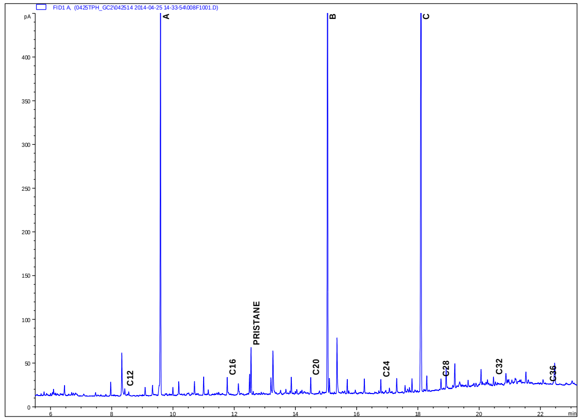
Sorting	Value	Inference
Coefficient	2.39	Very Poorly Sorted
Skewness	0.52	Very Positive (Coarse)
Kurtosis	1.05	Mesokurtic
% Fines	25.87%	Fine Sand
% Sands	70.42%	
% Gravel	3.71%	

Modified Folk classification

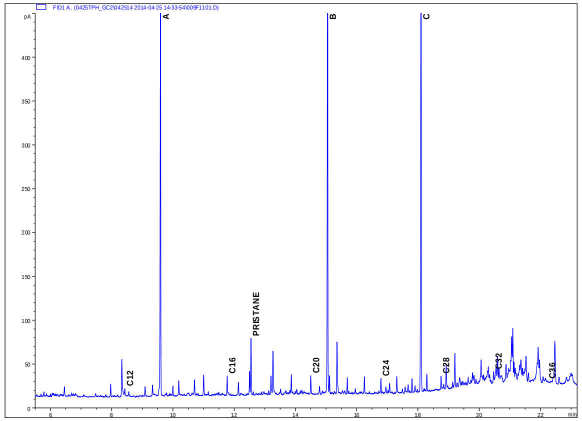


- M ______ Mud
- sM ______ Sandy mud
- (g)M ______ Slightly gravelly mud
- (g)sM ______ Slightly gravelly sandy mud
- gM ______ Gravelly mud
- S ______ Sand
- mS ______ Muddy sand
- (g)S ______ Slightly gravelly sand
- (g)mS ______ Slightly gravelly muddy sand
- gmS ______ Gravelly muddy sand
- gS ______ Gravelly sand
- G ______ Gravel
- mG ______ Muddy gravel
- msG ______ Muddy sandy gravel
- sG ______ Sandy gravel

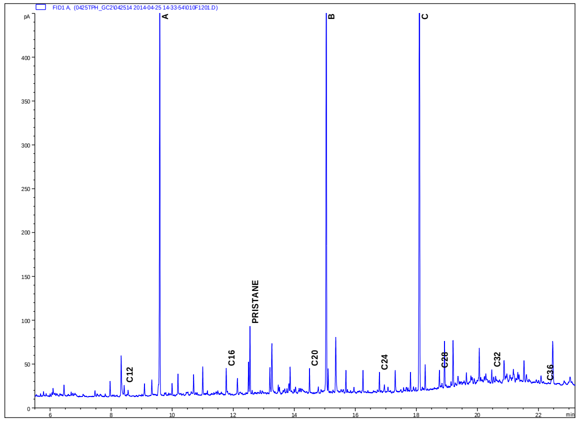
APPENDIX IV - GC-FID TRACES (SATURATES)



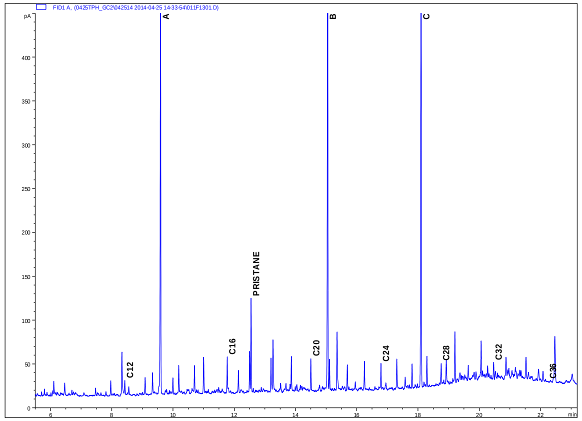
A/20/ENV



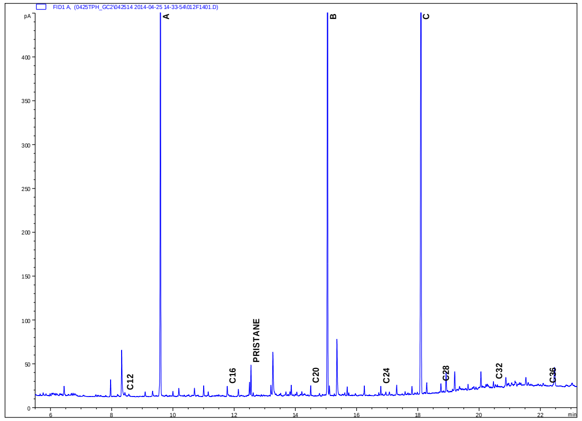
A/26/ENV



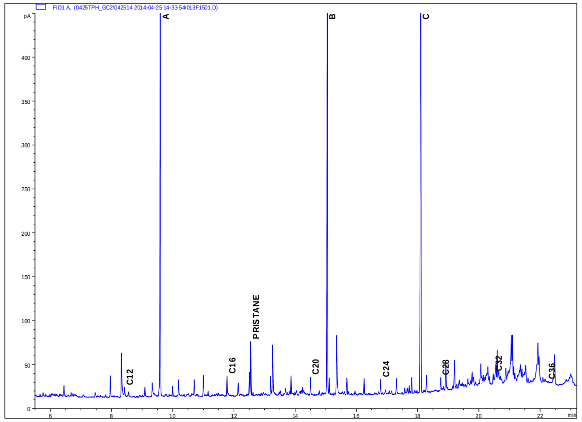
A/27/ENV



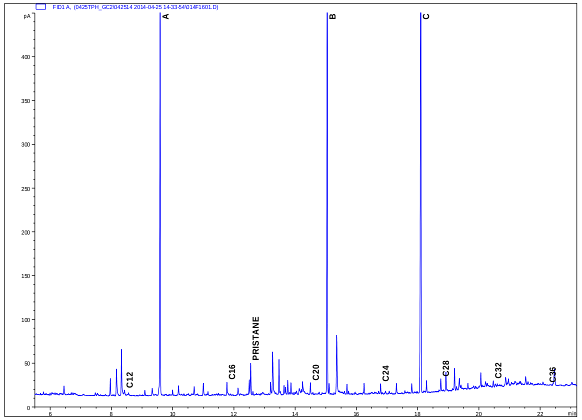
A/3/ENV



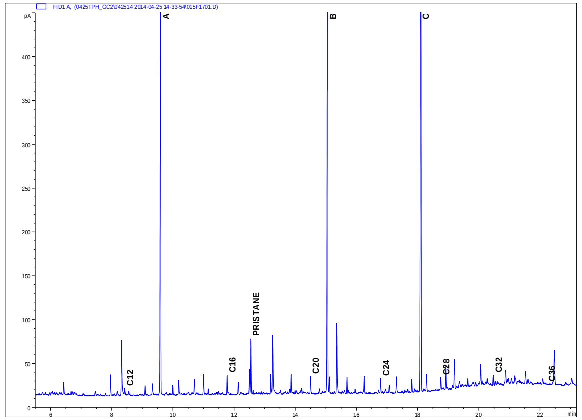
A/301/ENV



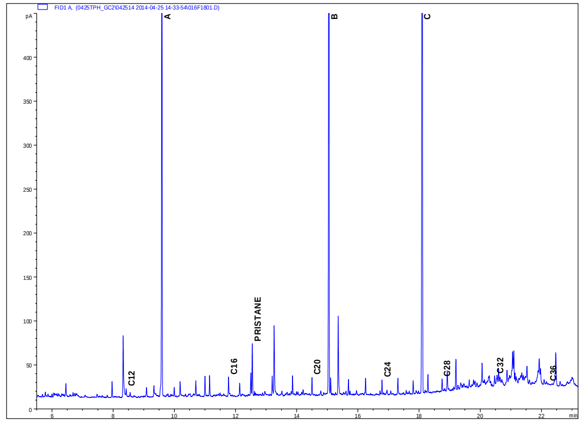
A/302/ENV



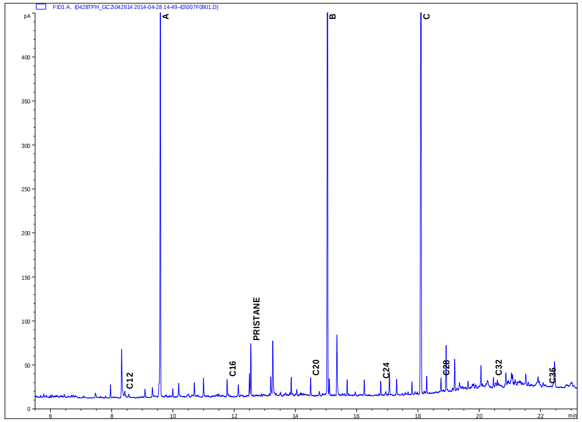
A/303/ENV



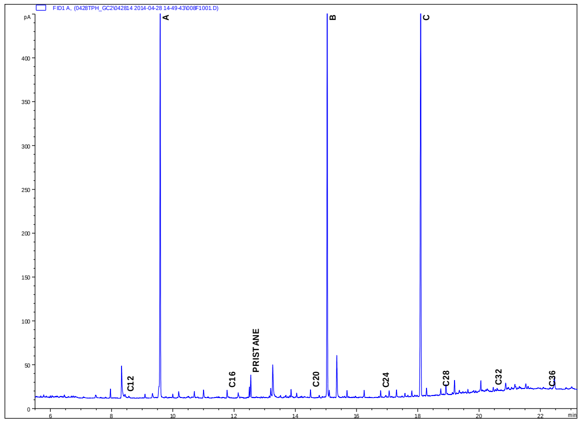
A/304/ENV



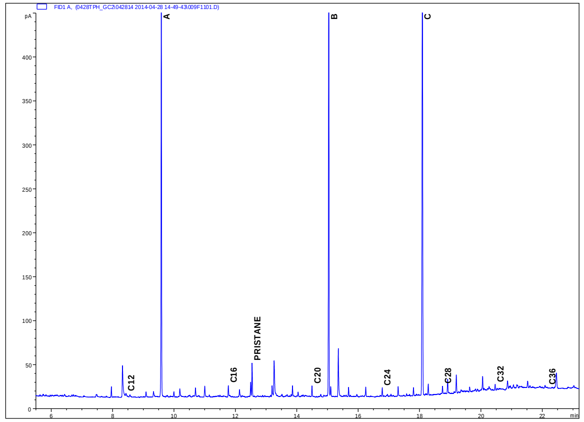
A/9/ENV



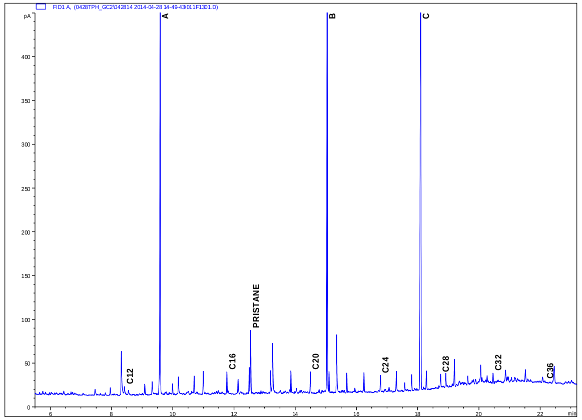
A/14/ENV



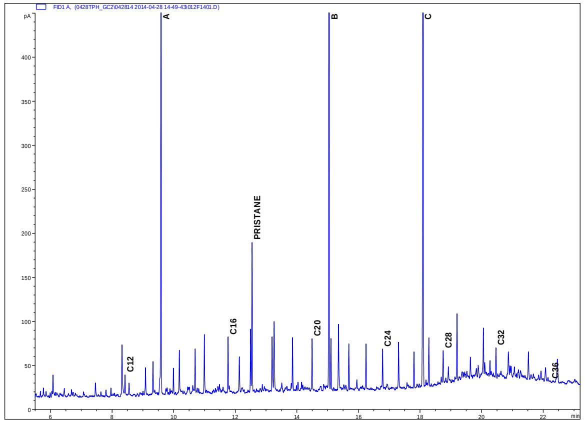
A/1011/ENV



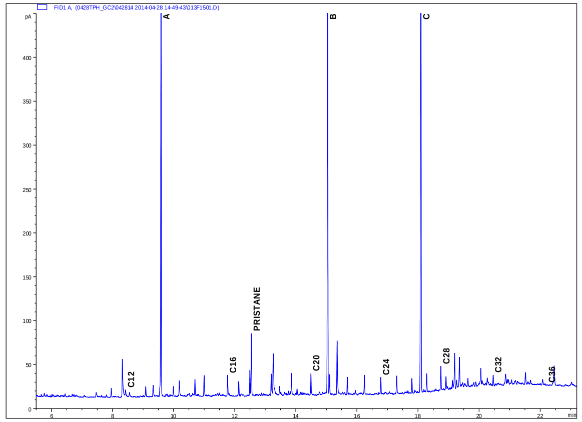
A/306/ENV



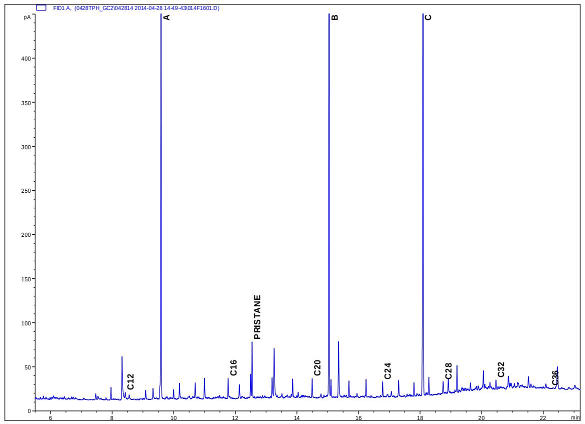
A/3010/ENV



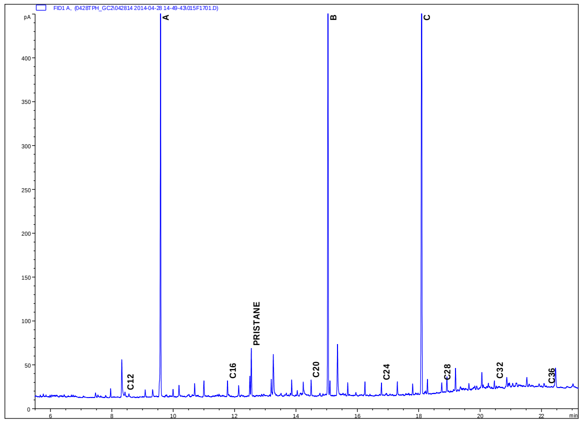
A/204/ENV



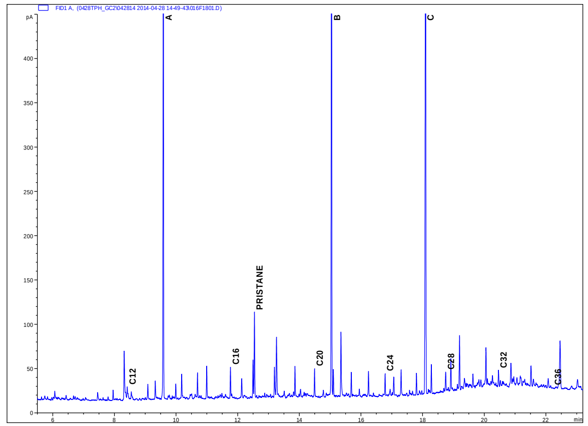
A/22/ENV



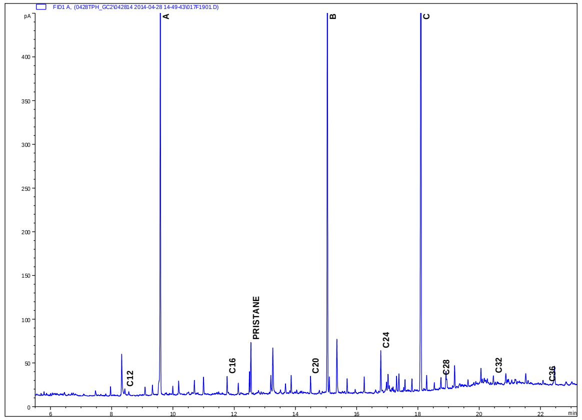
A/309/ENV



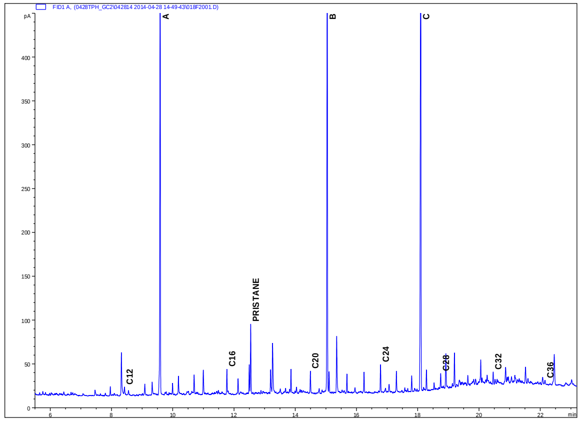
A/1008/ENV



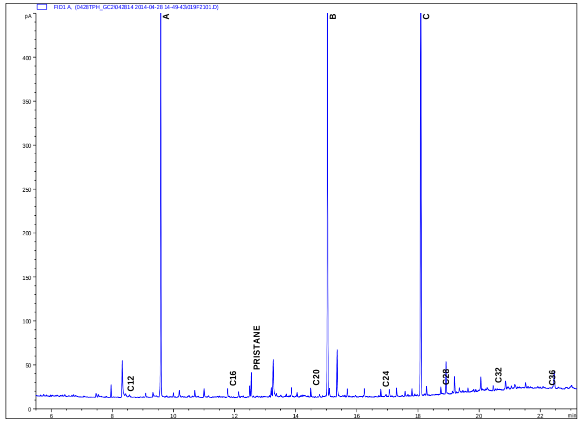
A/1015/ENV



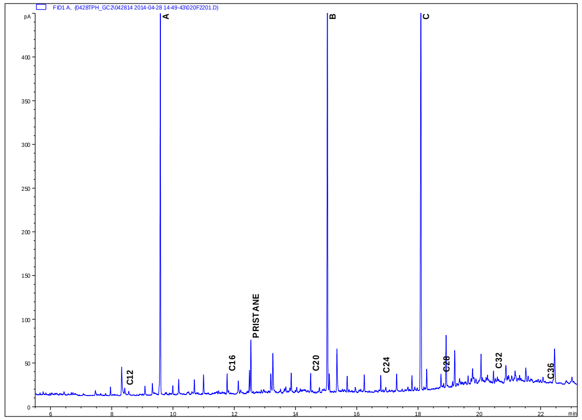
A/307/ENV



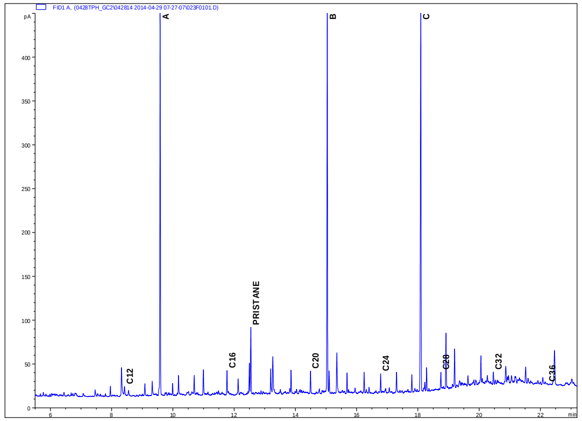
A/18/ENV



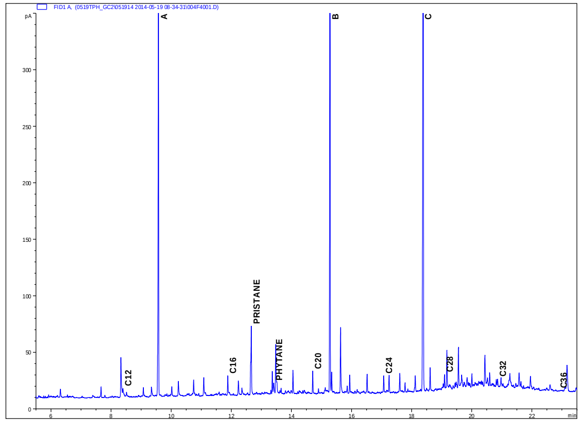
A/202/ENV



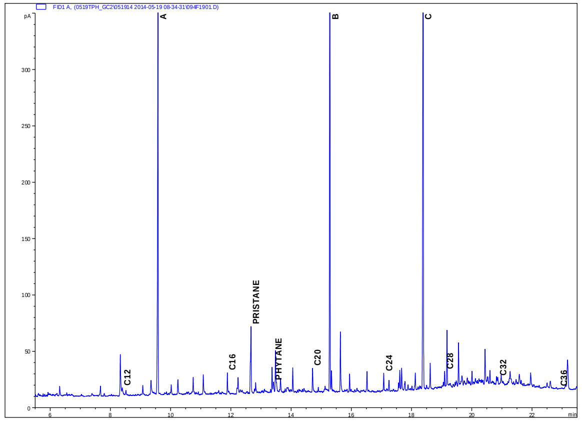
A/1013/ENV



A/10/ENV



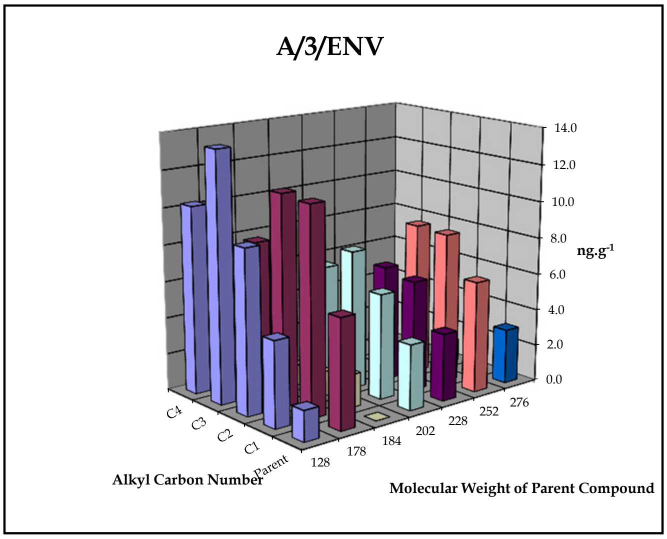
A/21/ENV

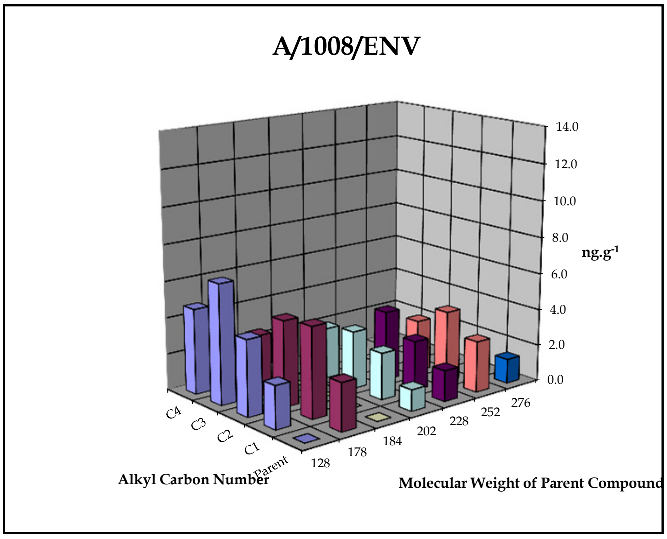

FID1 A, (0519TPH_GC2\051914 2014-05-19 08-34-31\094F1901.D)
pA
A
B
C
PRISTANE
PHYTANE
C12
C16
C20
C24
C28
C32
C36
min

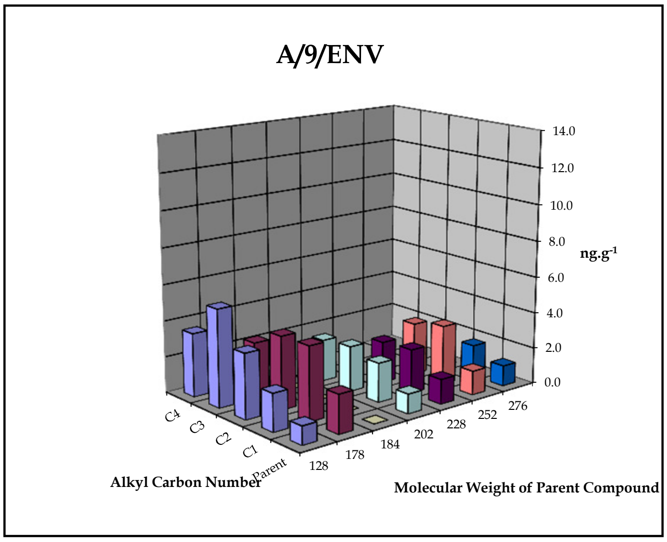
A/305/ENV

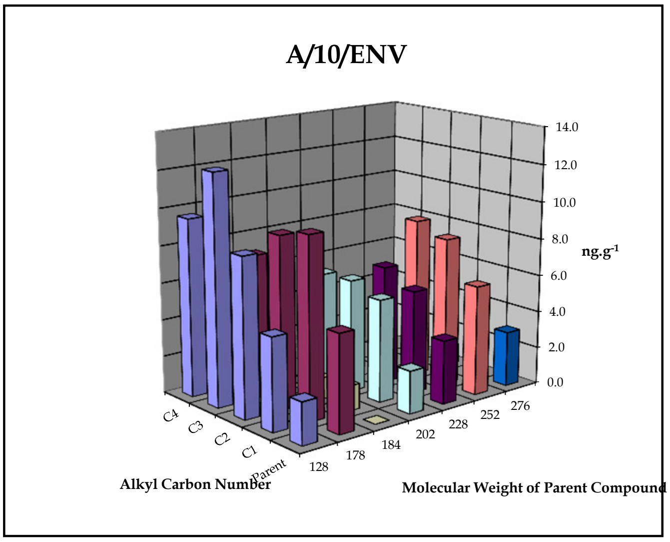
APPENDIX V - POLYCYCLIC AROMATIC HYDROCARBONS

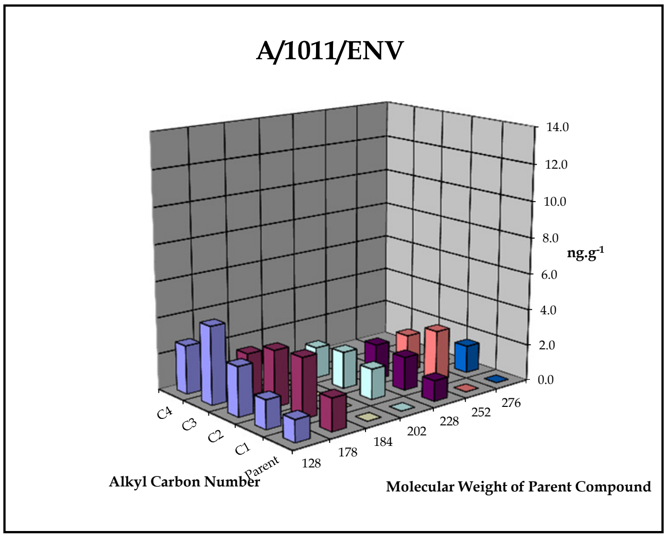
Polycyclic Aromatic Hydrocarbons - Parent and Alkylated Compounds

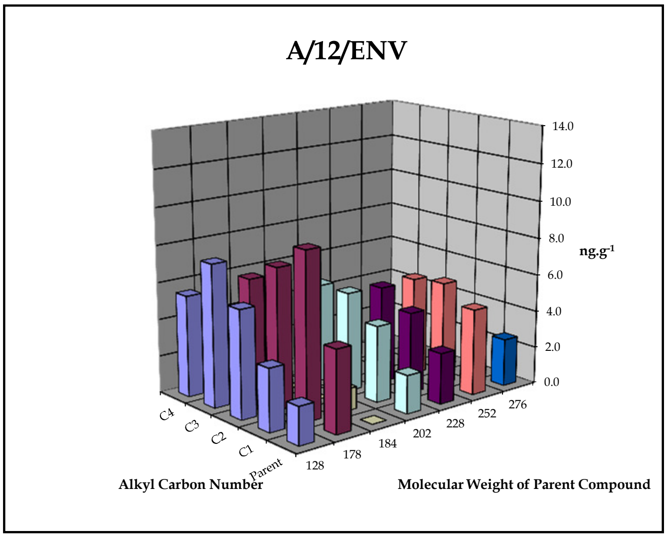






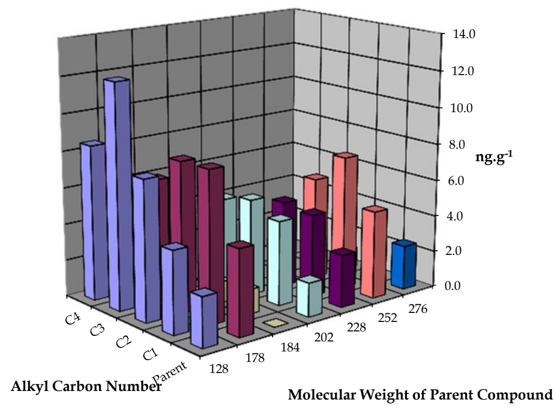




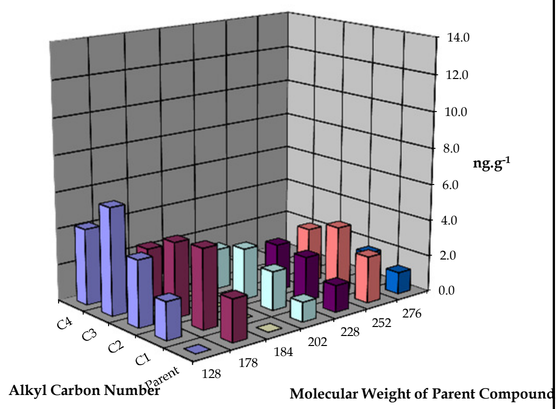


Polycyclic Aromatic Hydrocarbons - Parent and Alkylated Compounds

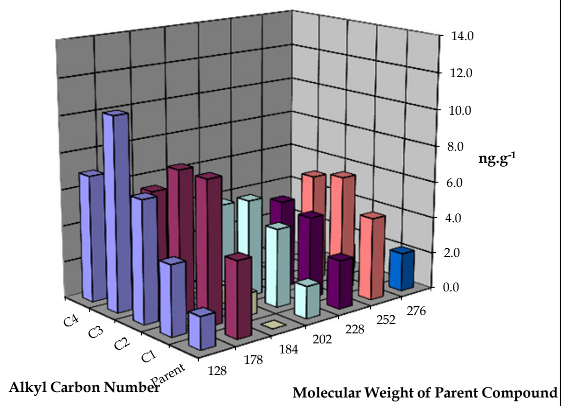
A/1013/ENV



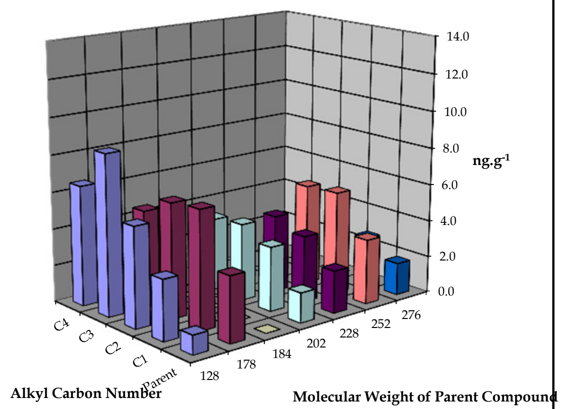
A/14/ENV



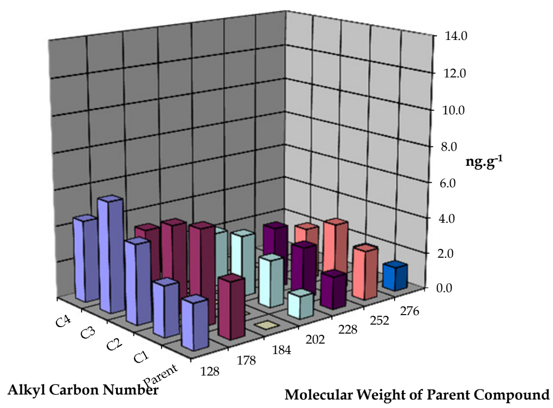
A/1015/ENV



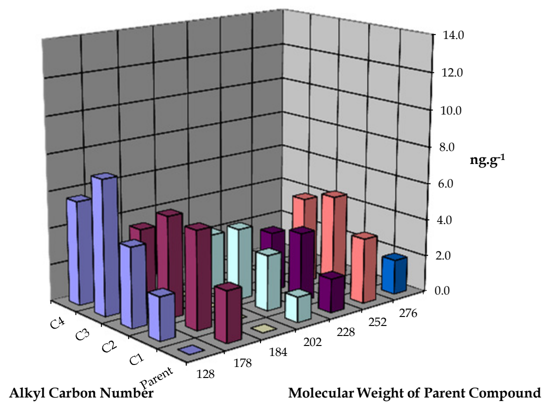
A/18/ENV



A/20/ENV

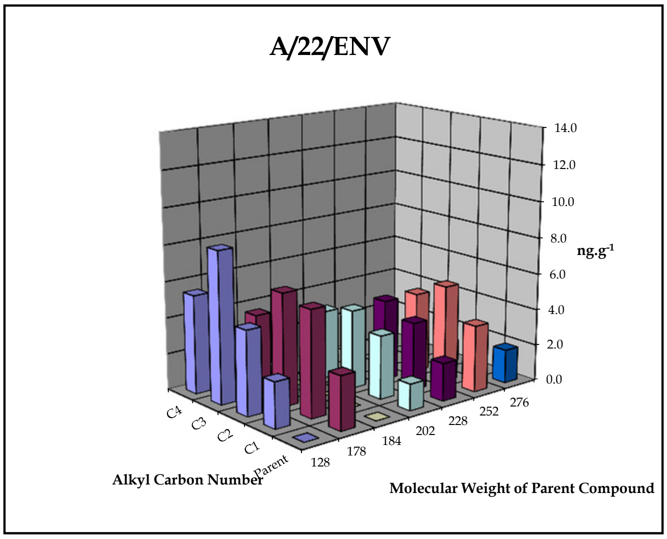


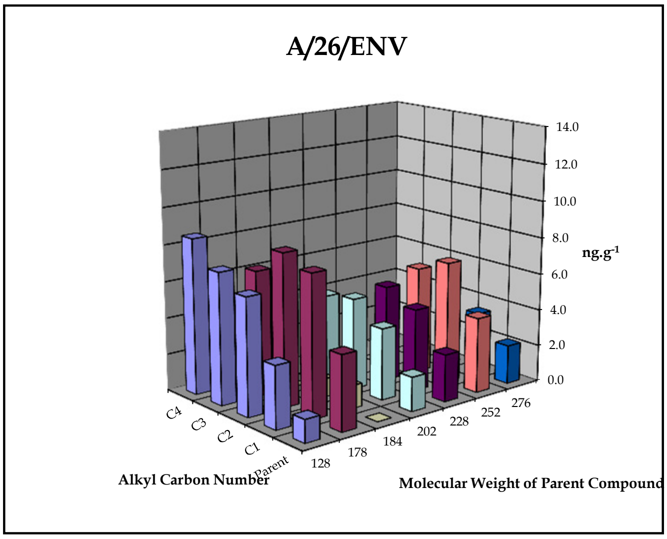
A/21/ENV

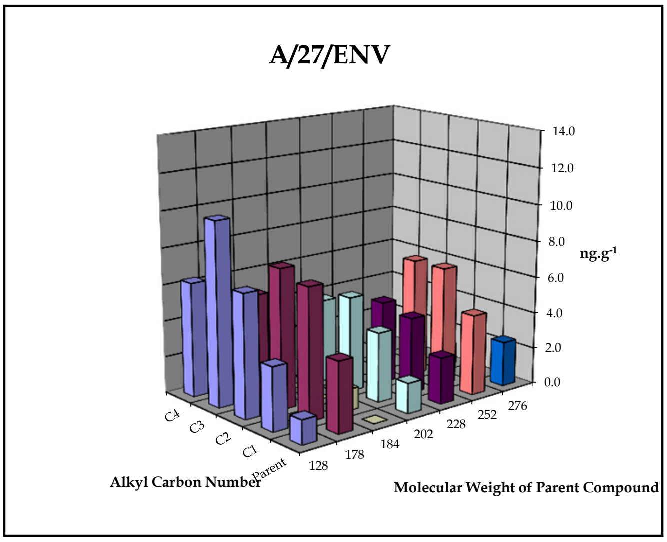


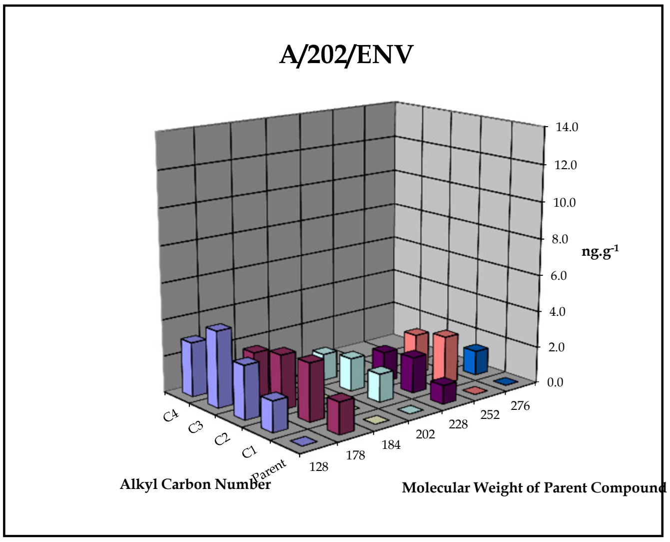
Benthic Solutions

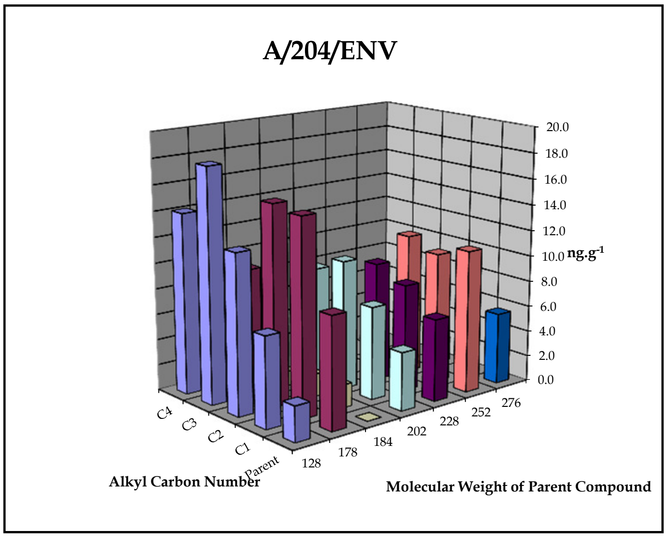
Polycyclic Aromatic Hydrocarbons - Parent and Alkylated Compounds

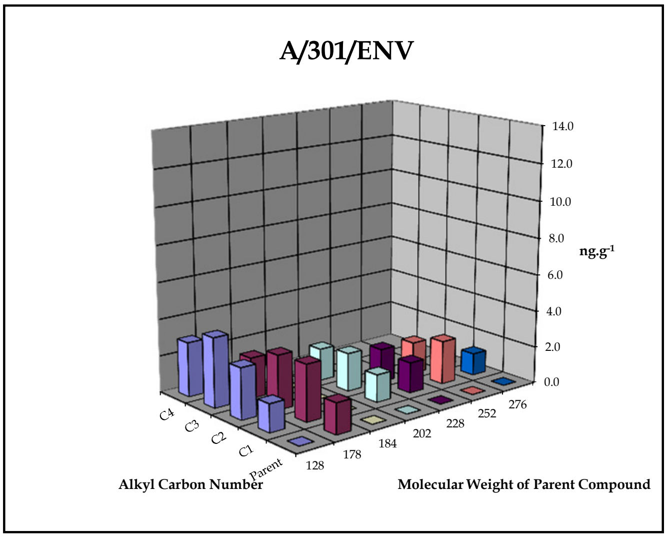




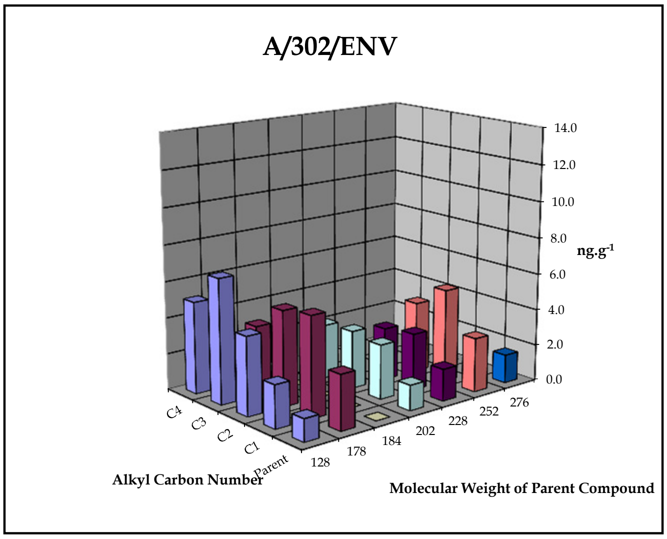


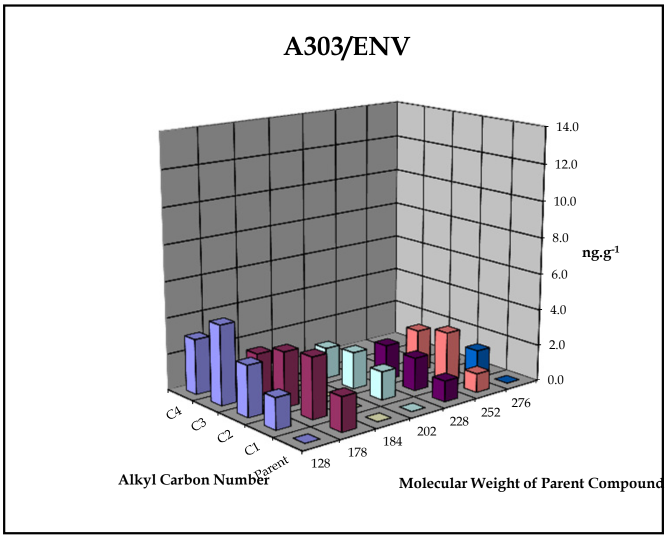


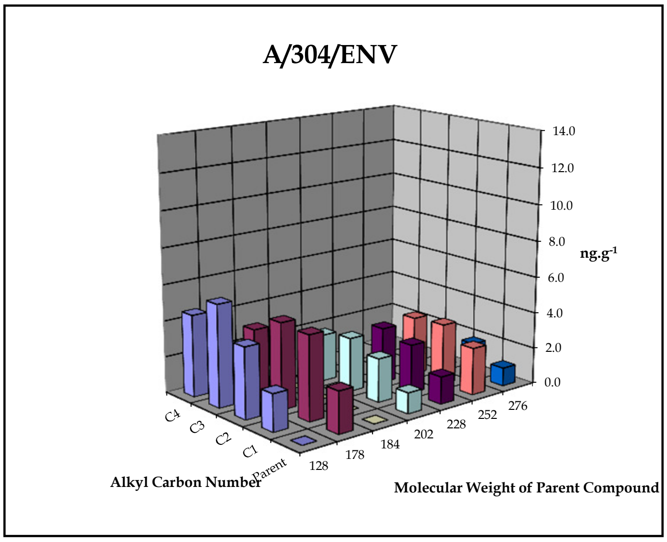


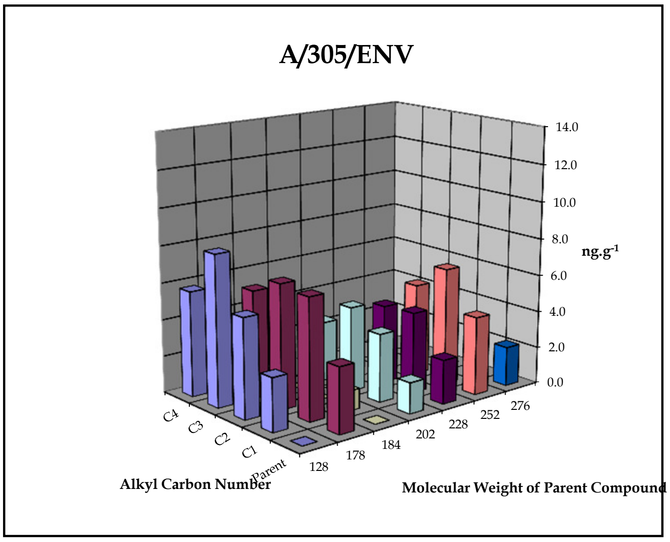


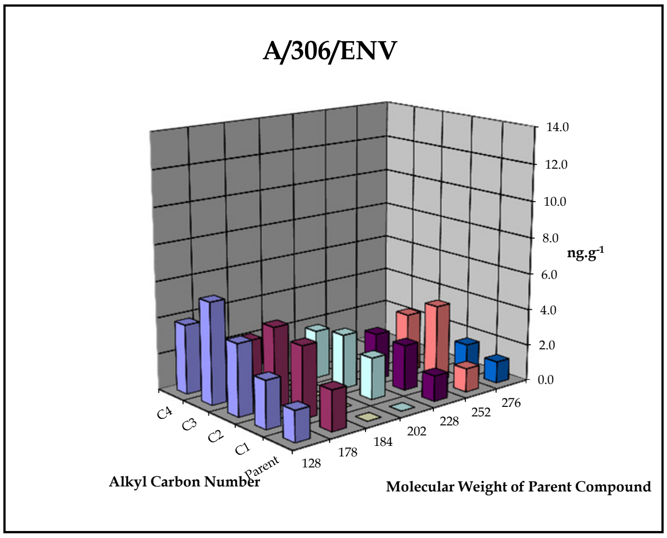
Polycyclic Aromatic Hydrocarbons - Parent and Alkylated Compounds

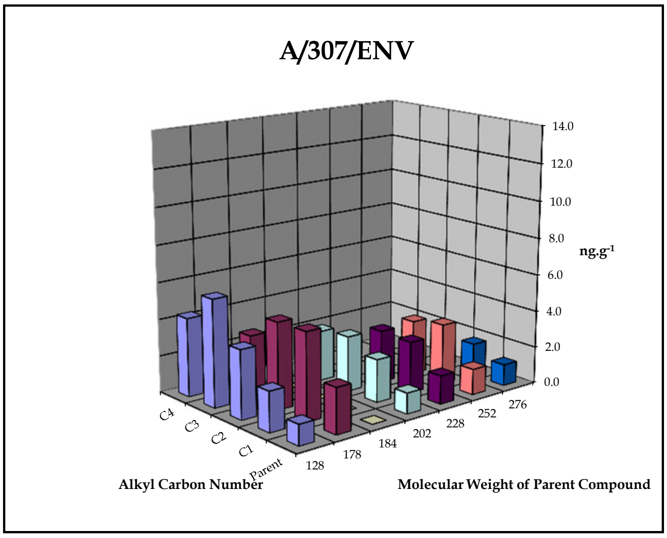






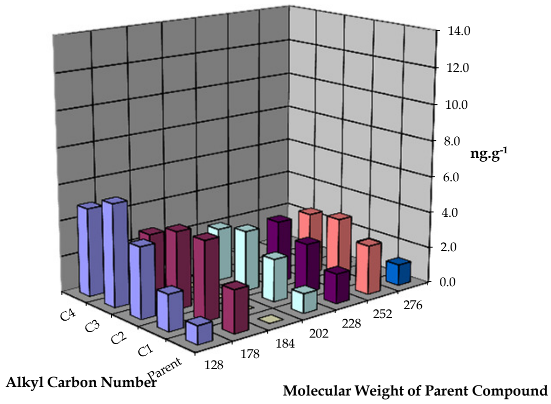




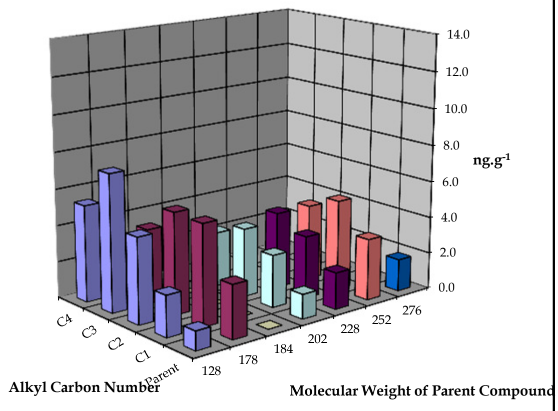


Polycyclic Aromatic Hydrocarbons - Parent and Alkylated Compounds

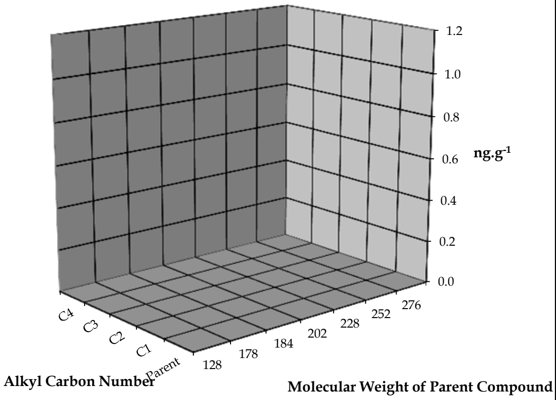
A/309/ENV



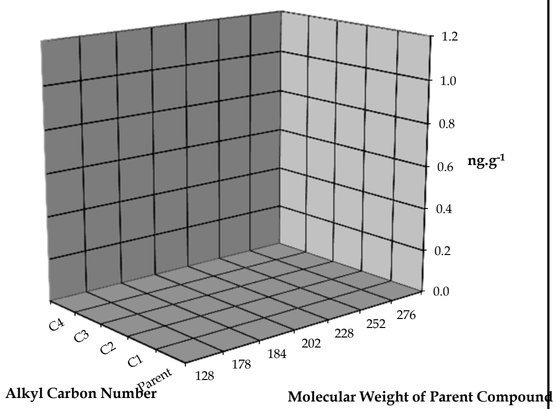
A/3010/ENV



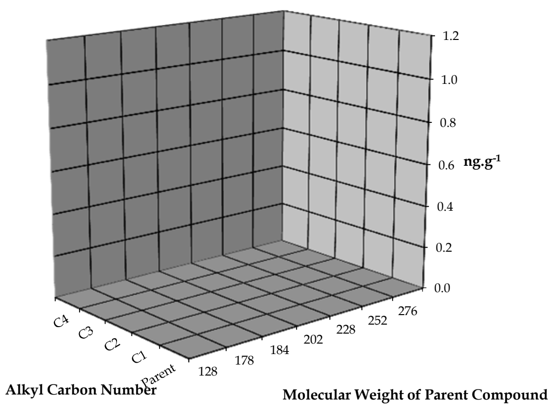
0



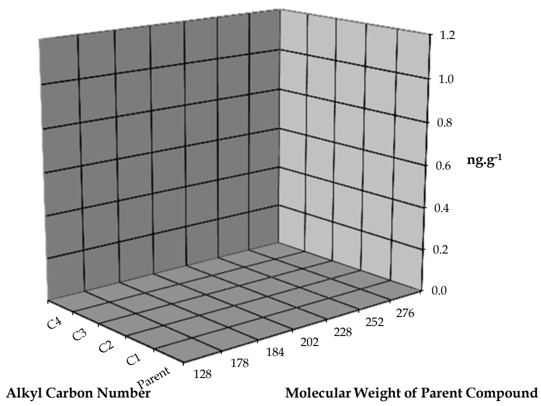
0



0



0



Polyaromatic Hydrocarbon Concentrations (ng/g dry weight basis) EPA 16 PAHs

PAH Fraction	# PAH	Station : Mass	A/3/ENV	A/1008/EN	A/9/ENV	A/10/ENV	A/1011/ENV	A/12/EN	A/1013/EN	A/14/EN	A/1015/EN	A/18/EN	A/20/EN
Naphthalene	1	128	1.7	<1	1.0	2.3	1.2	2.0	2.7	<1	1.8	1.0	2.5
C1 Naphthalenes		142	4.7	2.3	2.1	5.0	1.6	3.4	4.5	2.1	3.8	3.3	2.7
C2 Naphthalenes		156	8.9	4.2	3.6	8.6	2.7	5.8	7.6	3.7	6.7	5.4	4.3
C3 Naphthalenes		170	13.6	6.6	5.4	12.4	4.3	7.7	12.2	5.9	10.6	8.7	6.1
C4 Naphthalenes		184	10.2	4.7	3.5	9.6	2.7	5.5	8.5	4.2	6.9	6.5	4.5
Sum Naphthalenes			39	18	16	38	13	24	36	16	30	25	20
Phenanthrene / Anthracene	2	178	5.9	2.6	2.1	5.2	1.8	4.4	4.7	2.3	4.1	3.5	3.1
C1 178		192	11	5	4	10	3	9	8	4	8	6	5
C2 178		206	11	5	4	9	3	8	8	4	8	6	5
C3 178		220	8	3	3	8	2	6	7	3	6	5	4
Sum 178			37	16	13	32	11	27	28	14	26	21	17
Dibenzthiophene		184	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
C1 Dibenzthiophenes		198	2	<1	<1	1	<1	1	1	<1	1	<1	<1
C2 Dibenzthiophenes		212	1	<1	<1	1	<1	<1	1	<1	1	<1	<1
C3 Dibenzthiophenes		226	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Sum Dibenzthiophenes			4	0	0	3	0	1	3	0	2	0	0
Fluoranthene / pyrene	2	202	4	1	1	2	<1	2	2	1	2	2	1
C1 202		216	6	3	2	6	2	4	5	2	4	4	3
C2 202		230	8	3	3	6	2	5	5	3	5	4	3
C3 202		244	6	3	2	6	2	5	5	2	5	4	3
Sum 202			23	10	8	20	5	17	17	8	16	13	10
Benzanthracene / chrysene	2	228	4	2	1	3	1	3	3	1	3	2	2
C1 228		242	6	3	2	6	2	4	5	2	4	4	3
C2 228		256	6	4	2	6	2	5	5	3	5	4	3
Sum 228			16	8	6	15	5	12	12	7	12	10	8
Benzfluoranthenes /	3	252	6	3	1	6	<1	5	5	3	5	4	3
C1 252		266	8	4	3	8	3	6	7	4	6	6	4
C2 252		280	8	3	3	9	2	5	6	3	6	5	3
Sum 252			23	10	8	23	5	16	18	9	17	15	9
Aranthanthrenes /	3	276	3	1	1	3	<1	3	2	1	2	2	1
C1 276		290	1	2	2	4	2	3	3	2	3	3	2
C2 276		304	1	<1	<1	1	<1	<1	1	<1	1	<1	<1
Sum 276			5	3	3	8	2	5	7	3	6	4	3
Sum of all fractions			147	64	54	138	40	103	119	57	109	89	68
Sum of NPD fraction			80	33	29	72	23	53	66	30	58	46	37
NPD / 4-6 ring PAH ratio			1.20	1.09	1.18	1.10	1.37	1.06	1.24	1.10	1.14	1.09	1.22

Polyaromatic Hydrocarbon Concentrations (ng/g dry weight basis) EPA 16 PAHs

		Station :	A/21/ENV	A/22/ENV	A/26/EN	A/27/ENV	A/202/EN	A/204/ENV	A/301/EN	A/302/EN	A303/EN	A/304/EN
PAH Fraction	***# PAH***	***Mass***										
Naphthalene	1	128	<1	<1	1.2	1.3	<1	2.7	<1	1.2	<1	<1
C1 Naphthalenes		142	2.3	2.5	3.4	3.5	1.7	7.0	1.5	2.4	1.7	2.1
C2 Naphthalenes		156	4.3	4.6	6.4	6.7	2.9	12.4	2.8	4.3	2.8	3.9
C3 Naphthalenes		170	7.3	8.3	7.2	10.1	4.2	18.1	3.8	6.9	4.4	5.7
C4 Naphthalenes		184	5.7	5.4	8.5	6.3	3.0	14.1	3.0	5.1	3.1	4.5
Sum Naphthalenes			20	21	27	28	12	54	11	20	12	16
Phenanthrene / Anthracene	2	178	2.7	2.9	4.1	3.8	1.7	8.6	1.7	3.0	1.9	2.3
C1 178		192	5	6	8	7	3	15	3	6	3	5
C2 178		206	5	6	8	8	3	15	3	5	3	5
C3 178		220	4	4	7	6	3	10	2	4	2	4
Sum 178			18	19	27	24	10	49	10	18	11	16
Dibenzthiophene		184	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
C1 Dibenzthiophenes		198	<1	<1	1	1	<1	2	<1	<1	<1	<1
C2 Dibenzthiophenes		212	<1	<1	1	<1	<1	2	<1	<1	<1	<1
C3 Dibenzthiophenes		226	<1	<1	<1	<1	<1	1	<1	<1	<1	<1
Sum Dibenzthiophenes			0	0	2	1	0	5	0	0	0	0
Fluoranthene / pyrene	2	202	1	1	2	2	<1	5	<1	1	<1	1
C1 202		216	3	3	4	4	2	7	2	3	2	2
C2 202		230	4	4	5	5	2	10	2	3	2	3
C3 202		244	3	4	5	5	1	9	2	3	2	3
Sum 202			11	13	15	15	5	31	5	11	5	9
Benzanthracene / chrysene	2	228	2	2	3	3	1	6	<1	2	1	2
C1 228		242	4	4	4	4	2	8	2	3	2	3
C2 228		256	3	4	5	5	2	9	2	3	2	3
Sum 228			9	10	12	11	5	24	3	8	5	7
Benzfluoranthenes /	3	252	4	4	4	4	<1	11	<1	3	1	3
C1 252		266	5	5	7	7	3	10	2	5	3	3
C2 252		280	5	4	6	6	2	11	2	4	2	3
Sum 252			14	13	17	17	5	32	4	12	6	9
Aranthanthrenes /	3	276	2	2	2	2	<1	6	<1	2	<1	1
C1 276		290	2	2	3	3	1	5	1	2	1	2
C2 276		304	<1	1	<1	1	<1	2	<1	<1	<1	<1
Sum 276			4	5	6	7	1	13	1	3	1	3
Sum of all fractions			75	82	106	104	38	208	35	71	40	60
Sum of NPD fraction			37	40	56	53	22	108	21	37	23	32
NPD / 4-6 ring PAH ratio			0.99	0.96	1.12	1.06	1.42	1.09	1.49	1.12	1.28	1.11

Polyaromatic Hydrocarbon Concentrations (ng/g dry weight basis) EPA 16 PAHs

PAH Fraction	# PAH	Station : Mass	A/305/EN	A/306/EN	A/307/EN	A/309/EN	A/3010/EN
Naphthalene	1	128	<1	1.7	1.1	1.0	1.0
C1 Naphthalenes		142	2.9	2.6	2.2	2.0	2.2
C2 Naphthalenes		156	5.4	3.9	3.7	3.9	4.7
C3 Naphthalenes		170	8.2	5.6	5.8	5.7	7.5
C4 Naphthalenes		184	5.7	3.8	4.3	4.9	5.3
Sum Naphthalenes			22	18	17	17	21
Phenanthrene / Anthracene	2	178	3.5	2.2	2.5	2.3	2.9
C1 178		192	7	4	5	4	6
C2 178		206	7	4	5	4	6
C3 178		220	6	3	3	4	4
Sum 178			23	14	15	14	18
Dibenzthiophene		184	<1	<1	<1	<1	<1
C1 Dibenzthiophenes		198	1	<1	<1	<1	<1
C2 Dibenzthiophenes		212	<1	<1	<1	<1	<1
C3 Dibenzthiophenes		226	<1	<1	<1	<1	<1
Sum Dibenzthiophenes			1	0	0	0	0
Fluoranthene / pyrene	2	202	2	<1	1	1	1
C1 202		216	4	2	2	2	3
C2 202		230	5	3	3	3	4
C3 202		244	3	3	3	3	3
Sum 202			13	8	9	10	11
Benzanthracene / chrysene	2	228	2	1	2	2	2
C1 228		242	4	3	3	3	3
C2 228		256	4	3	3	3	4
Sum 228			11	6	7	8	10
Benzfluoranthenes /	3	252	4	1	1	3	3
C1 252		266	6	4	3	4	5
C2 252		280	5	3	3	3	4
Sum 252			16	9	8	10	13
Aranthanthrenes /	3	276	2	1	1	1	2
C1 276		290	3	2	2	2	2
C2 276		304	<1	<1	<1	<1	<1
Sum 276			5	3	3	3	4
Sum of all fractions			91	57	59	62	76
Sum of NPD fraction			46	31	33	32	39
NPD / 4-6 ring PAH ratio			1.02	1.20	1.21	1.06	1.04

APPENDIX VI - SAMPLING LOG SHEETS

Seabed Sampling (Deck Observations)

Job No:		BSL 1334		Operator:	BSL	Vessel:	MV Poseidon		Client:	Noble Energy Inc	
Date:	from: to:		31/12/13 16/03/14			Project:		FISA			
Sample Number	Station	Sampler Used	Water Depth (m)	Time (UTC)	Date	Volume	Sample Name	Comments	Sediment Colour	Sediment Description	Conspicuous Fauna/Comments
1	A/208/ENV	CAM	1206	09:47	31/12/2013	-	-	Time on overlay in local time (UTC -3h). Sonar cable coiled around camera frame, recovered to deck and switched top secondary winch.	-	-	-
2	A/208/ENV	CAM	1200	13:45	31/12/2013	-	-	Re-attempting previous camera location.	-	Fine sand and gravel.	White Branching bryozoan, dog whelk, holothurian, *Munida*, ophiuroids, Porifera, *Flustra*, Asteroidea, Anthozoa, pennatulids, annelids and Octocorallia.
3	A/09/ENV	CAM	1260	23:15	31/12/2013	-	-	-	-	Fine sand and gravel.	Pennatulids, cup coral, large isopod (possibly *Acanthoserolis schythei*), soft coral and large burrows.
4	A/10/ENV	CAM	1261	02:50	01/01/2014	-	-	Failed to locate beacon signal - recovered to deck.	-	-	-
5	A/10/ENV	CAM	1261	03:10	01/01/2014	-	-	Re-attempt of A/10/ENV - voltage leak - recovering - Two severed cables found and replaced (possibly severed by bridle shackles) - soft tow connection on dynema also broken by swell.	-	-	-
6	A/20/ENV	CAM	1350	04:55	03/01/2014	-	-	Failed deployment attempt due to weather/sea-state.	-	-	-
7	A/20/ENV	CAM	1350	07:16	03/01/2014	-	-	Re-attempt of A/20/ENV.	-	-	-
8	A/20/ENV	DVV	1350	11:44	03/01/2014	35%	FB	N/S on one side and small amount recovered on the other.	-	-	-
9	A/20/ENV	DVV	1350	12:30	03/01/2014	N/S	N/S	Re-attempt of A/20/ENV DVV.	-	-	-
10	A/20/ENV	DVV	1350	14:00	03/01/2014	70%	FA, PC (Supplementary FB)	Re-attempt of A/20/ENV DVV.	-	-	FB is supplementary fauna left from PC sample - Do not process first, - FA and FC should be proceed.
11	A/203/ENV	CAM	1321	16:17	03/01/2014	-	-	Attempt aborted due to cable twisting.	-	-	-
12	A/203/ENV	CAM	1321	18:30	03/01/2014	-	-	Re-attempt of A/203/ENV (No DVV).	-	-	-
13	A/1015/ENV	CAM	1362	22:40	03/01/2014	-	-	Cable issues, attempt aborted.	-	-	-
14	A/09/ENV	DVV	1260	06:30	04/01/2014	N/S	N/S	Failed attempt - no sample	-	-	-

Seabed Sampling (Deck Observations)

Job No:		**BSL 1334**		**Operator:**	**BSL**	**Vessel:**	**MV Poseidon**		**Client:**	**Noble Energy Inc**	
Date:	from: to:		**31/12/13** **16/03/14**			**Project:**		**FISA**			
								recovered.			
15	A/09/ENV	DVV	1260	07:35	04/01/2014	70%	FA, PC	Re-attempt - successful FA and PC.	Yellow brown, coarse black dusting on surface.	Fine sand and gravel.	Coarse dusting of black sediment over hard compact fine sand with gravel.
16	A/09/ENV	DVV	1260	08:50	04/01/2014	N/S	N/S	FB and FC failed attempt - no sample recovered.	-	-	
17	A/09/ENV	DVV	1260	10:45	04/01/2014	N/S	N/S	Failed attempt - no sample recovered.	-	-	
18	A/10/ENV	CAM	1261	13:00	04/01/2014	-	-	No beacon detected at 90m, recovered to deck.	-	-	
19	A/10/ENV	CAM	1261	13:30	04/01/2014	-	-	Re-attempt – successful.	-	-	
20	A/10/ENV	DVV	1261	16:20	04/01/2014	85%	FA, PC	-	Olive brown with speckled grey (sand).	Fine/medium sand with some small gravel.	Cup coral, ophiuroid, polychaetes, possible Foraminifera
21	A/10/ENV	DVV	1261	17:30	04/01/2014	80%	FB, FC	-	Olive brown	Fine/medium sand with some small gravel.	Bryozoan and tubeworms.
22	A/12/ENV	CAM	1280	19:20	04/01/2014	-	-	-	-	-	-
23	A/12/ENV	DVV	1280	22:00	04/01/2014	40%	FA, FC	FA and FC samples gained.	Olive brown with speckled grey (Sand)	-	Cup coral, calcareous bryozoans and polychaetes.
24	A/12/ENV	DVV	1280	23:00	04/01/2014	N/S	N/S	Re-deployed for PC samples – failed.	-	-	-
25	A/12/ENV	DVV	1280	00:30	05/01/2014	N/S	N/S	Re-deployed for PC samples – failed.	-	-	-
26	A/26/ENV	CAM	1260	02:03	05/01/2014	-	-	No beacon detected at 50m, recovered to deck.	-	-	-
27	A/26/ENV	CAM	1260	03:20	05/01/2014	-	-	Beacon dropping in and out fixes taken when it comes in.	Cream with dark flecks.	Compact medium sand with some coarse sediment and drop stones.	Bryozoan, encrusting sponge and worm tubes.
28	A/26/ENV	DVV	1260	05:27	05/01/2014	70%	FA, FC	Beacon secured to cable 500m from grab to negate dropping out.	Cream with dark flecks.	Compact fine sands with mixed pebbles and cobbles.	-
29	A/26/ENV	DVV	1260	06:45	05/01/2014	60%	PC, FB	Beacon replaced on grab - one large cobble in FB - no epifauna so pics then removed.	Cream with dark flecks.	Compact fine sands with mixed pebbles and cobbles.	-
30	A/207/ENV	CAM	1250	09:40	05/01/2014	-	-	Transect north of original.	-	Compact sands with mixed pebbles and cobbles. Larger dropstones with encrusting, sponges and soft coral.	-

Seabed Sampling (Deck Observations)											
Job No:		**BSL 1334**		**Operator:**	**BSL**	**Vessel:**	**MV Poseidon**		**Client:**	**Noble Energy Inc**	
Date:	from: to:		**31/12/13** **16/03/14**			**Project:**		**FISA**			
31	A/1011/ENV	CAM	1315	11:07	05/01/2014	-	-	N/S	-	-	-
32	A/1011/ENV	DVV	1315	14:30	05/01/2014	N/S	N/S	N/S, down on weather.	-	-	-
33	A/304/ENV	CAM	1250	14:40	08/01/2014	-	-	-	-	-	-
34	A/304/ENV	DVV	1250	17:44	08/01/2014	80%	PC, FC	PC and FC samples gained.	Cream with dark flecks.	Fine to medium sand with occasional fine gravel.	Scaphopoda tusk shell, polychaetes, worm tubes and pycnogonid.
35	A/304/ENV	DVV	1250	18:59	08/01/2014	N/S	N/S	N/S	-	-	-
36	A/304/ENV	DVV	1250	20:03	08/01/2014	80%	FA/FB	FA and FB samples gained.	Cream with dark flecks.	Fine to medium sand with occasional fine gravel.	Scaphopoda tusk shell, polychaete, worm tubes, urchin, ophiuroid and bivalve shells.
37	A/301/ENV	CAM	1250	23:05	08/01/2014	-	-	Coral garden and concretion. Cable re-term.	-	-	-
38	A/301/ENV	DVV	1250	01:50	09/01/2014	70%	FC/PC	FC slightly washed out.	Cream with dark flecks.	Darker coarser surface layer then fine to medium compact sand with occasional fine gravel.	Scaphopoda tusk shells, bivalve shells and tube casts.
39	A/301/ENV	DVV	1250	03:30	09/01/2014	-	N/S	Small amount of sand as grab bounced on seabed.	-	-	-
40	A/301/ENV	DVV	1250	04:15	09/01/2014	-	N/S	Small amount of sand as grab bounced on seabed.	-	-	-
41	A/27/ENV	CAM	1260	06:45	09/01/2014	-	-	Cable re-term after drop.	Cream with dark flecks.	Boulders with epifauna, fine and compact sand.	-
42	A/27/ENV	DVV	1260	09:00	09/01/2014	80%	FA/PC	FA and PC samples gained.	Cream with darker surface layer.	Darker, coarse surface layer over cream fine to med compact sands.	Worm tubes, polychaetes, bivalve shells and gastropods.
43	A/27/ENV	DVV	1260	10:10	09/01/2014	85%	FB/FC	FC and FB samples gained.	Cream with darker surface layer.	Darker, coarse surface layer over cream fine to med compact sands.	Bryozoan, worm tubes, ophiuroids, polychaetes, bivalve shells, gastropod
44	A/303/ENV	CAM	1285	11:40	09/01/2014	-	-	Flash and winch issues but enough images taken.	-	-	-
45	A/303/ENV	DVV	1285	15:00	09/01/2014	80%	FA/PC	FA and PC samples gained.	Cream with darker surface layer.	Darker, coarse surface layer over cream fine to med compact sands	Cup coral fragments, worm tubes and polychaetes.
46	A/303/ENV	DVV	1285	16:00	09/01/2014	45%	FB/FC	FB and FC samples gained.	Mostly dark, some lighter grey.	Dark coarse gravel and rocks then fine to medium sand component.	Worm tubes, polychaetes and gastropods.
47	A/302/ENV	CAM	1330	18:40	09/01/2014	-	-	-	-	-	
48	A/302/ENV	DVV	1330	22:30	09/01/2014	80%	FA/FC	FA and FC samples gained.	Olive grey with darker surface layer.	Mostly clay with flecks of dark gravel.	Polychaetes, worm tubes and ophiuroid.
49	A/302/ENV	DVV	1330	23:20	09/01/2014	80%	PC/NS	PC gained and N/S.	-	-	-
50	A/302/ENV	DVV	1330	23:53	09/01/2014	30%	FC(2)	One very small washed out	Dark.	Largely dark medium	Ascidian, polychaetes and bivalve

Seabed Sampling (Deck Observations)

Job No:		**BSL 1334**		**Operator:**	**BSL**	**Vessel:**	**MV Poseidon**		**Client:**	**Noble Energy Inc**	
Date:	from: to:		**31/12/13** **16/03/14**			**Project:**		**FISA**			
								sample - likely bounced - taken as FC2.		sands with some large pebbles/gravel.	shell.
51	A/302/ENV	DVV	1330	00:50	10/01/2014	60%	FB	-	Dark surface layer, cream below.	Darker, coarse surface layer over cream fine to med compact sands.	Polychaetes, possible echiuran, bivalve and gastropod shells.
52	A/305/ENV	CAM	1267	04:45	12/01/2014	-	-	No beacon signal at 50m - recovered too deck.	-	-	-
53	A/305/ENV	CAM	1267	06:04	12/01/2014	-	-	Redeployment.	White cream sands – homogenous.	Darker, coarse surface layer over cream fine to medium compact sands - disturbance on surface.	Cup corals and crustacean.
54	A/305/ENV	BC	1267	09:26	12/01/2014	60%	FA/FB/PC/ARC	FA/FB/PC/ Archive core gained.	Dark surface layer, cream below.	Darker, coarse surface layer over cream fine to medium compact sands.	Isopod (FB), polychaetes and tubes.
55	A/306/ENV	CAM	1350	13:11	12/01/2014	-	-	-	-	-	-
56	A/306/ENV	HG	1350	15:00	12/01/2014	70%	FA	FA sample gained.	Dark with light grey clay.	Coarse pebbles and rocks suspended in clay.	Bryozoans, worm tubes, polychaetes, bivalve shells.
57	A/306/ENV	HG	1350	16:30	12/01/2014	60%	PC	PC sample gained.	Dark with light grey clay.	Coarse pebbles and rocks suspended in clay.	-
58	A/306/ENV	HG	1350	17:30	12/01/2014	70%	FB	FB sample gained.	Dark with light grey clay.	Coarse pebbles and rocks suspended in clay.	Bryozoans, ophiuroid, worm tubes and polychaetes.
59	A/1013/ENV	CAM	1350	20:12	12/01/2014	-	-	-		-	-
60	A/1013/ENV	HG	1350	22:00	12/01/2014	75%	FA	FA sample gained.	Freckled black sand with cement coloured *Lophelia*.	Clay, sand and dead *Lophelia*.	Dead *Lophelia* and worm tubes.
61	A/1013/ENV	HG	1350	23:00	12/01/2014	N/S	N/S	No sample.	-	-	-
62	A/1013/ENV	HG	1350	23:38	12/01/2014	75%	PC	PC sample gained.	Freckled black sand with cement coloured *Lophelia*.	Hard compact sand and dead *Lophelia*.	Dead *Lophelia*.
63	A/1013/ENV	HG	1350	00:55	13/01/2014	-	FB	FB sample gained.	Freckled black sand with cement coloured *Lophelia*.	Hard compact sand and dead *Lophelia*.	Dead *Lophelia*, urchin spine, polychaetes, worm tubes, bivalve shells.
64	A/1008/ENV	CAM	1280	02:23	13/01/2014	-	-	-	-	-	
65	A/1008/ENV	HG	1280	05:54	13/01/2014	80%	FA	FA sample gained.	Beige sand with black specks.	Hard compact coarse sands with cobbles and dead *Lophelia*.	Ophiuroids, polychaetes, bivalve shells, dead *Lophelia* and urchin spines.
66	A/1008/ENV	DVV	1280	06:43	13/01/2014	70%	PC/FB	FB/PC sample gained.	Beige sand with	Soft sands with cobbles.	-

Seabed Sampling (Deck Observations)

Job No:		BSL 1334		Operator:	BSL	Vessel:	MV Poseidon		Client:	Noble Energy Inc	
Date:	from: to:		**31/12/13** **16/03/14**			**Project:**		**FISA**			

									black specks.		
67	A/1015/ENV	CAM	1358	07:40	13/01/2014	-	-		-	-	-
68	A/1015/ENV	BC	1358	12:00	13/01/2014	-	FA/FB/PC/ARC	FA/FB/PC/ Archive core gained.	Dark surface layer with light grey clay.	Coarse pebbles and rocks suspended in clay.	Tunicata, bivalve shells, tubeworms, polychaetes, ophiuroids and bryozoans.
69	A/14/ENV	CAM	1316	12:55	13/01/2014	-	-	Camera deployed then retrieved after signal failure. Re-term.	-	-	-
70	A/14/ENV	CAM	1316	14:05	13/01/2014	-	-	Redeployed.	-	-	-
71	A/14/ENV	BC	1316	16:05	13/01/2014	55%	FA/FB/PC/ARC	FA/FB/PC/ Archive core gained.	Dark surface layer with mid-grey clay.	Coarse pebbles and rocks suspended in clay.	Bryozoans, calcified bryozoans, worm tubes, polychaetes, bivalve shells.
72	A/308/ENV	CAM	1380	17:40	13/01/2014	-	-	-	-		
73	A/308/ENV	BC	1380	19:53	13/01/2014	N/S	N/S	Box corer damaged by large rock. No sample.	Dark surface layer with mid-grey clay.	Coarse pebbles and rocks suspended in clay.	Bryozoans, calcified bryozoans, worm tubes, polychaetes, bivalve shells.
74	A/309/ENV	CAM	1395	21:30	13/01/2013	-	-	-	-	-	-
75	A/309/ENV	BC	1395	23:44	13/01/2012	30%	FA/FB/PC	Good sample although small.	Dark speckled.	Dark compact medium sand.	Tubeworm casts, tubeworms, gastropod shell, bryozoan.
76	A/21/ENV	CAM	1430	02:00	14/01/2014	-	-	-	-	-	-
77	A/21/ENV	BC	1430	04:11	14/01/2014	30%	FA/FB/PC	Good sample although small.	Dark homogenous.	Dark compact medium sand.	Worm tubes, gastropod shell, bivalve shell.
78	A/307/ENV	CAM	1400	06:35	14/01/2014	-	-	-	-	-	-
79	A/307/ENV	BC	1400	08:54	14/01/2014	N/S	N/S	BC failed to trigger at seafloor.	-	-	-
80	A/307/ENV	BC	1400	10:16	14/01/2014	-	FA/FB/PC	Redeployment - no sieve photo for FB.	-	-	-
81	A/12/ENV	HG	1280	13:20	14/01/2014	-	PC	-	-	-	-
82	A/1011/ENV	BC	1325	14:57	14/01/2014	30%	FA/FB/PC/ARC	-	Dark compact med clay/sand with thin cream surface layer.	Dark compact medium clay/sand with thin cream surface layer.	-
83	A/301/ENV	HG	1250	16:47	14/01/2014	40%	FA	-	Light/olive grey sediment.	Broken rock fragments and hard clay substrate with fauna attached.	-
84	A/301/ENV	HG	1250	17:59	14/01/2014	-	-	HG failed to trigger at seafloor.	-	-	-
85	A/202/ENV	CAM	1153	22:35	14/01/2014	-	-	-	-	-	-
86	A/202/ENV	BC	1153	00:50	15/01/2014	-	FA/FB/PC/ARC	-	Light/olive grey sediment with dark surface layer.	Hard compact medium sand with clay lumps.	Polychaetes, worm tubes, bryozoan, sponge, asteroid.
87	A/201/ENV	CAM	1120	04:15	15/01/2014	-	-	-	Hard compact fine sands with	-	-

Seabed Sampling (Deck Observations)											
Job No:		**BSL 1334**		**Operator:**	**BSL**	**Vessel:**	**MV Poseidon**		**Client:**	**Noble Energy Inc**	
Date:	from: to:		**31/12/13 16/03/14**			**Project:**		**FISA**			
									cobbles and boulders.		
88	A/106/ENV	CAM	1302	20:55	16/01/2014	-	-	-	-	-	-
89	A/106/ENV	BC	1302	22:52	16/01/2014	N/S	N/S	Failed to trigger.	-	-	-
90	A/106/ENV	BC	1302	23:40	16/01/2014	N/S	N/S	Insufficient sample.	-	-	-
91	A/106/ENV	BC	1302	00:41	17/01/2014	N/S	N/S	Triggered in water column/bounced.	-	-	-
92	A/204/ENV	CAM	1302	04:00	17/01/2014	-	-	-	-	-	-
93	A/204/ENV	BC/NISKIN	1302	06:18	17/01/2014	55%	FA/FB/PC/ARC	Niskin failed to trigger.	Light/olive grey sediment with dark surface layer.	Hard compact medium sand with clay from 10cm down.	Dead *Lophelia*, polychaetes, worm tubes, anemones and gastropod shells.
94	A/11/GEO	6m GC	1500	09:48	17/01/2014	N/S	N/S	Bent barrel.	-	-	-
95	A/12/GEO	6m GC	1340	13:14	17/01/2014	N/S	N/S	Bent barrel.	-	-	-
96	A/09/GEO	CAM	1070	17:25	17/01/2014	-	-	-	-	-	-
97	A/09/GEO	3m GC	1070	19:13	17/01/2014	250cm	2xHSG, 2xLPH, MPOG, Eh, Archive	-	-	-	-
98	A/10A/GEO	3m GC	1217	21:05	17/01/2014	30cm	Archive	-	-	-	-
99	A/10B/GEO	3m GC	1217	21:57	17/01/2014	30cm	Archive	-	-	-	-
100	A/21/GEO	3m GC	1304	23:42	17/01/2014	22cm	Archive	-	Brown/grey	Wet, stiff clay over hard dried clay/mud.	-
101	A/20/GEO	3m GC	1300	01:57	18/01/2014	102cm	HSG, LPH, MPOG, Eh	-	Dark grey.	Firm fine sands to muds - some clay.	-
102	A/12B/GEO	3m GC	1340	04:00	18/01/2014	62cm	LPH, MPOG, Eh	-	Grey to dark grey.	Firm fine sands to muds.	-
103	A/12C/GEO	3m GC	1340	04:59	18/01/2014	55cm	Archive	-	Grey to dark grey.	Firm fine sands to muds.	-
104	A/11B/GEO	3m GC	1500	07:12	18/01/2014	22cm	Archive	Small sample.	Olive and black speckled.	Hard compact medium sand.	-
105	A/11C/GEO	3m GC	1500	08:07	18/01/2014	N/S	N/S	Some trace of gravel, likely bounced.	-	-	-
106	A/22/GEO	3m GC	917	12:44	18/01/2014	145cm	LPH, MPOG, Eh, HSG, GORE	-	Grey to dark grey.	Silty sand.	-
107	A/23/GEO	3m GC	1087	15:09	18/01/2014	220m	LPH, MPOG, Eh, HSG, GORE	-	Grey to dark grey.	-	-
108	A/24/GEO	3m GC	985	17:31	18/01/2014	60cm	MPOG	-	Grey to dark grey.	-	-
109	A/08/GEO	3m GC	1187	19:52	18/01/2014	40cm	Archive	Small sample.	Grey to dark grey.	-	-
110	A/08B/GEO	3m GC	1187	20:33	18/01/2014	N/S	N/S	N/S	-	-	-
111	A/08C/GEO	3m GC	1187	21:08	18/01/2014	70cm	MPOG, Archive	Small sample (third attempt).	Mid-grey and black speckled.	-	-
112	A/14A/GEO	3m GC	1206	22:48	18/01/2014	160cm	HSG, LPH,	Large sample with 3m	Olive and black	Medium compact sand	-

Seabed Sampling (Deck Observations)

Job No:	BSL 1334	Operator:	BSL	Vessel:	MV Poseidon	Client:	Noble Energy Inc
Date:	from: 31/12/13 to: 16/03/14			Project:	FISA		

							MPOG, Eh, Archive	barrel.	speckled at surface; dark grey/green at bottom.	with some mud at surface: dense, moist, compact sandy mud at bottom.	
113	A/14B/GEO	6m GC	1206	23:35	18/01/2014	203cm	HSG, LPH, MPOG, Eh, Archive	Re-attempt with 6m barrel.	Olive and black speckled at surface; dark grey at bottom.	Medium compact sand with some mud at surface: dense, firm, compact sandy mud at bottom.	-
114	A/07/GEO	3m GC	1265	11:22	19/01/2014	90cm	LPH, MPOG, Eh, Archive	No HSG.	Olive and black speckled at surface; dark grey at bottom.	Medium compact sand with some mud at surface: dense, firm, compact sandy mud at bottom.	-
115	A/07B/GEO	3m GC	1275	12:11	19/01/2014	N/S	N/S	N/S (liner cut too short)	-	-	-
116	A/13/GEO	3m GC	1267	14:13	19/01/2014	N/S	N/S	N/S	-	-	-
117	A/13B/GEO	3m GC	1267	14:54	19/01/2014	N/S	N/S	N/S	-	-	-
118	A/6/GEO	3m GC	1340	16:21	19/01/2014	N/S	N/S	N/S	-	-	-
119	A/6B/GEO	3m GC	1340	17:06	19/01/2014	N/S	N/S	N/S	-	-	-
120	A/6C/GEO	3m GC	1340	18:03	19/01/2014	60cm	MPOG	Archived.	-	-	-
121	A/5/GEO	3m GC	1335	19:54	19/01/2014	115cm	HSG, LPH, MPOG, Eh, Archive	-	Beige to very dark grey.	Very soft silty fine sand.	-
122	A/19/GEO	3m GC	1330	09:25	20/01/2014	N/S	Archive (bag)	No core, just gravel. Bagged as archive.	-	Medium to coarse gravel - mixed materials.	-
123	A/4/GEO	3m GC	1265	12:10	20/01/2014	25cm	Archive (bag)	Small sample (archived).	Grey to dark grey silty SAND.	-	-
124	A/4B/GEO	3m GC	1265	12:56	20/01/2014	32cm	Archive (bag)	Small sample (archived).	Black sand and dark grey silt.	Fine sand.	-
125	A/2/GEO	3m GC	1334	15:29	20/01/2014	52cm	MPOG and Archive (bag)	Small sample (archived).	Black/grey silty sand.	Fine sand.	-
126	A/2B/GEO	3m GC	1334	16:06	20/01/2014	39cm	Archive (bag)	Small sample (archived).	Grey to dark grey silty sand.	-	-
127	A/3/GEO	3m GC	1247	17:59	20/01/2014	<5cm	Archive (bag)	Small sample (archived).	Grey to dark grey silty sand.	-	-
128	A/3B/GEO	3m GC	1247	18:33	20/01/2014	23cm	Archive (bag)	Small sample (archived).	Black/grey silty sand.	Fine sand	-
129	A/18/GEO	3m GC	1266	20:25	20/01/2014	87cm	LPH, MPOG, Eh, Gore, Archive	-	Grey to dark grey silty sand.	-	-
130	A/18B/GEO	3m GC	1266	20:59	20/01/2014	90cm	LPH, MPOG, Eh, Gore, Archive	-	Grey to dark grey silty sand.	-	-
131	A/17A/GEO	3m GC	1170	12:34	21/01/2014	39cm	Archive	-	Olive with black speckles surface - dark	Compact sand surface - spongy silty mud at bottom.	-

Seabed Sampling (Deck Observations)

Job No:		**BSL 1334**		**Operator:**	**BSL**	**Vessel:**	**MV Poseidon**		**Client:**	**Noble Energy Inc**	
Date:	from: to:		**31/12/13** **16/03/14**			**Project:**		**FISA**			
									grey bottom.		
132	A/17B/GEO	3m GC	1170	01:13	21/01/2014	275cm	HSG x2, LPH x2, MPOG, Eh x2, GORE, Archive x2	-	-	-	-
133	A/17C/GEO	6m GC	1170	02:01	21/01/2014	250cm	HSG x2, LPH x2, MPOG, Eh x2, GORE, Archive x2	-	-	-	-
134	A/1A/GEO	3m GC	1085	03:19	21/01/2014	26cm	Archive	-	Olive with black speckles.	Compact sand.	-
135	A/1B/GEO	3m GC	1085	04:07	21/01/2014	26cm	Archive	-	Olive with black speckles.	Compact sand.	-
136	A/16A/GEO	3m GC	1070	05:15	21/01/2014	N/S	Archive bag	Only fine gravel in core.	Dark brown.	Fine gravel - likely cut from concretion - clay based.	-
137	A/16B/GEO	3m GC	1070	06:00	21/01/2014	5cm	Archive bag	Very hard concretion at 3cm depth. -	Olive with black speckles surface - dark cream/yellow concretion below.	Compact sand surface - solid concretion below, likely clay based.	-
138	A/15A/GEO	3m GC	1070	07:16	21/01/2014	49cm	Archive core	-	Olive with black speckles.	Compact sand.	-
139	A/15B/GEO	3m GC	1070	07:54	21/01/2014	34cm	Archive core	-	Olive with black speckles.	Compact sand.	-
140	A/25/GEO	3m GC	820	11:46	21/01/2014	230cm	HSG, LPH, MPOG, Eh, Archive	-	Olive grey to black.	Soft cohesive CLAY with fine sand through to black sand.	-
141	A/25B/GEO	3m GC	820	12:21	21/01/2014	240cm	HSG, LPH, MPOG, Eh, Archive	Claystones present.	Olive grey to black.	Soft cohesive CLAY with fine sand through to black sand.	-
142	A/27/GEO	CAM	484	18:40	21/01/2014	-	-	Original core site.	-	-	-
143	A/27B/GEO	CAM	484	19:55	21/01/2014	-	-	Fault site.	-	-	-
144	A/27/GEO	3m GC	502	21:21	21/01/2014	250cm	HSG (a&b), LPH (a&b), MPOG, Eh, Archive	-	Olive grey/green becoming darker grey with core depth.	Soft CLAY with occasional fine sand becoming darker grey with a larger cohesive CLAY component with core depth.	-
145	A/27B/GEO	3m GC	502	21:51	21/01/2014	204cm	HSG, LPH, MPOG, Eh, Archive	-	Olive grey/green becoming darker grey with core depth.	Soft CLAY with occasional fine sand becoming darker grey with a larger cohesive CLAY component with core depth.	-

Seabed Sampling (Deck Observations)											
Job No:		**BSL 1334**		**Operator:**	**BSL**	**Vessel:**	**MV Poseidon**		**Client:**	**Noble Energy Inc**	
Date:	from: to:		**31/12/13** **16/03/14**			**Project:**		**FISA**			
146	A/28/GEO	3m GC	345	01:22	22/01/2014	77cm	LPH, MPOG, Eh, Archive	-	Olive grey/green becoming darker grey with core depth.	Very firm compact clayey sands, olive grey small nodules and concretion sediments within.	-
147	A/28B/GEO	3m GC	345	01:52	22/01/2014	97cm	LPH, MPOG, Eh, Archive	-	Olive grey/green becoming darker grey with core depth.	Very firm compact clayey sands, olive grey small nodules and concretion sediments within.	-
148	A/29/GEO	3m GC	673	04:33	22/01/2014	270cm	HSG, LPH x2, MPOG, Ehx2, GORE, Archive	-	Olive grey/green becoming darker grey with core depth.	Soft clayey sand with coarser granules.	-
149	A/29B/GEO	6m GC	673	05:06	22/01/2014	310cm	HSG, LPH x2, MPOG, Ehx2, GORE, Archive	-	Olive grey/green becoming darker grey with core depth.	Soft clayey sand with coarser granules.	-
150	A/26/GEO	6m GC	520	09:33	22/01/2014	230cm	HSG, LPH x2, MPOG, Ehx2, GORE, Archive	-	Olive grey/green becoming darker grey with core depth.	Soft clayey sand with coarser granules.	-
151	A/26B/GEO	6m GC	520	10:15	22/01/2014	210cm	HSG, LPH x2, MPOG, Ehx2, GORE, Archive	-	Olive grey/green becoming darker grey with core depth.	Soft clayey sand with coarser granules.	-
152	A/23/GEO (revisited)	3m GC	1100	14:35	22/01/2014	18cm	Archive	-	-	-	-
153	A/23B/GEO (revisited)	3m GC	1100	15:20	22/01/2014	16cm	Archive	-	-	-	-
154	A/23/Water 1100m	Niskin	1100	16:30	22/01/2014	-	N/S	Did not trigger.	-	-	-
155	A/23/Water 1100m	Niskin	1100	17:00	22/01/2014	-	3x plastic 1L, 1x glass 1L	-	-	-	-
156	A/23/Water 500m	Niskin	1100	17:40	22/01/2014	-	3x plastic 1L, 1x glass 1L	-	-		-
157	A/23/Water 50m	Niskin	1100	18:00	22/01/2014	-	3x plastic 1L, 1x glass 1L	-	-		-

Seabed Sampling (Deck Observations)

Job No:	**BSL 1334**	**Operator:**	**BSL**	**Vessel:**	**MV Poseidon**	**Client:**	**Noble Energy Inc**
Date:	from: **31/12/13** to: **16/03/14**			**Project:**	**FISA**		

158	A/23/Water 0m	Niskin	1100	18:15	22/01/2014	-	3x plastic 1L, 1x glass 1L	-	-		-
190	A/18/ENV	CAM	1415	12:40	01/02/2014	-		-	-		-
191	A/18/ENV	BC	1415	15:00	01/02/2014	55%	FA, FB, HC, HM, PSA, TOC	-	Light/olive grey sediment with dark surface layer.	Fine to medium sand with occasional fine gravel.	Ophiuroids and polychaetes.
192	A/22/ENV	CAM	1524	17:48	01/02/2014	-		-		-	Pennatulids and urchins.
193	A/22/ENV	BC	1522	19:53	01/02/2014	54%	FA, FB, HC, HM, PSA, TOC	-	Light/olive grey sediment with dark surface layer.	Fine to medium sand with fine gravel.	Hard coral, worm tubes, bryozoan, orange encrusting sponge. Possible relic *Lophelia*.
194	A/206/ENV	CAM	1530	22:52	01/02/2014	-	-	-	-	-	Stalked crinoid, relic *Lophelia*, *Munida*, anemone, hard corals and sea whips.
195	A/205/ENV	CAM	1540	04:25	02/02/2014	-	-	No flash function - so stills used longer aperture time so some blurriness - screenshots taken additionally - some beacon problems.	-	-	Coarse sediment with shell and relic coral possibly *Lophelia*, rocky outcrops covered with sponges (05:33 possible *Phakallia* sp.), hard corals and sea whips.
196	A/3/ENV	CAM	1124	11:30	02/02/2014	-	-	No flash function - some blurriness in stills, some screen shots additionally, 2 videos as camera rebooted during line.	-	-	Ophiuroids, pennatulids and batoid.
197	A/3/ENV	BC	1134	13:52	02/02/2014	20%	FA, FB, HC, HM, PSA, TOC	No depth reading from the beacon.	Light/olive grey sediment with dark surface layer.	Silty SAND.	Isopod, hydroid and polychaetes.
198	A/3/ENV	Niskin	1134	13:52	02/02/2014	-	HM, NUT, spare, HC.	Seabed, attached to BC.	-	-	-
199	A/3/ENV	Niskin	Surface	16:55	02/02/2014	-	HM, NUT, spare, HC.	Wire parted on winch, no further samples could be obtained at this location - further samples to be taken at the end of wreck multibeam line.	-	-	-
200	A/3/ENV	Niskin	50	01:03	03/02/2014	-	N/S	Niskin bottle failed to trigger.	-	-	-
201	A/3/ENV	Niskin	50	01:09	03/02/2014	-	N/S	Niskin bottle failed to trigger.	-	-	-
202	A/3/ENV	Niskin	50	01:54	03/02/2014	-	N/S	Niskin bottle failed to trigger.	-	-	-

Seabed Sampling (Deck Observations)											
Job No:		**BSL 1334**		**Operator:**	**BSL**	**Vessel:**	**MV Poseidon**		**Client:**	**Noble Energy Inc**	
Date:	from: to:		**31/12/13** **16/03/14**			**Project:**		**FISA**			
203	A/3/ENV	Niskin	50	02:34	03/02/2014	-	HM, NUT, spare, HC.	50m water sample.	-	-	-
204	A/3/ENV	Niskin	400	02:52	03/02/2014	-	N/S	Niskin bottle failed to trigger.	-	-	-
205	A/3/ENV	Niskin	400	03:25	03/02/2014	-	N/S	Niskin bottle failed to trigger.	-	-	-
206	A/3/ENV	Niskin	400	04:02	03/02/2014	-	HM, NUT, spare, HC.	400m water sample (max length on dyneema).	-	-	-
207	A/3010/ENV	CAM	1540	13:10	05/02/2014	-	-	-	-	-	-
208	A/3010/ENV	BC	1540	15:10	05/02/2014	N/S	N/S	Sample rejected due to washout, small gravel caught between bucket edge and spade.	-	-	-
209	A/3010/ENV	BC	1540	16:35	05/02/2014	50%	FA, FB, HC, HM, PSA, TOC	-	Light/olive grey sediment with dark surface layer.	Fine to medium sand with fine gravel.	Polychaetes and possible Foraminifera.
302	A/30/GEO	3m GC	1040	10:39	16/03/2014	70cm	Archive C, LPHx2, MPOG x 2, X and Y	-	-	Medium sandy silt to fine sandy silt.	-
303	A/30B/GEO	3m GC	1040	11:31	16/03/2014	90cm	Archive C, LPHx2, MPOG x 2, X and Y	-	-	Medium sandy silt to fine sandy silt.	-

GC = Gravity core (geochemical sample)
BC = Box corer (environmental sample)
DVV = double van Veen grab (Environmental sample)
CAM = seabed camera
HSG = Headspace gas (geochemical sample)
LPH = Liquid phase hydrocarbons (geochemical sample)
MPOG = Microbial prospecting for Oil and Gas (geochemical sample)
eH = Redox potential (geochemical sample)
HC = Hydrocarbon sample (Environmental sample)
HM = Heavy metals (Environmental sample)
PSA = Particle size analysis (Environmental sample)
TOC = Total organic carbon (Environmental sample)

APPENDIX VII – MACRO-INVERTEBRATE MATRIX

Aphia ID	Species	Authority	A3_ENV_FA	A3_ENV_FB	A09_ENV_FA	A09_ENV_FB	A09_ENV_FC	A10_ENV_FA	A10_ENV_FB	A10_ENV_FC	A12_ENV_FA	A12_ENV_FC	A14_ENV_FA	A14_ENV_FB	A18_ENV_FA	A18_ENV_FB
1267	**CNIDARIA**															
128484	Pennatulidae	Ehrenberg, 1834														
1360	*Actinaria*								1							
100665	Edwardsiidae	Andres, 1881			1								1		1	
173052	*Flabellum (Flabellum) curvatum*	Moseley, 1881						1			1					
152391	**NEMERTEA**															
152391	Nemertea		1			2										1
799	**NEMATODA**															
799	Nematoda		2		1	1					1	1				
1268	**SIPUNCULA**															
410734	Nephasoma (Nephasoma) diaphanes	(Gerould, 1913)			1									3	3	1
	ECHIURIDA															
110352	*Bonellia sp*	Rolando, 1821													1	
882	**ANNELIDA**															
129285	*Euphrosine Sp* 1 (no recorded NHM)†	Lamarck, 1818														
173263	*Euphrosine cirrata magellanica*	Ehlers, 1900														1
939	Polynoidae	Kinberg, 1856												2		
129487	*Eunoe*	Malmgren, 1866			1			2				1			1	
174391	*Polyeunoa laevis*	McIntosh, 1885	1													
174468	*Harmothoe magellanica*	(McIntosh, 1885)	1													
129590	*Leanira*	Kinberg, 1856														
	Sigalionidae (not recorded by NHM)†															
129443	*Eteone*	Savigny, 1818														1
129450	*Mystides*	Théel, 1879														
130118	*Glycera capitata*	Örsted, 1843					1	2			1			1		
948	Syllidae	Grube, 1850	1			1							1			
129677	*Sphaerosyllis*	Claparède, 1863														
340445	*Gymnonereis fauveli*	(Hartmann-Schröder, 1962	2	7		2				2	1		3	4	1	2
173522	*Lumbrineris magalhaensis*	Kinberg, 1865				2	1									
129280	*Lysidice*	Lamarck, 1818									1					
129366	*Aglaophamus (posteriobranchiatus* NHM)	Kinberg, 1865			1				1							1
	Aglaophanus sp I															1
129370	Nephtys	Cuvier, 1817											1			
196680	Rhamphobrachium (Spinigerium) ehlersi	Monro, 1930		1	1	9	5	4	8	4	1		11	15	6	2
966	Eunicidae	Berthold, 1827														
129278	Eunice	Cuvier, 1817														
130467	Nothria conchylega	(Sars, 1835)						1					1		1	
129425	Scoloplos	Blainville, 1828														
129430	Aricidea	Webster, 1879	2	1			1						1	2		
326595	Aricidea (Allia) oculata	Hartmann-Schröder & Rosenfeldt, 1990						1								
525485	Aricidea (Acmira) strelzovi	Hartmann-Schröder & Rosenfeldt, 1990							1	1		1	1			
903	Paraonidae	Cerruti, 1909		1	1	2								1		
129198	Apistobranchus sp I	Levinsen, 1883	2	1	2	3	1		2	1			2	1		1
129198	Apistobranchus sp II	Levinsen, 1883														
913	Spionidae	Grube, 1850												1		
129620	Prionospio	Malmgren, 1867			1				1							
129623	Scolelepis	Blainville, 1828									1					1
129613	Laonice (Laonice sp2 NHM)	Malmgren, 1867														
129291	Flabelligera	Sars, 1829														
129289	Brada sp	Stimpson, 1854														
923	Maldanidae	Malmgren, 1867		1		1			3	1	1	1		2		1
173557	Asychis amphiglypta	(Ehlers, 1897)								1		1				
130305	Maldane sarsi	Malmgren, 1865														
130331	Rhodine loveni	Malmgren, 1865													2	

Aphia ID	Species	Authority	A3_ENV_FA	A3_ENV_FB	A09_ENV_FA	A09_ENV_FB	A09_ENV_FC	A10_ENV_FA	A10_ENV_FB	A10_ENV_FC	A12_ENV_FA	A12_ENV_FC	A14_ENV_FA	A14_ENV_FB	A18_ENV_FA	A18_ENV_FB
129924	Spiochaetopterus typicus	M. Sars, 1856	1		2			1						2		
	Chaetozone sp 8 † (NHM)															
129243	Cirratulus Sp2	Lamarck, 1818					1								3	
129245	Pseudoscalibregma bransfeldia†	Hartman, 1936												2		2
129241	Caulleriella	Chamberlin, 1919		1	1	2	2		4	1			1	2		1
129955	Chaetozone setosa (Chaetozone sp 5 NHM)	Malmgren, 1867		1		1								1		
173159	Tharyx fusiformis	Monro, 1939												1	1	
129249	Tharyx	Webster & Benedict, 1887														
129898	Notomastus latericeus	Sars, 1851								1						
130503	Ophelina cylindricaudata	(Hansen, 1879)							1							1
129413	Ophelia	Savigny, 1822	1													
130980	Scalibregma inflatum	Rathke, 1843			1											1
152252	Ampharetinae	Malmgren, 1866														
129177	Samytha	Malmgren, 1866						1								1
129153	Amage	Malmgren, 1866		1												1
129804	Melinna cristata (complex)	(M. Sars, 1851)			3			3	3	3	1			1	1	1
129708	Pista	Malmgren, 1866	1													
131573	Terebellides stroemii	Sars, 1835	1			1	1			1				2		1
982	Terebellidae	Johnston, 1846				1			1							
174568	Perkinsiana antarctica	(Kinberg, 1867)														
985	Sabellidae	Latreille, 1825		2				1	1					2		
154918	Fabriciidae	Rioja, 1923									1		1			1
129530	Fabriciola	Friedrich, 1939								1						
129533	Jasmineira	Langerhans, 1880	1													
129525	Chone	Krøyer, 1856		1												
174564	Euchone pallida (Euchone sp1 NHM)	Ehlers, 1908	1	1	1	1	1	1	1	1		1				1
2036	Oligochaeta			1		3	1			2				2		
988	Serpulidae	Rafinesque, 1815														
147018	Microrbinia	Hartman, 1965	2													
244666	Phylo felix	Kinberg, 1866									1		1	2		
734535	Phylo minima	(Hartmann-Schröder & Rosenfeldt, 1990)	2													
146949	Galathowenia	Kirkegaard, 1959	1							1	1			1		
1066	**CRUSTACEA**															
106115	Scalpellum	Leach, 1818				2										
106140	Verruca	Schumacher, 1817														
106137	Altiverruca	Pilsbry, 1916														
1078	Ostracoda	Latreille, 1802		1		1							1	1		
1080	Copepoda				1			1			1	1	1			
101436	Phtisica	Slabber, 1769														
1135	Amphipoda	Latreille, 1816	2			2							1			
101409	Stenothoidae	Boeck, 1871														
101409	Stenothoidae	Boeck, 1871														
101789	Urothoe	Dana, 1852		5	1				1	1			1	1		1
101403	Phoxocephalidae	Sars, 1891			1								1			
101403	Phoxocephalidae	Sars, 1891		1					2				2	2	1	
101723	Phoxocephalus	Stebbing, 1888								1						
101675	Maera	Leach, 1814			1											
101393	Leucothoidae	Dana, 1852												1		
176788	Lysianassoidea	Dana, 1849	2													
176788	Lysianassoidea	Dana, 1849		12										1		
101445	Ampelisca	Krøyer, 1842	1	2	5	4	2	2	3	2	1		2	4		
101445	Ampelisca	Krøyer, 1842	4													
101445	Ampelisca	Krøyer, 1842														
101445	Ampelisca	Krøyer, 1842													1	2
101365	Amphilochidae	Boeck, 1871	3			1					1					1
101410	Synopiidae	Dana, 1853														
101563	Photis	Krøyer, 1842						1		1			2			
101470	Leptocheirus	Zaddach, 1884				2								1		
101519	Eusirus	Krøyer, 1845														

Aphia ID	Species	Authority	A3_ENV_FA	A3_ENV_FB	A09_ENV_FA	A09_ENV_FB	A09_ENV_FC	A10_ENV_FA	A10_ENV_FB	A10_ENV_FC	A12_ENV_FA	A12_ENV_FC	A14_ENV_FA	A14_ENV_FB	A18_ENV_FA	A18_ENV_FB
101734	Dulichia	Krøyer, 1845														
118437	Gnathia	Leach, 1814														
257124	Caecognathia c.f.polaris	(Hodgson, 1902)														
118354	Ilyarachna	Sars, 1870														
256200	Munna argentinae	Menzies, 1962														
118371	Macrostylis	G.O. Sars, 1864														
118371	Macrostylis II	G.O. Sars, 1864														
118351	Haploniscus	Richardson, 1908														
118358	Ischnomesus	Richardson, 1908				1										
118356	Haplomesus	Richardson, 1908														1
n/a	Stylomesus elegans	Menzies, 1962														
174952	Stylomesus	Wolff, 1956					1									
118319	Desmosoma	G.O. Sars, 1864		2		2									1	
118323	Eugerda	Meinert, 1890				1										
118360	Janirella	Bonnier, 1896														
248358	Abyssianira	Menzies, 1956														
118399	Cirolana	Leach, 1818	1	1	1											
118399	Cirolana	Leach, 1818														
213013	Pseudanthura lateralis	Richardson, 1911		1	1					2						
255448	Haliophasma antarctica	(Kensley, 1982)	1					1								
174514	Antarcturus	zur Strassen, 1902				1			1				13	1		
136164	Tanaidae	Dana, 1849	1													
136164	Tanaidae	Dana, 1849														
136222	Agathotanais	Hansen, 1913	2			1										1
136229	Leptognathia	Sars, 1882	3	2	1	3				1		1			1	4
136256	Typhlotanais	Sars, 1882											2			
136185	Apseudes	Leach, 1813													1	
136200	Pseudosphyrapus sp I	Gutu, 1980														
136200	Pseudosphyrapus sp II	Gutu, 1980														
182287	Eudorella gracilior	Zimmer, 1907														
110414	Leucon	Krøyer, 1846	1													
110398	Diastylis	Say, 1818	1	1					1						1	
110398	Diastylis sp II	Say, 1818													1	
110415	Campylaspis	G.O. Sars, 1865														
110415	Campylaspis spII	G.O.Sars, 1865														
110404	Makrokylindrus	Stebbing, 1912	1													
51	**MOLLUSCA**															
138249	"Neomenia"															
138249	"Neomenia"															
138249	"Neomenia "															
138249	"Neomenia"															
343675	Neopilina Lemche, 1957	Lemche, 1957														
104	Scaphopoda	Bronn, 1862														
138024	Cadulus	Philippi, 1844		1												
138013	Fissurella	Bruguière, 1789														
138508	Skenea	Fleming, 1825									1					
138508	Skenea	Fleming, 1825														
137970	Eulima	Risso, 1826												1		
147109	Polinices	Montfort, 1810														
147109	Polinices	Montfort, 1810								1						
390535	Fusitriton	Cossmann, 1903			1									1		
390535	Fusitriton	Cossmann, 1903	1	1												
138432	Retusa	T. Brown, 1827														
138217	Dacrydium	Torell, 1859														
138259	Nuculana	Link, 1807														1
138672	Yoldia	Möller, 1842												2		
138132	Limopsis	Sassi, 1827				1										
138323	Pecten	O. F. Müller, 1776														
147153	Similipecten	Winckworth, 1932														

Aphia ID	Species	Authority	A3_ENV_FA	A3_ENV_FB	A09_ENV_FA	A09_ENV_FB	A09_ENV_FC	A10_ENV_FA	A10_ENV_FB	A10_ENV_FC	A12_ENV_FA	A12_ENV_FC	A14_ENV_FA	A14_ENV_FB	A18_ENV_FA	A18_ENV_FB
197227	Limatula hodgsoni	(E. A. Smith, 1907)		1					1							
505622	Limea pygmaea	Philippi, 1845)														
138186	Mysella	Angas, 1877														
138654	Lyonsiella sp	G.O. Sars, 1872														
197467	Thracia meridionalis	E. A. Smith, 1885			1											
137858	Cuspidaria	Nardo, 1840	1	1				1								
137863	Tropidomya	Dall & E. A. Smith, 1886													1	
152413	Axinulus	Verrill & Bush, 1898									1			2		
138552	Thyasira	Lamarck, 1818				2								1		
138552	Thyasira II	Lamarck, 1818			2				2					2		
1806	**ECHINODERMATA**	Bruguière, 1791 [ex Klein, 1734]														
172707	Anseropoda antarctica †	Fisher, 1940													1	
172769	Acodontaster elongatus	(Sladen, 1889)														
123567	Ophiophycis aff mirabilis†	Koehler, 1901														
173102	Amphiura belgicae	Koehler, 1900		1				1								
123206	Amphiuridae	Ljungman, 1867	1													
123200	Ophiuridae	Müller & Troschel, 1840														
236013	Ophiozonella falklandica	Mortensen, 1936							1					1		
160790	Brisaster antarcticus †	(Döderlein, 1906)														
123494	aff Thyone	Jaeger, 1833														
123473	Echinocucumis sp	M. Sars, 1859														
146121	Psolus	Oken, 1815														
	Psolus spII															
123182	Synaptidae	Burmeister, 1837														
123441	Myriotrochus	Steenstrup, 1851														
1803	**BRACHIOPODA**	Duméril, 1805														
1803	Brachiopoda	Duméril, 1805														
1803	Brachiopoda II	Duméril, 1805														
183339	Pelagodiscus	atlanticus (King, 1868)														
	CHAETOGNATHA															
105413	Spadella	Langerhans, 1880														
		S	**33**	**28**	**25**	**29**	**12**	**17**	**21**	**21**	**17**	**8**	**22**	**36**	**20**	**28**
		N	**49**	**53**	**34**	**56**	**18**	**25**	**40**	**30**	**17**	**8**	**51**	**72**	**30**	**35**
		d	**8.222**	**6.801**	**6.806**	**6.956**	**3.806**	**4.971**	**5.422**	**5.88**	**5.647**	**3.366**	**5.341**	**8.184**	**5.586**	**7.594**
		J'	**0.9694**	**0.8686**	**0.9539**	**0.9352**	**0.9213**	**0.9526**	**0.9142**	**0.9596**	**1**	**1**	**0.8283**	**0.905**	**0.927**	**0.9719**
		H'(log2)	**4.89**	**4.175**	**4.43**	**4.543**	**3.303**	**3.894**	**4.015**	**4.215**	**4.087**	**3**	**3.694**	**4.679**	**4.006**	**4.672**
		1-Lambda'	**0.9821**	**0.9267**	**0.9715**	**0.9604**	**0.9216**	**0.96**	**0.941**	**0.9701**	**1**	**1**	**0.8894**	**0.9476**	**0.9494**	**0.9832**

Aphia ID	Species	A20_ENV_FA	A20_ENV_FB	A20_ENV_FC	A21_ENV_FA	A21_ENV_FB	A22_ENV_FA	A22_ENV_FB	A26_ENV_FA	A26_ENV_FB	A26_ENV_FC	A27_ENV_FA	A27_ENV_FB	A27_ENV_FC	A202_ENV_FA	A202_ENV_FB	A204_ENV_FA
1267	**CNIDARIA**																
128484	Pennatulidae													1			
1360	*Actinaria*						1				1						14
100665	Edwardsiidae				1				1					1		1	
173052	*Flabellum (Flabellum) curvatum*																
152391	**NEMERTEA**																
152391	Nemertea	1				2			1	1				2		1	1
799	**NEMATODA**																
799	Nematoda								3			1			1		3
1268	**SIPUNCULA**																
410734	Nephasoma (Nephasoma) diaphanes				4	2	1	1		3			1			1	2
	ECHIURIDA																
110352	*Bonellia sp*																
882	**ANNELIDA**																
129285	*Euphrosine Sp* 1 (no recorded NHM)†								2								
173263	*Euphrosine cirrata magellanica*								1	1							
939	Polynoidae																
129487	*Eunoe*				2		1		1	1	2						2
174391	*Polyeunoa laevis*																
174468	*Harmothoe magellanica*																
129590	*Leanira*												1				
	Sigalionidae (not recorded by NHM)†												1				
129443	*Eteone*									2						1	2
129450	*Mystides*											1					
130118	*Glycera capitata*									1					1	1	
948	Syllidae	1							2				1				
129677	*Sphaerosyllis*											2					
340445	*Gymnonereis fauveli*								3						6	4	
173522	*Lumbrineris magalhaensis*	1			1	4	1					1		1			1
129280	*Lysidice*																
129366	*Aglaophamus (posteriobranchiatus* NHM)																
	Aglaophanus sp I																
129370	Nephtys											1		1			
196680	Rhamphobrachium (Spinigerium) ehlersi	1	4		18	3	3	2	6	1	2	7	9	7	4	4	
966	Eunicidae																1
129278	Eunice												1				
130467	Nothria conchylega								1								
129425	Scoloplos					1						1					
129430	Aricidea																
326595	Aricidea (Allia) oculata																
525485	Aricidea (Acmira) strelzovi													1			
903	Paraonidae																
129198	Apistobranchus sp I										1				4	4	
129198	Apistobranchus sp II																
913	Spionidae																
129620	Prionospio													1		1	
129623	Scolelepis					1									1		
129613	Laonice (Laonice sp2 NHM)																
129291	Flabelligera																
129289	Brada sp								1								3
923	Maldanidae						1	1	1	1			1			1	
173557	Asychis amphiglypta							2	2	1					1		
130305	Maldane sarsi							1				2					
130331	Rhodine loveni																

Aphia ID	Species	A20_ENV_FA	A20_ENV_FB	A20_ENV_FC	A21_ENV_FA	A21_ENV_FB	A22_ENV_FA	A22_ENV_FB	A26_ENV_FA	A26_ENV_FB	A26_ENV_FC	A27_ENV_FA	A27_ENV_FB	A27_ENV_FC	A202_ENV_FA	A202_ENV_FB	A204_ENV_FA
129924	Spiochaetopterus typicus	1	1						1				1	1	1	1	1
	Chaetozone sp 8 † (NHM)																1
129243	Cirratulus Sp2																1
129245	Pseudoscalibregma bransfeldia†									1						1	
129241	Caulleriella				1		2	4			1		3	2	2	1	1
129955	Chaetozone setosa (Chaetozone sp 5 NHM)		1		1			1	1								
173159	Tharyx fusiformis											1					
129249	Tharyx											2					
129898	Notomastus latericeus				1					1		1	1			1	
130503	Ophelina cylindricaudata														1		
129413	Ophelia																
130980	Scalibregma inflatum																
152252	Ampharetinae											1					
129177	Samytha											1					
129153	Amage															1	
129804	Melinna cristata (complex)																
129708	Pista											1					
131573	Terebellides stroemii								1				1				
982	Terebellidae									1	1						
174568	Perkinsiana antarctica														3		
985	Sabellidae							1			1		2				
154918	Fabriciidae								1						2	1	
129530	Fabriciola											1					
129533	Jasmineira																
129525	Chone																
174564	Euchone pallida (Euchone sp1 NHM)		1			1							2		1	1	2
2036	Oligochaeta											4				1	
988	Serpulidae																
147018	Microrbinia																
244666	Phylo felix													1		1	
734535	Phylo minima																
146949	Galathowenia							1	1					2			
1066	**CRUSTACEA**																
106115	Scalpellum																
106140	Verruca								1								
106137	Altiverruca							1									14
1078	Ostracoda								3						1		2
1080	Copepoda	1	13	2	1				2				1		13	1	2
101436	Phtisica				1												2
1135	Amphipoda								1			1		1	2		3
101409	Stenothoidae								2								
101409	Stenothoidae				3												2
101789	Urothoe					2	1					2	2		3	4	
101403	Phoxocephalidae																
101403	Phoxocephalidae				2	3			1			1	1		1		2
101723	Phoxocephalus																
101675	Maera				1		3	4		1					2		2
101393	Leucothoidae															2	
176788	Lysianassoidea											1			1		1
176788	Lysianassoidea																
101445	Ampelisca					2		1		1		2	1		3		1
101445	Ampelisca																
101445	Ampelisca																
101445	Ampelisca		1														
101365	Amphilochidae											1	1				
101410	Synopiidae																
101563	Photis					2	3		1				1				2
101470	Leptocheirus														1	4	
101519	Eusirus				1												

Aphia ID	Species	A20_ENV_FA	A20_ENV_FB	A20_ENV_FC	A21_ENV_FA	A21_ENV_FB	A22_ENV_FA	A22_ENV_FB	A26_ENV_FA	A26_ENV_FB	A26_ENV_FC	A27_ENV_FA	A27_ENV_FB	A27_ENV_FC	A202_ENV_FA	A202_ENV_FB	A204_ENV_FA
101734	Dulichia				3										1		
118437	Gnathia												1				
257124	Caecognathia c.f.polaris																1
118354	Ilyarachna												1				1
256200	Munna argentinae																
118371	Macrostylis																1
118371	Macrostylis II																1
118351	Haploniscus															1	1
118358	Ischnomesus						2										
118356	Haplomesus																
n/a	Stylomesus elegans					1											
174952	Stylomesus																4
118319	Desmosoma				2					1						2	1
118323	Eugerda																
118360	Janirella																1
248358	Abyssianira				1												
118399	Cirolana									1							
118399	Cirolana																
213013	Pseudanthura lateralis								1					1			
255448	Haliophasma antarctica							1				1			1		
174514	Antarcturus						1										
136164	Tanaidae																1
136164	Tanaidae																
136222	Agathotanais															1	
136229	Leptognathia				5	1	1	2	1							2	1
136256	Typhlotanais																
136185	Apseudes							1									
136200	Pseudosphyrapus sp I												1			1	
136200	Pseudosphyrapus sp II																
182287	Eudorella gracilior																
110414	Leucon															1	
110398	Diastylis				3	2						1	1			2	3
110398	Diastylis sp II														1		3
110415	Campylaspis				1												
110415	Campylaspis spII																1
110404	Makrokylindrus																
51	**MOLLUSCA**																
138249	"Neomenia"																
138249	"Neomenia"																1
138249	"Neomenia "												1				
138249	"Neomenia"						1										
343675	Neopilina Lemche, 1957				1												
104	Scaphopoda														1		
138024	Cadulus																1
138013	Fissurella																
138508	Skenea																
138508	Skenea																
137970	Eulima																
147109	Polinices																
147109	Polinices																
390535	Fusitriton												1				
390535	Fusitriton																
138432	Retusa																
138217	Dacrydium				1				1		1				1	1	
138259	Nuculana																1
138672	Yoldia								1								
138132	Limopsis																
138323	Pecten																
147153	Similipecten													1			

Aphia ID	Species	A20_ENV_FA	A20_ENV_FB	A20_ENV_FC	A21_ENV_FA	A21_ENV_FB	A22_ENV_FA	A22_ENV_FB	A26_ENV_FA	A26_ENV_FB	A26_ENV_FC	A27_ENV_FA	A27_ENV_FB	A27_ENV_FC	A202_ENV_FA	A202_ENV_FB	A204_ENV_FA
197227	Limatula hodgsoni																
505622	Limea pygmaea																
138186	Mysella				2	1											
138654	Lyonsiella sp														1		
197467	Thracia meridionalis								1								
137858	Cuspidaria				1							1	1	1			
137863	Tropidomya																
152413	Axinulus											1					
138552	Thyasira				1				1	1		1	1				
138552	Thyasira II					3		1		2						4	
1806	**ECHINODERMATA**																
172707	Anseropoda antarctica †																
172769	Acodontaster elongatus															1	
123567	Ophiophycis aff mirabilis†																1
173102	Amphiura belgicae				1				1								2
123206	Amphiuridae																
123200	Ophiuridae																
236013	Ophiozonella falklandica									1			1				
160790	Brisaster antarcticus †					1											
123494	aff Thyone																
123473	Echinocucumis sp																
146121	Psolus				1					1							
	Psolus spII																
123182	Synaptidae				1									1			
123441	Myriotrochus		1							1						1	
1803	**BRACHIOPODA**																
1803	Brachiopoda				2												
1803	Brachiopoda II																
183339	Pelagodiscus																
	CHAETOGNATHA																
105413	Spadella		1														
		6	**8**	**1**	**29**	**17**	**14**	**16**	**32**	**21**	**8**	**27**	**28**	**17**	**28**	**34**	**43**
		6	**23**	**2**	**64**	**32**	**22**	**25**	**48**	**25**	**10**	**41**	**41**	**26**	**61**	**56**	**94**
		2.791	**2.233**	**0**	**6.733**	**4.617**	**4.206**	**4.66**	**8.008**	**6.213**	**3.04**	**7.001**	**7.271**	**4.911**	**6.568**	**8.198**	**9.244**
		1	**0.6947**	********	**0.8526**	**0.9613**	**0.9532**	**0.941**	**0.9513**	**0.9775**	**0.974**	**0.9336**	**0.9151**	**0.9086**	**0.8863**	**0.9449**	**0.8896**
		2.585	**2.084**	**0**	**4.142**	**3.929**	**3.629**	**3.764**	**4.756**	**4.294**	**2.922**	**4.439**	**4.399**	**3.714**	**4.261**	**4.807**	**4.827**
		1	**0.668**	**0**	**0.9092**	**0.9577**	**0.9524**	**0.95**	**0.9743**	**0.9833**	**0.9556**	**0.961**	**0.9488**	**0.9262**	**0.9355**	**0.974**	**0.9508**

Aphia ID	Species	A204_ENV_FB	A301_ENV_FA	A301_ENV_FC	A302_ENV_FA	A302_ENV_FB	A302_ENV_FC	A303_ENV_FA	A303_ENV_FB	A303_ENV_FC	A304_ENV_FA	A304_ENV_FC	A305_ENV_FA	A305_ENV_FB	A306_ENV_FA	A306_ENV_FB
1267	**CNIDARIA**															
128484	Pennatulidae	1									1					
1360	*Actinaria*	14	1													
100665	Edwardsiidae										2	1		1		
173052	*Flabellum (Flabellum) curvatum*		1													1
152391	**NEMERTEA**															
152391	Nemertea												1		4	
799	**NEMATODA**															
799	Nematoda	2					1									1
1268	**SIPUNCULA**															
410734	Nephasoma (Nephasoma) diaphanes	2			1				2		3		1	2		3
	ECHIURIDA															
110352	*Bonellia sp*															1
882	**ANNELIDA**															
129285	*Euphrosine Sp* 1 (no recorded NHM)†								1							
173263	*Euphrosine cirrata magellanica*															
939	Polynoidae															
129487	*Eunoe*		2								1					
174391	*Polyeunoa laevis*															
174468	*Harmothoe magellanica*															
129590	*Leanira*															
	Sigalionidae (not recorded by NHM)†															
129443	*Eteone*								1							
129450	*Mystides*															
130118	*Glycera capitata*										2		1	2		
948	Syllidae	1	1		2	1					1			1	1	
129677	*Sphaerosyllis*															
340445	*Gymnonereis fauveli*				2			1			2		3	1	4	2
173522	*Lumbrineris magalhaensis*					2						1		2		
129280	*Lysidice*											1				
129366	*Aglaophamus (posteriobranchiatus* NHM)				1											
	Aglaophanus sp I															
129370	Nephtys												1			
196680	Rhamphobrachium (Spinigerium) ehlersi	1		6	11	2	2	1	1	1	8	3	9	4	7	8
966	Eunicidae															
129278	Eunice															
130467	Nothria conchylega					1			1							
129425	Scoloplos			1								1		2	1	
129430	Aricidea								1			2				
326595	Aricidea (Allia) oculata															
525485	Aricidea (Acmira) strelzovi										1					
903	Paraonidae					1			3		1	1				
129198	Apistobranchus sp I					1		2	1		2	1	3		1	2
129198	Apistobranchus sp II													2		
913	Spionidae															
129620	Prionospio											1				
129623	Scolelepis															
129613	Laonice (Laonice sp2 NHM)								1						2	
129291	Flabelligera															
129289	Brada sp															
923	Maldanidae			1	3	1	4				2	3	2	1	2	
173557	Asychis amphiglypta					1			1							3
130305	Maldane sarsi															
130331	Rhodine loveni														1	

Aphia ID	Species	A204_ENV_FB	A301_ENV_FA	A301_ENV_FC	A302_ENV_FA	A302_ENV_FB	A302_ENV_FC	A303_ENV_FA	A303_ENV_FB	A303_ENV_FC	A304_ENV_FA	A304_ENV_FC	A305_ENV_FA	A305_ENV_FB	A306_ENV_FA	A306_ENV_FB
129924	Spiochaetopterus typicus							1	1		2	2		1	3	2
	Chaetozone sp 8 † (NHM)															
129243	Cirratulus Sp2															
129245	Pseudoscalibregma bransfeldia†	1											1			
129241	Caulleriella		1								2	2	2		1	1
129955	Chaetozone setosa (Chaetozone sp 5 NHM)				2						1	1			1	
173159	Tharyx fusiformis															
129249	Tharyx															
129898	Notomastus latericeus									1	1		1		1	
130503	Ophelina cylindricaudata															
129413	Ophelia															
130980	Scalibregma inflatum											1		1		
152252	Ampharetinae															
129177	Samytha															
129153	Amage				1											
129804	Melinna cristata (complex)								2		1	2	2		1	2
129708	Pista															
131573	Terebellides stroemii										1	3		2	1	1
982	Terebellidae					1									1	
174568	Perkinsiana antarctica												1			
985	Sabellidae				3		1					1		1	1	
154918	Fabriciidae								1		2					
129530	Fabriciola															
129533	Jasmineira						1									
129525	Chone															
174564	Euchone pallida (Euchone sp1 NHM)					2			2		3			1		2
2036	Oligochaeta	2						1			1		2			
988	Serpulidae												1			
147018	Microrbinia															
244666	Phylo felix									1				1		
734535	Phylo minima															
146949	Galathowenia	1												1		
1066	**CRUSTACEA**															
106115	Scalpellum								1						1	
106140	Verruca															
106137	Altiverruca															
1078	Ostracoda	1	1								1	1	3		18	
1080	Copepoda	1			6	4	30		2	2			2			
101436	Phtisica															1
1135	Amphipoda	1	1						1							
101409	Stenothoidae															
101409	Stenothoidae															
101789	Urothoe				1		1			1	4	1	3	4	3	2
101403	Phoxocephalidae															
101403	Phoxocephalidae					1					2		1		3	
101723	Phoxocephalus						1									
101675	Maera	3													1	
101393	Leucothoidae										1					
176788	Lysianassoidea		1						1							
176788	Lysianassoidea															
101445	Ampelisca					4	1		2		2	1		1		
101445	Ampelisca						1					2				
101445	Ampelisca															
101445	Ampelisca															
101365	Amphilochidae					2	1		1		2	1				
101410	Synopiidae									1						
101563	Photis				1	2										1
101470	Leptocheirus															
101519	Eusirus				1											

Aphia ID	Species	A204_ENV_FB	A301_ENV_FA	A301_ENV_FC	A302_ENV_FA	A302_ENV_FB	A302_ENV_FC	A303_ENV_FA	A303_ENV_FB	A303_ENV_FC	A304_ENV_FA	A304_ENV_FC	A305_ENV_FA	A305_ENV_FB	A306_ENV_FA	A306_ENV_FB
101734	Dulichia															
118437	Gnathia															
257124	Caecognathia c.f.polaris															
118354	Ilyarachna															
256200	Munna argentinae								1							
118371	Macrostylis										1					
118371	Macrostylis II	2														
118351	Haploniscus					2										
118358	Ischnomesus															
118356	Haplomesus															
n/a	Stylomesus elegans															
174952	Stylomesus															
118319	Desmosoma	1			1	2			2							
118323	Eugerda															
118360	Janirella															
248358	Abyssianira															
118399	Cirolana												1			
118399	Cirolana						2									
213013	Pseudanthura lateralis													2		3
255448	Haliophasma antarctica													2		
174514	Antarcturus						1				1					
136164	Tanaidae															
136164	Tanaidae															
136222	Agathotanais															
136229	Leptognathia								2				1			1
136256	Typhlotanais															
136185	Apseudes												1			
136200	Pseudosphyrapus sp I															
136200	Pseudosphyrapus sp II															
182287	Eudorella gracilior													1		
110414	Leucon												1			
110398	Diastylis				1		1		1			1				
110398	Diastylis sp II						1									
110415	Campylaspis						1									
110415	Campylaspis spII															
110404	Makrokylindrus															
51	**MOLLUSCA**															
138249	"Neomenia"															
138249	"Neomenia"															
138249	"Neomenia "			1							1					
138249	"Neomenia"															
343675	Neopilina Lemche, 1957															
104	Scaphopoda															
138024	Cadulus															
138013	Fissurella															
138508	Skenea															
138508	Skenea															
137970	Eulima															
147109	Polinices	1														
147109	Polinices															
390535	Fusitriton															
390535	Fusitriton															
138432	Retusa															
138217	Dacrydium	1	3						1		2					
138259	Nuculana															
138672	Yoldia					1					1					
138132	Limopsis		1													
138323	Pecten															
147153	Similipecten					2	1									

Aphia ID	Species	A204_ENV_FB	A301_ENV_FA	A301_ENV_FC	A302_ENV_FA	A302_ENV_FB	A302_ENV_FC	A303_ENV_FA	A303_ENV_FB	A303_ENV_FC	A304_ENV_FA	A304_ENV_FC	A305_ENV_FA	A305_ENV_FB	A306_ENV_FA	A306_ENV_FB
197227	Limatula hodgsoni															
505622	Limea pygmaea	1														
138186	Mysella								3						1	
138654	Lyonsiella sp															
197467	Thracia meridionalis															
137858	Cuspidaria															
137863	Tropidomya															
152413	Axinulus															
138552	Thyasira												2			
138552	Thyasira II					1					2	2		2		
1806	**ECHINODERMATA**															
172707	Anseropoda antarctica †															
172769	Acodontaster elongatus															
123567	Ophiophycis aff mirabilis†															
173102	Amphiura belgicae		1													2
123206	Amphiuridae															
123200	Ophiuridae															
236013	Ophiozonella falklandica		1													
160790	Brisaster antarcticus †										1					
123494	aff Thyone														1	
123473	Echinocucumis sp										1					
146121	Psolus		1													
	Psolus spII				1											
123182	Synaptidae															
123441	Myriotrochus															
1803	**BRACHIOPODA**															
1803	Brachiopoda		2													
1803	Brachiopoda II															
183339	Pelagodiscus						1									1
	CHAETOGNATHA															
105413	Spadella															
		18	**14**	**4**	**16**	**20**	**18**	**5**	**26**	**6**	**35**	**24**	**24**	**23**	**24**	**20**
		37	**18**	**9**	**38**	**34**	**52**	**6**	**37**	**7**	**62**	**36**	**46**	**38**	**61**	**40**
		4.708	**4.498**	**1.365**	**4.124**	**5.388**	**4.302**	**2.232**	**6.923**	**2.569**	**8.238**	**6.418**	**6.007**	**6.048**	**5.595**	**5.151**
		0.8211	**0.9675**	**0.7233**	**0.8576**	**0.9594**	**0.6328**	**0.9697**	**0.9731**	**0.9755**	**0.9485**	**0.9685**	**0.9224**	**0.9623**	**0.8324**	**0.9291**
		3.424	**3.684**	**1.447**	**3.43**	**4.146**	**2.639**	**2.252**	**4.574**	**2.522**	**4.865**	**4.44**	**4.229**	**4.353**	**3.816**	**4.015**
		0.8529	**0.9673**	**0.5833**	**0.8876**	**0.9643**	**0.6659**	**0.9333**	**0.9805**	**0.9524**	**0.972**	**0.9762**	**0.9478**	**0.9701**	**0.8923**	**0.9436**

Aphia ID	Species	A307_ENV_FA	A307_ENV_FB	A309_ENV_FA	A309_ENV_FB	A1008_ENV_FA	A1008_ENV_FB	A1011_ENV_FA	A1011_ENV_FB	A1013_ENV_FA	A1013_ENV_FB	A1015_ENV_FA	A1015_ENV_FB	A3010_ENV_FA	A3010_ENV_FB
1267	**CNIDARIA**														
128484	Pennatulidae					1				1					
1360	*Actinaria*		1									1		1	
100665	Edwardsiidae						1							2	
173052	*Flabellum (Flabellum) curvatum*														
152391	**NEMERTEA**														
152391	Nemertea	1		1			1	1		1			1		
799	**NEMATODA**														
799	Nematoda		1				1		1	1		1			3
1268	**SIPUNCULA**														
410734	Nephasoma (Nephasoma) diaphanes		2	1	1		2	1		3	1		3	3	
	ECHIURIDA														
110352	*Bonellia sp*														
882	**ANNELIDA**														
129285	*Euphrosine Sp* 1 (no recorded NHM)†											2			
173263	*Euphrosine cirrata magellanica*					1									
939	Polynoidae														
129487	*Eunoe*					1	1			2		1			1
174391	*Polyeunoa laevis*														
174468	*Harmothoe magellanica*														
129590	*Leanira*														
	Sigalionidae (not recorded by NHM)†														
129443	*Eteone*		1										2		
129450	*Mystides*														
130118	*Glycera capitata*													1	1
948	Syllidae		3			14	3						4	1	
129677	*Sphaerosyllis*										2		2		
340445	*Gymnonereis fauveli*	1						4	1			1	2	2	
173522	*Lumbrineris magalhaensis*					1						1		1	
129280	*Lysidice*														
129366	*Aglaophamus (posteriobranchiatus* NHM)												2		
	Aglaophanus sp I														
129370	Nephtys			1			1								
196680	Rhamphobrachium (Spinigerium) ehlersi		2	4	2	4		4	4	4	2	3	4	5	7
966	Eunicidae														
129278	Eunice														
130467	Nothria conchylega						2		1			1			1
129425	Scoloplos														
129430	Aricidea														
326595	Aricidea (Allia) oculata														
525485	Aricidea (Acmira) strelzovi							1							1
903	Paraonidae	1					1		1						
129198	Apistobranchus sp I	2	2		1	2	3	2	3					1	2
129198	Apistobranchus sp II														
913	Spionidae														
129620	Prionospio								1						
129623	Scolelepis														
129613	Laonice (Laonice sp2 NHM)							1						2	1
129291	Flabelligera												1		
129289	Brada sp											1			
923	Maldanidae			1									1	1	1
173557	Asychis amphiglypta							1							
130305	Maldane sarsi														
130331	Rhodine loveni														

Aphia ID	Species	A307_ENV_FA	A307_ENV_FB	A309_ENV_FA	A309_ENV_FB	A1008_ENV_FA	A1008_ENV_FB	A1011_ENV_FA	A1011_ENV_FB	A1013_ENV_FA	A1013_ENV_FB	A1015_ENV_FA	A1015_ENV_FB	A3010_ENV_FA	A3010_ENV_FB
129924	Spiochaetopterus typicus	1		1						2		1	1		
	Chaetozone sp 8 † (NHM)														
129243	Cirratulus Sp2														
129245	Pseudoscalibregma bransfeldia†												1	1	
129241	Caulleriella	1		2			1					4			2
129955	Chaetozone setosa (Chaetozone sp 5 NHM)														
173159	Tharyx fusiformis														
129249	Tharyx														
129898	Notomastus latericeus					1		1							
130503	Ophelina cylindricaudata		1												
129413	Ophelia														
130980	Scalibregma inflatum														
152252	Ampharetinae														
129177	Samytha												1		
129153	Amage							1							
129804	Melinna cristata (complex)						3		2		1		1		
129708	Pista														
131573	Terebellides stroemii	1													
982	Terebellidae	1					1					1			
174568	Perkinsiana antarctica														
985	Sabellidae			1						1		1	1	2	
154918	Fabriciidae		2					1			1				
129530	Fabriciola														
129533	Jasmineira														
129525	Chone						1								
174564	Euchone pallida (Euchone sp1 NHM)		1	1	1	3					2	1		1	
2036	Oligochaeta		1				1	3		1			2		1
988	Serpulidae														
147018	Microrbinia														
244666	Phylo felix			2			1	1		1					
734535	Phylo minima														
146949	Galathowenia		1	1		1									
1066	**CRUSTACEA**														
106115	Scalpellum												1		
106140	Verruca														
106137	Altiverruca											6	1		
1078	Ostracoda	1					1					1	4	1	1
1080	Copepoda			2	7			3		1	5				
101436	Phtisica		7			1	1								
1135	Amphipoda														1
101409	Stenothoidae														
101409	Stenothoidae						1								
101789	Urothoe		1	1				5	1			1		2	
101403	Phoxocephalidae														
101403	Phoxocephalidae		2				1		1	1					
101723	Phoxocephalus														
101675	Maera	1									1	2		2	
101393	Leucothoidae														
176788	Lysianassoidea		2						1				3		2
176788	Lysianassoidea														
101445	Ampelisca		3			1	2		2						2
101445	Ampelisca							2							
101445	Ampelisca							1							
101445	Ampelisca														
101365	Amphilochidae						1	2					2		
101410	Synopiidae														
101563	Photis														
101470	Leptocheirus														
101519	Eusirus														

Aphia ID	Species	A307_ENV_FA	A307_ENV_FB	A309_ENV_FA	A309_ENV_FB	A1008_ENV_FA	A1008_ENV_FB	A1011_ENV_FA	A1011_ENV_FB	A1013_ENV_FA	A1013_ENV_FB	A1015_ENV_FA	A1015_ENV_FB	A3010_ENV_FA	A3010_ENV_FB
101734	Dulichia						3								3
118437	Gnathia														
257124	Caecognathia c.f.polaris														
118354	Ilyarachna														
256200	Munna argentinae														
118371	Macrostylis														
118371	Macrostylis II														
118351	Haploniscus									1		1			
118358	Ischnomesus						1								
118356	Haplomesus														
n/a	Stylomesus elegans														
174952	Stylomesus											1			
118319	Desmosoma												1	1	1
118323	Eugerda														
118360	Janirella														
248358	Abyssianira														
118399	Cirolana														
118399	Cirolana														
213013	Pseudanthura lateralis				1										
255448	Haliophasma antarctica												1		
174514	Antarcturus						2			1		1			
136164	Tanaidae														
136164	Tanaidae							2						2	
136222	Agathotanais							2						2	1
136229	Leptognathia		1			1	3	2	1						1
136256	Typhlotanais														
136185	Apseudes			1			1						1		
136200	Pseudosphyrapus sp I		2												
136200	Pseudosphyrapus sp II									1					
182287	Eudorella gracilior														
110414	Leucon		1												
110398	Diastylis						1					1			
110398	Diastylis sp II		1						1						
110415	Campylaspis														
110415	Campylaspis spII														
110404	Makrokylindrus														
51	**MOLLUSCA**														
138249	"Neomenia"										1				
138249	"Neomenia"														
138249	"Neomenia "		1												
138249	"Neomenia"					1									
343675	Neopilina Lemche, 1957														
104	Scaphopoda														
138024	Cadulus														
138013	Fissurella												1		
138508	Skenea												1		
138508	Skenea											1			
137970	Eulima														
147109	Polinices														
147109	Polinices														
390535	Fusitriton						1						1		
390535	Fusitriton														
138432	Retusa		1												
138217	Dacrydium													1	
138259	Nuculana											1			
138672	Yoldia														1
138132	Limopsis										1	1			
138323	Pecten													1	
147153	Similipecten														1

Aphia ID	Species	A307_ENV_FA	A307_ENV_FB	A309_ENV_FA	A309_ENV_FB	A1008_ENV_FA	A1008_ENV_FB	A1011_ENV_FA	A1011_ENV_FB	A1013_ENV_FA	A1013_ENV_FB	A1015_ENV_FA	A1015_ENV_FB	A3010_ENV_FA	A3010_ENV_FB
197227	Limatula hodgsoni						1								
505622	Limea pygmaea														
138186	Mysella													1	
138654	Lyonsiella sp													1	
197467	Thracia meridionalis											1			
137858	Cuspidaria						2			1					
137863	Tropidomya														
152413	Axinulus							1							
138552	Thyasira														
138552	Thyasira II						2	2						2	2
1806	**ECHINODERMATA**														
172707	Anseropoda antarctica †						1								
172769	Acodontaster elongatus														
123567	Ophiophycis aff mirabilis†														
173102	Amphiura belgicae					2	1					2	2		
123206	Amphiuridae														
123200	Ophiuridae						3								
236013	Ophiozonella falklandica					1				1					
160790	Brisaster antarcticus †								1						
123494	aff Thyone														
123473	Echinocucumis sp														1
146121	Psolus											1			
	Psolus spII														
123182	Synaptidae		3										3		
123441	Myriotrochus														
1803	**BRACHIOPODA**														
1803	Brachiopoda														
1803	Brachiopoda II		1									1	1		
183339	Pelagodiscus														
	CHAETOGNATHA														
105413	Spadella							1							
		10	**25**	**14**	**6**	**16**	**35**	**24**	**15**	**17**	**10**	**29**	**30**	**25**	**23**
		11	**44**	**20**	**13**	**36**	**53**	**45**	**22**	**24**	**17**	**42**	**52**	**40**	**38**
		3.753	**6.342**	**4.34**	**1.949**	**4.186**	**8.564**	**6.042**	**4.529**	**5.035**	**3.177**	**7.491**	**7.339**	**6.506**	**6.048**
		0.9867	**0.9411**	**0.9513**	**0.7872**	**0.806**	**0.9676**	**0.95**	**0.9465**	**0.9509**	**0.9186**	**0.9421**	**0.9569**	**0.961**	**0.9323**
		3.278	**4.37**	**3.622**	**2.035**	**3.224**	**4.963**	**4.356**	**3.698**	**3.887**	**3.052**	**4.576**	**4.695**	**4.463**	**4.217**
		0.9818	**0.9609**	**0.9526**	**0.7179**	**0.8381**	**0.9826**	**0.9646**	**0.9524**	**0.9601**	**0.9044**	**0.9686**	**0.9744**	**0.9718**	**0.9545**

Aphia ID	Species	FISA _A3_ENV	FISA _A09_ENV	FISA _A10_ENV	FISA _A12_ENV	FISA _A14_ENV	FISA _A18_ENV	FISA _A20_ENV	FISA _A21_ENV	FISA _A22_ENV	FISA _A26_ENV	FISA _A27_ENV	FISA _A202_ENV	FISA _A204_ENV
1267	**CNIDARIA**													
128484	Pennatulidae											1		1
1360	*Actinaria*			1						1	1			28
100665	Edwardsiidae		1			1	1		1		1	1	1	
173052	*Flabellum (Flabellum) curvatum*			1	1									
152391	**NEMERTEA**													
152391	Nemertea	1	2				1	1	2		2	2	1	1
799	**NEMATODA**													
799	Nematoda	2	2		2						3	1	1	5
1268	**SIPUNCULA**													
410734	Nephasoma (Nephasoma) diaphanes		1			3	4		6	2	3	1	1	4
	ECHIURIDA													
110352	*Bonellia sp*						1							
882	**ANNELIDA**													
129285	*Euphrosine Sp* 1 (no recorded NHM)†										2			
173263	*Euphrosine cirrata magellanica*						1				2			
939	Polynoidae					2								
129487	*Eunoe*		1	2	1		1		2	1	4			2
174391	*Polyeunoa laevis*	1												
174468	*Harmothoe magellanica*	1												
129590	*Leanira*											1		
	Sigalionidae (not recorded by NHM)†											1		
129443	*Eteone*						1				2		1	2
129450	*Mystides*											1		
130118	*Glycera capitata*		1	2	1	1					1		2	
948	Syllidae	1	1			1		1			2	1		1
129677	*Sphaerosyllis*											2		
340445	*Gymnonereis fauveli*	9	2	2	1	7	3				3		10	
173522	*Lumbrineris magalhaensis*		3					1	5	1		2		1
129280	*Lysidice*				1									
129366	*Aglaophamus (posteriobranchiatus* NHM)		1	1			1							
	Aglaophanus sp I						1							
129370	Nephtys					1						2		
196680	Rhamphobrachium (Spinigerium) ehlersi	1	15	16	1	26	8	5	21	5	9	23	8	1
966	Eunicidae													1
129278	Eunice											1		
130467	Nothria conchylega			1		1	1				1			
129425	Scoloplos								1			1		
129430	Aricidea	3	1			3								
326595	Aricidea (Allia) oculata			1										
525485	Aricidea (Acmira) strelzovi			2	1	1						1		
903	Paraonidae	1	3			1								
129198	Apistobranchus sp I	3	6	3		3	1				1		8	
129198	Apistobranchus sp II													
913	Spionidae					1								
129620	Prionospio		1	1								1	1	
129623	Scolelepis				1		1		1				1	
129613	Laonice (Laonice sp2 NHM)													
129291	Flabelligera													
129289	Brada sp										1			3
923	Maldanidae	1	1	4	2	2	1			2	2	1	1	
173557	Asychis amphiglypta			1	1					2	3		1	
130305	Maldane sarsi									1		2		
130331	Rhodine loveni						2							

Aphia ID	Species	FISA _A3_ENV	FISA _A09_ENV	FISA _A10_ENV	FISA _A12_ENV	FISA _A14_ENV	FISA _A18_ENV	FISA _A20_ENV	FISA _A21_ENV	FISA _A22_ENV	FISA _A26_ENV	FISA _A27_ENV	FISA _A202_ENV	FISA _A204_ENV
129924	Spiochaetopterus typicus	1	2	1		2		2			1	2	2	1
	Chaetozone sp 8 † (NHM)													1
129243	Cirratulus Sp2		1				3							1
129245	Pseudoscalibregma bransfeldia†					2	2				1		1	1
129241	Caulleriella	1	5	5		3	1		1	6	1	5	3	1
129955	Chaetozone setosa (Chaetozone sp 5 NHM)	1	1			1		1	1	1	1			
173159	Tharyx fusiformis					1	1					1		
129249	Tharyx											2		
129898	Notomastus latericeus			1					1		1	2	1	
130503	Ophelina cylindricaudata			1			1						1	
129413	Ophelia	1												
130980	Scalibregma inflatum		1				1							
152252	Ampharetinae											1		
129177	Samytha			1			1					1		
129153	Amage	1					1						1	
129804	Melinna cristata (complex)		3	9	1	1	2							
129708	Pista	1										1		
131573	Terebellides stroemii	1	2	1		2	1				1	1		
982	Terebellidae		1	1							2			
174568	Perkinsiana antarctica												3	
985	Sabellidae	2		2		2				1	1	2		
154918	Fabriciidae				1	1	1				1		3	
129530	Fabriciola			1								1		
129533	Jasmineira	1												
129525	Chone	1												
174564	Euchone pallida (Euchone sp1 NHM)	2	3	3	1		1	1	1			2	2	2
2036	Oligochaeta	1	4	2		2						4	1	2
988	Serpulidae													
147018	Microrbinia	2												
244666	Phylo felix				1	3						1	1	
734535	Phylo minima	2												
146949	Galathowenia	1		1	1	1				1	1	2		1
1066	**CRUSTACEA**													
106115	Scalpellum		2											
106140	Verruca										1			
106137	Altiverruca									1				14
1078	Ostracoda	1	1			2					3		1	3
1080	Copepoda		1	1	2	1		16	1		2	1	14	3
101436	Phtisica								1					2
1135	Amphipoda	2	2			1					1	2	2	4
101409	Stenothoidae										2			
101409	Stenothoidae								3					2
101789	Urothoe	5	1	2		2	1		2	1		4	7	
101403	Phoxocephalidae		1			1								
101403	Phoxocephalidae	1		2		4	1		5		1	2	1	2
101723	Phoxocephalus			1										
101675	Maera		1						1	7	1		2	5
101393	Leucothoidae					1							2	
176788	Lysianassoidea	2										1	1	1
176788	Lysianassoidea	12				1								
101445	Ampelisca	3	11	7	1	6			2	1	1	3	3	1
101445	Ampelisca	4												
101445	Ampelisca													
101445	Ampelisca						3	1						
101365	Amphilochidae	3	1		1		1					2		
101410	Synopiidae													
101563	Photis			2		2			2	3	1	1		2
101470	Leptocheirus		2			1							5	
101519	Eusirus								1					

Aphia ID	Species	FISA _A3_ENV	FISA _A09_ENV	FISA _A10_ENV	FISA _A12_ENV	FISA _A14_ENV	FISA _A18_ENV	FISA _A20_ENV	FISA _A21_ENV	FISA _A22_ENV	FISA _A26_ENV	FISA _A27_ENV	FISA _A202_ENV	FISA _A204_ENV
101734	Dulichia								3				1	
118437	Gnathia											1		
257124	Caecognathia c.f.polaris													1
118354	Ilyarachna											1		1
256200	Munna argentinae													
118371	Macrostylis													1
118371	Macrostylis II													3
118351	Haploniscus												1	1
118358	Ischnomesus		1							2				
118356	Haplomesus						1							
n/a	Stylomesus elegans								1					
174952	Stylomesus		1											4
118319	Desmosoma	2	2				1		2		1		2	2
118323	Eugerda		1											
118360	Janirella													1
248358	Abyssianira								1					
118399	Cirolana	2	1								1			
118399	Cirolana													
213013	Pseudanthura lateralis	1	1	2							1	1		
255448	Haliophasma antarctica	1		1						1		1	1	
174514	Antarcturus		1	1		14				1				
136164	Tanaidae	1												1
136164	Tanaidae													
136222	Agathotanais	2	1				1						1	
136229	Leptognathia	5	4	1	1		5		6	3	1		2	1
136256	Typhlotanais					2								
136185	Apseudes						1			1				
136200	Pseudosphyrapus sp I											1	1	
136200	Pseudosphyrapus sp II													
182287	Eudorella gracilior													
110414	Leucon	1											1	
110398	Diastylis	2		1			1		5			2	2	3
110398	Diastylis sp II						1						1	3
110415	Campylaspis								1					
110415	Campylaspis spII													1
110404	Makrokylindrus	1												
51	**MOLLUSCA**													
138249	"Neomenia"													
138249	"Neomenia"													1
138249	"Neomenia "											1		
138249	"Neomenia"									1				
343675	Neopilina Lemche, 1957								1					
104	Scaphopoda												1	
138024	Cadulus	1												1
138013	Fissurella													
138508	Skenea				1									
138508	Skenea													
137970	Eulima					1								
147109	Polinices													1
147109	Polinices			1										
390535	Fusitriton		1			1						1		
390535	Fusitriton	2												
138432	Retusa													
138217	Dacrydium								1		2		2	1
138259	Nuculana						1							1
138672	Yoldia					2					1			
138132	Limopsis		1											
138323	Pecten													
147153	Similipecten											1		

Aphia ID	Species	FISA _A3_ENV	FISA _A09_ENV	FISA _A10_ENV	FISA _A12_ENV	FISA _A14_ENV	FISA _A18_ENV	FISA _A20_ENV	FISA _A21_ENV	FISA _A22_ENV	FISA _A26_ENV	FISA _A27_ENV	FISA _A202_ENV	FISA _A204_ENV
197227	Limatula hodgsoni	1		1										
505622	Limea pygmaea													1
138186	Mysella								3					
138654	Lyonsiella sp												1	
197467	Thracia meridionalis		1								1			
137858	Cuspidaria	2		1					1			3		
137863	Tropidomya						1							
152413	Axinulus				1	2						1		
138552	Thyasira		2			1			1		2	2		
138552	Thyasira II		2	2		2			3	1	2		4	
1806	**ECHINODERMATA**													
172707	Anseropoda antarctica †						1							
172769	Acodontaster elongatus												1	
123567	Ophiophycis aff mirabilis†													1
173102	Amphiura belgicae	1		1					1		1			2
123206	Amphiuridae	1												
123200	Ophiuridae													
236013	Ophiozonella falklandica			1		1					1	1		
160790	Brisaster antarcticus †								1					
123494	aff Thyone													
123473	Echinocucumis sp													
146121	Psolus								1		1			
	Psolus spII													
123182	Synaptidae								1			1		
123441	Myriotrochus							1			1		1	
1803	**BRACHIOPODA**													
1803	Brachiopoda								2					
1803	Brachiopoda II													
183339	Pelagodiscus													
	CHAETOGNATHA													
105413	Spadella							1						
		51	**50**	**44**	**22**	**47**	**42**	**11**	**39**	**24**	**50**	**56**	**50**	**52**
		102	**108**	**95**	**25**	**123**	**65**	**31**	**96**	**47**	**83**	**108**	**117**	**131**
		10.81	**10.47**	**9.443**	**6.524**	**9.559**	**9.822**	**2.912**	**8.325**	**5.974**	**11.09**	**11.75**	**10.29**	**10.46**
		0.9209	**0.9002**	**0.8885**	**0.9875**	**0.854**	**0.9346**	**0.7084**	**0.8692**	**0.9132**	**0.9496**	**0.8871**	**0.8951**	**0.854**
		5.224	**5.081**	**4.851**	**4.404**	**4.744**	**5.04**	**2.451**	**4.594**	**4.187**	**5.359**	**5.152**	**5.052**	**4.868**
		0.9703	**0.9619**	**0.953**	**0.99**	**0.9351**	**0.9731**	**0.7183**	**0.9366**	**0.9482**	**0.9797**	**0.9486**	**0.963**	**0.9372**

Aphia ID	Species	FISA _A301_ENV	FISA _A302_ENV	FISA _A303_ENV	FISA _A304_ENV	FISA _A305_ENV	FISA _A306_ENV	FISA _A307_ENV	FISA _A309_ENV	FISA _A1008_ENV	FISA _A1011_ENV	FISA _A1013_ENV	FISA _A1015_ENV	FISA _A3010_ENV
1267	**CNIDARIA**													
128484	Pennatulidae				1					1		1		
1360	*Actinaria*	1						1					1	1
100665	Edwardsiidae				3	1				1				2
173052	*Flabellum (Flabellum) curvatum*	1					1							
152391	**NEMERTEA**													
152391	Nemertea					1	4	1	1	1	1	1	1	
799	**NEMATODA**													
799	Nematoda		1				1	1		1	1	1	1	3
1268	**SIPUNCULA**													
410734	Nephasoma (Nephasoma) diaphanes		1	2	3	3	3	2	2	2	1	4	3	3
	ECHIURIDA													
110352	*Bonellia sp*						1							
882	**ANNELIDA**													
129285	*Euphrosine Sp* 1 (no recorded NHM)†			1									2	
173263	*Euphrosine cirrata magellanica*									1				
939	Polynoidae													
129487	*Eunoe*	2			1					2		2	1	1
174391	*Polyeunoa laevis*													
174468	*Harmothoe magellanica*													
129590	*Leanira*													
	Sigalionidae (not recorded by NHM)†													
129443	*Eteone*			1				1					2	
129450	*Mystides*													
130118	*Glycera capitata*				2	3								2
948	Syllidae	1	3		1	1	1	3		17			4	1
129677	*Sphaerosyllis*											2	2	
340445	*Gymnonereis fauveli*		2	1	2	4	6	1			5		3	2
173522	*Lumbrineris magalhaensis*		2		1	2				1			1	1
129280	*Lysidice*				1									
129366	*Aglaophamus (posteriobranchiatus* NHM)		1										2	
	Aglaophanus sp I													
129370	Nephtys					1			1	1				
196680	Rhamphobrachium (Spinigerium) ehlersi	6	15	3	11	13	15	2	6	4	8	6	7	12
966	Eunicidae													
129278	Eunice													
130467	Nothria conchylega		1	1						2	1		1	1
129425	Scoloplos	1			1	2	1							
129430	Aricidea			1	2									
326595	Aricidea (Allia) oculata													
525485	Aricidea (Acmira) strelzovi				1						1			1
903	Paraonidae		1	3	2			1		1	1			
129198	Apistobranchus sp I		1	3	3	3	3	4	1	5	5			3
129198	Apistobranchus sp II					2								
913	Spionidae													
129620	Prionospio				1						1			
129623	Scolelepis													
129613	Laonice (Laonice sp2 NHM)			1			2				1			3
129291	Flabelligera												1	
129289	Brada sp												1	
923	Maldanidae	1	8		5	3	2		1				1	2
173557	Asychis amphiglypta		1	1			3				1			
130305	Maldane sarsi													
130331	Rhodine loveni						1							

Aphia ID	Species	FISA _A301_ENV	FISA _A302_ENV	FISA _A303_ENV	FISA _A304_ENV	FISA _A305_ENV	FISA _A306_ENV	FISA _A307_ENV	FISA _A309_ENV	FISA _A1008_ENV	FISA _A1011_ENV	FISA _A1013_ENV	FISA _A1015_ENV	FISA _A3010_ENV
129924	Spiochaetopterus typicus			2	4	1	5	1	1			2	2	
	Chaetozone sp 8 † (NHM)													
129243	Cirratulus Sp2													
129245	Pseudoscalibregma bransfeldia†					1							1	1
129241	Caulleriella	1			4	2	2	1	2	1			4	2
129955	Chaetozone setosa (Chaetozone sp 5 NHM)		2		2		1							
173159	Tharyx fusiformis													
129249	Tharyx													
129898	Notomastus latericeus			1	1	1	1			1	1			
130503	Ophelina cylindricaudata							1						
129413	Ophelia													
130980	Scalibregma inflatum				1	1								
152252	Ampharetinae													
129177	Samytha												1	
129153	Amage		1								1			
129804	Melinna cristata (complex)			2	3	2	3			3	2	1	1	
129708	Pista													
131573	Terebellides stroemii				4	2	2	1						
982	Terebellidae		1				1	1		1			1	
174568	Perkinsiana antarctica					1								
985	Sabellidae		4		1	1	1		1			1	2	2
154918	Fabriciidae			1	2			2			1	1		
129530	Fabriciola													
129533	Jasmineira		1											
129525	Chone									1				
174564	Euchone pallida (Euchone sp1 NHM)		2	2	3	1	2	1	2	3		2	1	1
2036	Oligochaeta			1	1	2		1		1	3	1	2	1
988	Serpulidae					1								
147018	Microrbinia													
244666	Phylo felix			1		1			2	1	1	1		
734535	Phylo minima													
146949	Galathowenia					1		1	1	1				
1066	**CRUSTACEA**													
106115	Scalpellum			1			1						1	
106140	Verruca													
106137	Altiverruca												7	
1078	Ostracoda	1			2	3	18	1		1			5	2
1080	Copepoda		40	4		2			9		3	6		
101436	Phtisica						1	7		2				
1135	Amphipoda	1		1										1
101409	Stenothoidae													
101409	Stenothoidae									1				
101789	Urothoe		2	1	5	7	5	1	1		6		1	2
101403	Phoxocephalidae													
101403	Phoxocephalidae		1		2	1	3	2		1	1	1		
101723	Phoxocephalus		1											
101675	Maera						1	1				1	2	2
101393	Leucothoidae				1									
176788	Lysianassoidea	1		1				2			1		3	2
176788	Lysianassoidea													
101445	Ampelisca		5	2	3	1		3		3	2			2
101445	Ampelisca		1		2						2			
101445	Ampelisca										1			
101445	Ampelisca													
101365	Amphilochidae		3	1	3					1	2		2	
101410	Synopiidae			1										
101563	Photis		3				1							
101470	Leptocheirus													
101519	Eusirus		1											

Aphia ID	Species	FISA _A301_ENV	FISA _A302_ENV	FISA _A303_ENV	FISA _A304_ENV	FISA _A305_ENV	FISA _A306_ENV	FISA _A307_ENV	FISA _A309_ENV	FISA _A1008_ENV	FISA _A1011_ENV	FISA _A1013_ENV	FISA _A1015_ENV	FISA _A3010_ENV
101734	Dulichia									3				3
118437	Gnathia													
257124	Caecognathia c.f.polaris													
118354	Ilyarachna													
256200	Munna argentinae			1										
118371	Macrostylis				1									
118371	Macrostylis II													
118351	Haploniscus		2									1	1	
118358	Ischnomesus									1				
118356	Haplomesus													
n/a	Stylomesus elegans													
174952	Stylomesus												1	
118319	Desmosoma		3	2									1	2
118323	Eugerda													
118360	Janirella													
248358	Abyssianira													
118399	Cirolana					1								
118399	Cirolana		2											
213013	Pseudanthura lateralis					2	3		1					
255448	Haliophasma antarctica					2							1	
174514	Antarcturus		1		1					2		1	1	
136164	Tanaidae													
136164	Tanaidae										2			2
136222	Agathotanais										2			3
136229	Leptognathia			2		1	1	1		4	3			1
136256	Typhlotanais													
136185	Apseudes					1			1	1			1	
136200	Pseudosphyrapus sp I							2						
136200	Pseudosphyrapus sp II											1		
182287	Eudorella gracilior					1								
110414	Leucon					1		1						
110398	Diastylis		2	1	1					1			1	
110398	Diastylis sp II		1					1			1			
110415	Campylaspis		1											
110415	Campylaspis spII													
110404	Makrokylindrus													
51	**MOLLUSCA**													
138249	"Neomenia"											1		
138249	"Neomenia"													
138249	"Neomenia "	1			1			1						
138249	"Neomenia"									1				
343675	Neopilina Lemche, 1957													
104	Scaphopoda													
138024	Cadulus													
138013	Fissurella												1	
138508	Skenea												1	
138508	Skenea												1	
137970	Eulima													
147109	Polinices													
147109	Polinices													
390535	Fusitriton									1			1	
390535	Fusitriton													
138432	Retusa							1						
138217	Dacrydium	3		1	2									1
138259	Nuculana												1	
138672	Yoldia		1		1									1
138132	Limopsis	1										1	1	1
138323	Pecten													1
147153	Similipecten		3											1

Aphia ID	Species	FISA _A301_ENV	FISA _A302_ENV	FISA _A303_ENV	FISA _A304_ENV	FISA _A305_ENV	FISA _A306_ENV	FISA _A307_ENV	FISA _A309_ENV	FISA _A1008_ENV	FISA _A1011_ENV	FISA _A1013_ENV	FISA _A1015_ENV	FISA _A3010_ENV
197227	Limatula hodgsoni									1				
505622	Limea pygmaea													
138186	Mysella			3			1							1
138654	Lyonsiella sp													1
197467	Thracia meridionalis												1	
137858	Cuspidaria									2		1		
137863	Tropidomya													
152413	Axinulus										1			
138552	Thyasira					2								
138552	Thyasira II		1		4	2				2	2			4
1806	**ECHINODERMATA**													
172707	Anseropoda antarctica †									1				
172769	Acodontaster elongatus													
123567	Ophiophycis aff mirabilis†													
173102	Amphiura belgicae	1					2			3			4	
123206	Amphiuridae													
123200	Ophiuridae									3				
236013	Ophiozonella falklandica	1								1		1		
160790	Brisaster antarcticus †				1						1			
123494	aff Thyone						1							
123473	Echinocucumis sp				1									1
146121	Psolus	1											1	
	Psolus spII		1											
123182	Synaptidae							3					3	
123441	Myriotrochus													
1803	**BRACHIOPODA**													
1803	Brachiopoda	2												
1803	Brachiopoda II							1					2	
183339	Pelagodiscus		1				1							
	CHAETOGNATHA													
105413	Spadella										1			
		18	**39**	**32**	**44**	**41**	**36**	**34**	**16**	**44**	**34**	**24**	**51**	**39**
		27	**124**	**50**	**98**	**84**	**101**	**55**	**33**	**89**	**67**	**41**	**94**	**78**
		5.158	**7.883**	**7.924**	**9.378**	**9.028**	**7.584**	**8.235**	**4.29**	**9.58**	**7.848**	**6.193**	**11.01**	**8.722**
		0.9248	**0.7743**	**0.9647**	**0.9377**	**0.9186**	**0.8648**	**0.9437**	**0.8669**	**0.8988**	**0.9254**	**0.9184**	**0.9418**	**0.9332**
		3.856	**4.092**	**4.823**	**5.119**	**4.922**	**4.471**	**4.801**	**3.467**	**4.907**	**4.708**	**4.211**	**5.343**	**4.932**
		0.943	**0.8752**	**0.9796**	**0.9726**	**0.9621**	**0.936**	**0.9717**	**0.8958**	**0.9533**	**0.9643**	**0.9512**	**0.979**	**0.9657**

Aphia ID	Species	Authority	A3_ENV_FA	A3_ENV_FB	A09_ENV_FA	A09_ENV_FB	A09_ENV_FC	A10_ENV_FA	A10_ENV_FB	A10_ENV_FC	A12_ENV_FA	A12_ENV_FC	A14_ENV_FA	A14_ENV_FB	A18_ENV_FA	A18_ENV_FB	A20_ENV_FA	A20_ENV_FB	A20_ENV_FC	A21_ENV_FA	A21_ENV_FB	A22_ENV_FA	A22_ENV_FB
Epifaunal Species																							
1267	**CNIDARIA**																						
117136	Lafoea	Lamouroux, 1821																					
117103	*Halecinum sp*	Oken, 1815																					
116999	Aglaophenia	Lamouroux, 1812																					
117243	Lepidopora	Pourtalès, 1871																					
174823	*Stylaster densicaulis*	Moseley, 1879										+	+	+						+	+	+	+
125287	*Sarcodictyon Forbes*	(in Johnston), 1847			+																		
173450	*Callozostron carlottae*	Kükenthal, 1909	+		+									+							+		
409519	*Fannyella (Fannyella) rossii*	Gray, 1872												+									
1365	Alcyonacea																						
135220	Scyphozoa		16	12	9	13	1	6	9	9	4	2		2	11	14	12	8	3		8	1	22
135095	*Lophelia*	Milne-Edwards & Haime, 1849																					
1821	**CHORDATA**																						
103506	*Eugyra*	Alder & Hancock, 1870		1		*1*			*1*											*1*			
173279	*Molgula pedunculata*	Herdman, 1881																					
579849	**GRAPTOLITHOIDEA**	Beklemishev, 1951																					
137594	Rhabdopleura	Allman, 1869																					
558	**PORIFERA**	Grant, 1836																					
131723	*Sycon*	Risso, 1827																					
132110	Hexactinella	Carter, 1885	+										+		+								+
132110	Hexactinella	Carter, 1885	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
131662	*Ancorinidae*	Schmidt, 1870																					
132077	*Tethya*	Lamarck, 1815																					
171200	*Gastrophanella*	Schmidt, 1879																					
132072	*Suberites*	Nardo, 1833																					
132046	*Polymastia*	Bowerbank, 1864																					+
170677	aff Radiella sol	Schmidt, 1870						+		+													
131882	*Eurypon*	Gray, 1867			1	+		+					+	+						+		+	+
131882	*Eurypon*	Gray, 1867											+										
131790	*Halicnemia*	Bowerbank, 1864																					
132053	*Tentorium*	Vosmaer, 1887						+															
131912	*Ulosa*	de Laubenfels, 1936							+														
131893	*Asbestopluma*	Topsent, 1901		+								+	+			+							
131893	*Asbestopluma II*	Topsent, 1901																					
131893	*Asbestopluma III*	Topsent, 1901																					
131936	*Crella*	Gray, 1867																					
131906	*Esperiopsis*	Carter, 1882	+					+												+			
131907	*Mycale*	Gray, 1867																					
131926	*Inflatella*	Schmidt, 1875																					
131905	*Isodictya*	Bowerbank, 1864											+										
131930	*Lissodendoryx*	Topsent, 1892																					+
131950	*Hymedesmia I*	Bowerbank, 1864																					
131950	*Hymedesmia II*	Bowerbank, 1864																					
131969	*Melonanchora*	Carter, 1874																					
131641	Microcionidae	Carter, 1875												+						+			
131786	*Monocrepidium sp*	Topsent, 1898																					
131834	*Haliclona*	Grant, 1836																+					
146142	**BRYOZOA**																						
111054	*Tubulipora*	Lamarck, 1816						+													+		
111029	*Annectocyma*	Hayward & Ryland, 1985			+	+	+	+	+	+	+	+	+		+			+		+	+		+
111052	*Idmidronea*	Canu & Bassler, 1920				+		+	+													+	
111041	*Hornera*	Lamouroux, 1821																					+
111041	*Hornera*	Lamouroux, 1821																					
111044	*Disporella*	Gray, 1848																					
111048	*Stomatopora*	Bronn, 1825			+			+						+				+		+			
468484	*Isosecuriflustra*	Liu & Hu, 1991											+		+								+
110851	*Callopora*	Gray, 1848			+	+				+	+	+		+				+					
110849	*Amphiblestrum*	Gray, 1848																					
173093	*Notoplites klugei*	(Hasenbank, 1932)		+																			
110865	*Notoplites*	Harmer, 1923																					
110869	*Cellaria*	Ellis & Solander, 1786		+							+												
173311	*Melicerita*	Milne Edwards, 1836																					
172987	*Cornucopina*	Levinsen, 1909																			+	+	
110965	*Escharella*	Gray, 1848	+		+	+	+			+			+							+		+	
110965	*Escharella*	Gray, 1848											+							+		+	
110972	*Escharina*	Milne Edwards, 1836						+		+										+			
110941	*Fenestrulina*	Jullien, 1888											+										
110931	*Hippothoa*	Lamouroux, 1821									+												
110932	*Plesiothoa*	Gordon & Hastings, 1979								+		+	+	+	+			+		+			+
110873	*Cellepora*	Linnaeus, 1767			+					+		+			+								+
173401	*Spigaleos*	Hayward, 1992																					

Aphia ID	Species	Authority	A3_ENV_FA	A3_ENV_FB	A09_ENV_FA	A09_ENV_FB	A09_ENV_FC	A10_ENV_FA	A10_ENV_FB	A10_ENV_FC	A12_ENV_FA	A12_ENV_FC	A14_ENV_FA	A14_ENV_FB	A18_ENV_FA	A18_ENV_FB	A20_ENV_FA	A20_ENV_FB	A20_ENV_FC	A21_ENV_FA	A21_ENV_FB	A22_ENV_FA	A22_ENV_FB
Epifaunal Species																							
Juvenile and fragmented species																							
1066	**CRUSTACEA**																						
118394	*Aega Frag.*	Leach, 1815																					
118394	*Aega juv*	Leach, 1815																					
1806	**ECHINODERMATA**	Bruguière, 1791 [ex Klein, 1734]																					
123080	Asteroidea juv																						
123083	Holothurioidea juv																						

Aphia ID	Species	Authority	A26_ENV_FA	A26_ENV_FB	A26_ENV_FC	A27_ENV_FA	A27_ENV_FB	A27_ENV_FC	A202_ENV_FA	A202_ENV_FB	A204_ENV_FA	A204_ENV_FB	A301_ENV_FA	A301_ENV_FC	A302_ENV_FA	A302_ENV_FB	A302_ENV_FC	A303_ENV_FA	A303_ENV_FB	A303_ENV_FC	A304_ENV_FA	A304_ENV_FC
Epifaunal Species																						
1267	**CNIDARIA**																					
117136	Lafoea	Lamouroux, 1821		+																		
117103	*Halecinum sp*	Oken, 1815																				
116999	Aglaophenia	Lamouroux, 1812																				
117243	Lepidopora	Pourtalès, 1871		+																		
174823	*Stylaster densicaulis*	Moseley, 1879	+		+						+	+										
125287	*Sarcodictyon Forbes*	(in Johnston), 1847																				
173450	*Callozostron carlottae*	Kükenthal, 1909											+									
409519	*Fannyella (Fannyella) rossii*	Gray, 1872	+										+									
1365	Alcyonacea																					
135220	Scyphozoa		2	4	2	21	15	2	3	4				12		**20**	15	11	6	5	3	2
135095	*Lophelia*	Milne-Edwards & Haime, 1849	+								+		+						+			
1821	**CHORDATA**																					
103506	*Eugyra*	Alder & Hancock, 1870				*1*				*1*												*1*
173279	*Molgula pedunculata*	Herdman, 1881	*1*										*1*			**2**						
579849	**GRAPTOLITHOIDEA**	Beklemishev, 1951																				
137594	Rhabdopleura	Allman, 1869	+								+											
558	**PORIFERA**	Grant, 1836																				
131723	*Sycon*	Risso, 1827																				
132110	Hexactinella	Carter, 1885			+	+	+	+			+	+		+								
132110	Hexactinella	Carter, 1885	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
131662	*Ancorinidae*	Schmidt, 1870																				
132077	*Tethya*	Lamarck, 1815																				
171200	*Gastrophanella*	Schmidt, 1879																				
132072	*Suberites*	Nardo, 1833																				
132046	*Polymastia*	Bowerbank, 1864			+																	
170677	aff Radiella sol	Schmidt, 1870	+	+													+					
131882	*Eurypon*	Gray, 1867	+	+	+							+	+		+	+		+	+		+	
131882	*Eurypon*	Gray, 1867									+											
131790	*Halicnemia*	Bowerbank, 1864																				
132053	*Tentorium*	Vosmaer, 1887																				
131912	*Ulosa*	de Laubenfels, 1936																				
131893	*Asbestopluma*	Topsent, 1901														+						
131893	*Asbestopluma II*	Topsent, 1901																				
131893	*Asbestopluma III*	Topsent, 1901																				
131936	*Crella*	Gray, 1867	+	+	+																	
131906	*Esperiopsis*	Carter, 1882															+					
131907	*Mycale*	Gray, 1867	+																			
131926	*Inflatella*	Schmidt, 1875			+																	
131905	*Isodictya*	Bowerbank, 1864																				
131930	*Lissodendoryx*	Topsent, 1892																				
131950	*Hymedesmia I*	Bowerbank, 1864	+																			
131950	*Hymedesmia II*	Bowerbank, 1864											+									
131969	*Melonanchora*	Carter, 1874																				
131641	Microcionidae	Carter, 1875	+																			
131786	*Monocrepidium sp*	Topsent, 1898	+																			
131834	*Haliclona*	Grant, 1836																				
146142	**BRYOZOA**																					
111054	*Tubulipora*	Lamarck, 1816				+							+		+	+				+		
111029	*Annectocyma*	Hayward & Ryland, 1985					+	+							+	+		+	+			
111052	*Idmidronea*	Canu & Bassler, 1920					+						+		+							
111041	*Hornera*	Lamouroux, 1821		+																		
111041	*Hornera*	Lamouroux, 1821									+		+									
111044	*Disporella*	Gray, 1848											+									
111048	*Stomatopora*	Bronn, 1825													+	+	+					
468484	*Isosecuriflustra*	Liu & Hu, 1991														+		+				
110851	*Callopora*	Gray, 1848					+		+				+	+		+			+			
110849	*Amphiblestrum*	Gray, 1848			+														+			
173093	*Notoplites klugei*	(Hasenbank, 1932)																				
110865	*Notoplites*	Harmer, 1923	+	+																		
110869	*Cellaria*	Ellis & Solander, 1786																				
173311	*Melicerita*	Milne Edwards, 1836											+								+	
172987	*Cornucopina*	Levinsen, 1909														+						
110965	*Escharella*	Gray, 1848	+		+											+			+			
110965	*Escharella*	Gray, 1848		+											+							
110972	*Escharina*	Milne Edwards, 1836	+																	+		
110941	*Fenestrulina*	Jullien, 1888	+										+			+						
110931	*Hippothoa*	Lamouroux, 1821																				
110932	*Plesiothoa*	Gordon & Hastings, 1979		+	+											+	+			+		
110873	*Cellepora*	Linnaeus, 1767		+	+			+				+	+			+			+	+		+
173401	*Spigaleos*	Hayward, 1992																				

Aphia ID	Species	Authority	A26_ENV_FA	A26_ENV_FB	A26_ENV_FC	A27_ENV_FA	A27_ENV_FB	A27_ENV_FC	A202_ENV_FA	A202_ENV_FB	A204_ENV_FA	A204_ENV_FB	A301_ENV_FA	A301_ENV_FC	A302_ENV_FA	A302_ENV_FB	A302_ENV_FC	A303_ENV_FA	A303_ENV_FB	A303_ENV_FC	A304_ENV_FA	A304_ENV_FC
Epifaunal Species																						
Juvenile and fragmented species																						
1066	**CRUSTACEA**																					
118394	*Aega Frag.*	Leach, 1815																				
118394	*Aega juv*	Leach, 1815																				
1806	**ECHINODERMATA**	Bruguière, 1791 [ex Klein, 1734]																				
123080	Asteroidea juv								1					1								
123083	Holothurioidea juv																					

Aphia ID	Species	Authority	A305_ENV_FA	A305_ENV_FB	A306_ENV_FA	A306_ENV_FB	A307_ENV_FA	A307_ENV_FB	A309_ENV_FA	A309_ENV_FB	A1008_ENV_FA	A1008_ENV_FB	A1011_ENV_FA	A1011_ENV_FB	A1013_ENV_FA	A1013_ENV_FB	A1015_ENV_FA	A1015_ENV_FB	A3010_ENV_FA	A3010_ENV_FB
Epifaunal Species																				
1267	**CNIDARIA**																			
117136	Lafoea	Lamouroux, 1821									+									
117103	*Halecinum sp*	Oken, 1815										+								
116999	Aglaophenia	Lamouroux, 1812										+								
117243	Lepidopora	Pourtalès, 1871																		
174823	*Stylaster densicaulis*	Moseley, 1879				+		+							+		+			
125287	*Sarcodictyon Forbes*	(in Johnston), 1847	+						+											
173450	*Callozostron carlottae*	Kükenthal, 1909										+			+					
409519	*Fannyella (Fannyella) rossii*	Gray, 1872													+		+			
1365	Alcyonacea							+												
135220	Scyphozoa		2	1	8	11	11	6	12	3	11	1	11	1	1		3	6	9	8
135095	*Lophelia*	Milne-Edwards & Haime, 1849													+	+				
1821	**CHORDATA**																			
103506	*Eugyra*	Alder & Hancock, 1870	*1*		*1*			*1*												
173279	*Molgula pedunculata*	Herdman, 1881																		
579849	**GRAPTOLITHOIDEA**	Beklemishev, 1951																		
137594	Rhabdopleura	Allman, 1869			+															
558	**PORIFERA**	Grant, 1836																		
131723	*Sycon*	Risso, 1827							**+**											
132110	Hexactinella	Carter, 1885			1				+			+	+							+
132110	Hexactinella	Carter, 1885	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
131662	*Ancorinidae*	Schmidt, 1870					+													
132077	*Tethya*	Lamarck, 1815				+											+	+		
171200	*Gastrophanella*	Schmidt, 1879									+									
132072	*Suberites*	Nardo, 1833										+								
132046	*Polymastia*	Bowerbank, 1864									+									
170677	aff Radiella sol	Schmidt, 1870	+	+				+								1		+		
131882	*Eurypon*	Gray, 1867				+						+			+			+		
131882	*Eurypon*	Gray, 1867										+						+		
131790	*Halicnemia*	Bowerbank, 1864															+			
132053	*Tentorium*	Vosmaer, 1887																+		
131912	*Ulosa*	de Laubenfels, 1936															+			
131893	*Asbestopluma*	Topsent, 1901									2	2								
131893	*Asbestopluma II*	Topsent, 1901									2	1								
131893	*Asbestopluma III*	Topsent, 1901									3									
131936	*Crella*	Gray, 1867															+			
131906	*Esperiopsis*	Carter, 1882																		
131907	*Mycale*	Gray, 1867																		
131926	*Inflatella*	Schmidt, 1875																		
131905	*Isodictya*	Bowerbank, 1864																		
131930	*Lissodendoryx*	Topsent, 1892																		
131950	*Hymedesmia I*	Bowerbank, 1864																		
131950	*Hymedesmia II*	Bowerbank, 1864																		
131969	*Melonanchora*	Carter, 1874																+		+
131641	Microcionidae	Carter, 1875																		
131786	*Monocrepidium sp*	Topsent, 1898																+		
131834	*Haliclona*	Grant, 1836																		
146142	**BRYOZOA**																			
111054	*Tubulipora*	Lamarck, 1816	+								+									+
111029	*Annectocyma*	Hayward & Ryland, 1985			+	+	+	+	+		+	+							+	+
111052	*Idmidronea*	Canu & Bassler, 1920																		
111041	*Hornera*	Lamouroux, 1821						+			+				+			+		
111041	*Hornera*	Lamouroux, 1821															+			
111044	*Disporella*	Gray, 1848																		
111048	*Stomatopora*	Bronn, 1825						+												
468484	*Isosecuriflustra*	Liu & Hu, 1991			+	+					+							+		
110851	*Callopora*	Gray, 1848		+				+				+							+	+
110849	*Amphiblestrum*	Gray, 1848															+	+		
173093	*Notoplites klugei*	(Hasenbank, 1932)																		
110865	*Notoplites*	Harmer, 1923									+				+		+			
110869	*Cellaria*	Ellis & Solander, 1786																		
173311	*Melicerita*	Milne Edwards, 1836									+				+					
172987	*Cornucopina*	Levinsen, 1909					+	+												
110965	*Escharella*	Gray, 1848			+			+			+	+								
110965	*Escharella*	Gray, 1848					+				+	+								
110972	*Escharina*	Milne Edwards, 1836																		
110941	*Fenestrulina*	Jullien, 1888					+					+								
110931	*Hippothoa*	Lamouroux, 1821							+											
110932	*Plesiothoa*	Gordon & Hastings, 1979			+	+	+												+	+
110873	*Cellepora*	Linnaeus, 1767			+			+	+										+	
173401	*Spigaleos*	Hayward, 1992																		+

Aphia ID	Species	Authority	A305_ENV_FA	A305_ENV_FB	A306_ENV_FA	A306_ENV_FB	A307_ENV_FA	A307_ENV_FB	A309_ENV_FA	A309_ENV_FB	A1008_ENV_FA	A1008_ENV_FB	A1011_ENV_FA	A1011_ENV_FB	A1013_ENV_FA	A1013_ENV_FB	A1015_ENV_FA	A1015_ENV_FB	A3010_ENV_FA	A3010_ENV_FB
Epifaunal Species																				
Juvenile and fragmented species																				
1066	**CRUSTACEA**																			
118394	*Aega Frag.*	Leach, 1815		*1*																
118394	*Aega juv*	Leach, 1815		*26*																
1806	**ECHINODERMATA**	Bruguière, 1791 [ex Klein, 1734]																		
123080	Asteroidea juv																			
123083	Holothurioidea juv						*1*													

APPENDIX VIII – SEABED AND SAMPLE PHOTOGRAPHS

Habitat Summary Information: A/1011/ENV

Survey Area: FISA

No. of Stills: 17 | **Mins of Video: 28** | **Track Length: 139m**

Site Selection Criteria
Deepest point of hollow feature

Analogue Interpretation
Very slight slope

Sediment Description
Light grey to black bioturbated slightly silty sand with occasional fine gravels

Conspicuous Fauna
Decapod Shrimp sp., Cup Coral: *Flabellum sp* ., Isopod: possibly *Acutiserolis neaera*,

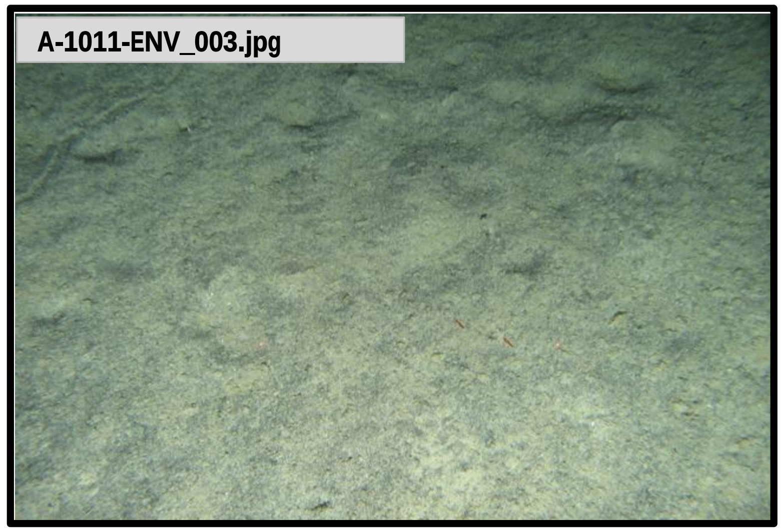


Photo Position: 784828 mE, 4213108 mN

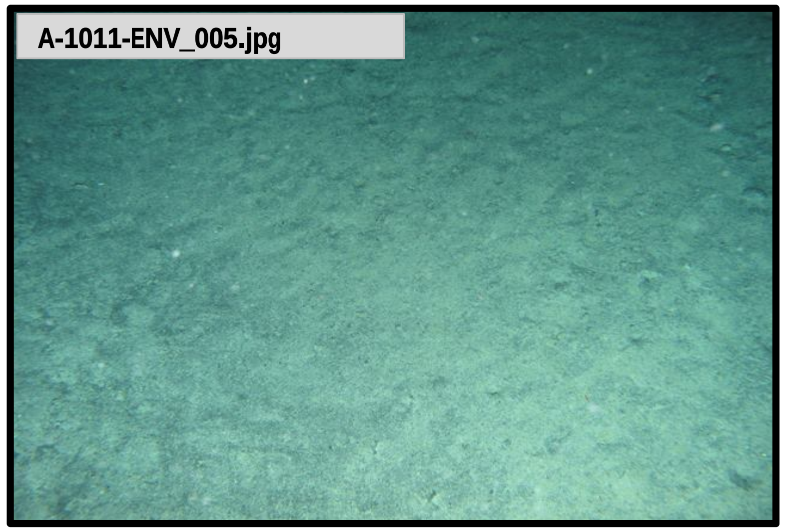


Photo Position: 784824 mE, 4213107 mN

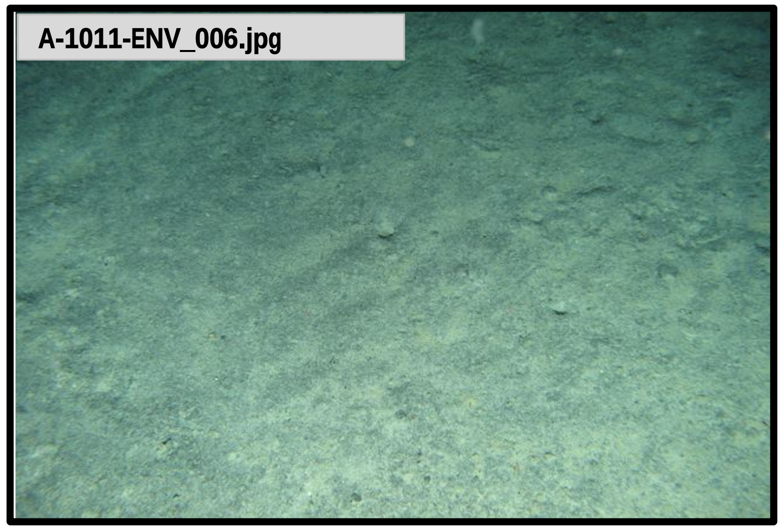


Photo Position: 784826 mE, 4213107 mN

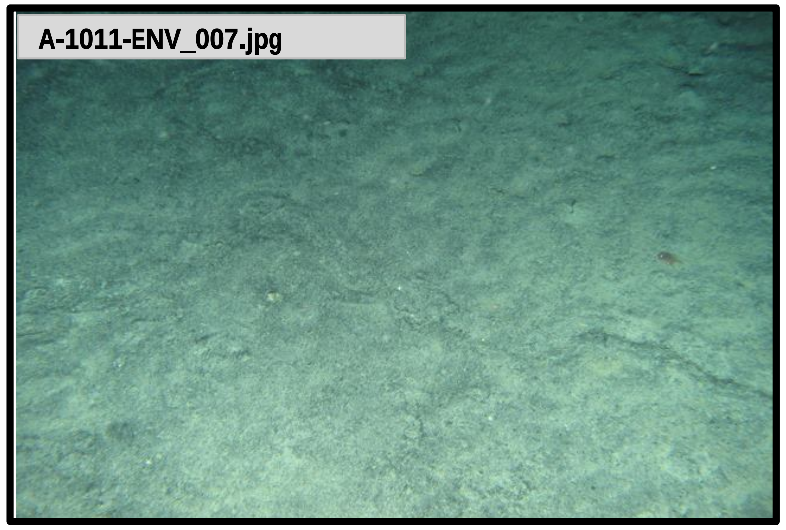


Photo Position: 784823 mE, 4213108 mN

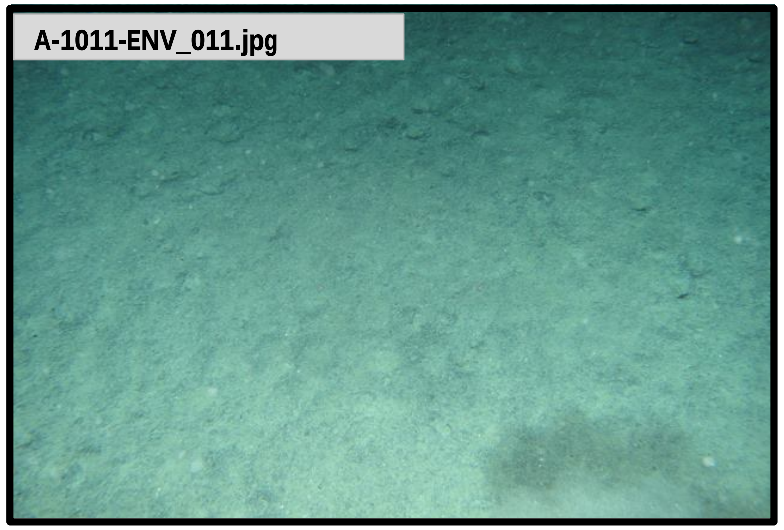


Photo Position: 784800 mE, 4213111 mN

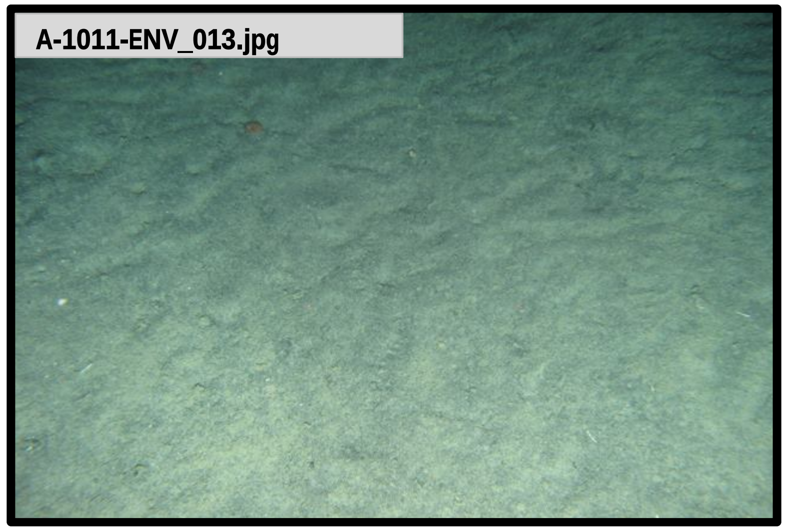
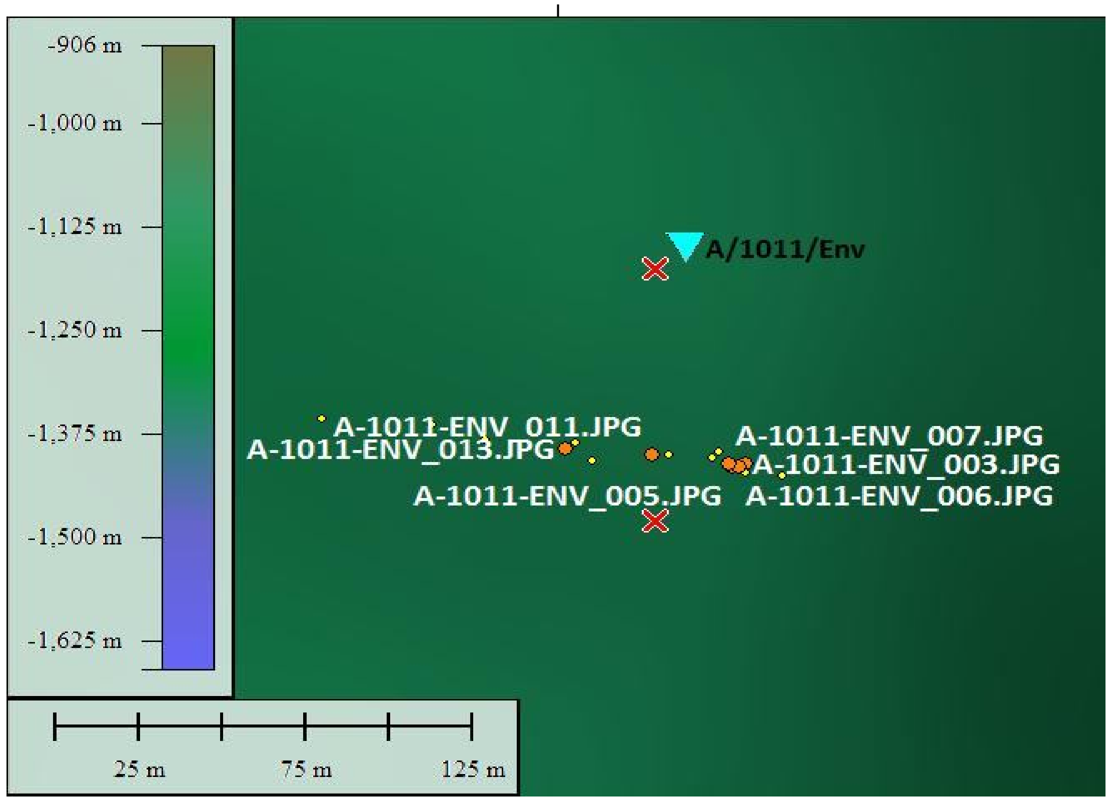


Photo Position: 784774 mE, 4213113 mN



Client
noble energy

Contractor
Benthic Solutions
Benthic Solutions Ltd., Marsh Road,

✕ Sample Location ● UW Photo ● UW Photo (featured)

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

Habitat Summary Information: A/106/ENV

Survey Area: FISA

No. of Stills: 24 **Mins of Video: 37** **Track Length: 630m**

Site Selection Criteria
Slightly raised linear feature

Analogue Interpretation
Slightly raised linear feature

Sediment Description
Light olive grey and black silty sand with mixed size gravels, pebbles, cobbles and boulders.

Conspicuous Fauna
Branched Stone Coral: Stylaster sp., Gorgonian sp., Branched Bryozoa sp., Nephropidae sp. *Thymops birsteini*, Brittlestar (Ophiuroid), Squat Lobster: Galatheidae sp., Hydroid sp., Sea Urchin: Echinoidea sp., Octocoral sp., Sea Pen: Pennatulacea,

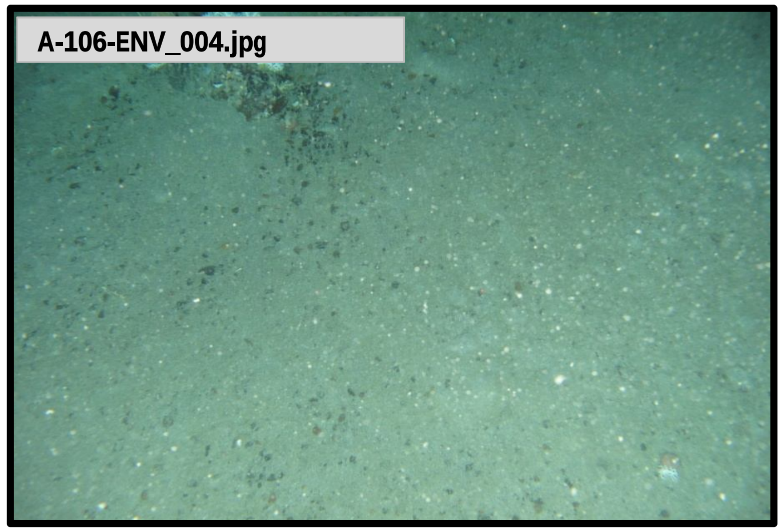


Photo Position: 743498 mE, 4180209 mN

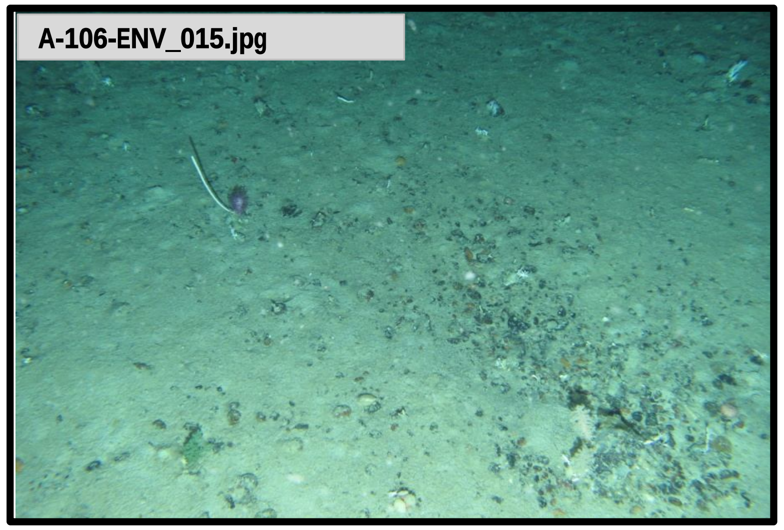


Photo Position: 743149 mE, 4179859 mN

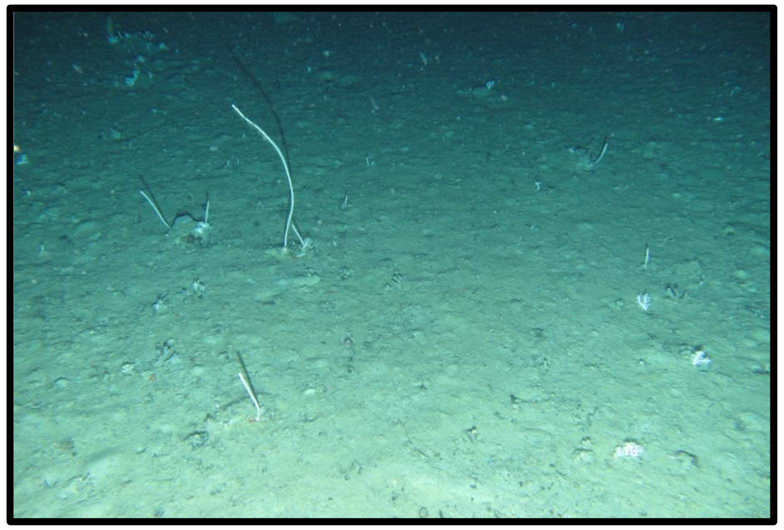


Photo Position: 743055 mE, 4179786 mN

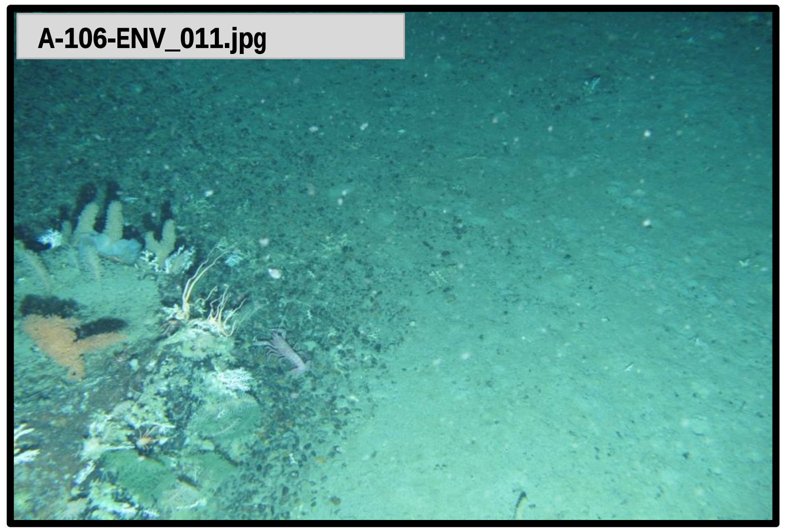


Photo Position: 743221 mE, 4179933 mN

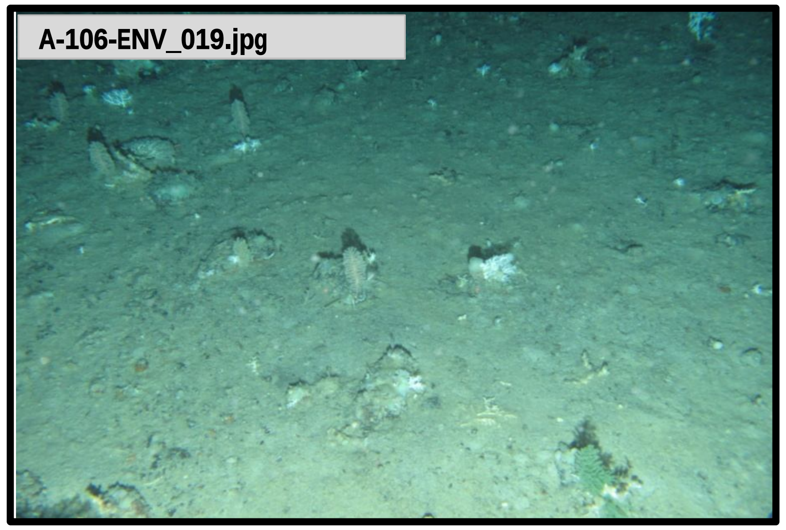


Photo Position: 743101 mE, 4179805 mN

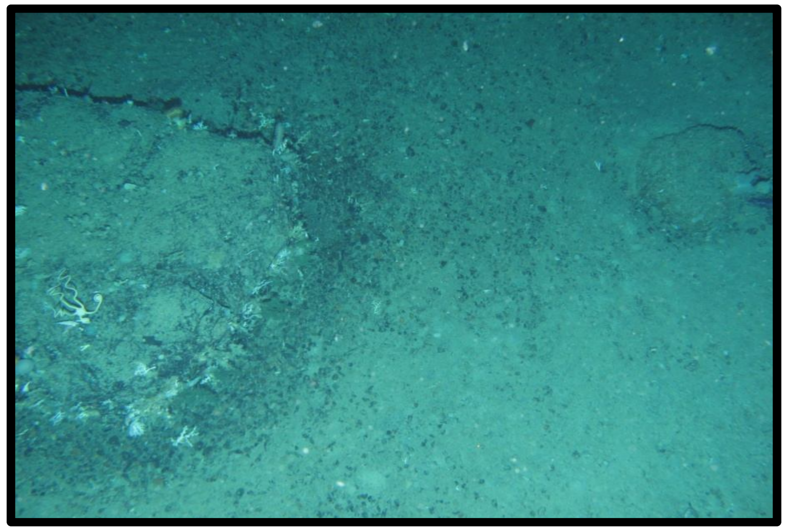
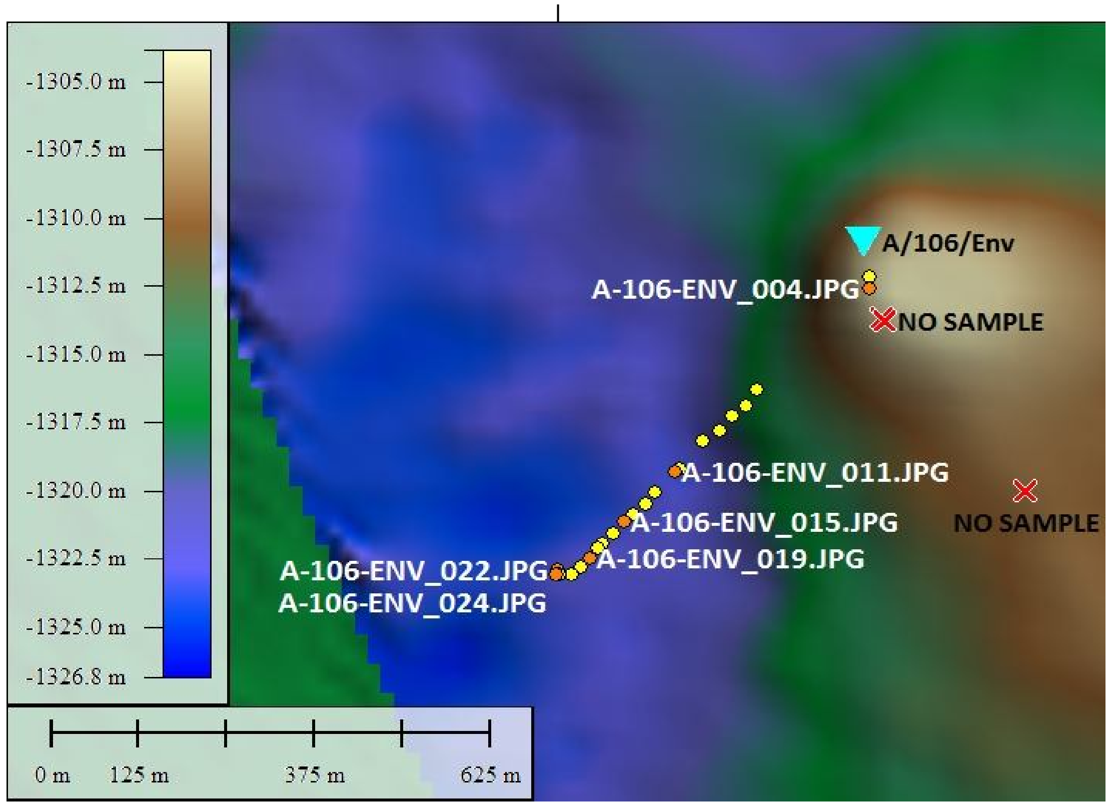


Photo Position: 743053 mE, 4179780 mN



Client
noble energy

Contractor
Benthic Solutions
Benthic Solutions Ltd., Marsh Road,

Sample Location | UW Photo | UW Photo (featured)

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

Habitat Summary Information: A/1008/ENV

Survey Area: FISA

No. of Stills: 41 **Mins of Video: 40** **Track Length: 278m**

Site Selection Criteria

Escarpment feature

Analogue Interpretation

Slightly raised linear feature

Sediment Description

Light olive grey and black silty sand with mixed size gravels, pebbles, cobbles and boulders.

Conspicuous Fauna

Branched Stone Coral: *Stylaster sp.* , Sea Pen: Pennatulacea, Sponge: Porifera sp., Relic *Lophelia sp* ., Sea Lily: Crinoidea sp., Branched Bryozoa sp., Bryozoa sp., Octocoral sp., Gorgonian sp., Pencil Urchin: possibly *Cidaris sp.,* Starfish: Asteroidea sp., *Lophelia pertusa,* Brittlestar (Ophiuroid), Hydroid sp.,

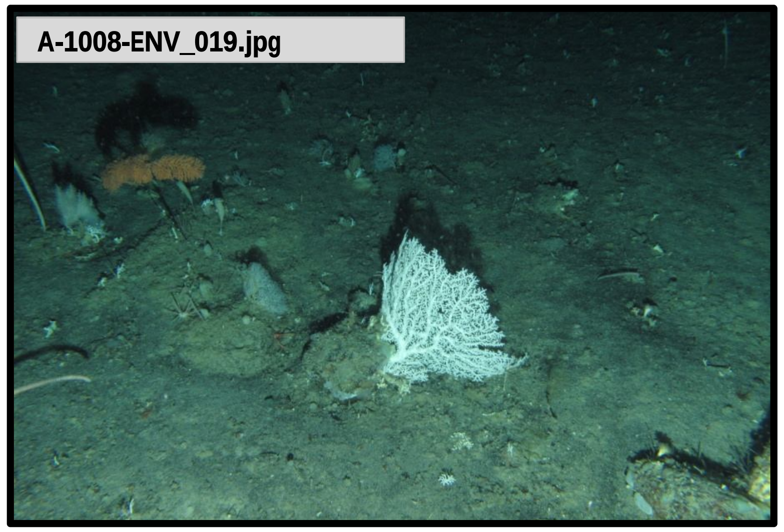


Photo Position: 784327 mE, 4202013 mN

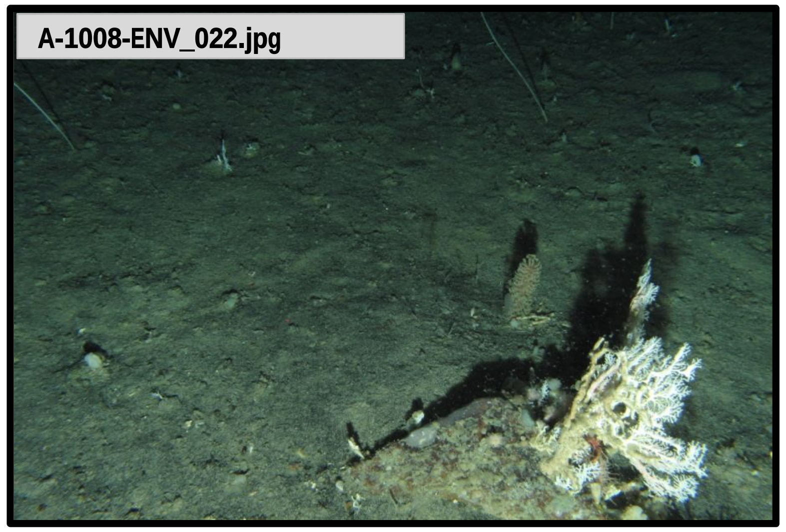


Photo Position: 784326 mE, 4201989 mN

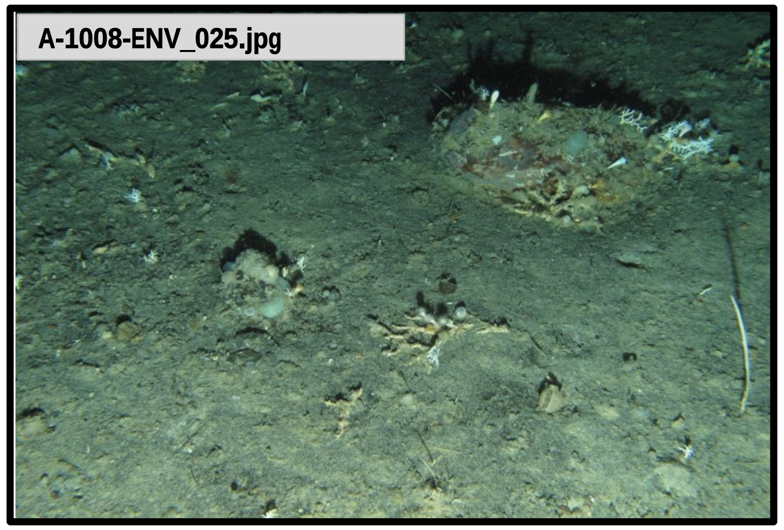
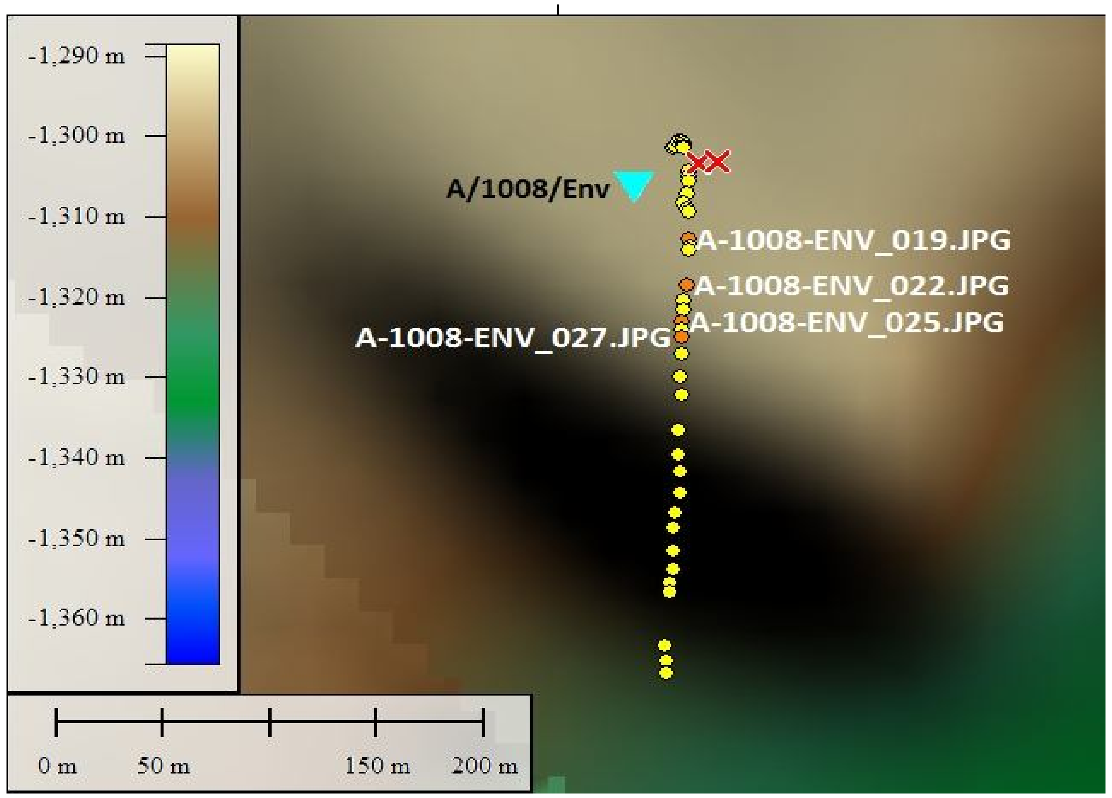


Photo Position: 784324 mE, 4201970 mN



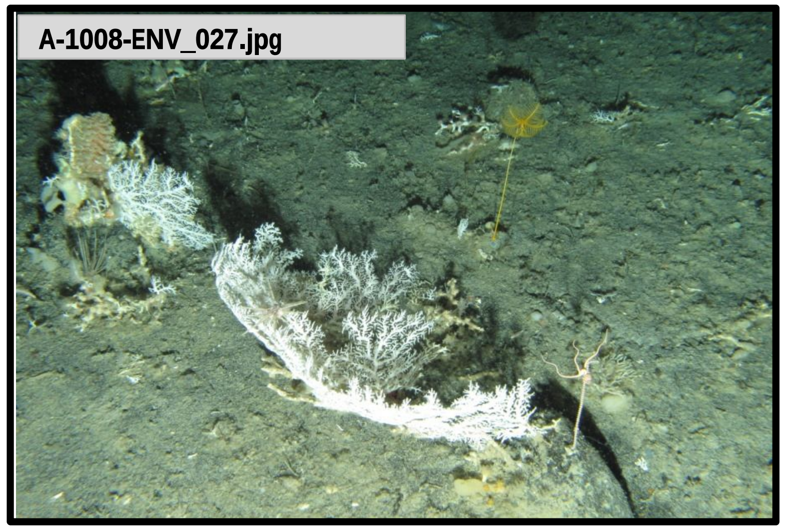


Photo Position: 784324 mE, 4201962 mN

Sediment Example Image

Client

noble energy

Contractor

Benthic Solutions

Benthic Solutions Ltd., Marsh Road,

Sieved Sample Image

✗ Sample Location ● UW Photo ● UW Photo (featured)

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

Habitat Summary Information: A/10/ENV

Survey Area: FISA

No. of Stills: 17 | Mins of Video: 19 | Track Length: 38m

Site Selection Criteria
Medium amplitude flat seabed feature

Analogue Interpretation
Medium amplitude flat seabed feature

Sediment Description
Light grey to black heavily bioturbated silty sand with occasional fine gravel.

Conspicuous Fauna
Sea Pen: Pennatulacea, Brittlestar (Ophiuroid), Decapod Shrimp sp., Batoidea sp., Polychaete sp., Isopod: possibly *Acutiserolis neaera* , Hydroid sp.,

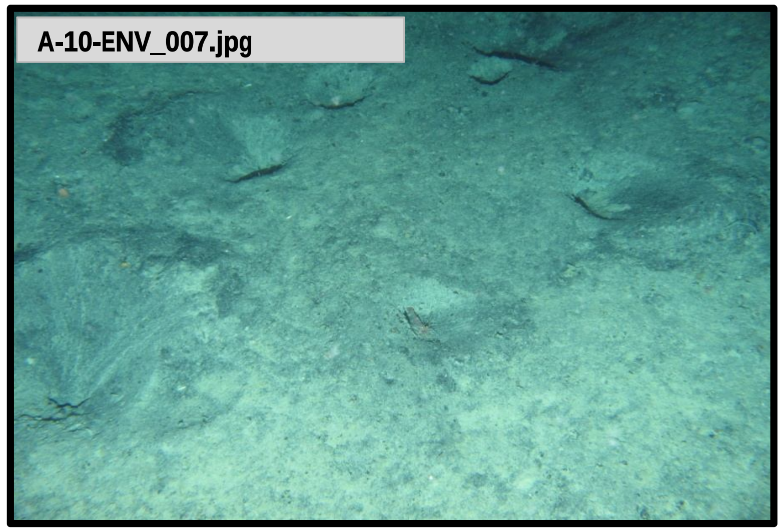


Photo Position: 774447 mE, 4205138 mN

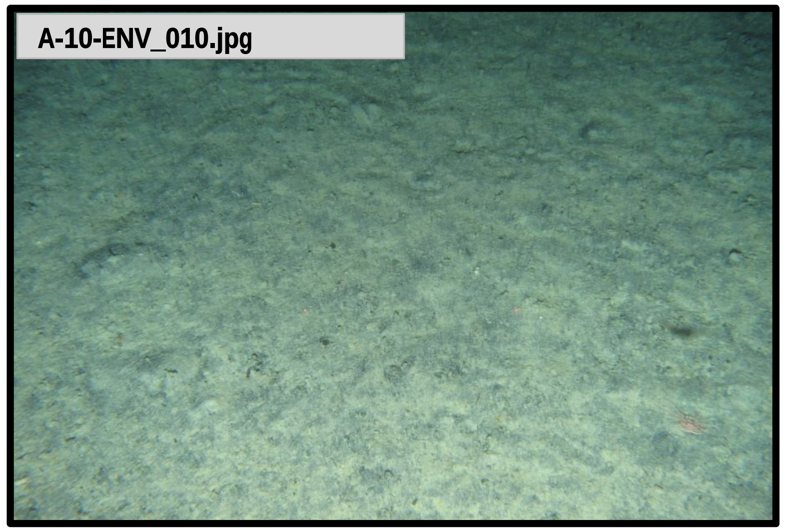


Photo Position: 774439 mE, 4205137 mN

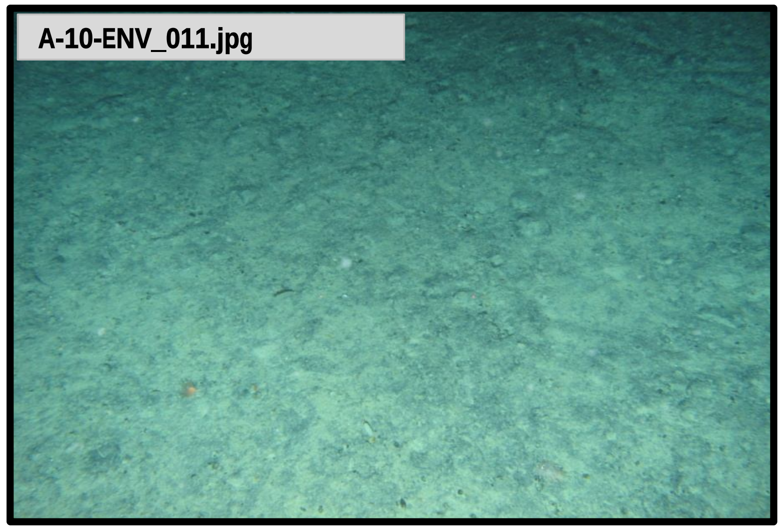


Photo Position: 774435 mE, 4205137 mN

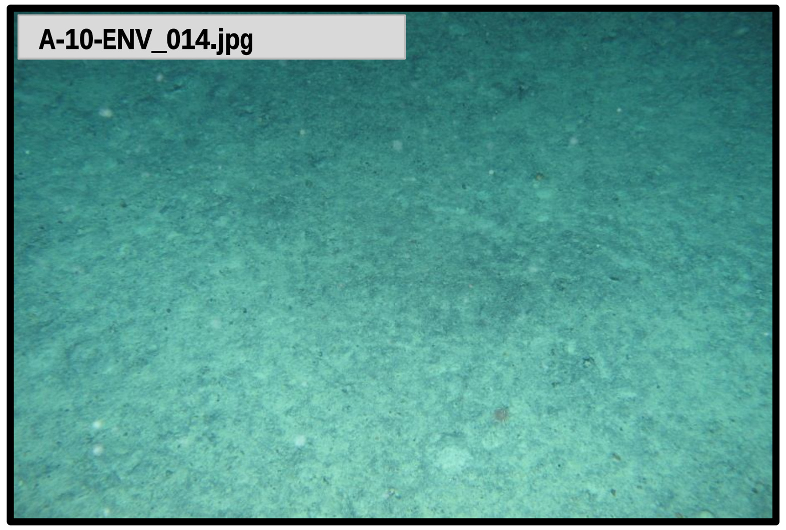
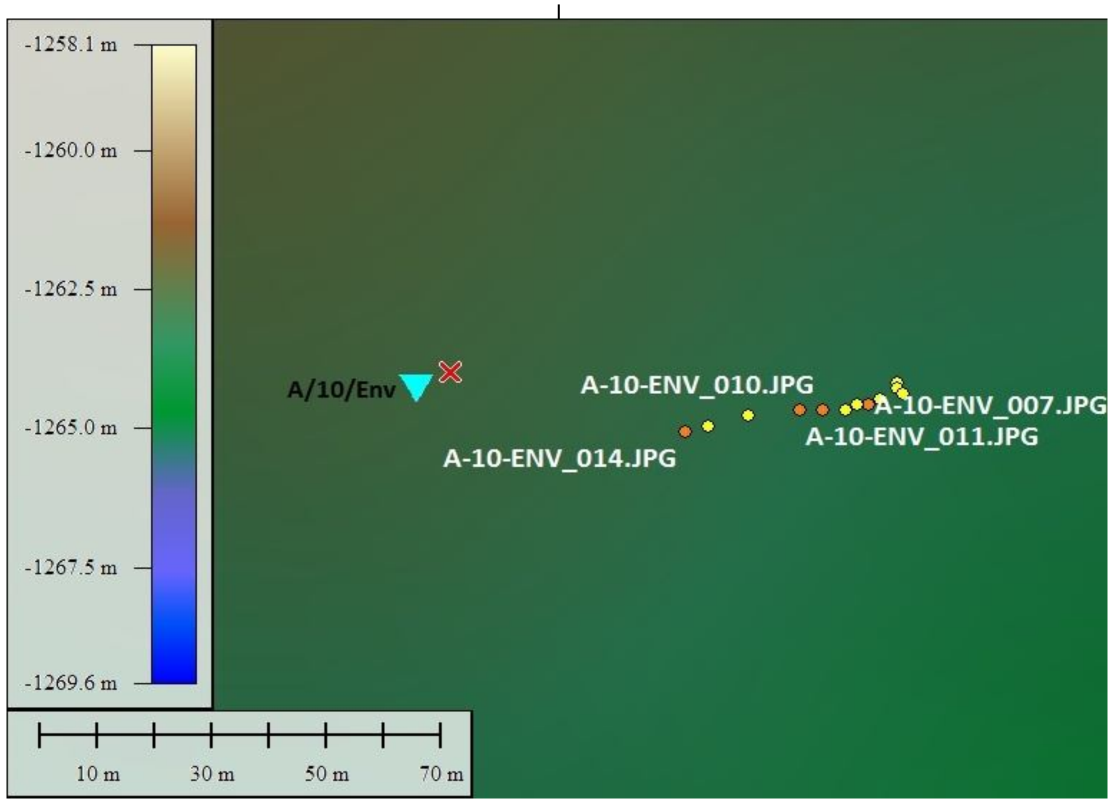


Photo Position: 774415 mE, 4205133 mN




Sediment Example Image


Sieved Sample Image

Client
noble energy

Contractor
Benthic Solutions
Benthic Solutions Ltd., Marsh Road,

Sample Location | UW Photo | UW Photo (featured)

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

Habitat Summary Information: A/09/ENV

Survey Area: FISA

No. of Stills: 27 **Mins of Video: 31** **Track Length: 102m**

Site Selection Criteria
Medium amplitude flat seabed feature

Analogue Interpretation
Relatively flat seabed

Sediment Description
Light grey to black bioturbated silty sand with occasional fine gravel.

Conspicuous Fauna
Cup Coral: Flabellum sp., Gorgonian sp., Sponge: Porifera sp., Brittlestar (Ophiuroid), Isopod: possibly *Acutiserolis neaera*,

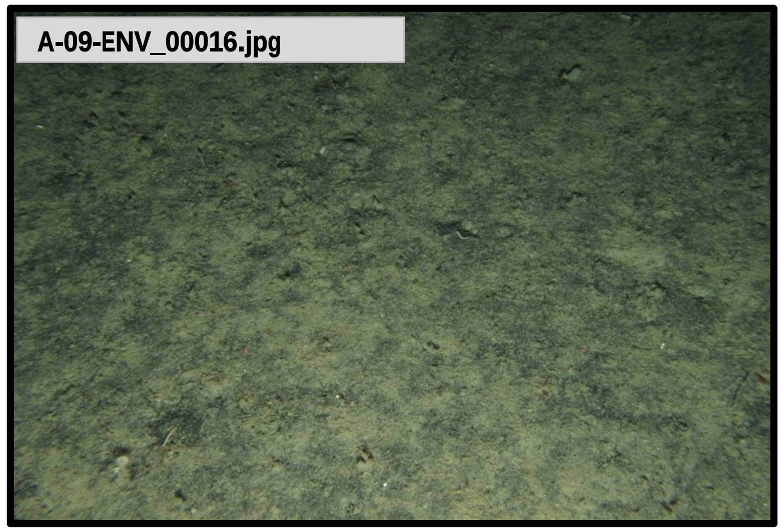


Photo Position: 774028 mE, 4201322 mN

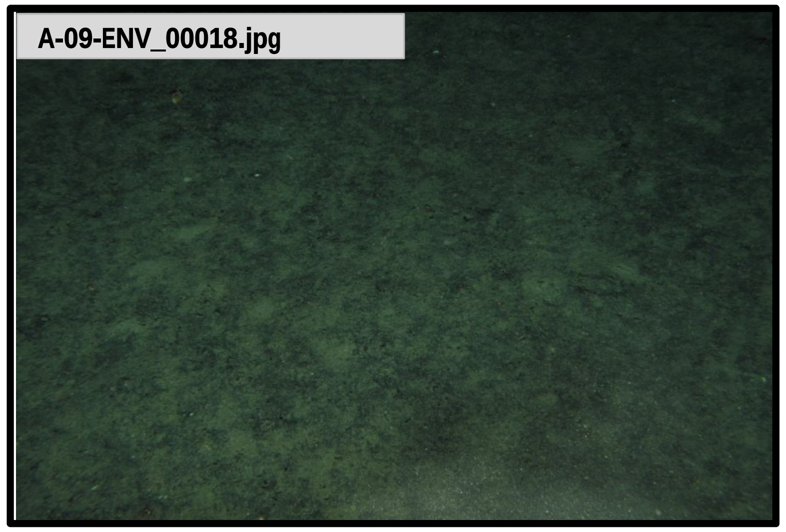


Photo Position: 774032 mE, 4201330 mN

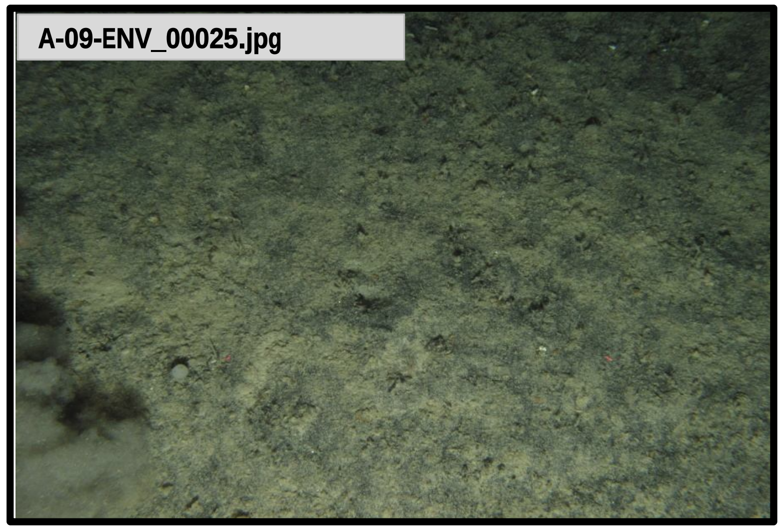


Photo Position: 774042 mE, 4201377 mN

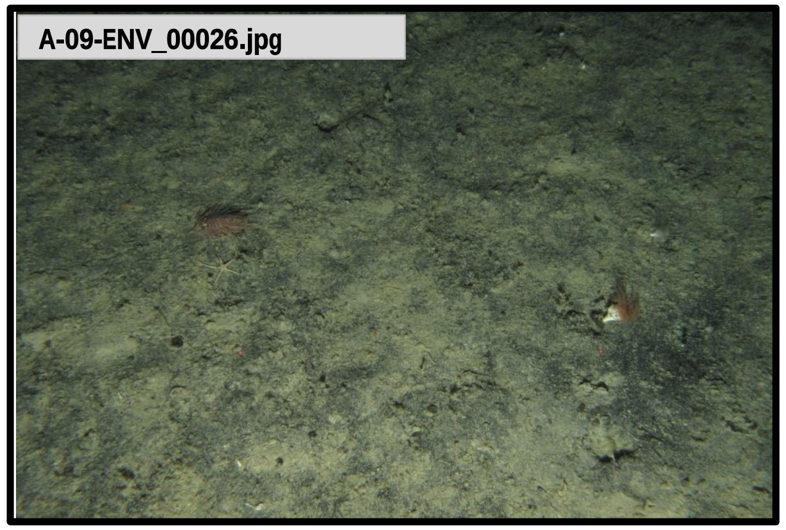
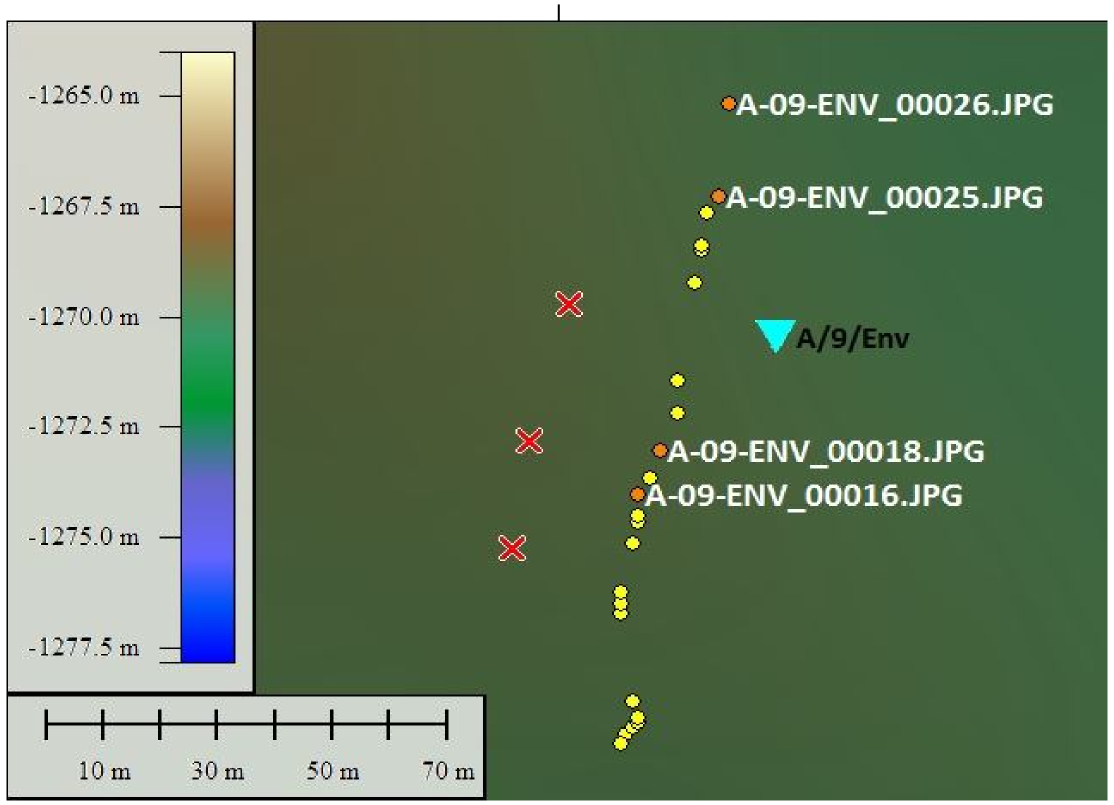
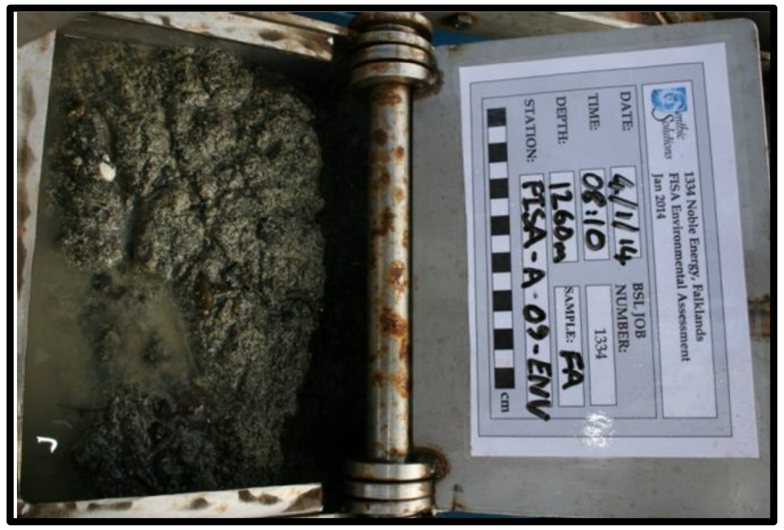


Photo Position: 774044 mE, 4201394 mN





Sediment Example Image

Sieved Sample Image

Client
noble energy

Contractor
Benthic Solutions
Benthic Solutions Ltd., Marsh Road,

Sample Location UW Photo UW Photo (featured)

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

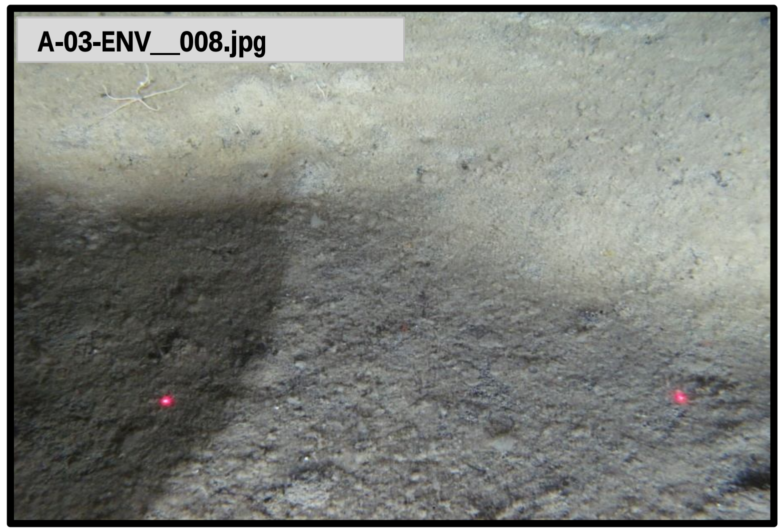


Photo Position: 737024 mE, 4188675 mN

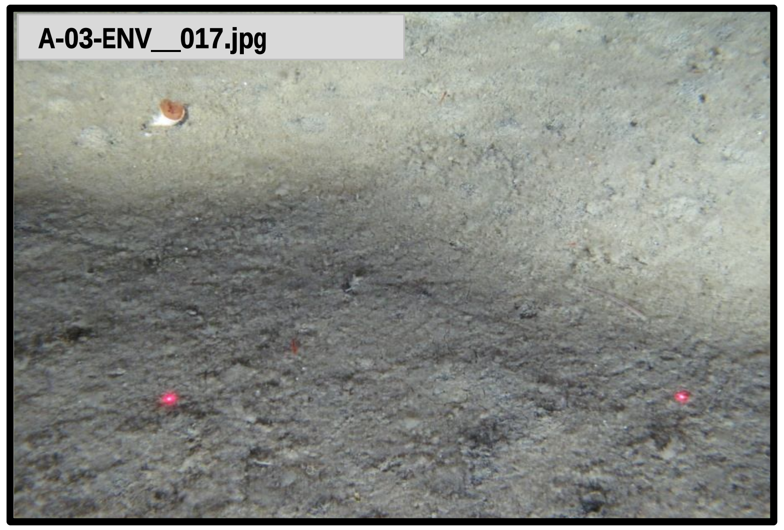


Photo Position: 737018 mE, 4188932 mN


Sediment Example Image

Habitat Summary Information: A/03/ENV

Survey Area: FISA

No. of Stills: 27 **Mins of Video: 14** **Track Length: 668m**

Site Selection Criteria

Regional sample with slight slope

Analogue Interpretation

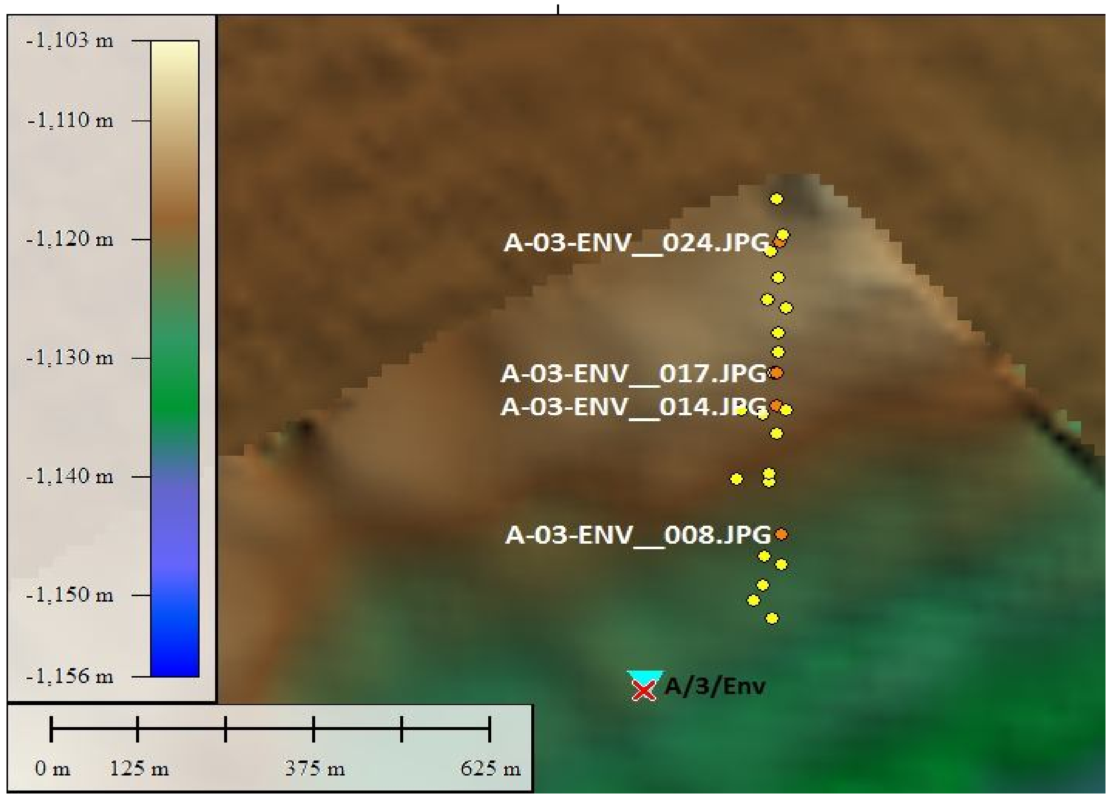
Very slight slope

Sediment Description

Light olive grey silty sand with a dark surface layer

Conspicuous Fauna

Bryozoa sp., Brittlestar (Ophiuroid), Decapod Shrimp sp., Cup Coral: *Flabellum sp* ., Sea Pen: possibly *Anthoptilum grandiflorum*, Sponge: Porifera sp.,



Client noble energy

Contractor Benthic Solutions

Benthic Solutions Ltd., Marsh Road,

Sample Location UW Photo UW Photo (featured)

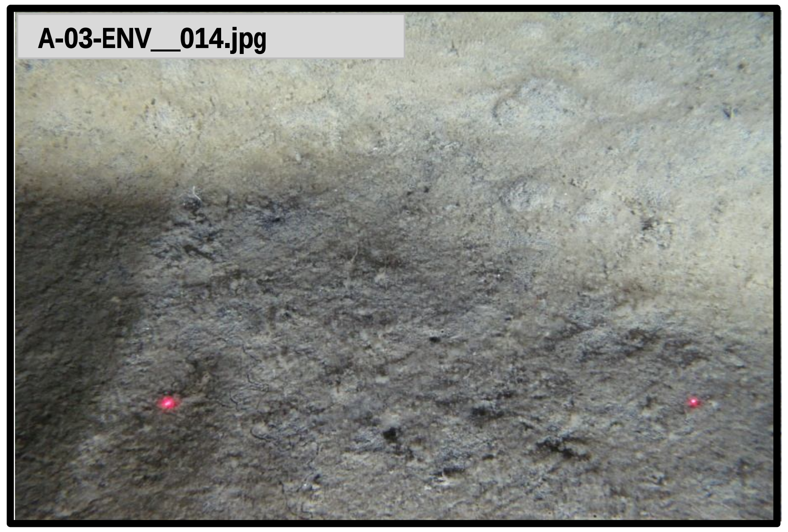


Photo Position: 737018 mE, 4188879 mN

Photo Position: 737022 mE, 4189140 mN


Sieved Sample Image

Geodetic Infomation: Datum: WGS84   Projection: Transverse Mercator   Central Meridian: 60° West

Habitat Summary Information: A/12/ENV

Survey Area: FISA

No. of Stills: 22 **Mins of Video: 26** **Track Length: 99m**

Site Selection Criteria
Regional sample

Analogue Interpretation
Relatively flat seabed

Sediment Description
Light grey to black bioturbated silty sand with occasional fine gravels, pebbles and cobbles

Conspicuous Fauna
Cup Coral: *Flabellum sp* ., Polychaete sp., Nephropidae sp. *Thymops birsteini,* Hydroid sp., Holothuroidea sp., Bryozoa sp.,

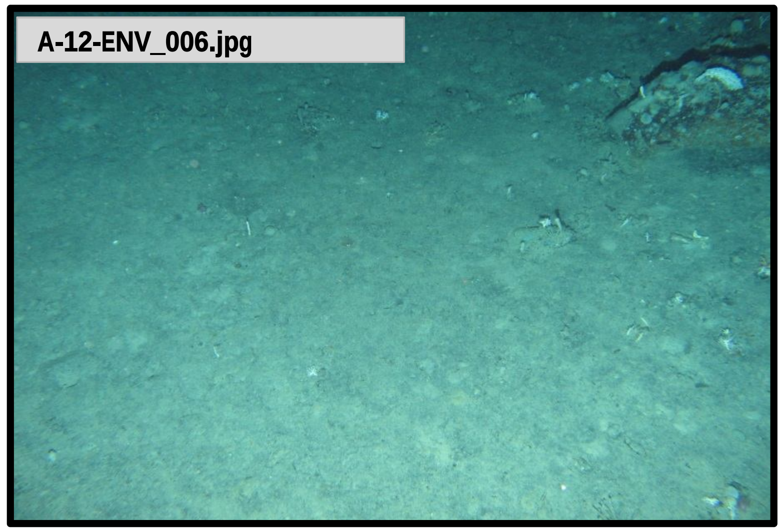


Photo Position: 783879 mE, 4203855 mN

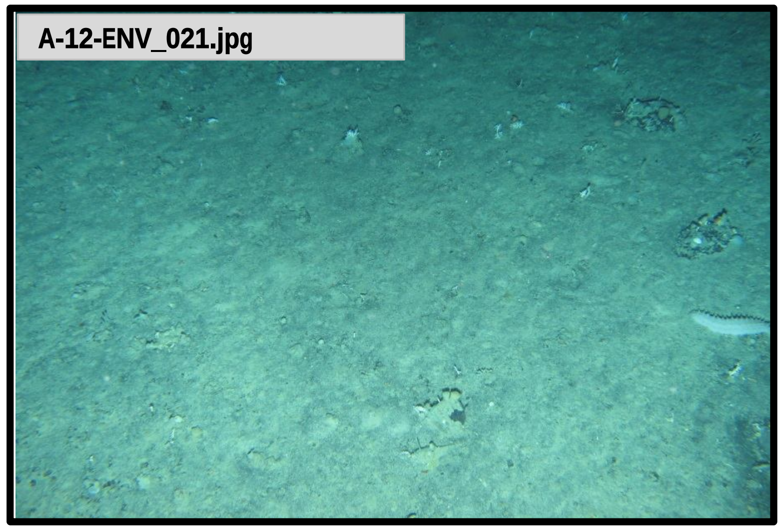


Photo Position: 783799 mE, 4203860 mN

Sediment Example Image

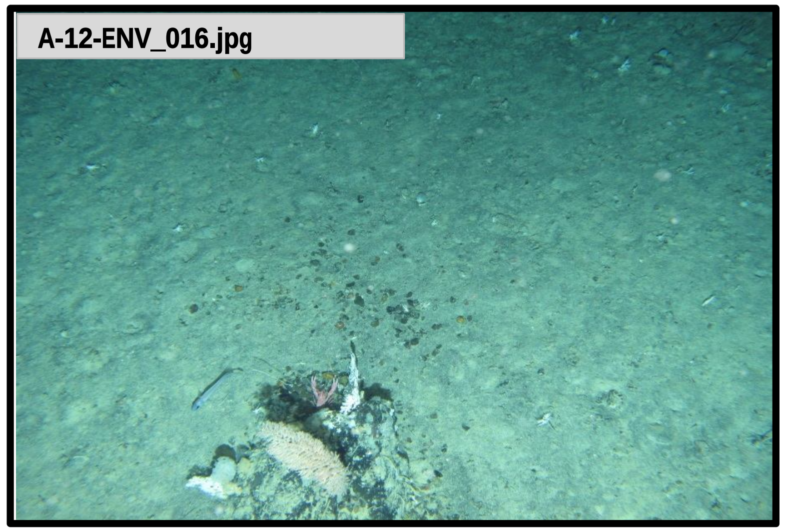


Photo Position: 783838 mE, 4203858 mN

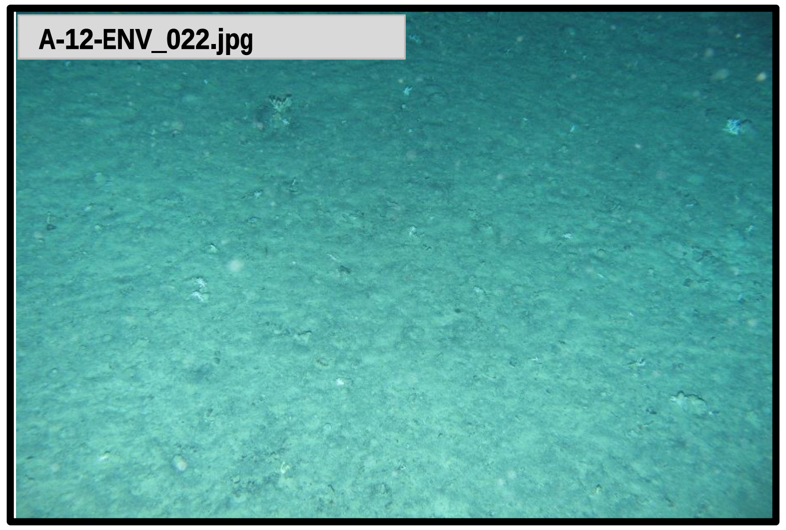
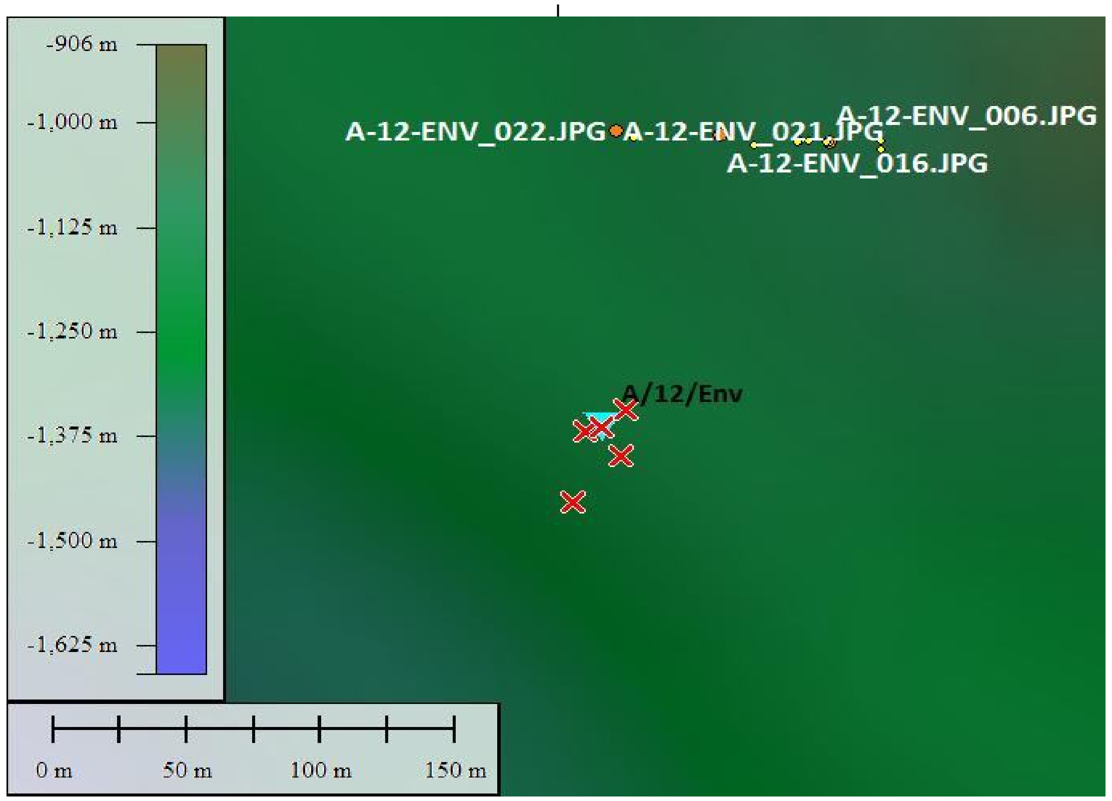


Photo Position: 783806 mE, 4203857 mN

Sieved Sample Image



Client
noble energy

Contractor
Benthic Solutions
Benthic Solutions Ltd., Marsh Road,

Sample Location UW Photo UW Photo (featured)

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

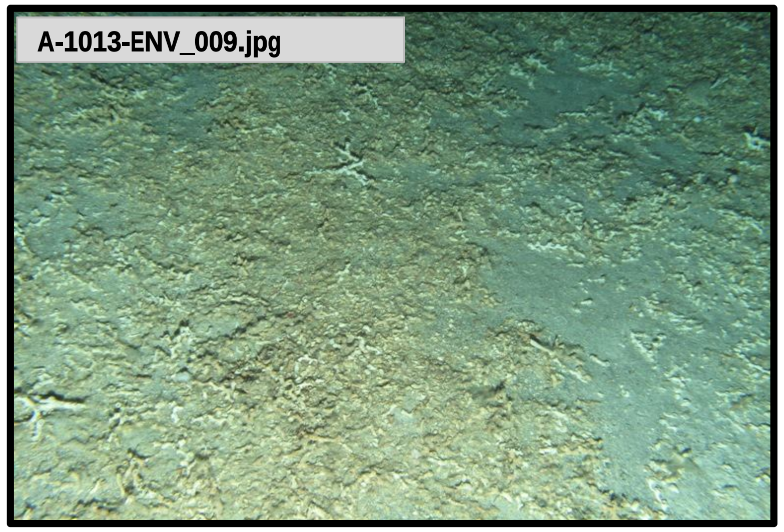


Photo Position: 790314 mE, 4204430 mN

Habitat Summary Information: A/1013/ENV

Survey Area: FISA

No. of Stills: 27 | **Mins of Video: 31** | **Track Length: 29m**

Site Selection Criteria
Deepest point of eroded hole

Analogue Interpretation
Relatively flat seabed

Sediment Description
Freckled black sand with cement coloured relic *Lophelia sp.*

Conspicuous Fauna
Tube-building Polychaete, Relic *Lophelia sp*., Stone Crab: *Paralomis sp*., Branched Stone Coral: *Stylaster sp*.,

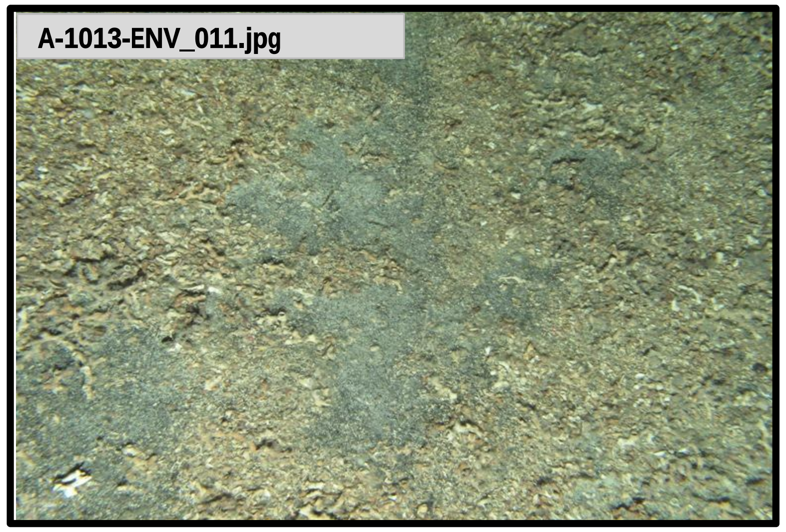


Photo Position: 790314 mE, 4204430 mN

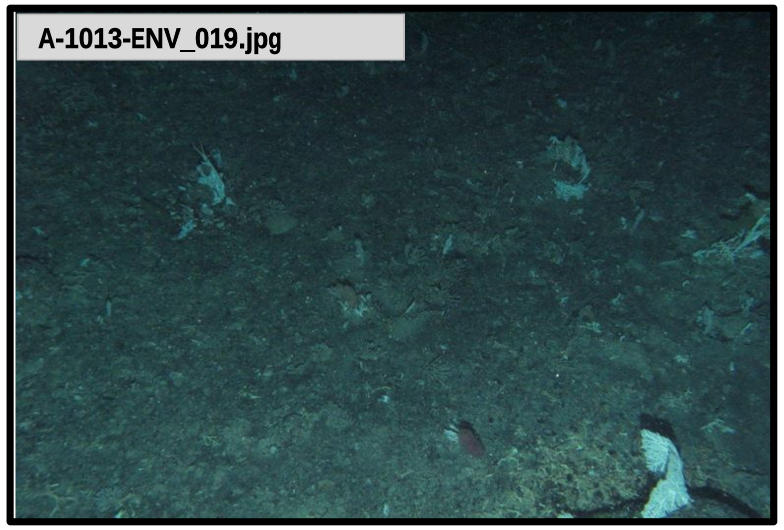
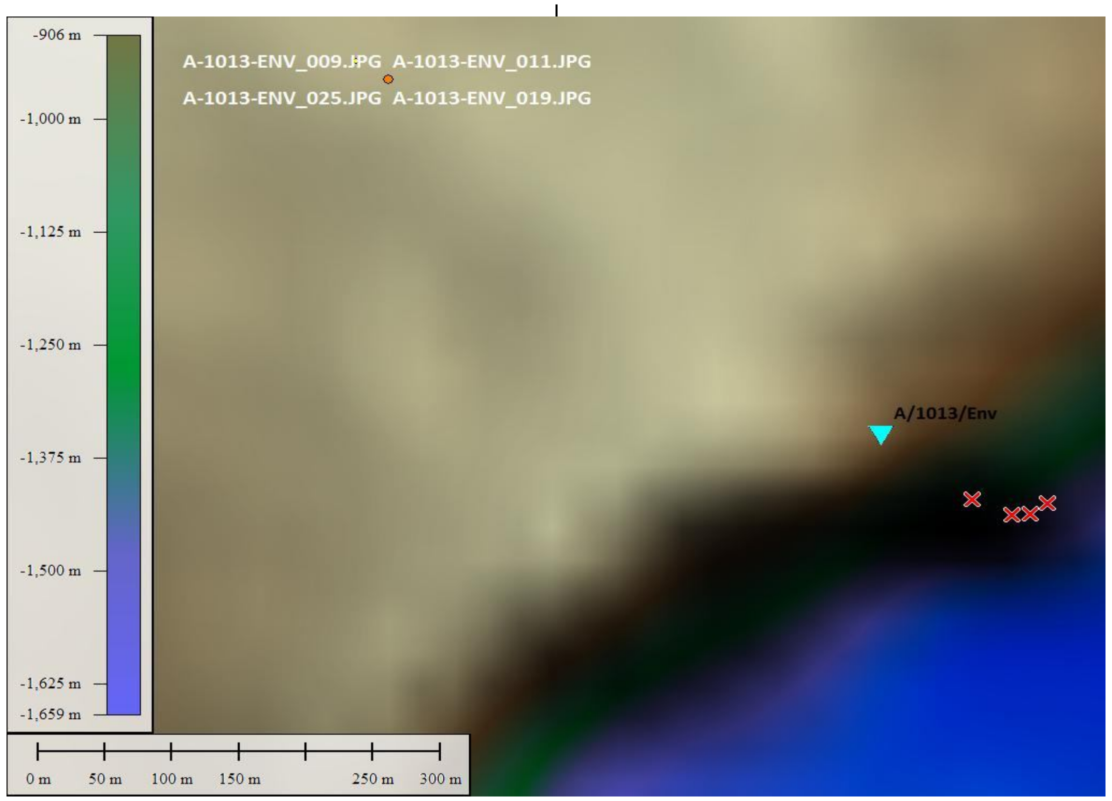


Photo Position: 790314 mE, 4204430 mN



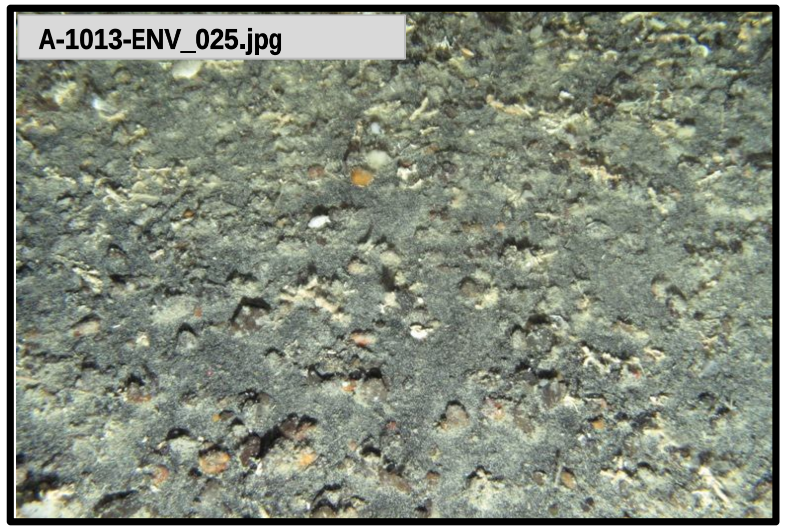


Photo Position: 790314 mE, 4204430 mN

Sediment Example Image

Client noble energy

Contractor Benthic Solutions
Benthic Solutions Ltd., Marsh Road,


Sieved Sample Image

✕ Sample Location   ○ UW Photo   ● UW Photo (featured)

Geodetic Infomation: Datum: WGS84   Projection: Transverse Mercator   Central Meridian: 60° West

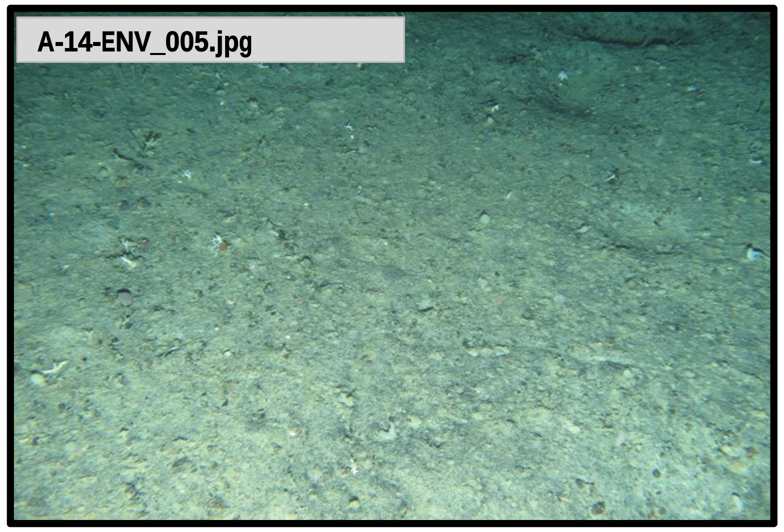


Photo Position: 782524 mE, 4194716 mN

Habitat Summary Information: A/14/ENV

Survey Area: FISA

No. of Stills: 15 | **Mins of Video: 23** | **Track Length: 165m**

Site Selection Criteria
Edge of regional flat area

Analogue Interpretation
Relatively flat seabed

Sediment Description
Coarse pebbles and rocks suspended in clay

Conspicuous Fauna
Tube-building Polychaete, Polychaete sp., Isopod: possibly *Acutiserolis neaera*, Bryozoa sp.,

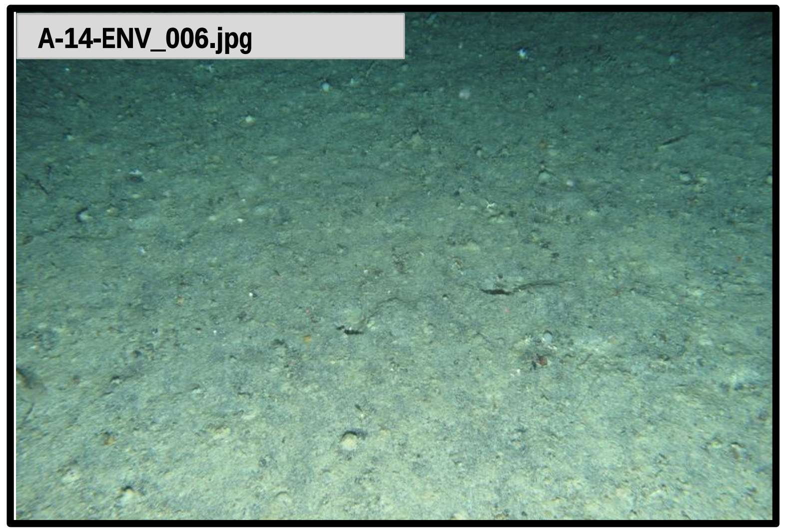


Photo Position: 782528 mE, 4194723 mN

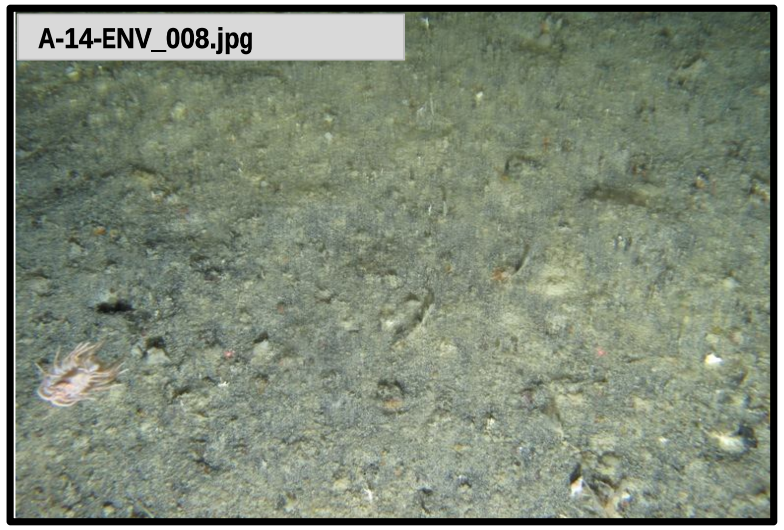
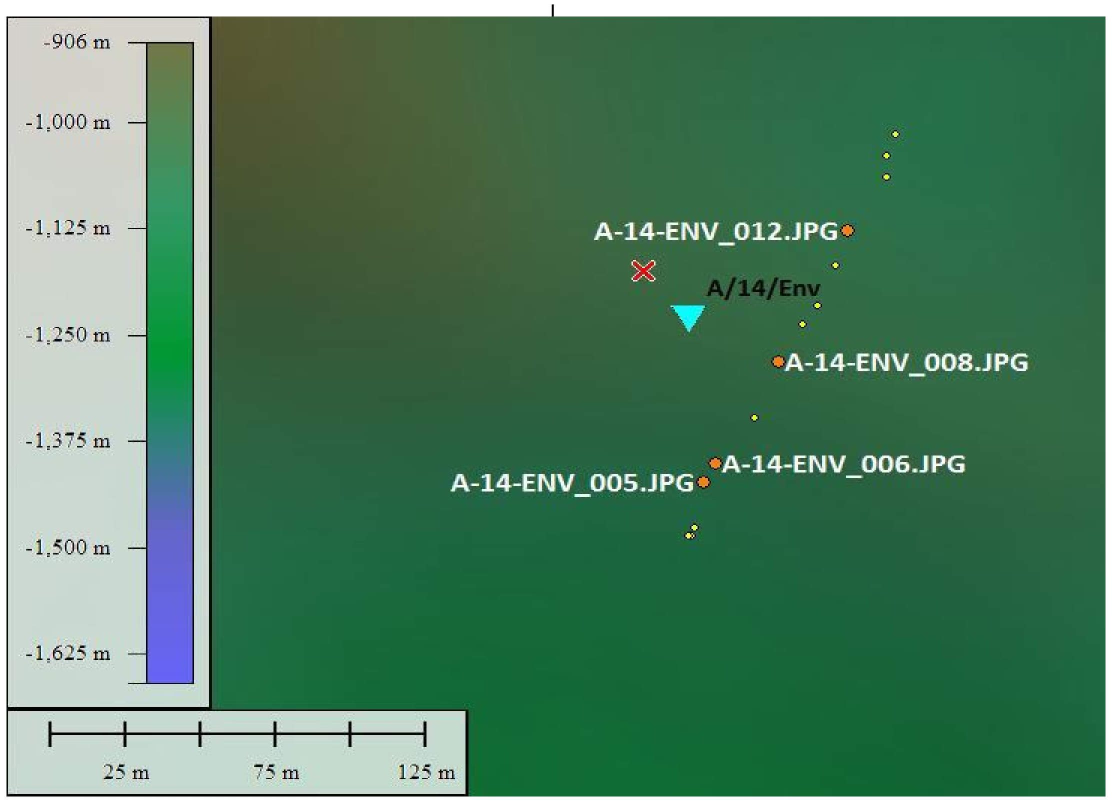


Photo Position: 782549 mE, 4194761 mN



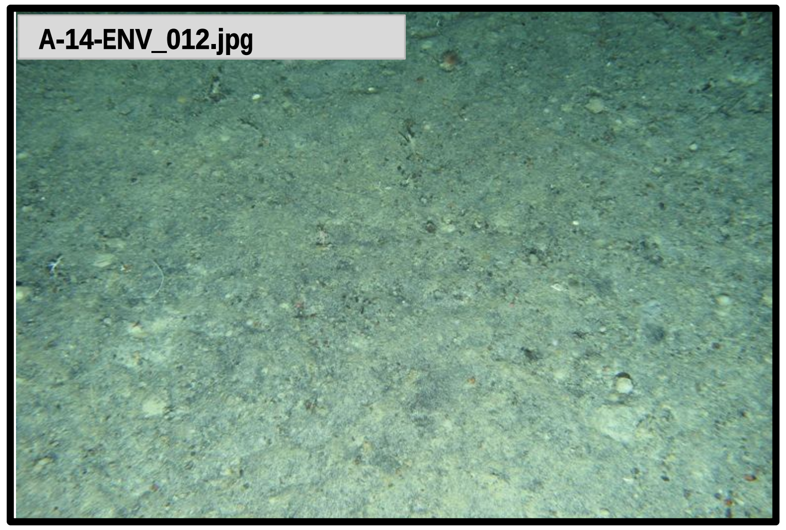


Photo Position: 782572 mE, 4194810 mN


Sediment Example Image

Client
noble energy

Contractor
Benthic Solutions
Benthic Solutions Ltd., Marsh Road,


Sieved Sample Image

Sample Location | UW Photo | UW Photo (featured)

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

Habitat Summary Information: A/1015/ENV

Survey Area: FISA

No. of Stills: 41 **Mins of Video: 41** **Track Length: 286m**

Site Selection Criteria

Deepest point of hollow feature

Analogue Interpretation

Hollow feature

Sediment Description

Coarse pebbles and rocks suspended in clay

Conspicuous Fauna

Brittlestar (Ophiuroid), Tube-building Polychaete, Polychaete sp., Bryozoa sp., Branched Stone Coral: *Stylaster sp* ., Tunicate sp., Relic *Lophelia sp.* , Cushion Starfish, Nephropidae sp. *Thymops birsteini,* Sponge: possibly *Suberites sp* ., Branched Sponge: Demospongiae sp.,

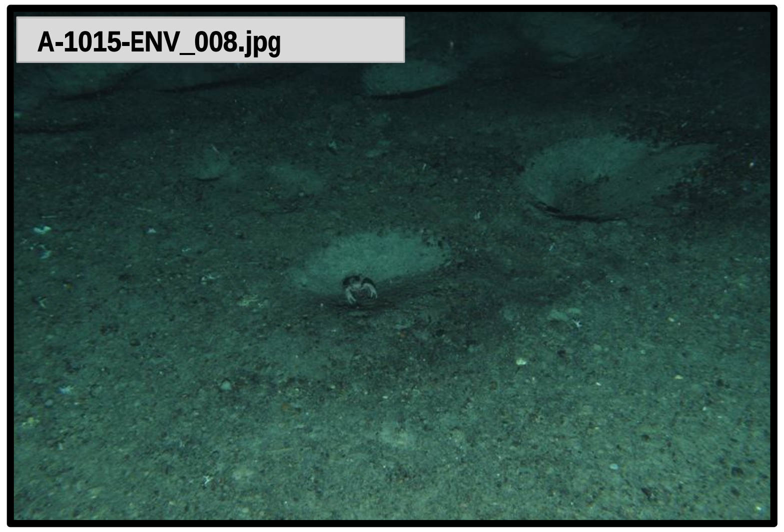


Photo Position: 786584 mE, 4198429 mN

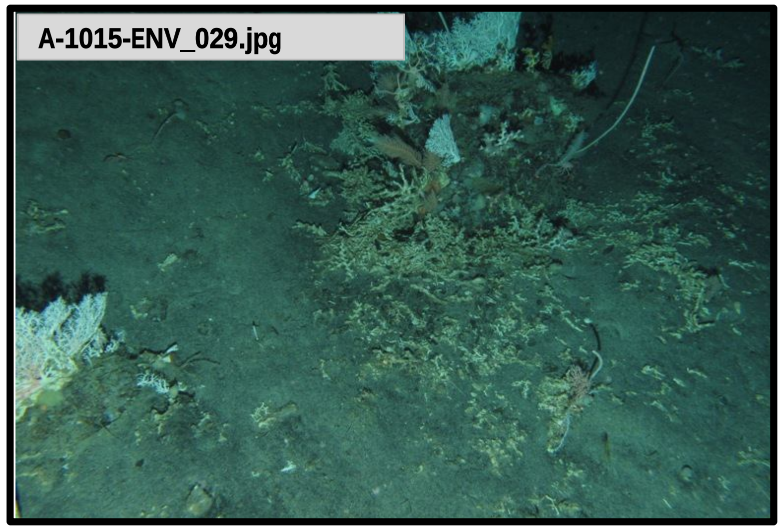


Photo Position: 786407 mE, 4198436 mN

Sediment Example Image

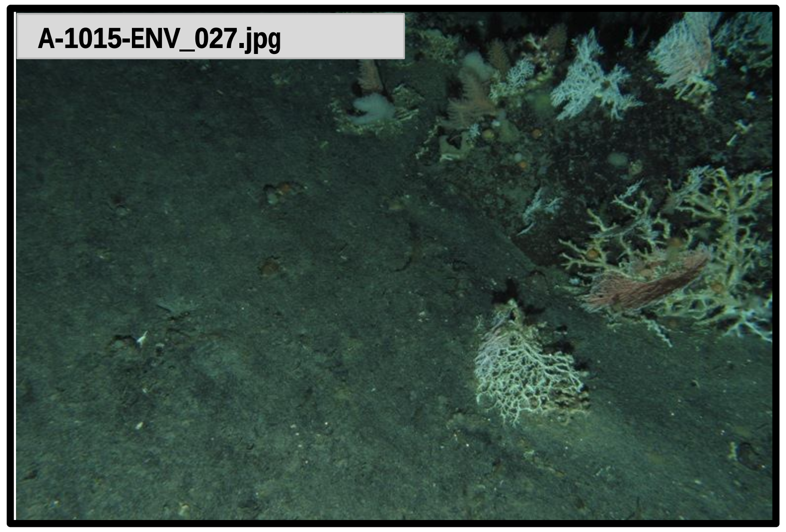


Photo Position: 786420 mE, 4198435 mN

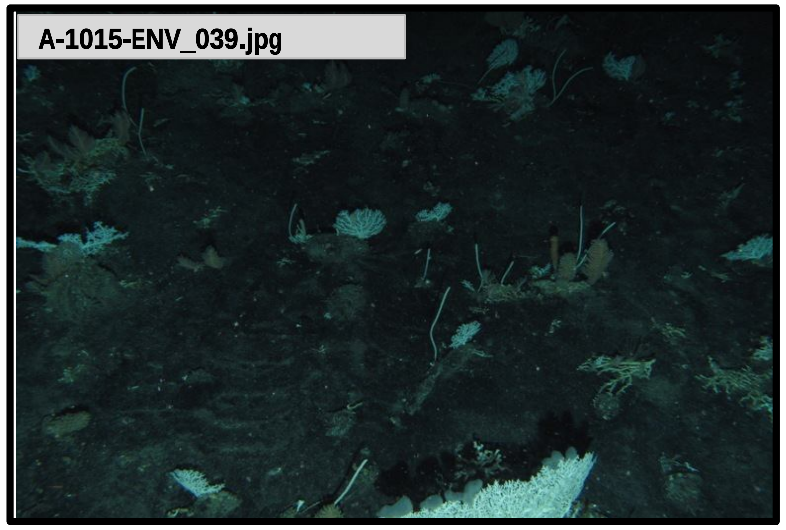
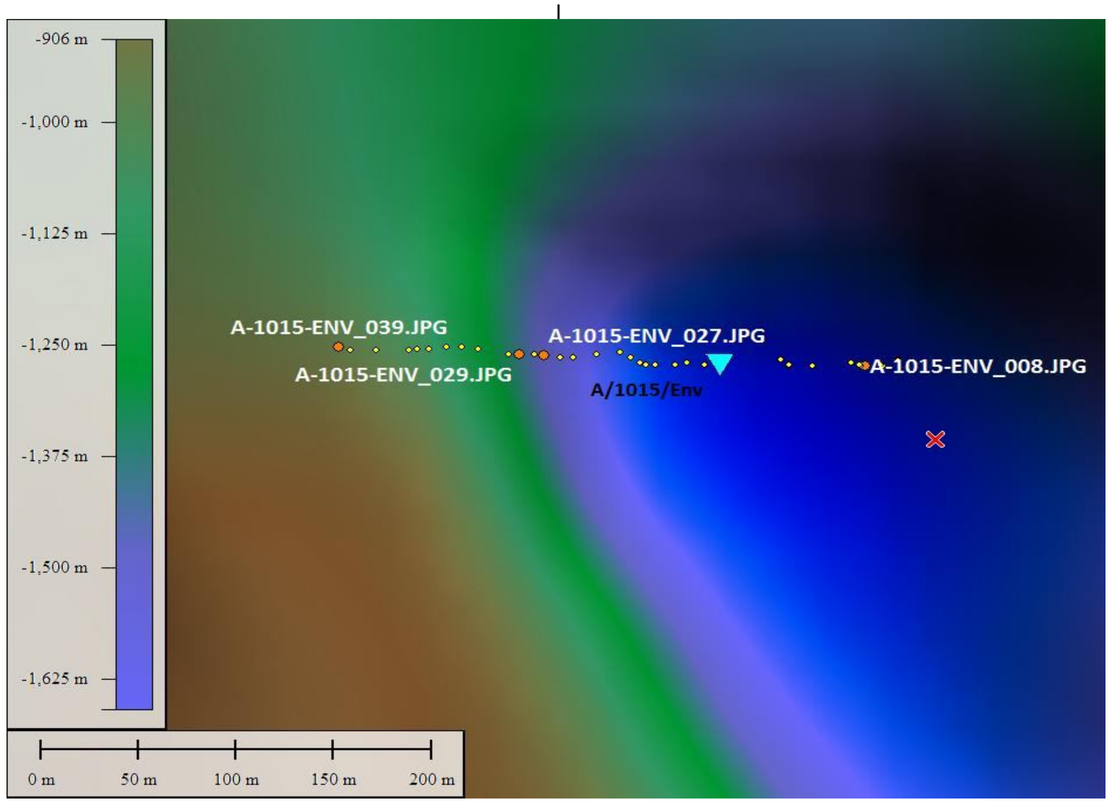


Photo Position: 786315 mE, 4198440 mN

Sieved Sample Image



Client noble energy

Contractor Benthic Solutions

Benthic Solutions Ltd., Marsh Road,

✕ Sample Location ● UW Photo ● UW Photo (featured)

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

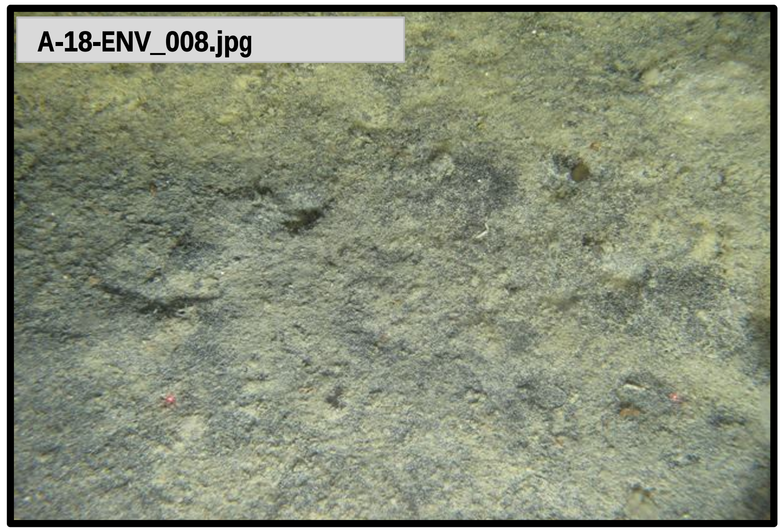


Photo Position: 768048 mE, 4173748 mN

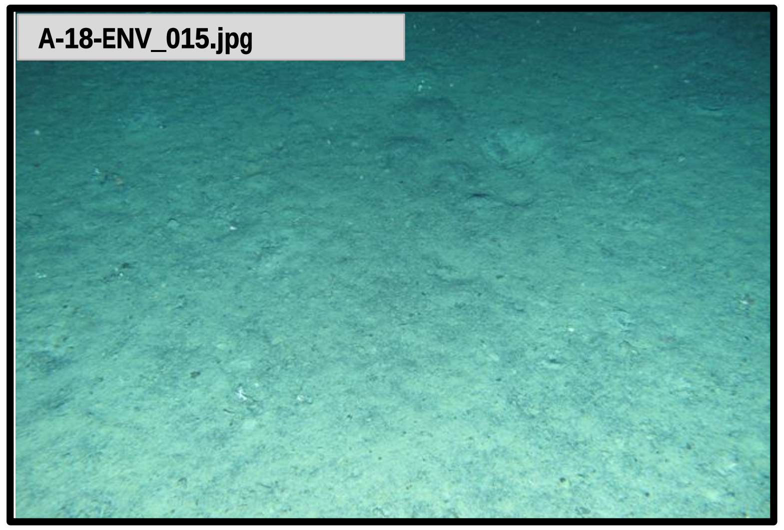


Photo Position: 767936 mE, 4173558 mN

Sediment Example Image

Habitat Summary Information: A/18/ENV

Survey Area: FISA

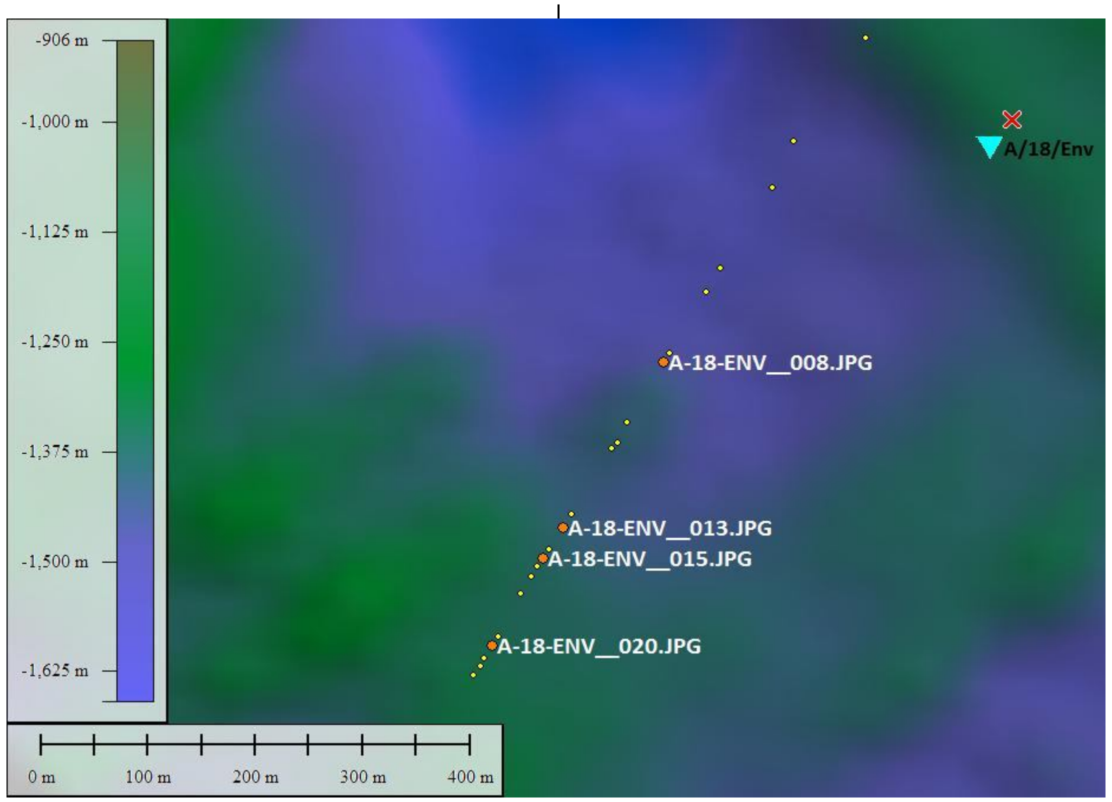
No. of Stills: 24 **Mins of Video: 32** **Track Length: 718m**

Site Selection Criteria
High amplitude in low relief area

Analogue Interpretation
Small shallow hollow feature

Sediment Description
Homogeneous beige and black silty sand with some gravel, with evidence of bioturbation

Conspicuous Fauna
Stone Crab: *Paralomis sp.* , Sponge: (unidentified), Polychaete sp., Cup Coral: *Flabellum sp.*,



Client
noble energy

Contractor
Benthic Solutions
Benthic Solutions Ltd., Marsh Road,

Sample Location UW Photo UW Photo (featured)

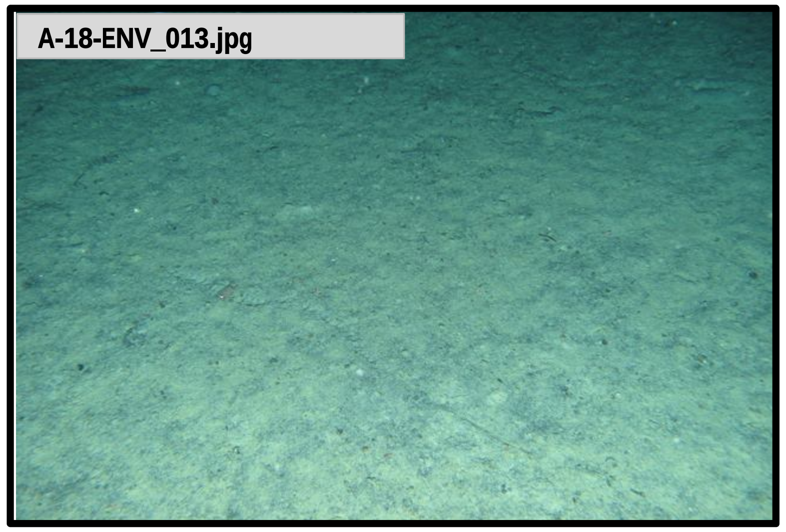


Photo Position: 767954 mE, 4173587 mN

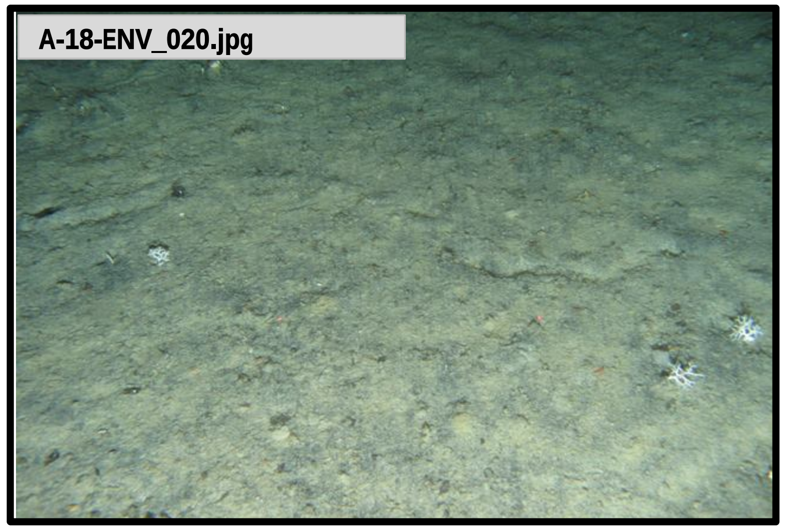


Photo Position: 767888 mE, 4173473 mN

Sieved Sample Image

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

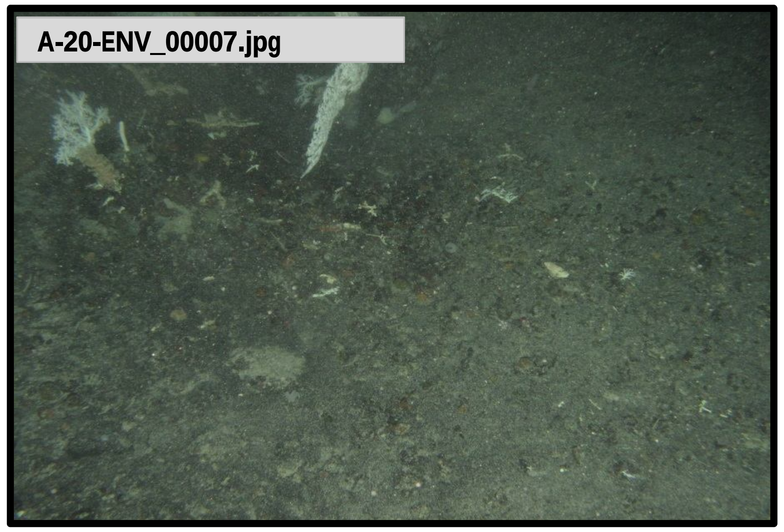


Photo Position: 791007 mE, 4195277 mN

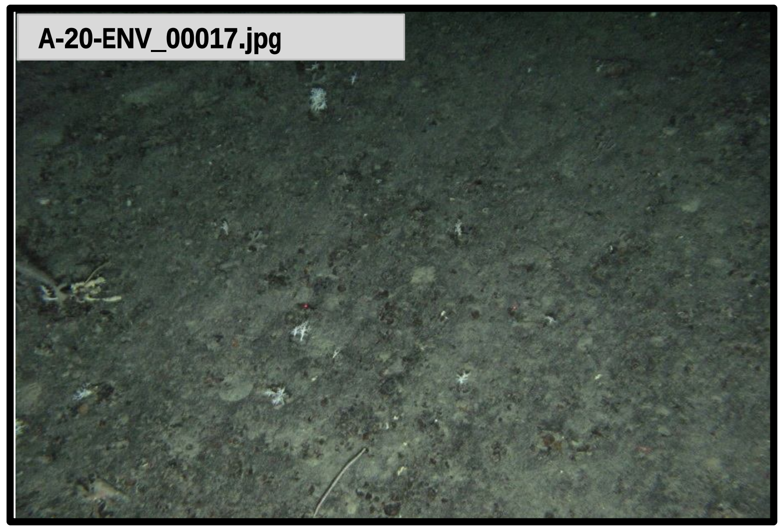


Photo Position: 791042 mE, 4195311 mN

Sediment Example Image

Habitat Summary Information: A/20/ENV

Survey Area: FISA

No. of Stills: 18 **Mins of Video: 33** **Track Length: 65m**

Site Selection Criteria

Regional station

Analogue Interpretation

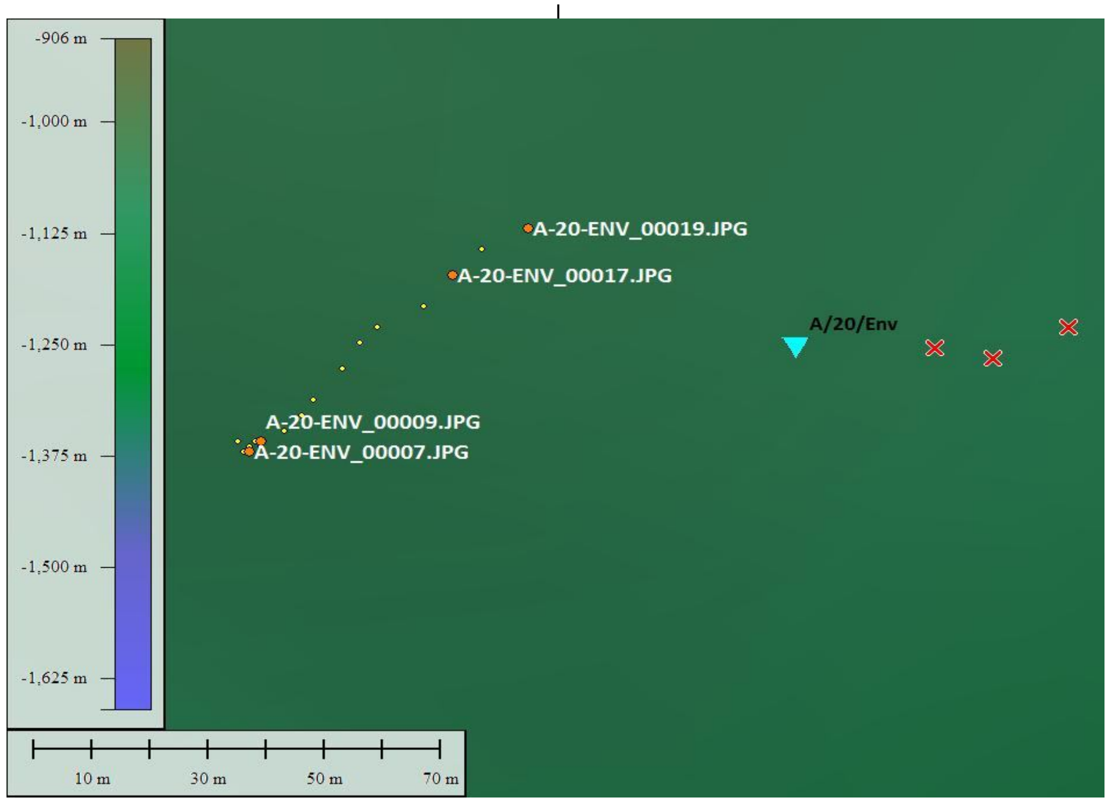
Relatively flat seabed

Sediment Description

Dark silty sand with gravel

Conspicuous Fauna

Sponge: (unidentified), Sea Pen: Pennatulacea, Brittlestar (Ophiuroid), Branched Stone Coral: *Stylaster sp.* , Hydroid sp.,



Client noble energy

Contractor Benthic Solutions

Benthic Solutions Ltd., Marsh Road,

Sample Location UW Photo UW Photo (featured)

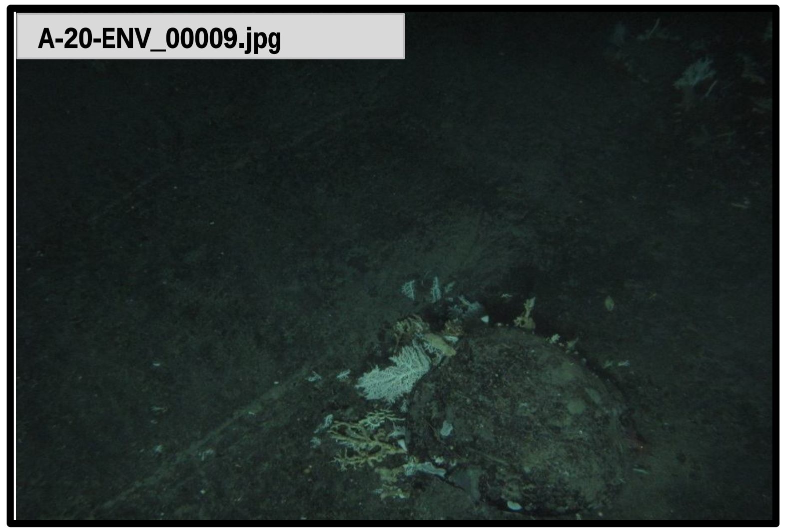


Photo Position: 791009 mE, 4195279 mN

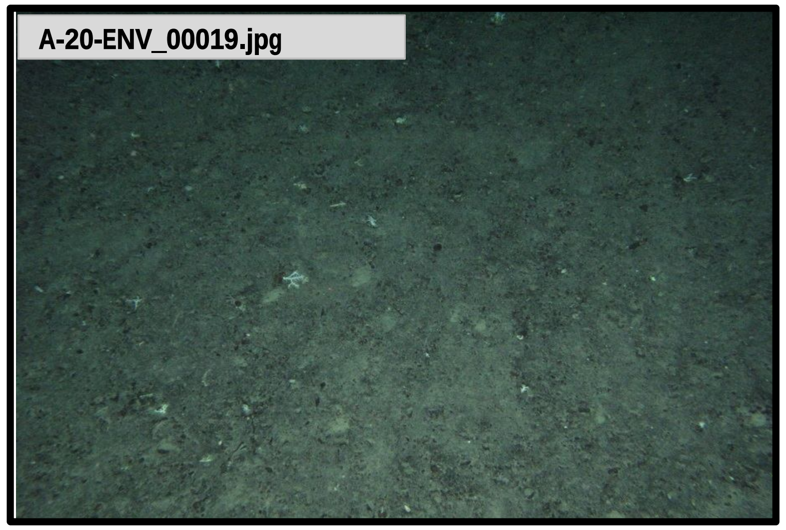
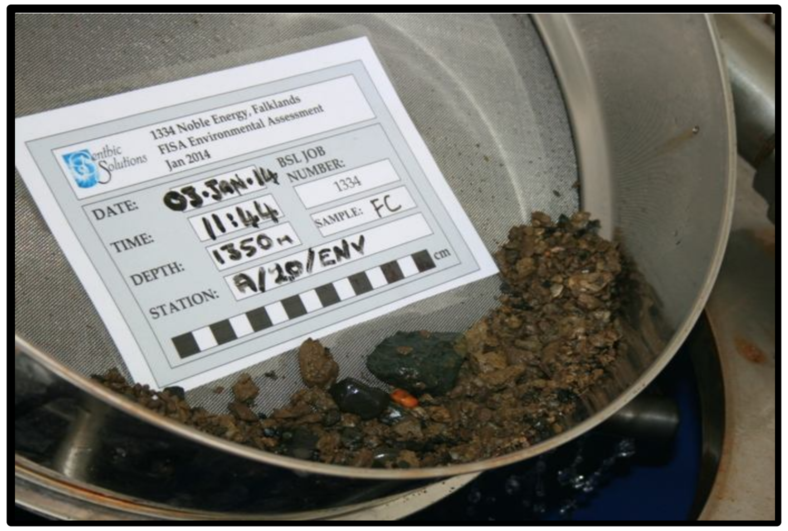


Photo Position: 791055 mE, 4195320 mN



Sieved Sample Image

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

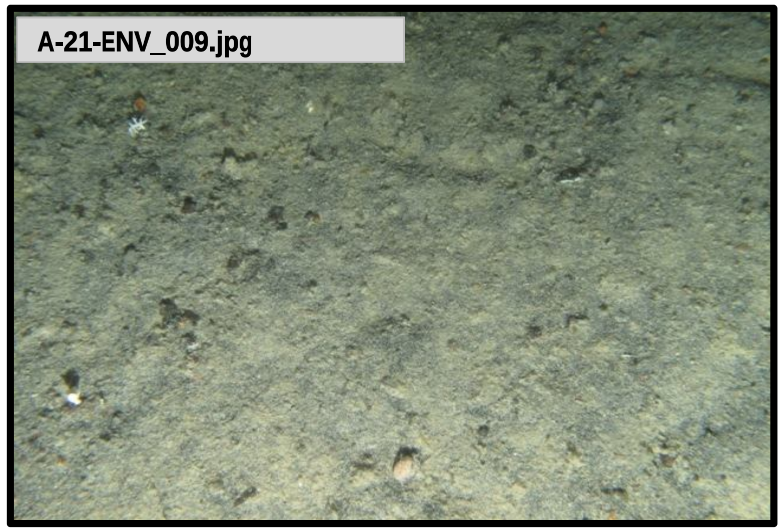


Photo Position: 798264 mE, 4195360 mN

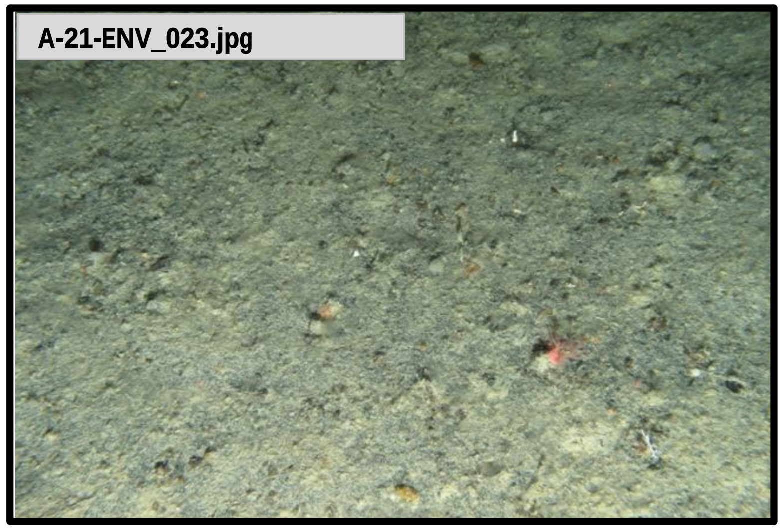


Photo Position: 798204 mE, 4195421 mN

Sediment Example Image

Habitat Summary Information: A/21/ENV

Survey Area: FISA

No. of Stills: 31 | **Mins of Video: 28** | **Track Length: 152m**

Site Selection Criteria

Regional station

Analogue Interpretation

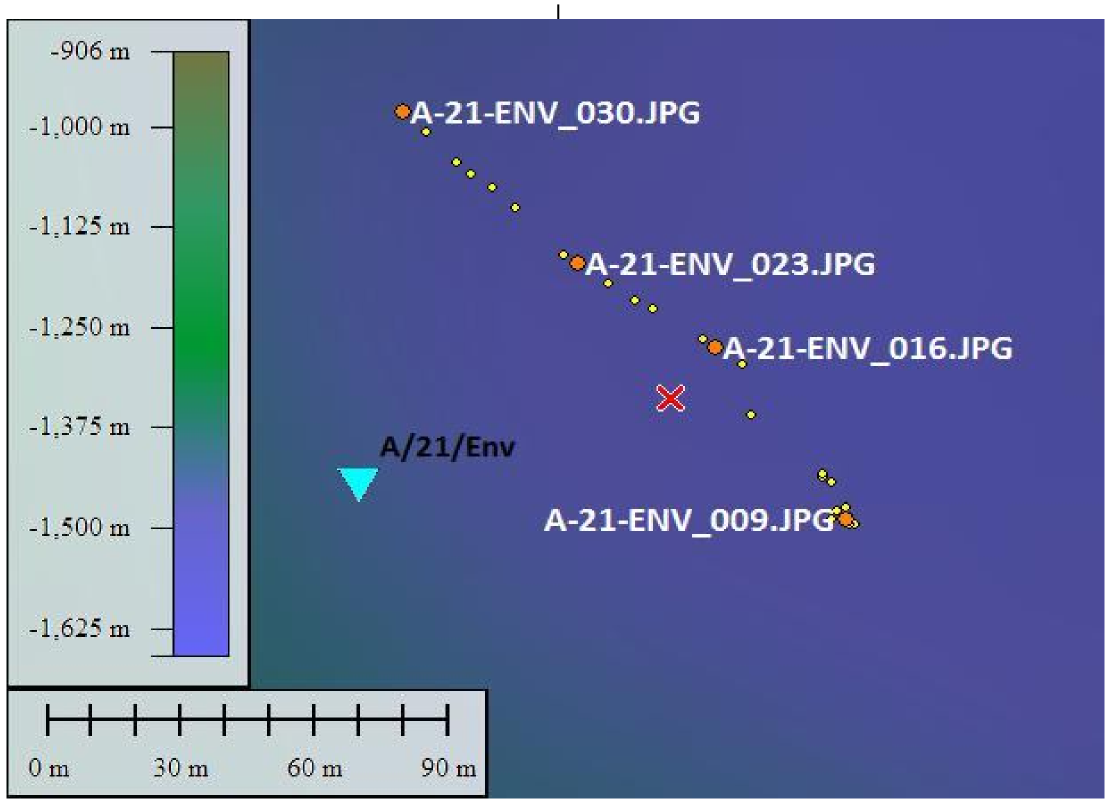
Relatively flat seabed with slight slope

Sediment Description

Black homogeneous sand

Conspicuous Fauna

Sponge: (unidentified), Tube-building Polychaete, Bryozoa sp.,



Client noble energy

Contractor Benthic Solutions

Benthic Solutions Ltd., Marsh Road,

Sample Location | UW Photo | UW Photo (featured)

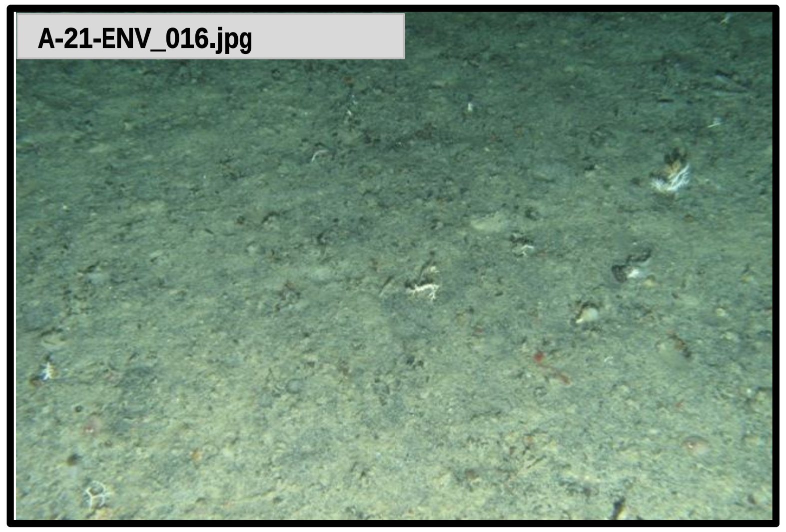


Photo Position: 798235 mE, 4195401 mN

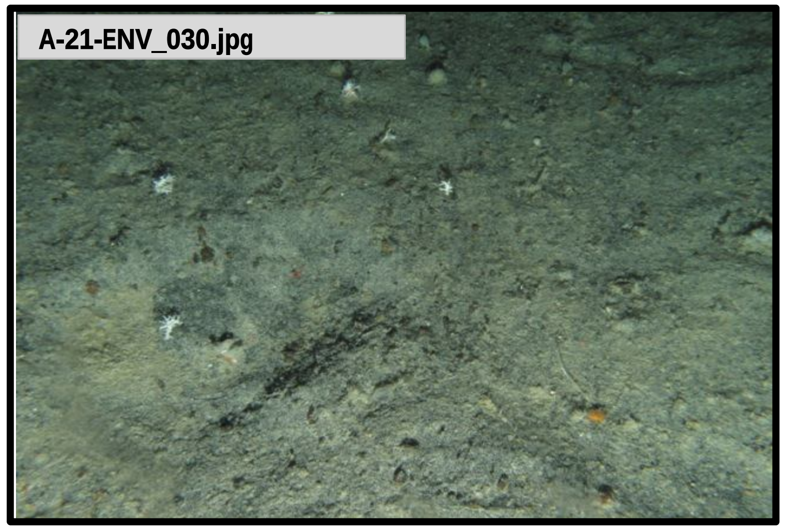


Photo Position: 798165 mE, 4195457 mN

Sieved Sample Image

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

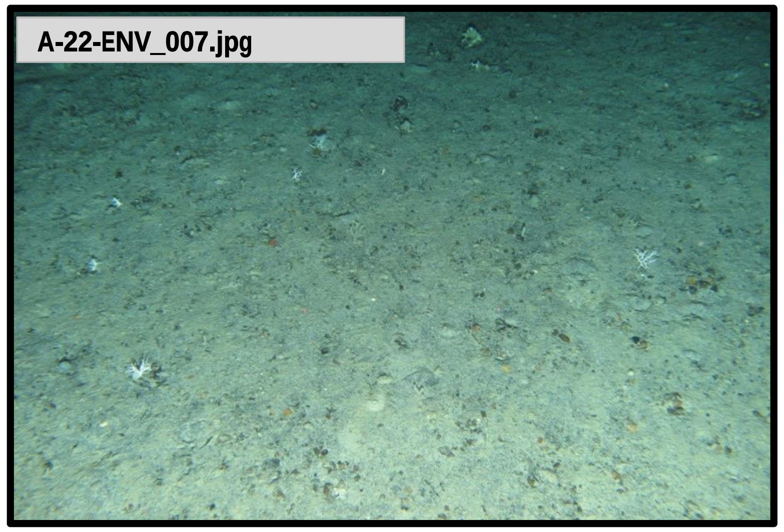


Photo Position: 768038 mE, 4163200 mN

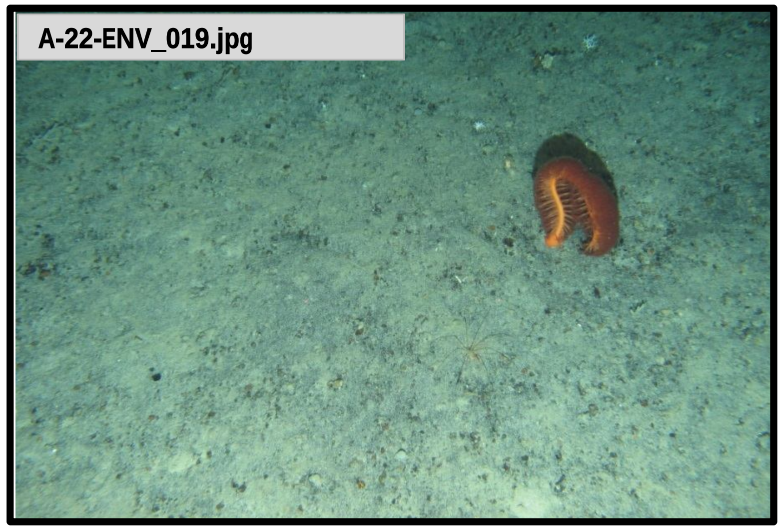


Photo Position: 768056 mE, 4163427 mN

Sediment Example Image

Habitat Summary Information: A/22/ENV

Survey Area: FISA

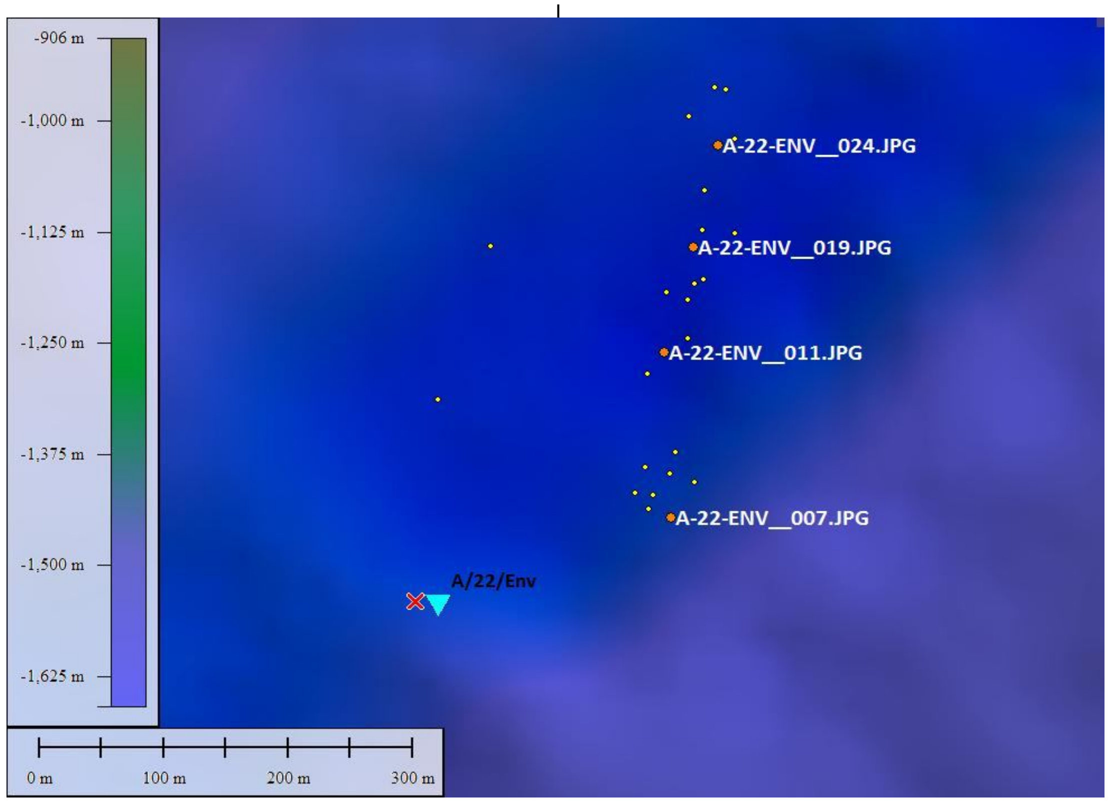
No. of Stills: 27 **Mins of Video: 26** **Track Length: 352m**

Site Selection Criteria
High amplitude base of slope

Analogue Interpretation
Sloped seabed

Sediment Description
Light/olive grey silty sand with mixed sized gravels

Conspicuous Fauna
Tube-building Polychaete, Bryozoa sp., Sea Pen: possibly *Anthoptilum grandiflorum* , Sea Spider: *Pycnogonida sp* ., Isopod: possibly *Acutiserolis neaera* , Sea Pen: Pennatulacea, Relic *Lophelia sp* ., Encrusting Sponge, Sea Urchin: Echinoidea sp., Branched Stone Coral: *Stylaster sp.,*



Client
noble energy

Contractor
Benthic Solutions
Benthic Solutions Ltd., Marsh Road,

✕ Sample Location ○ UW Photo ● UW Photo (featured)

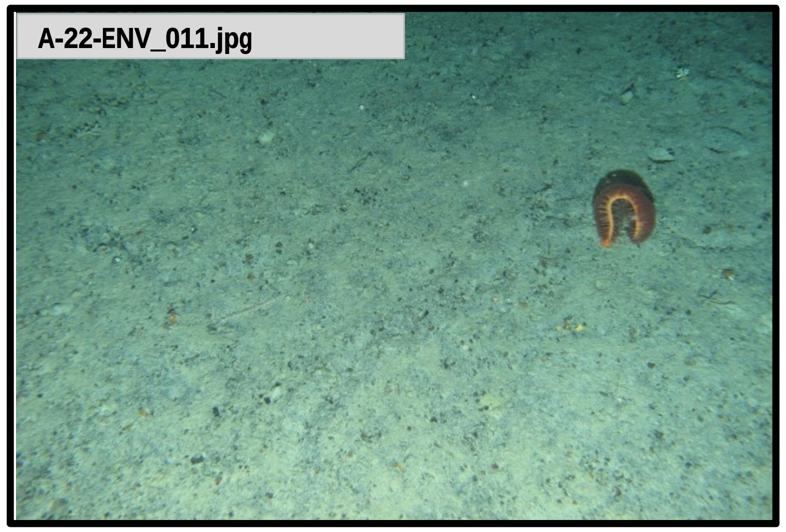


Photo Position: 768032 mE, 4163339 mN

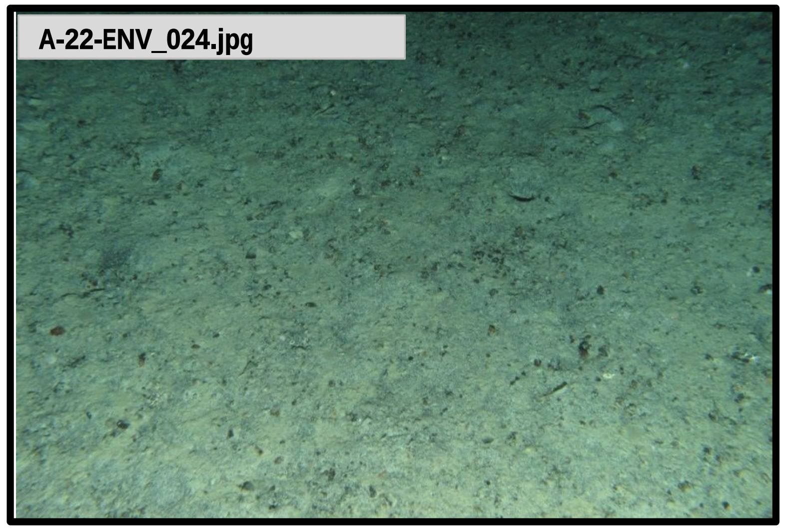


Photo Position: 768076 mE, 4163512 mN

Sieved Sample Image

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

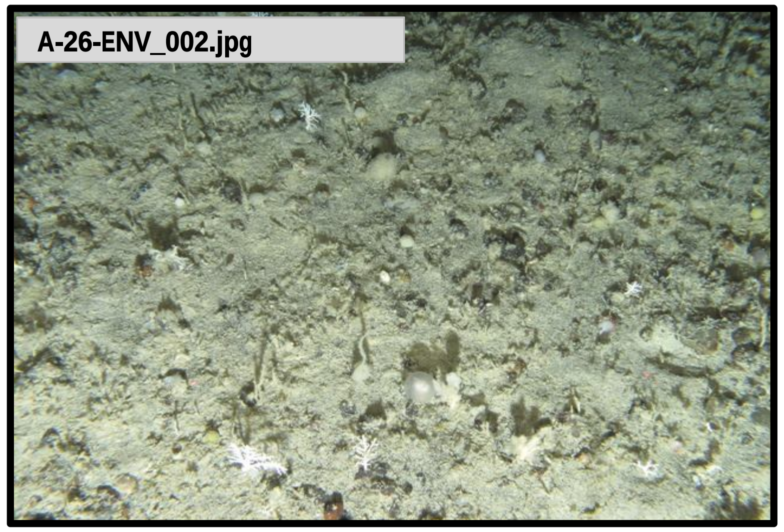


Photo Position: 768038 mE, 4163200 mN

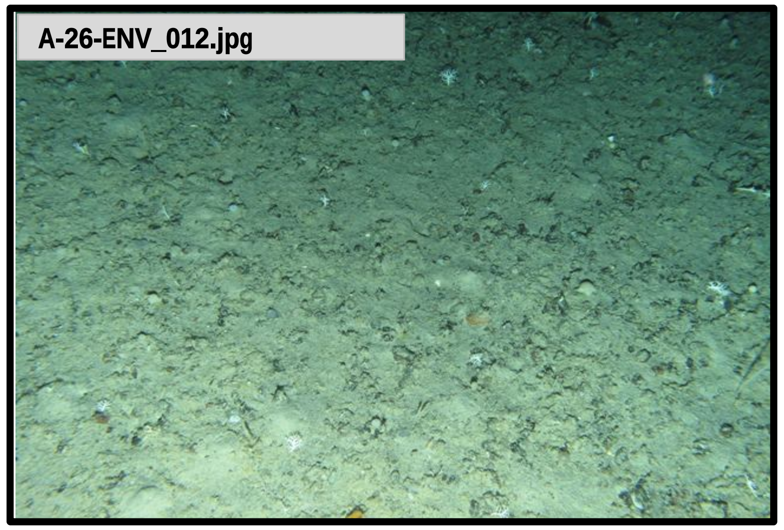


Photo Position: 768056 mE, 4163427 mN

Sediment Example Image

Habitat Summary Information: A/26/ENV

Survey Area: FISA

No. of Stills: 19 | **Mins of Video: 21** | **Track Length: 297m**

Site Selection Criteria

Close to proposed well location, (Finback-1)

Analogue Interpretation

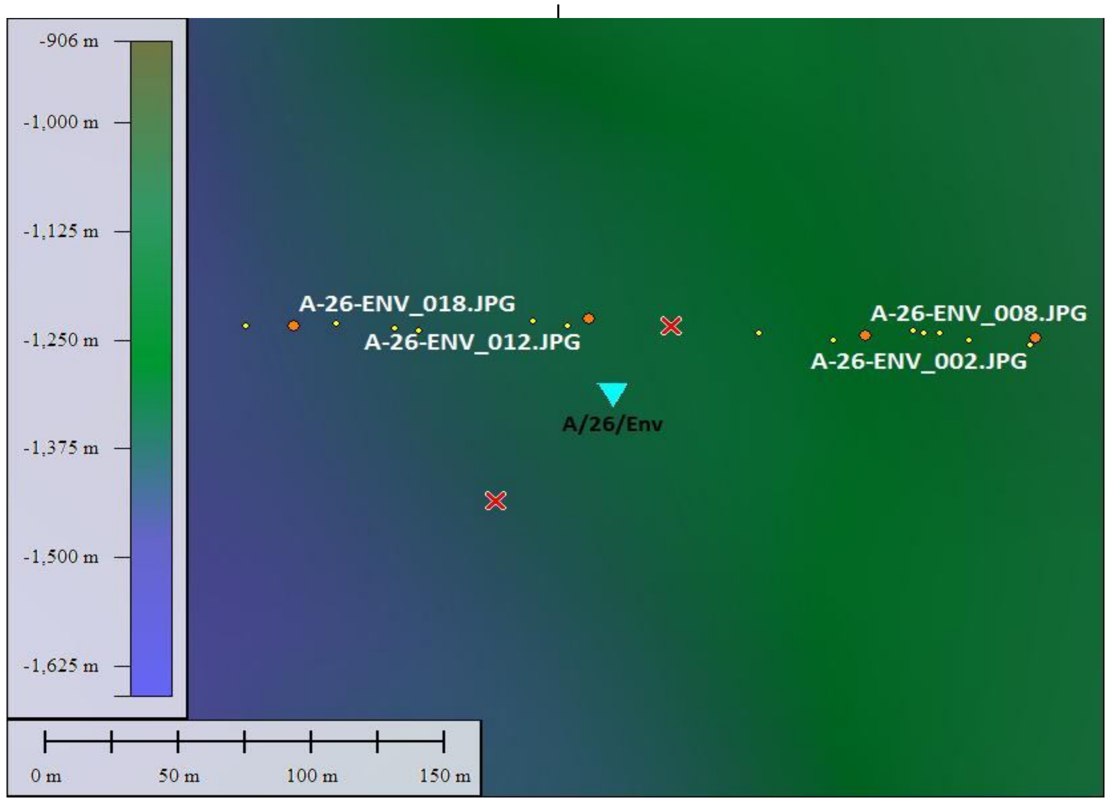
Slightly sloped seabed

Sediment Description

Compact medium sand with some coarse sediment and stones

Conspicuous Fauna

Tube-building Polychaete, Bryozoa sp., Encrusting Sponge, Isopod: possibly *Acutiserolis neaera* , Branched Stone Coral: *Stylaster sp.* , Branched Bryozoa sp., Sea Pen: Pennatulacea,



Client noble energy

Contractor Benthic Solutions

Benthic Solutions Ltd., Marsh Road,

✕ Sample Location ● UW Photo ● UW Photo (featured)

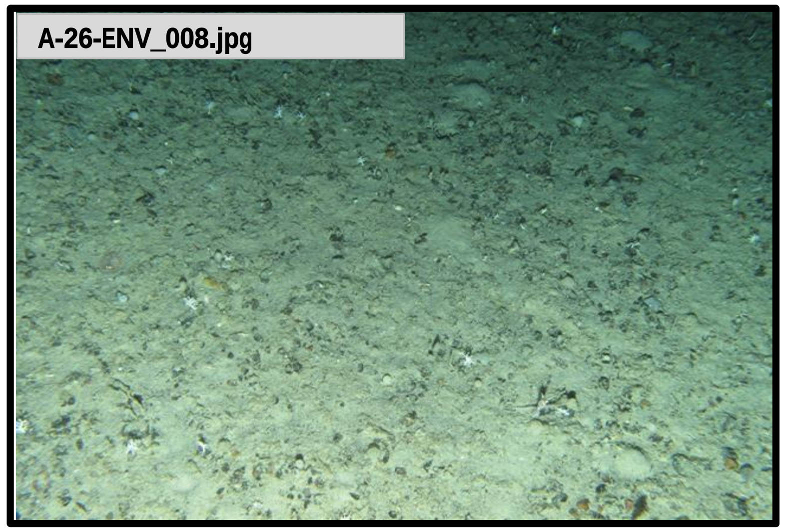


Photo Position: 768032 mE, 4163339 mN

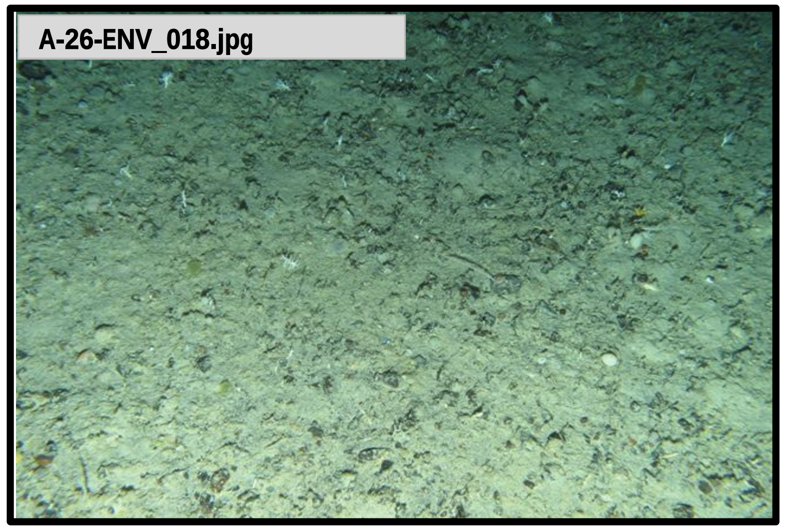


Photo Position: 768076 mE, 4163512 mN

Sieved Sample Image

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

A-27-ENV_004.jpg

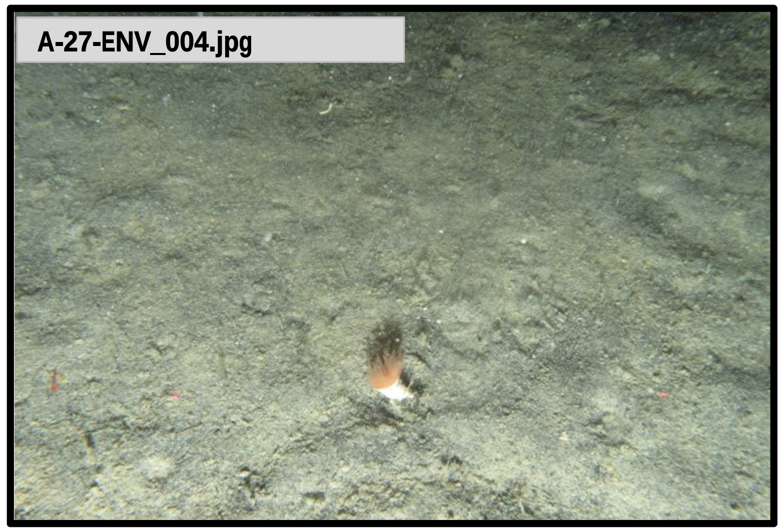


Photo Position: 792429 mE, 4213811 mN

A-27-ENV_015.jpg

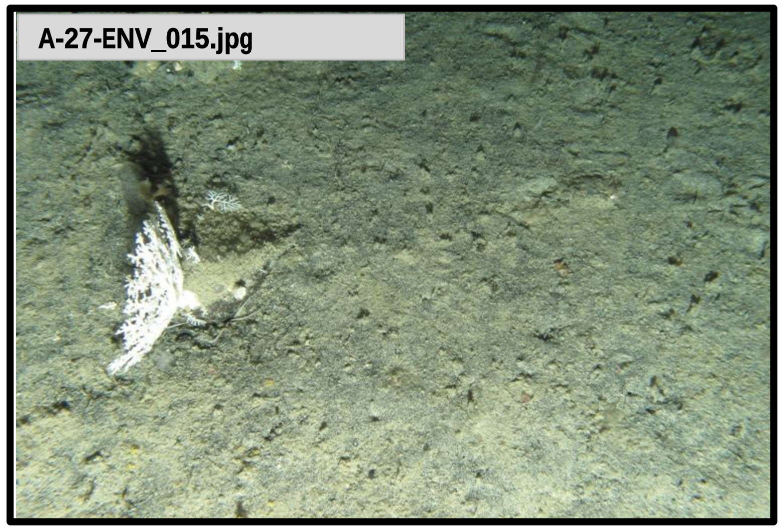


Photo Position: 792427 mE, 4213868 mN

Sediment Example Image

Habitat Summary Information: A/27/ENV

Survey Area: FISA

No. of Stills: 25 **Mins of Video: 23** **Track Length: 138m**

Site Selection Criteria

Close to proposed well location, (Humpback-1)

Analogue Interpretation

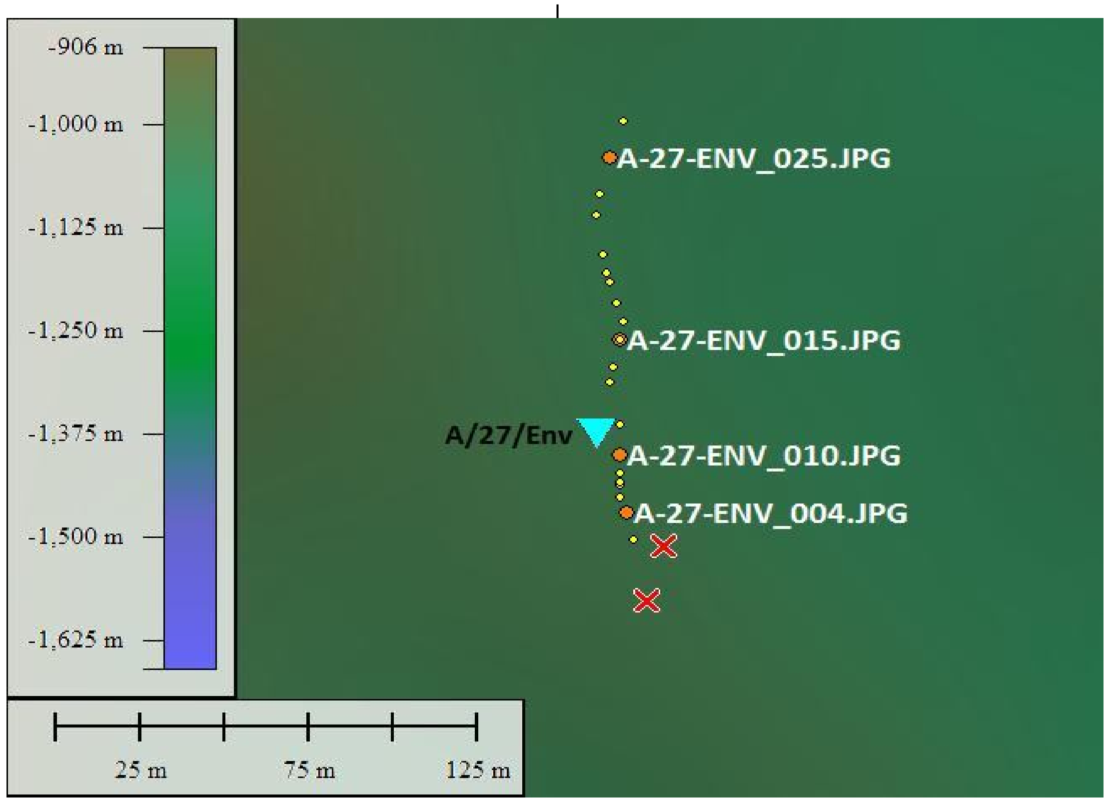
Slightly sloped seabed

Sediment Description

Fine and compact beige and black sand with boulders

Conspicuous Fauna

Cup Coral: Flabellum sp., Bryozoa sp., Branched Stone Coral: *Stylaster sp* ., Holothuroidea sp., Decapod Shrimp sp., Isopod: possibly *Acutiserolis neaera,* Encrusting Sponge, Sea Pen: Pennatulacea, Hydroid sp., Branched Bryozoa sp., Tunicate sp., Nephropidae sp. *Thymops birsteini,* Sea Urchin: Echinoidea sp., Brittlestar (Ophiuroid), Anthozoa: *Ceriantus sp,* Octocoral sp.,



Client

noble energy

Contractor

Benthic Solutions

Benthic Solutions Ltd., Marsh Road,

Sample Location UW Photo UW Photo (featured)

A-27-ENV_010.jpg

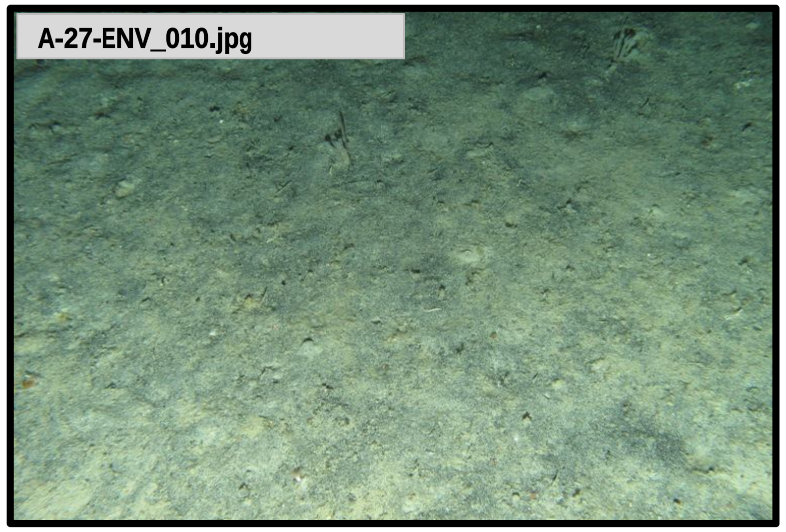


Photo Position: 792427 mE, 4213830 mN

A-27-ENV_025.jpg

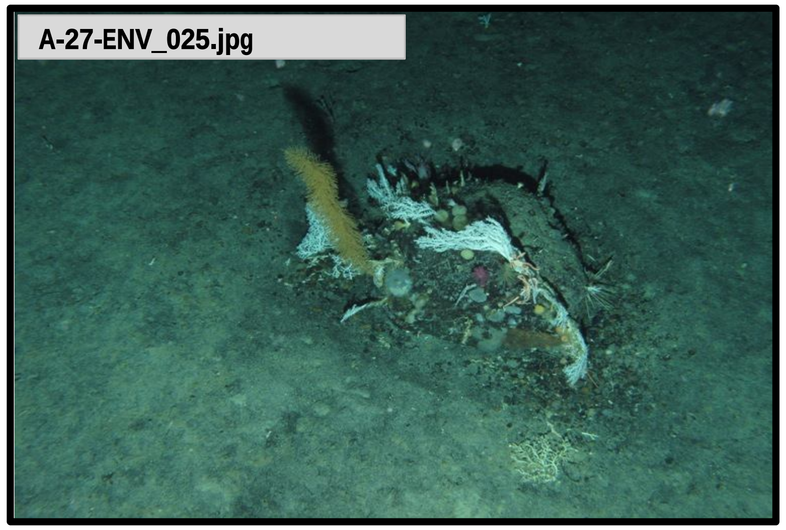


Photo Position: 792424 mE, 4213928 mN

Sieved Sample Image

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

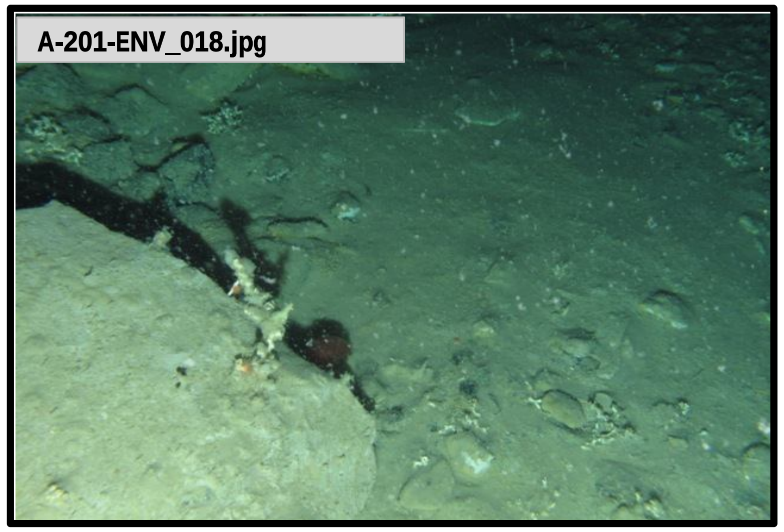


Photo Position: 734346 mE, 4206707 mN

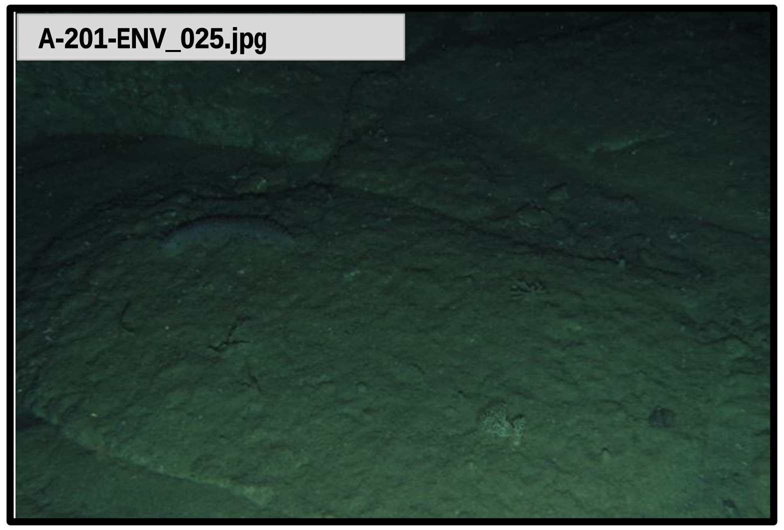


Photo Position: 734400 mE, 4206710 mN

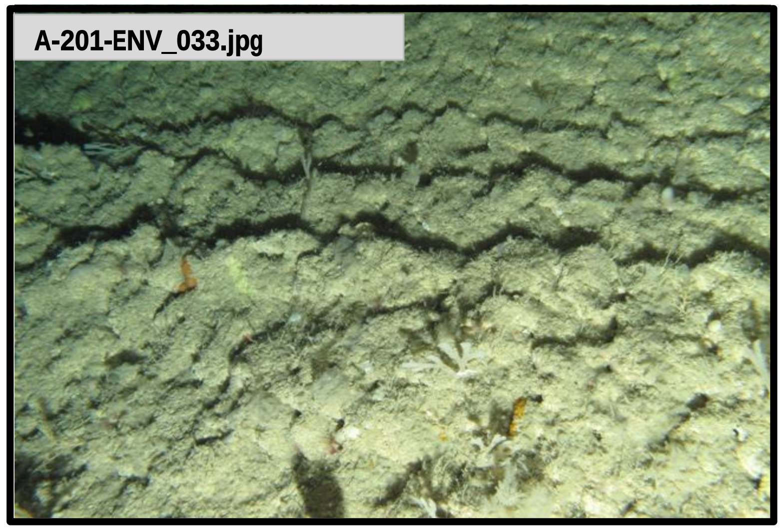


Photo Position: 734514 mE, 4206716 mN

Habitat Summary Information: A/201/ENV

Survey Area: FISA

No. of Stills: 41 **Mins of Video: 40** **Track Length: 393m**

Site Selection Criteria

Escarpment in 'hole' feature

Analogue Interpretation

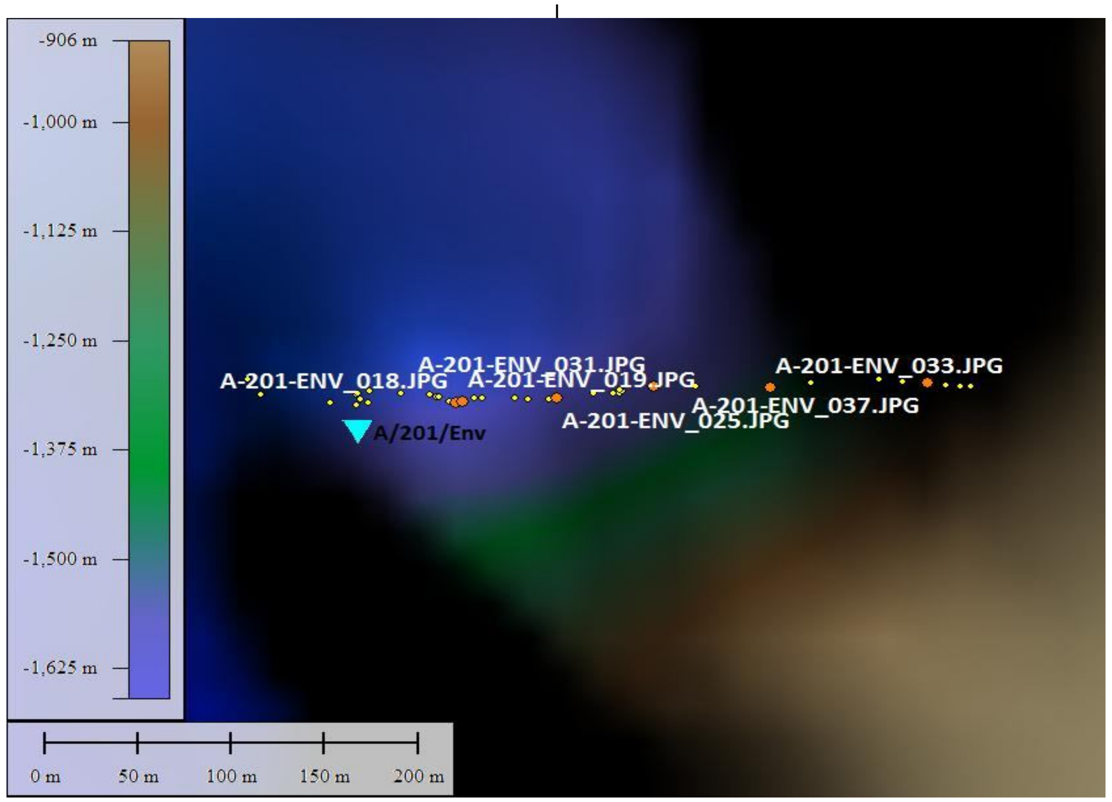
Escarpment feature

Sediment Description

Hard compact fine sand with cobbles and boulders

Conspicuous Fauna

Lophelia pertusa, Sea Pen: possibly *Anthoptilum grandiflorum* , Bryozoa sp., Sea Pen: Pennatulacea, Anthozoa: *Cerianthus sp,* Eelpout: *Lycenchelys sp.* , Tube-building Polychaete, Isopod: possibly *Acutiserolis neaera,* Brittlestar (Ophiuroid), Gastropoda sp., Relic *Lophelia sp* ., Branched Bryozoa sp., Relic Polychaete Tubes, Moridae sp., Squat Lobster: Galatheidae sp., Sponge: Porifera sp., Funnel Sponge: Demospongiae sp., Branched Stone Coral: *Stylaster sp.* , Hydroid sp., Holothuroidea sp., Cushion Starfish, Gastropoda sp.,



Client noble energy

Contractor Benthic Solutions

Benthic Solutions Ltd., Marsh Road,

Sample Location UW Photo UW Photo (featured)

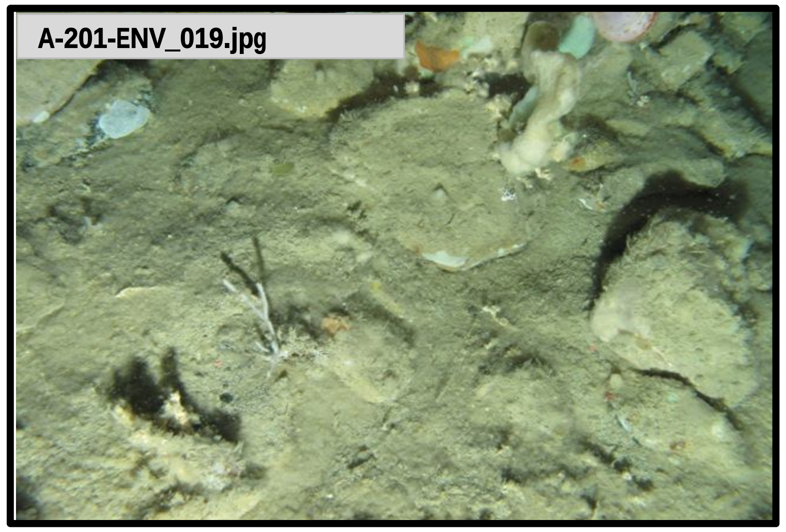


Photo Position: 734350 mE, 4206708 mN

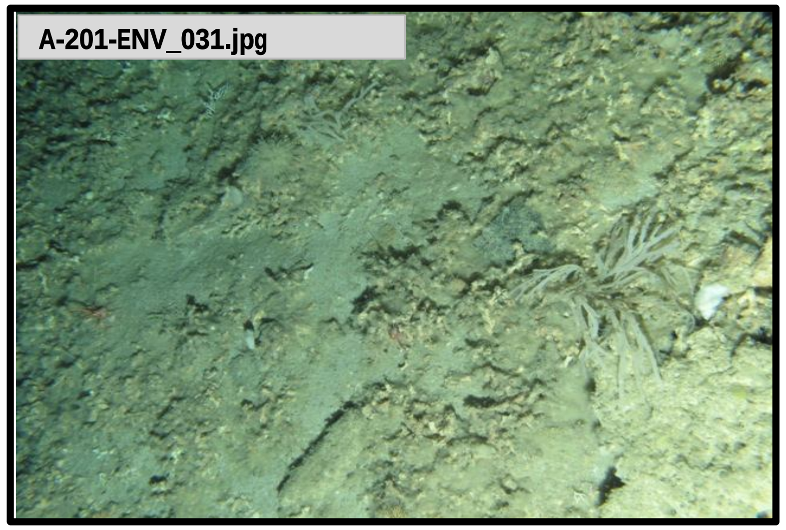


Photo Position: 734452 mE, 4206717 mN

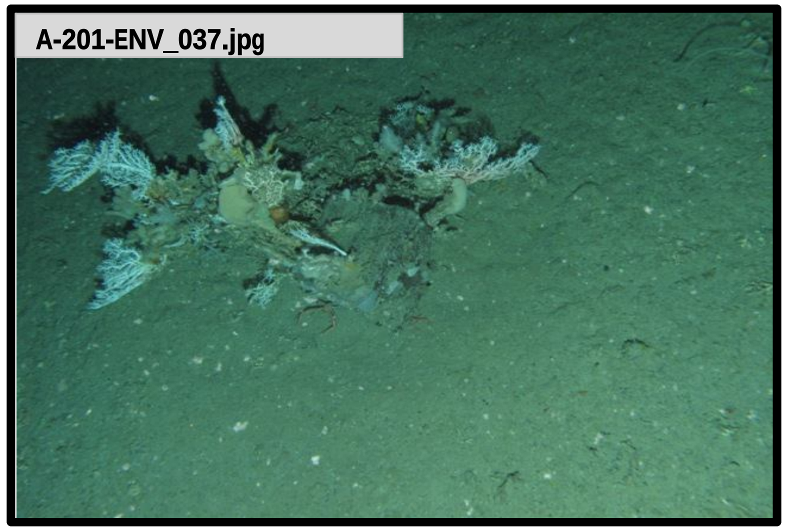


Photo Position: 734598 mE, 4206719 mN

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

Habitat Summary Information: A/202/ENV

Survey Area: FISA

No. of Stills: 33 | **Mins of Video: 43** | **Track Length: 93m**

Site Selection Criteria
Undulating seafloor

Analogue Interpretation
Base of slope

Sediment Description
Hard compact medium sand with clay lumps

Conspicuous Fauna
Brittlestar (Ophiuroid), Bryozoa sp., Tube-building Polychaete, Polychaete sp., Isopod: possibly *Acutiserolis neaera* , Sea Pen: possibly *Anthoptilum grandiflorum*, Cup Coral: *Flabellum sp.*,

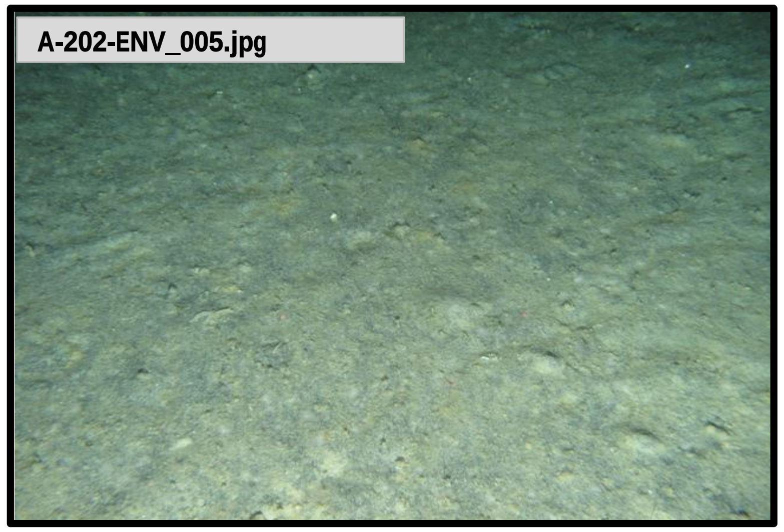


Photo Position: 754157 mE, 4216068 mN

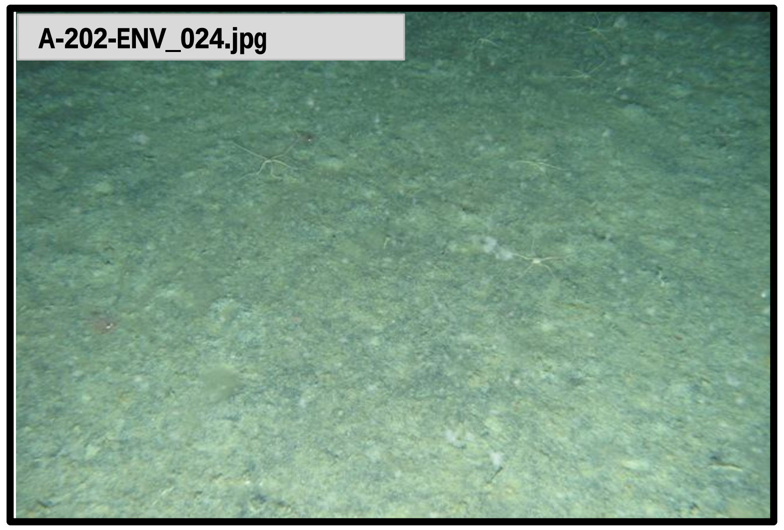
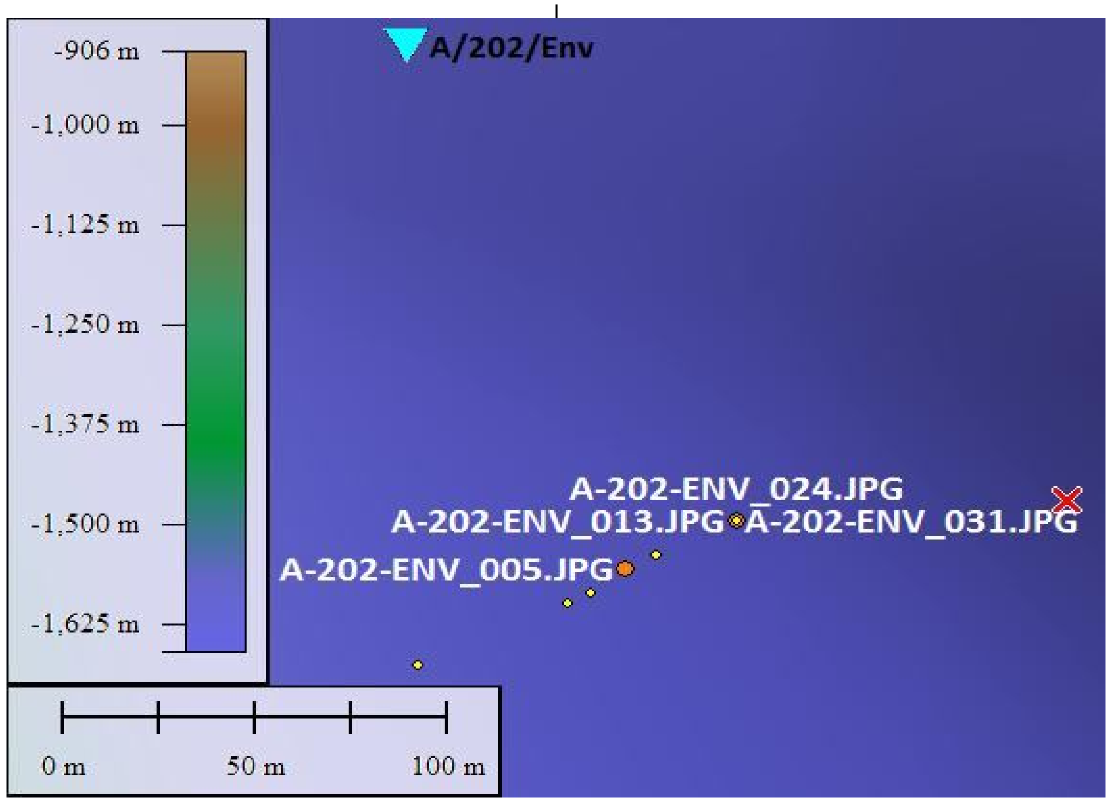


Photo Position: 754186 mE, 4216082 mN


Sediment Example Image



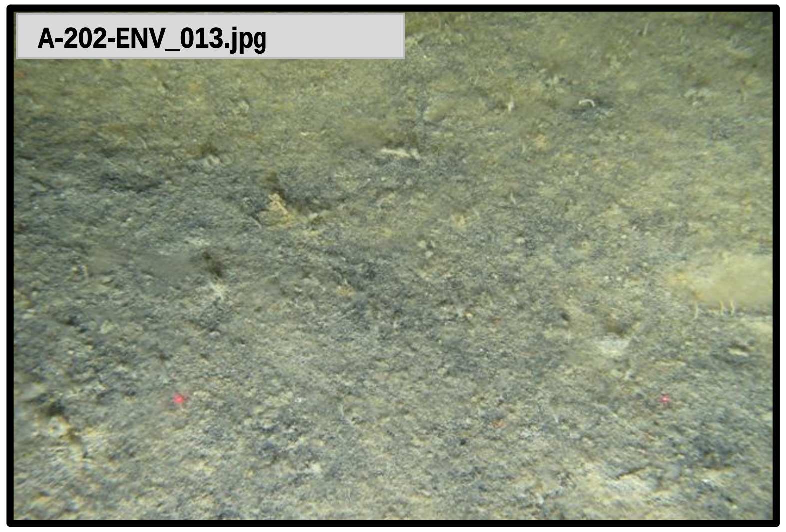


Photo Position: 754186 mE, 4216082 mN

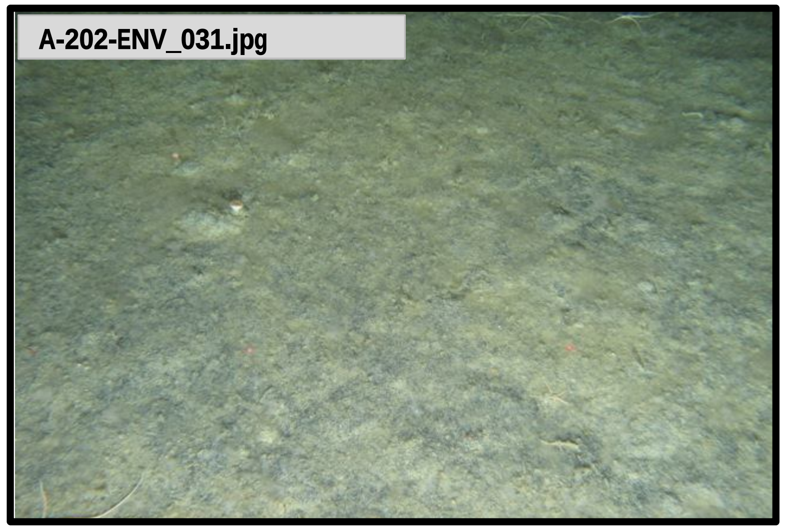
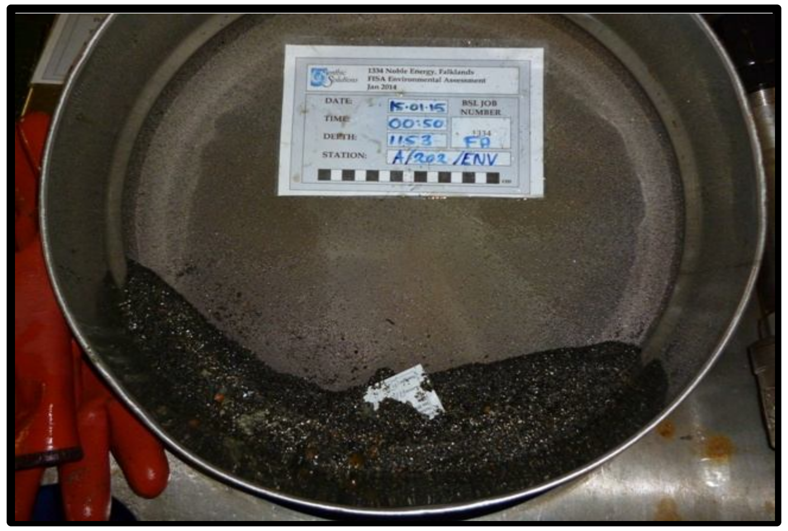


Photo Position: 754186 mE, 4216082 mN


Sieved Sample Image

Client
noble energy

Contractor
Benthic Solutions
Benthic Solutions Ltd., Marsh Road,

✕ Sample Location | UW Photo | UW Photo (featured)

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

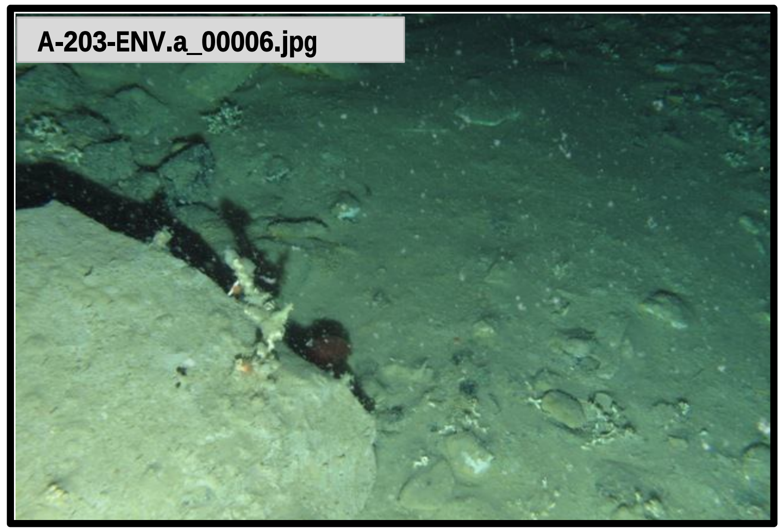


Photo Position: 787586 mE, 4199232 mN

Habitat Summary Information: A/203/ENV

Survey Area: FISA

No. of Stills: 37 **Mins of Video: 26** **Track Length: 130m**

Site Selection Criteria
Camera transect on isolated feature

Analogue Interpretation
Sloped seabed

Sediment Description
Hard compact fine sand with cobbles and boulders

Conspicuous Fauna
Lophelia pertusa, Relic *Lophelia sp* ., Tube-building Polychaete, Brittlestar (Ophiuroid), Gorgonian sp., Squat Lobster: Galatheidae sp., Branched Bryozoa sp., Sea Pen: Pennatulacea, Branched Stone Coral: Stylaster sp., Hydroid sp., Anthozoa: Soft coral, Pencil Urchin: possibly *Cidaris sp.*, Sponge: Porifera sp., Moridae sp., Hake: possibly *Merluccius hubbsi*, Decapod Shrimp sp.,

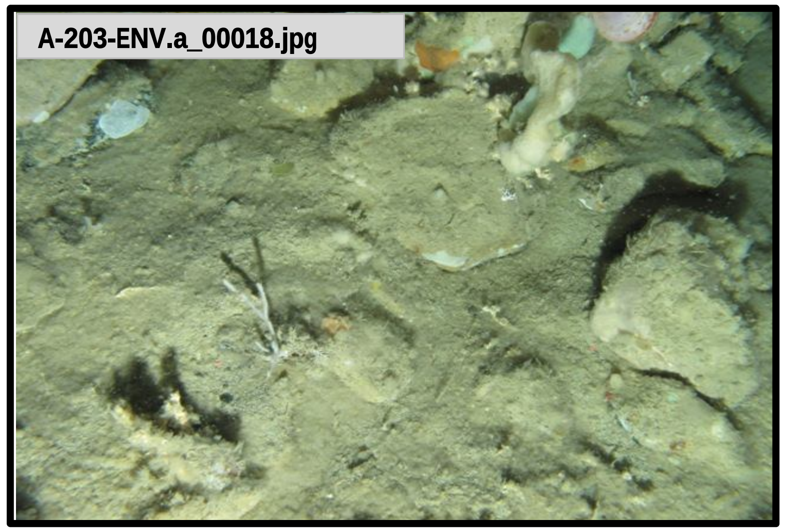


Photo Position: 787570 mE, 4199182 mN

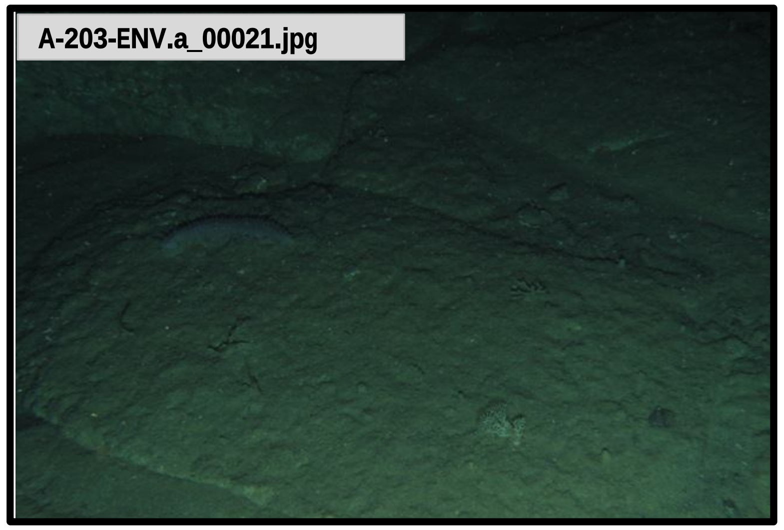
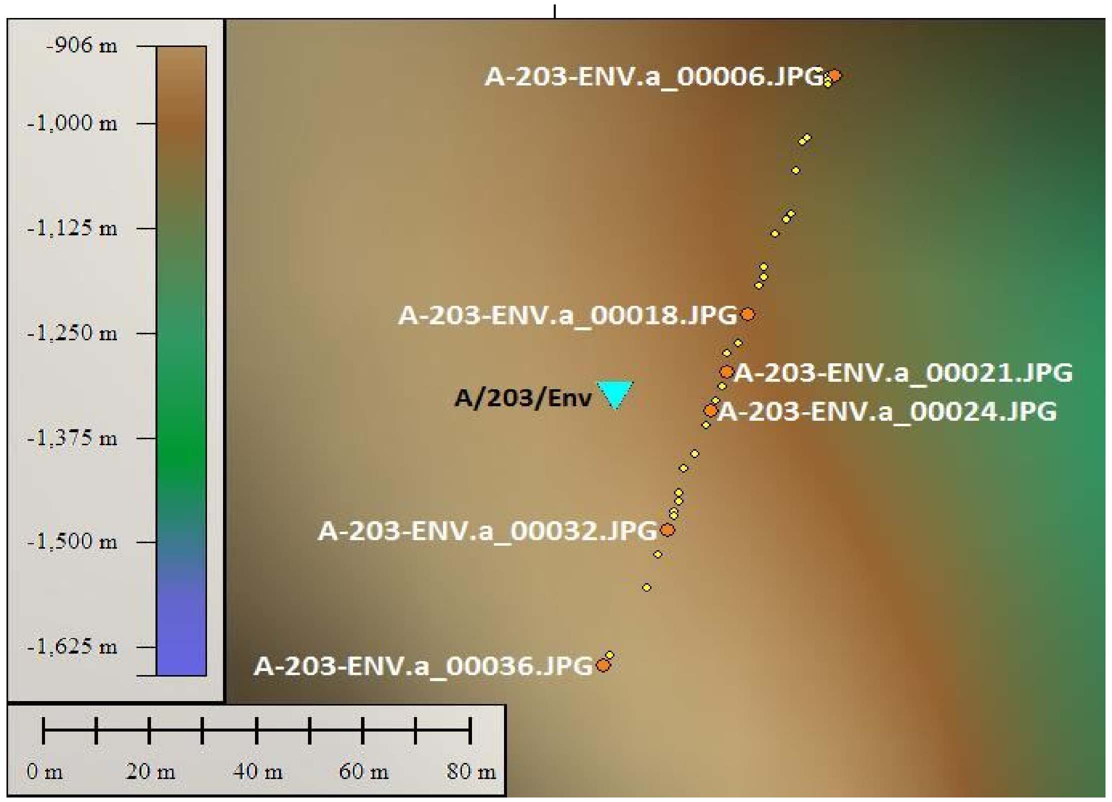


Photo Position: 787566 mE, 4199170 mN



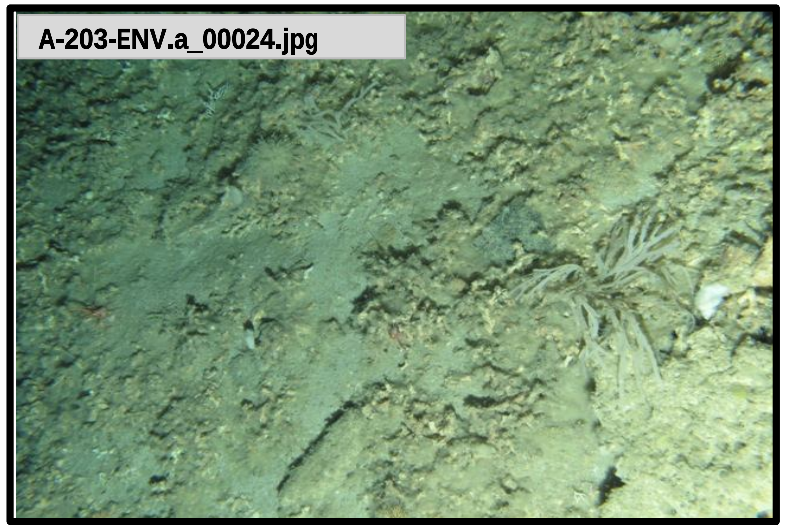


Photo Position: 787563 mE, 4199162 mN

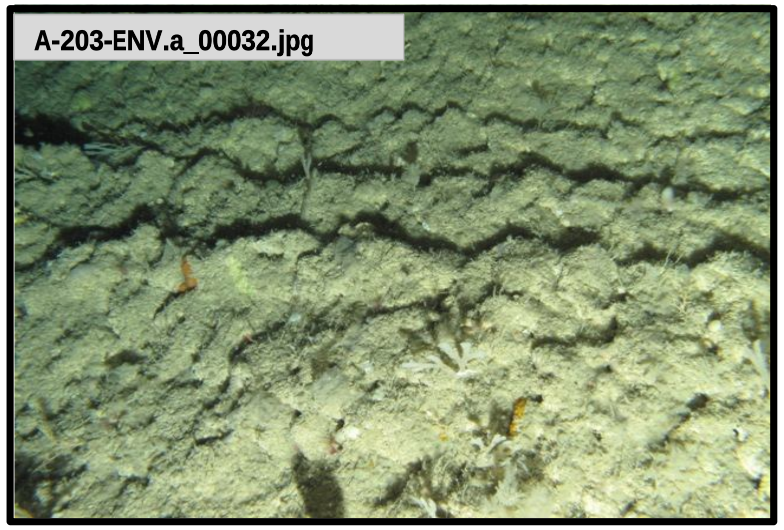


Photo Position: 787555 mE, 4199137 mN

Client noble energy

Contractor Benthic Solutions
Benthic Solutions Ltd., Marsh Road,

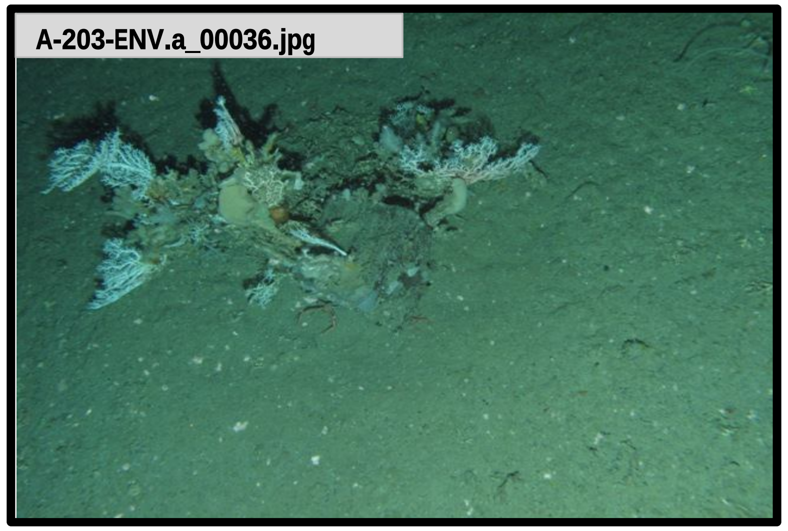
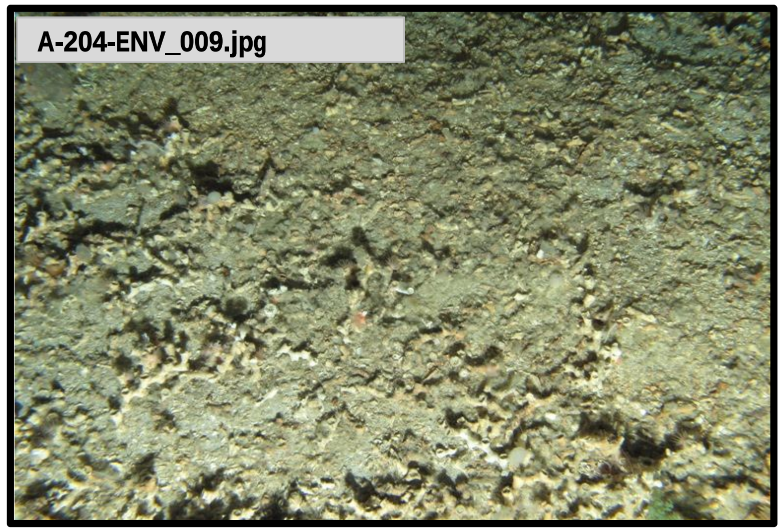


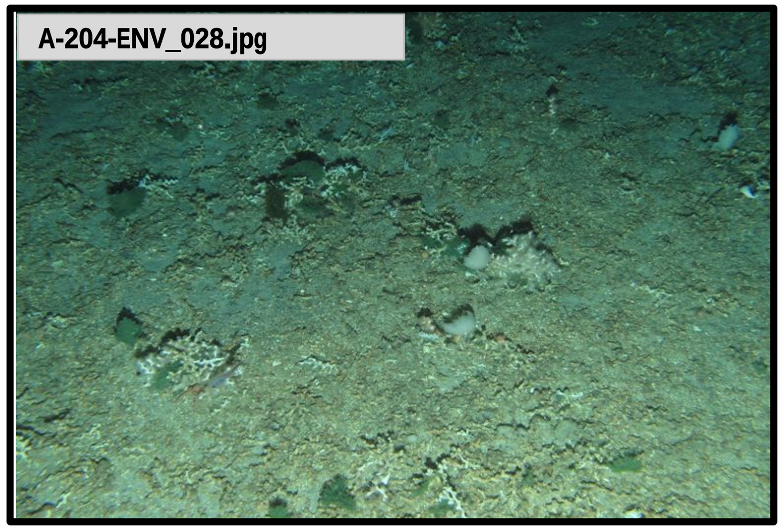
Photo Position: 787543 mE, 4199109 mN

✕ Sample Location ○ UW Photo ● UW Photo (featured)

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West



No beacon data acquired



No beacon data acquired

Sediment Example Image

Habitat Summary Information: A/204/ENV

Survey Area: FISA

No. of Stills: 50 **Mins of Video: 27** **Track Length: No Data**

Site Selection Criteria

Slump feature

Analogue Interpretation

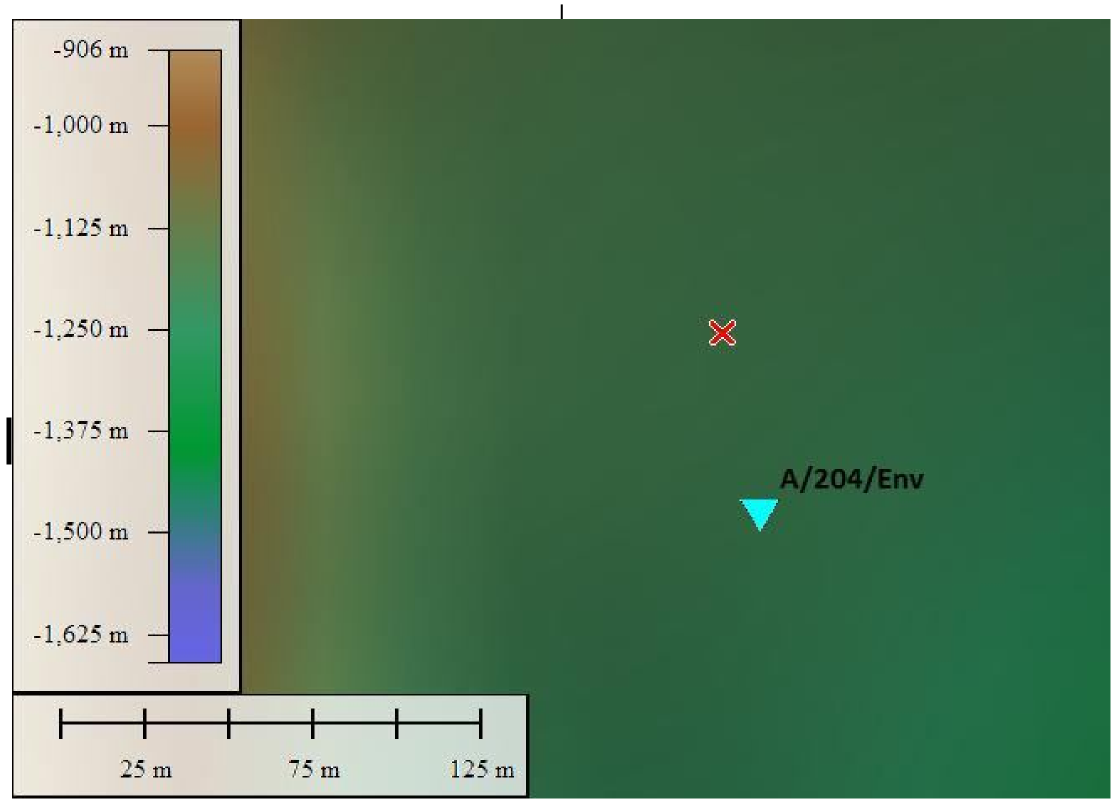
Slump feature

Sediment Description

Coarse beige and dark sediment, larger boulder pile-up/slump feature with multiple collapses

Conspicuous Fauna

Lophelia pertusa, Relic *Lophelia sp.*, Anthozoa: Soft coral, Hydroid sp., Sponge: Porifera sp., Branched Stone Coral: *Stylaster sp.*, Gorgonian sp., Brittlestar (Ophiuroid), Moridae sp., Squat Lobster: Galatheidae sp., Bryozoa sp., Sea Pen: Pennatulacea, Branched Bryozoa sp., Encrusting Sponge,

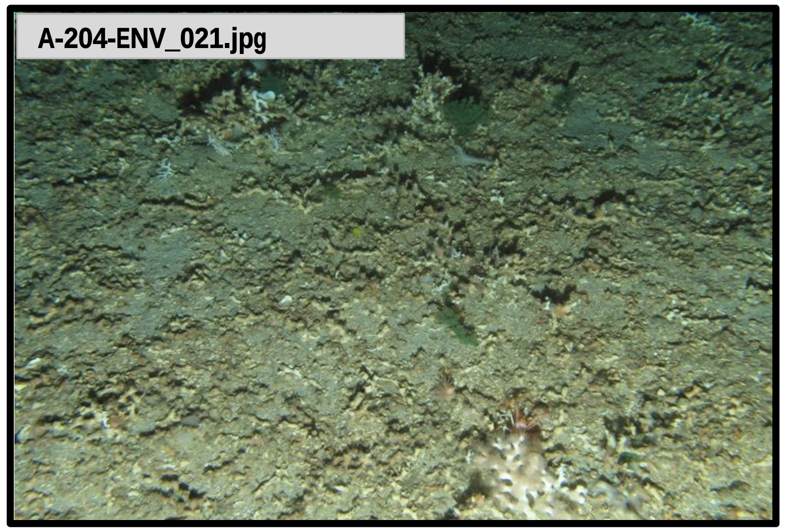


Client noble energy

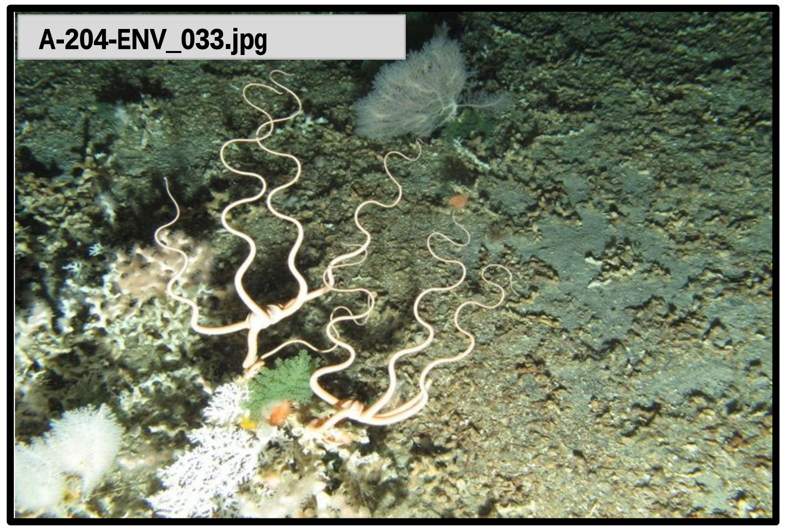
Contractor Benthic Solutions

Benthic Solutions Ltd., Marsh Road,

Sample Location UW Photo UW Photo (featured)



No beacon data acquired



No beacon data acquired

Sieved Sample Image

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

Habitat Summary Information: A/205/ENV

Survey Area: FISA

No. of Stills: 12 | **Mins of Video: 40** | **Track Length: 198m**

Site Selection Criteria
Discrete slope failure

Analogue Interpretation
Sloped seabed

Sediment Description
Very large boulder, coarse sediment, rocky outcrops

Conspicuous Fauna
Lophelia pertusa , Relic *Lophelia sp* ., Sponge: Porifera sp., Branched Stone Coral: *Stylaster sp* ., Sea Pen: Pennatulacea,

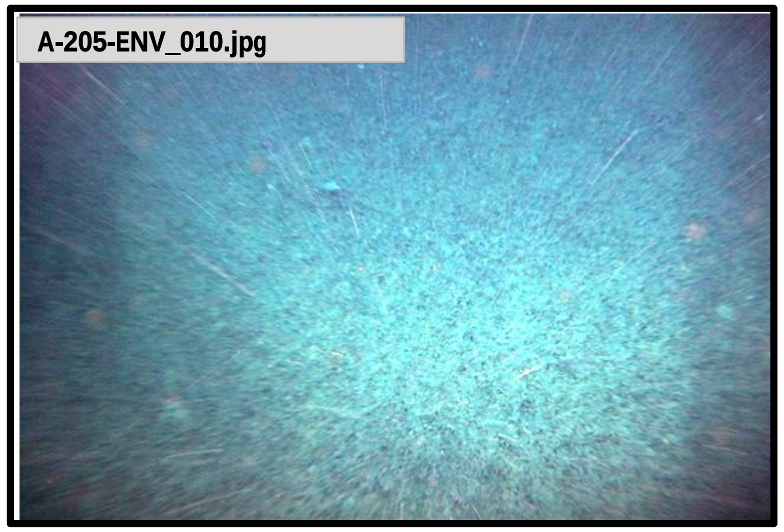


Photo Position: 792218 mE, 4178377 mN

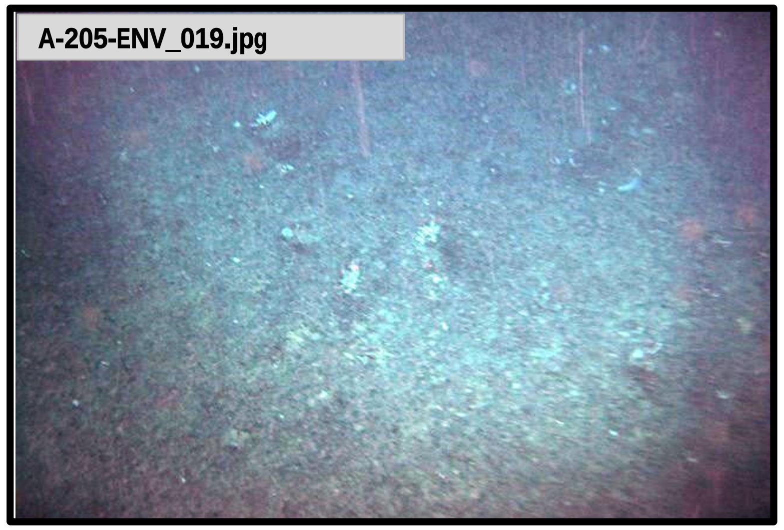


Photo Position: 792218 mE, 4178377 mN

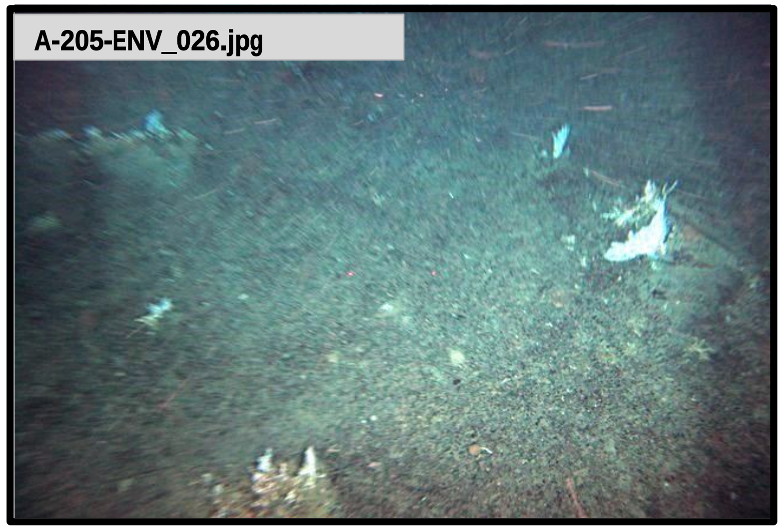


Photo Position: 792218 mE, 4178377 mN

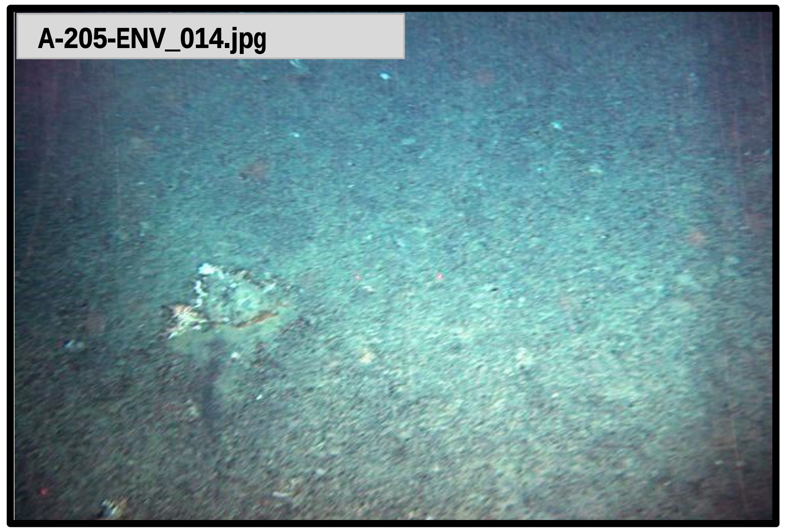


Photo Position: 792218 mE, 4178377 mN

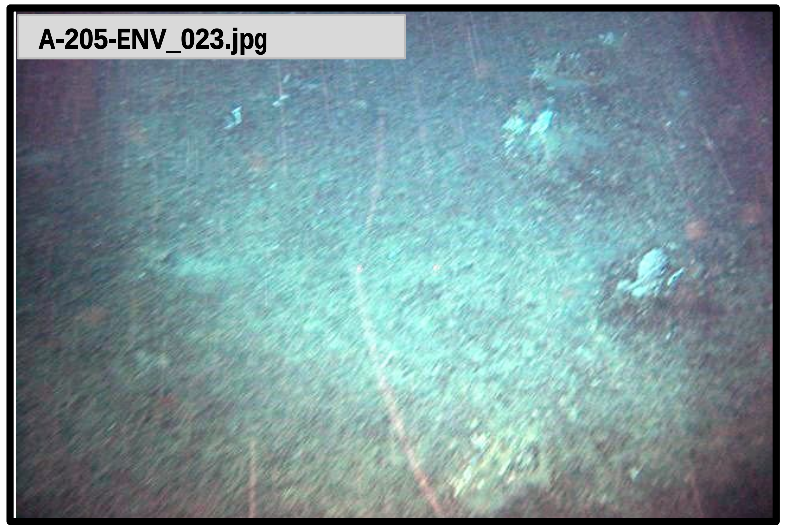


Photo Position: 792218 mE, 4178377 mN

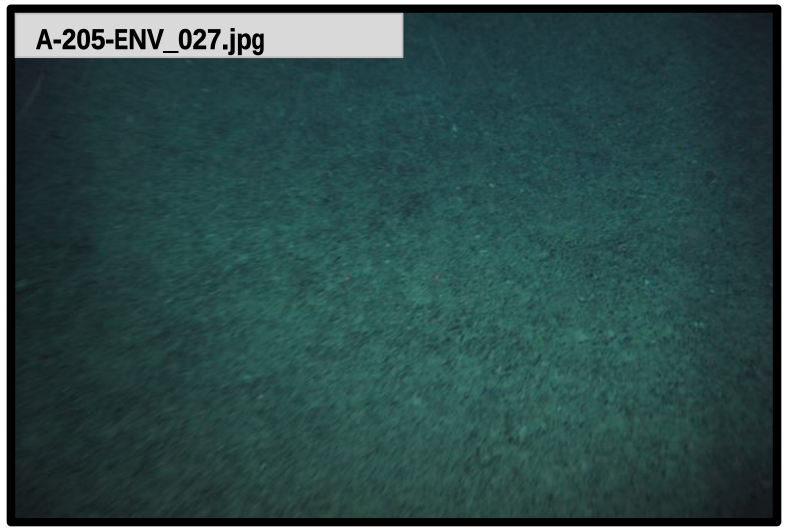
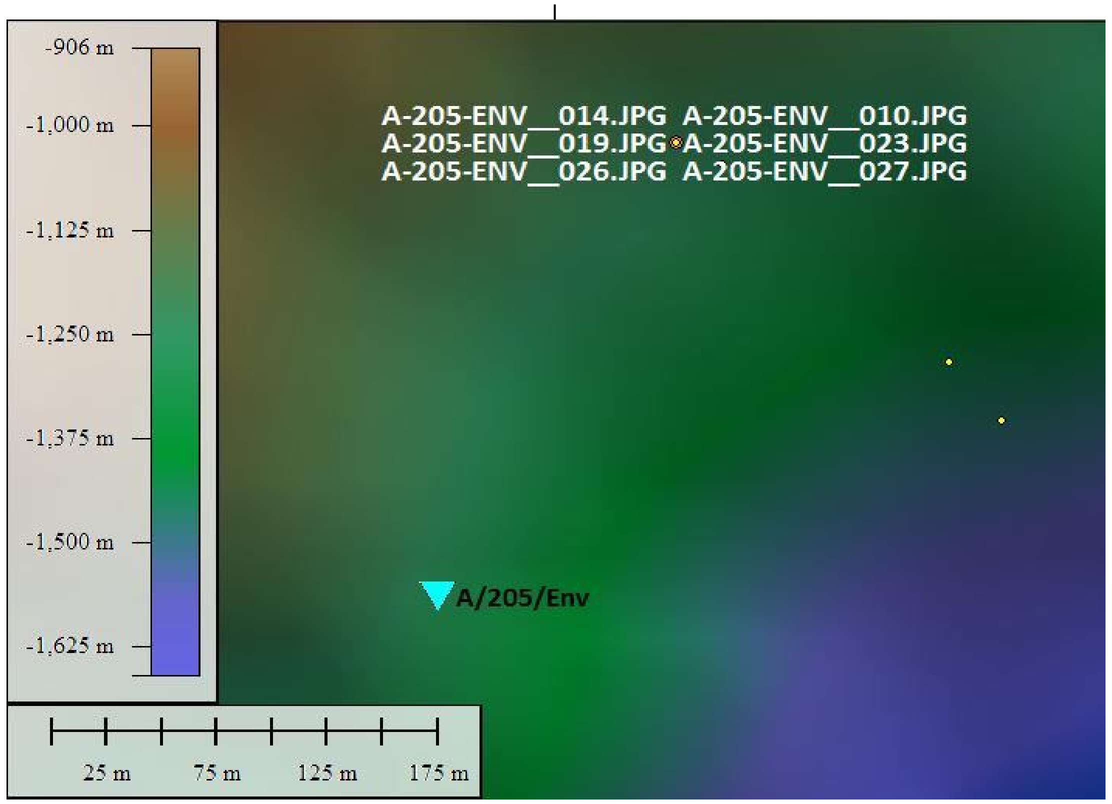


Photo Position: 792218 mE, 4178377 mN



Client noble energy

Contractor Benthic Solutions
Benthic Solutions Ltd., Marsh Road,

✕ Sample Location | UW Photo | UW Photo (featured)

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

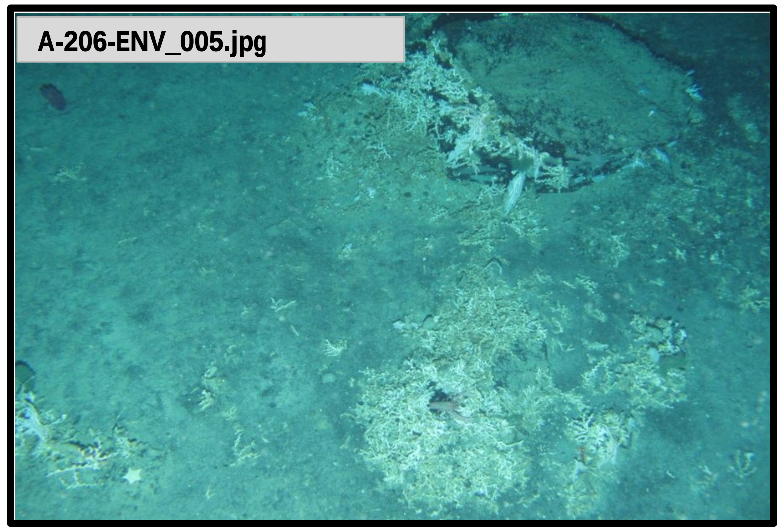


Photo Position: 776850 mE, 4163322 mN

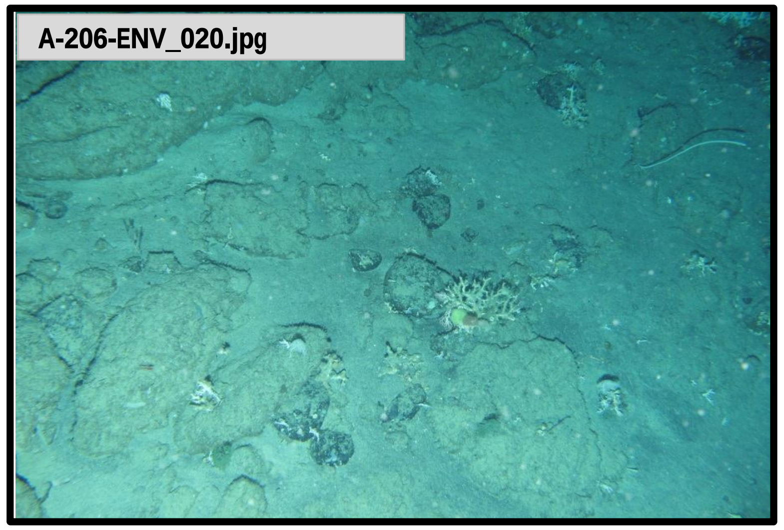


Photo Position: 776867 mE, 4163426 mN

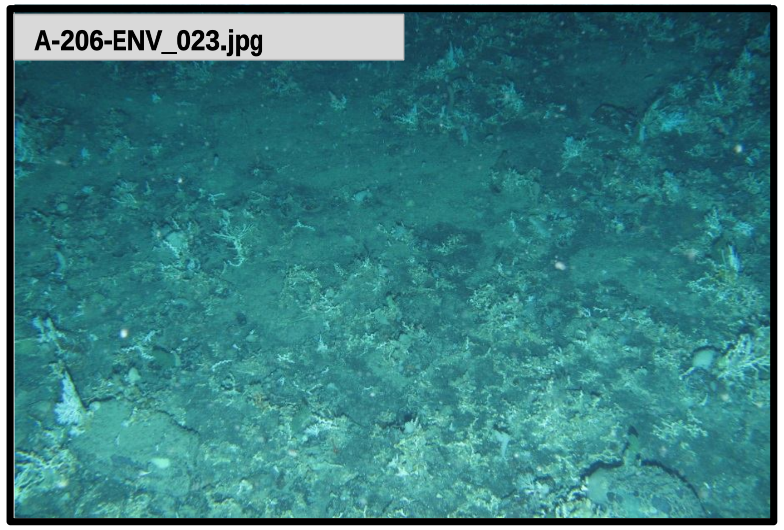


Photo Position: 776857 mE, 4163484 mN

Habitat Summary Information: A/206/ENV

Survey Area: FISA

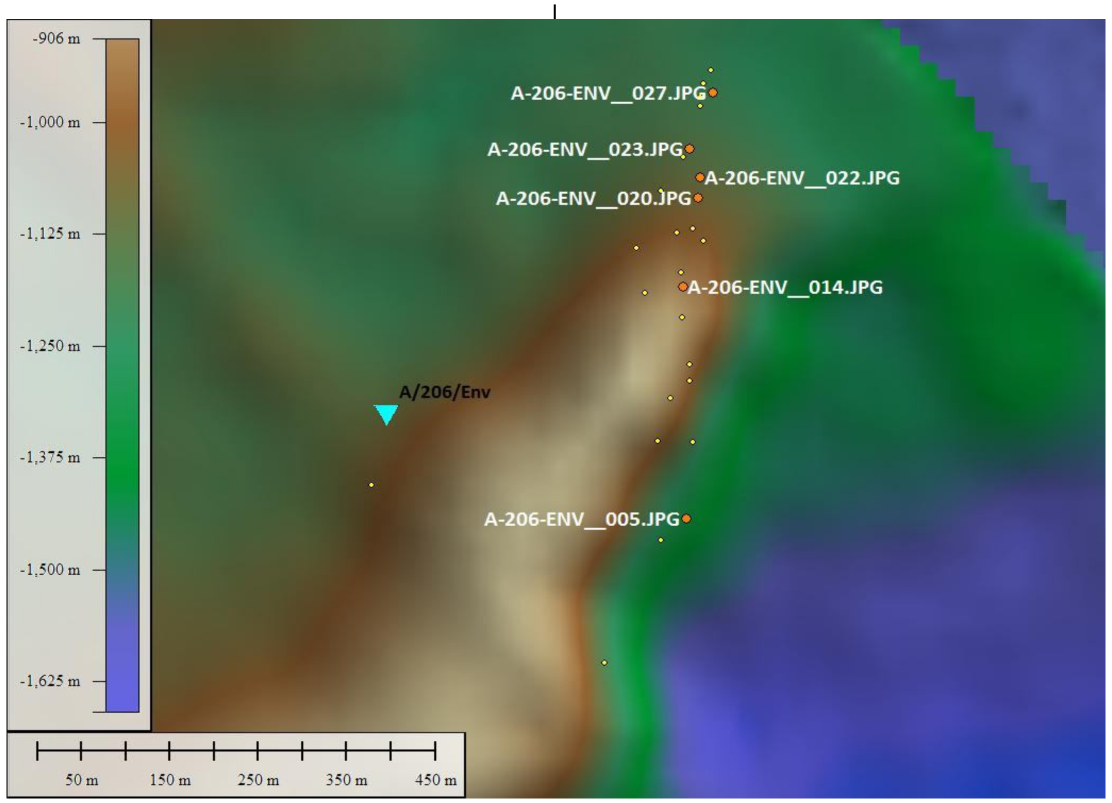
No. of Stills: 29 **Mins of Video: 32** **Track Length: 690m**

Site Selection Criteria
Discrete feature

Analogue Interpretation
Slope feature

Sediment Description
Upslope, rocky outcrops

Conspicuous Fauna
Relic *Lophelia sp.*, Branched Stone Coral: *Stylaster sp*., Sea Lily: Crinoidea sp., Gorgonian sp., Hydroid sp., Decapod Shrimp sp., Nephropidae sp. *Thymops birsteini*, Lophelia pertusa, Sea Pen: Pennatulacea, Sponge: Porifera sp.,



Client noble energy

Contractor Benthic Solutions
Benthic Solutions Ltd., Marsh Road,

Sample Location UW Photo UW Photo (featured)

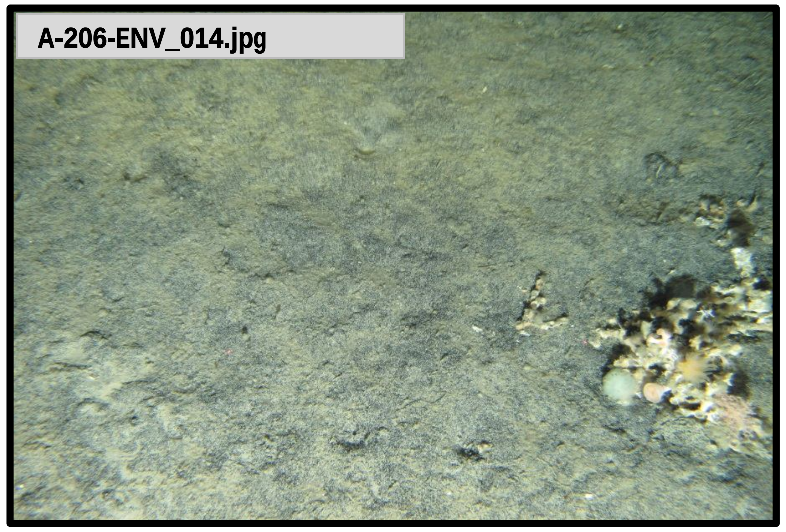


Photo Position: 776850 mE, 4163322 mN

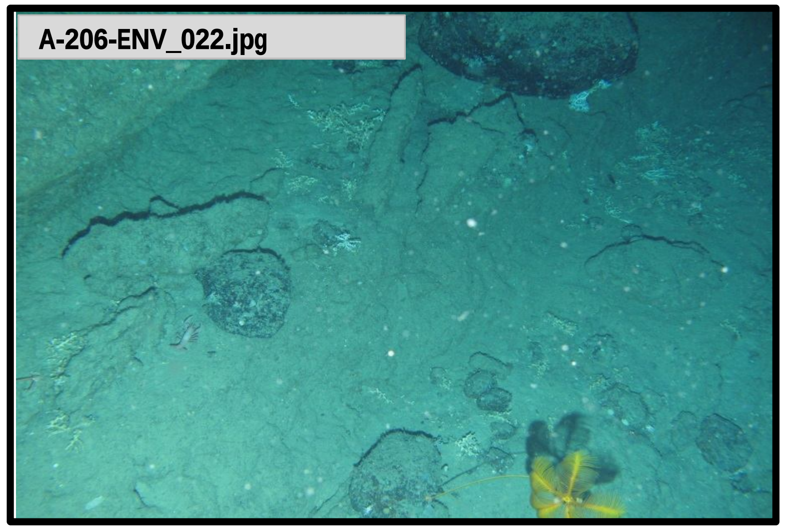


Photo Position: 776689 mE, 4163450 mN

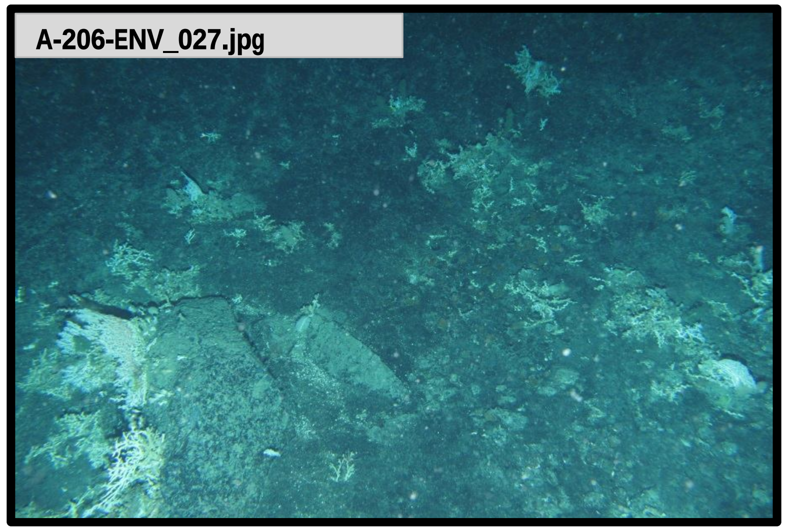


Photo Position: 776884 mE, 4163550 mN

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

Habitat Summary Information: A/207/ENV

Survey Area: FISA

No. of Stills: 35 **Mins of Video: 27** **Track Length: 154m**

Site Selection Criteria

Discrete 'reef' area

Analogue Interpretation

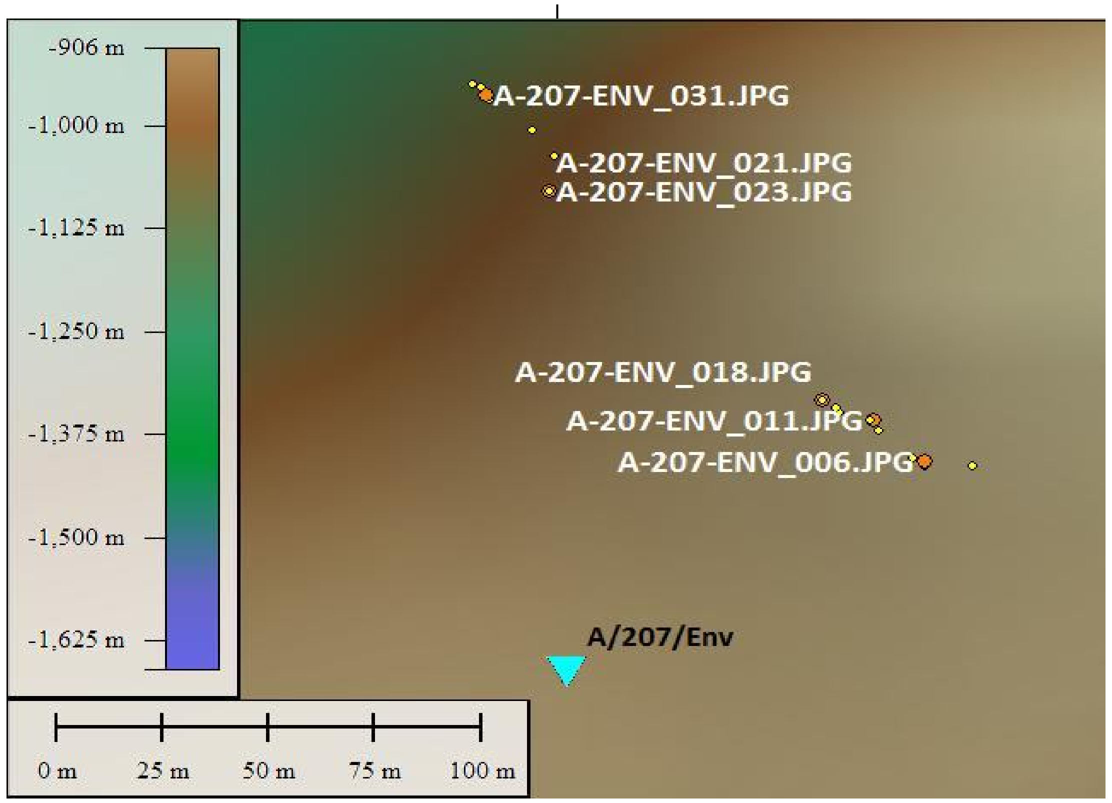
Sloped seabed

Sediment Description

Homogeneous beige sand, gravel and boulders

Conspicuous Fauna

Branched Stone Coral: *Stylaster sp.* , Squat Lobster: Galatheidae sp., Branched Bryozoa sp., Sponge: possibly *Suberites sp.*, Sea Pen: Pennatulacea, Gorgonian sp., Hydroid sp., Isopod: possibly *Acutiserolis neaera*, Bryozoa sp.,



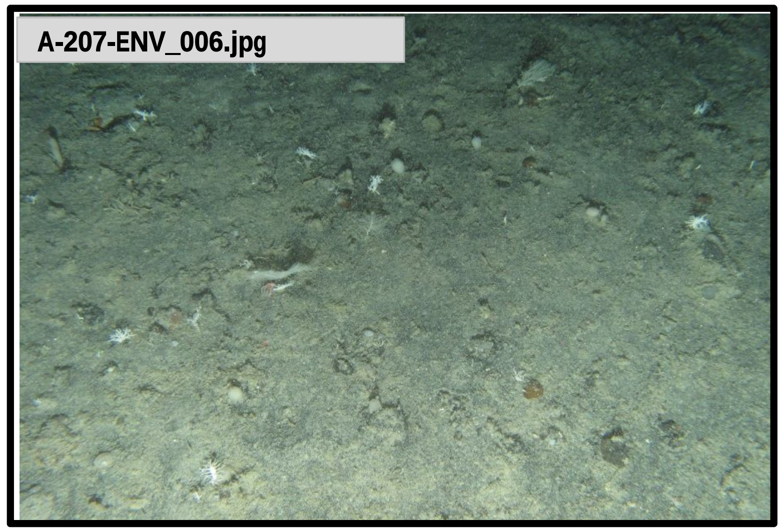


Photo Position: 786682 mE, 4209681 mN

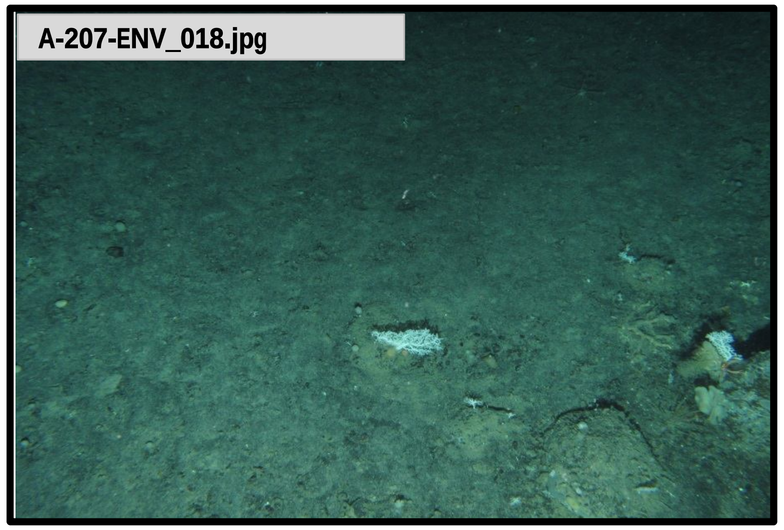


Photo Position: 786670 mE, 4209686 mN

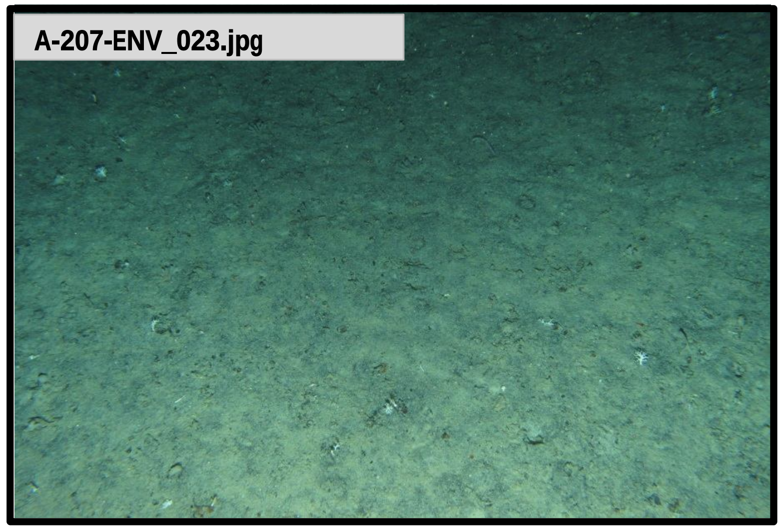


Photo Position: 786606 mE, 42097441 mN

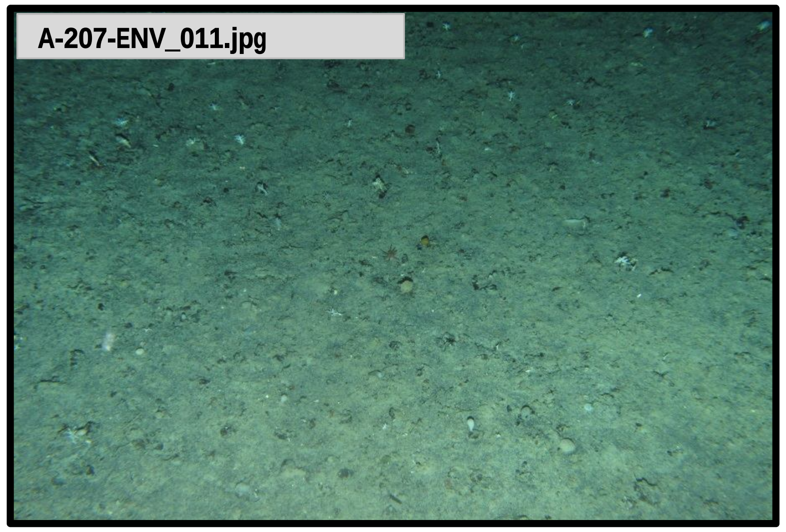


Photo Position: 786682 mE, 4209681 mN

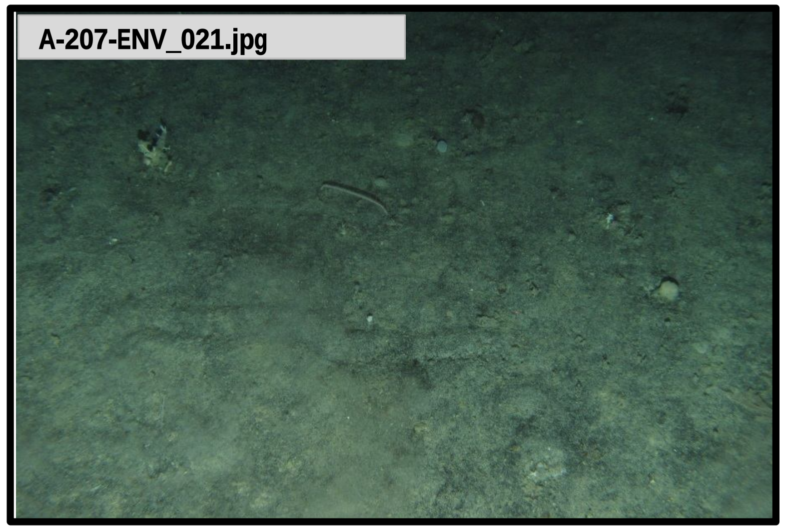


Photo Position: 786606 mE, 4209741 mN

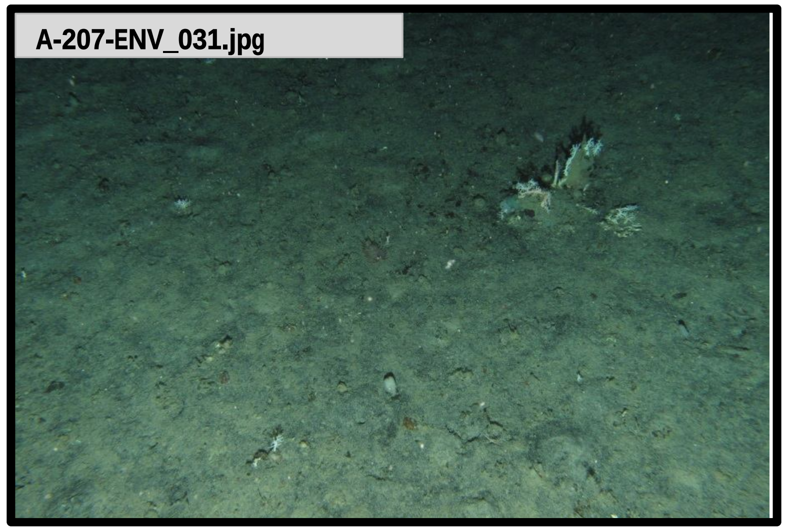


Photo Position: 786591 mE, 4209766 mN

Client noble energy

Contractor Benthic Solutions

Benthic Solutions Ltd., Marsh Road,

✕ Sample Location ○ UW Photo ● UW Photo (featured)

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

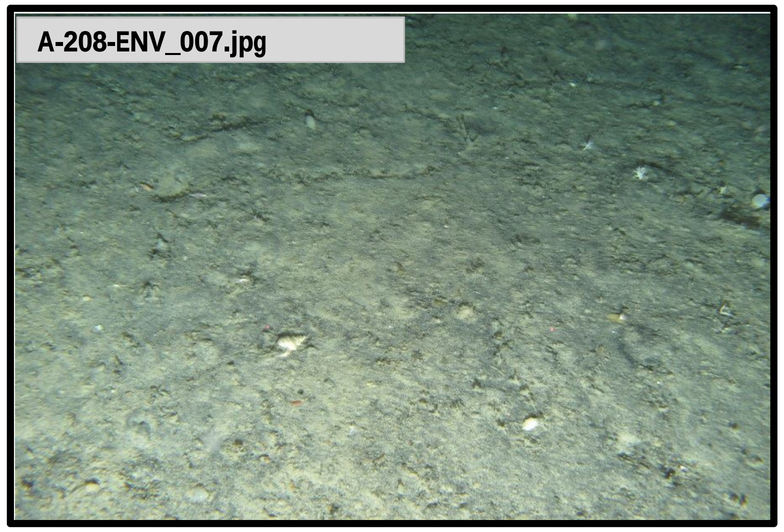


Photo Position: 773671 mE, 4228281 mN

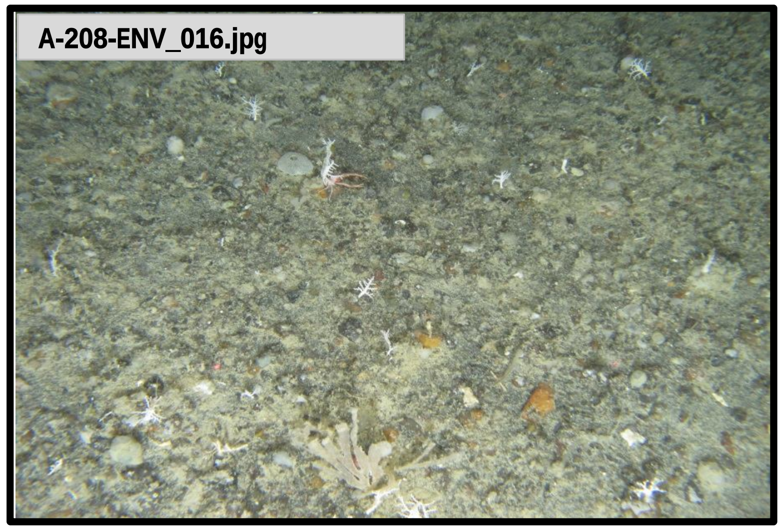


Photo Position: 773698 mE, 4228315 mN

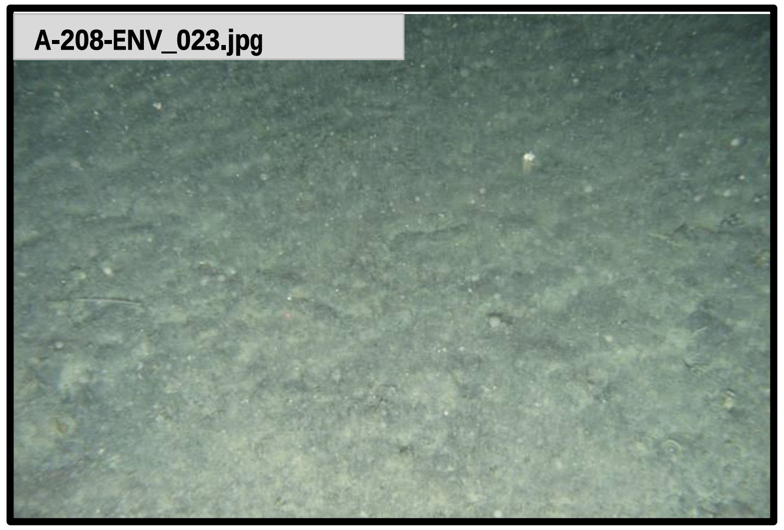


Photo Position: 773729 mE, 4228356 mN

Habitat Summary Information: A/208/ENV

Survey Area: FISA

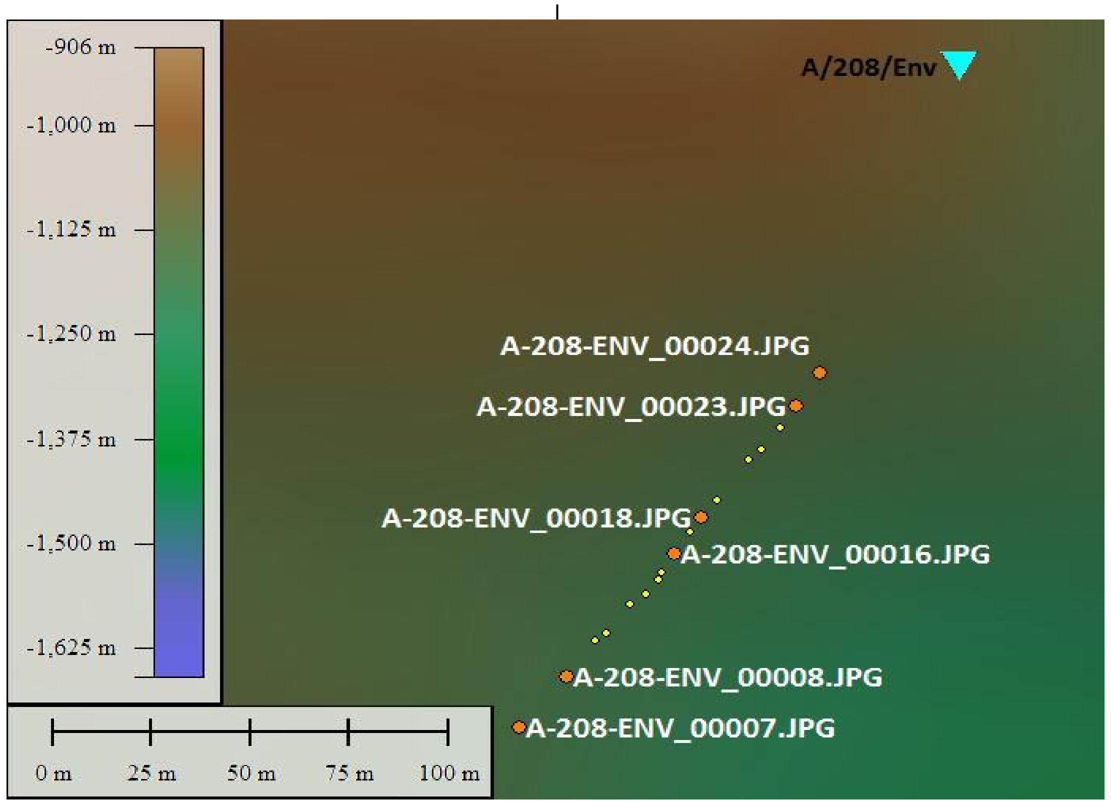
No. of Stills: 25 **Mins of Video: 40** **Track Length: 124m**

Site Selection Criteria
Geographical coverage

Analogue Interpretation
Slightly sloped seabed

Sediment Description
Homogeneous beige sand with gravel, occasional cobbles

Conspicuous Fauna
Branched Stone Coral: *Stylaster sp.* , Isopod: possibly *Acutiserolis neaera* , Sponge: Porifera sp., Holothuroidea sp., Bryozoa sp., Squat Lobster: Galatheidae sp., Starfish: Asteroidea sp., Cup Coral: *Flabellum sp.*, Sea Pen: Pennatulacea,



Client
noble energy

Contractor
Benthic Solutions
Benthic Solutions Ltd., Marsh Road,

Sample Location UW Photo UW Photo (featured)

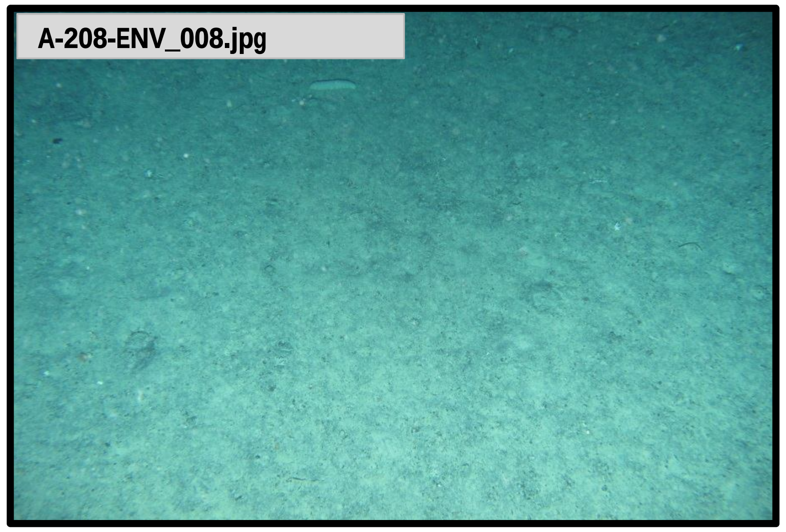


Photo Position: 773671 mE, 4228281 mN

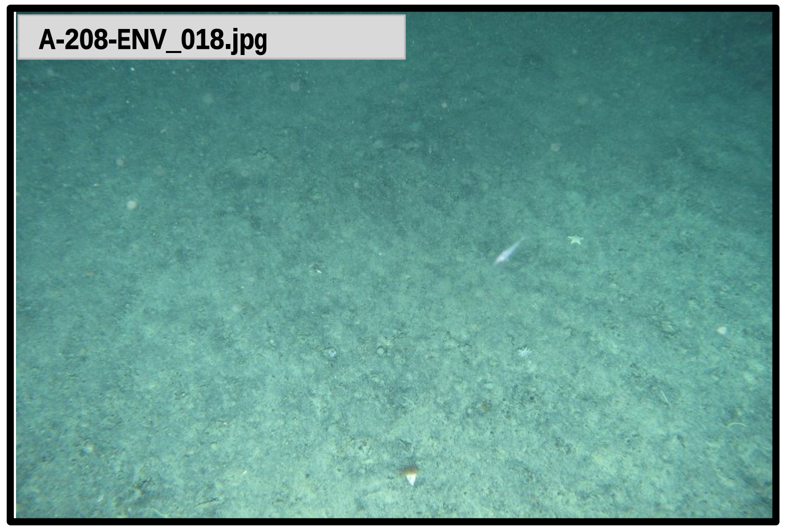


Photo Position: 773705 mE, 4228325 mN

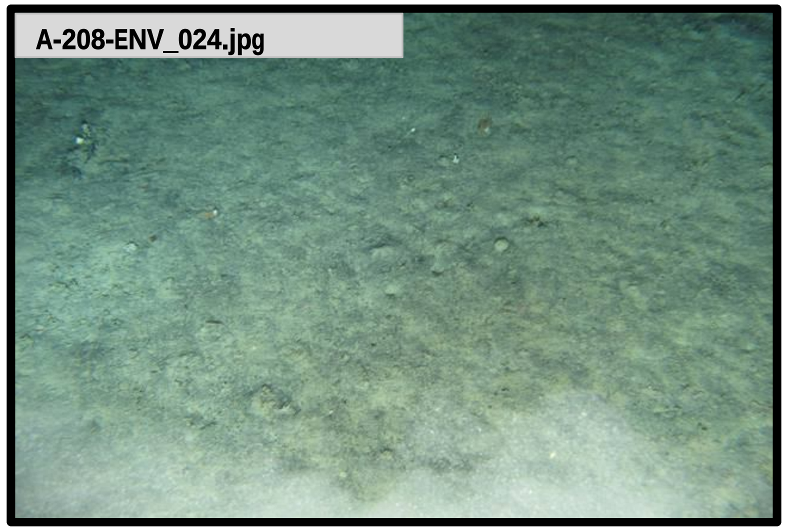


Photo Position: 773735 mE, 4228365 mN

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

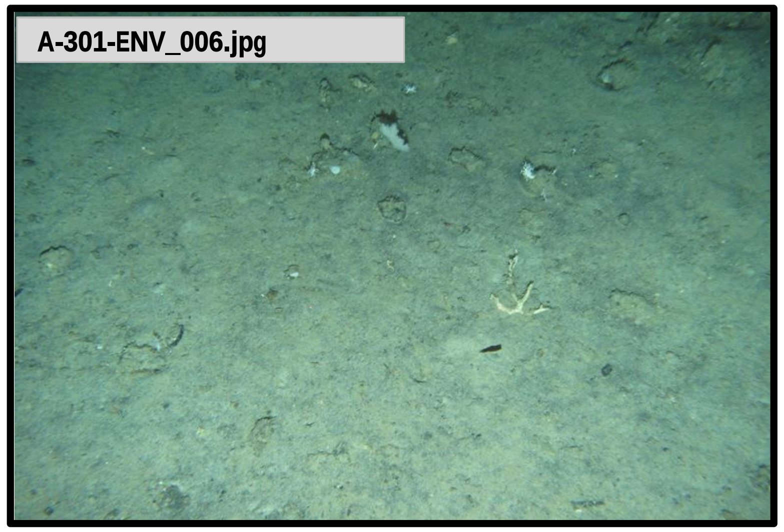


Photo Position: 790831 mE, 4215005 mN

Habitat Summary Information: A/301/ENV

Survey Area: FISA

No. of Stills: 35 **Mins of Video: 29** **Track Length: 56m**

Site Selection Criteria

Slope feature

Analogue Interpretation

Slope feature

Sediment Description

Paving slabs, homogeneous beige sand and cobbles with evidence of bioturbation

Conspicuous Fauna

Lophelia pertusa, Relic *Lophelia sp* ., Sea Pen: Pennatulacea, Cup Coral: *Flabellum sp.* , Gorgonian sp., Hydroid sp., Brittlestar (Ophiuroid), Sponge: Porifera sp., Moridae sp., Bryozoa sp., Branched Bryozoa sp., Isopod: possibly *Acutiserolis neaera,* Squat Lobster: Galatheidae sp., Encrusting Sponge, Glass Sponge: Hexactinellida sp., Gastropoda sp., Branched Stone Coral: *Stylaster sp.,*

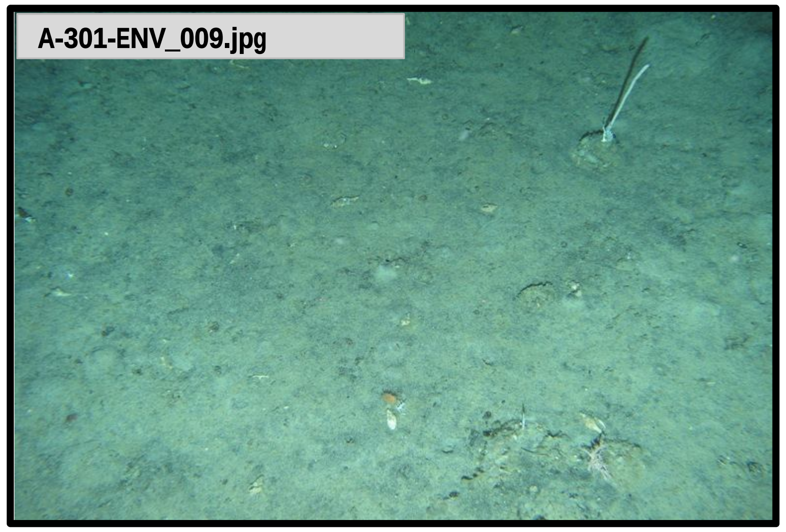


Photo Position: 790831 mE, 4215005 mN

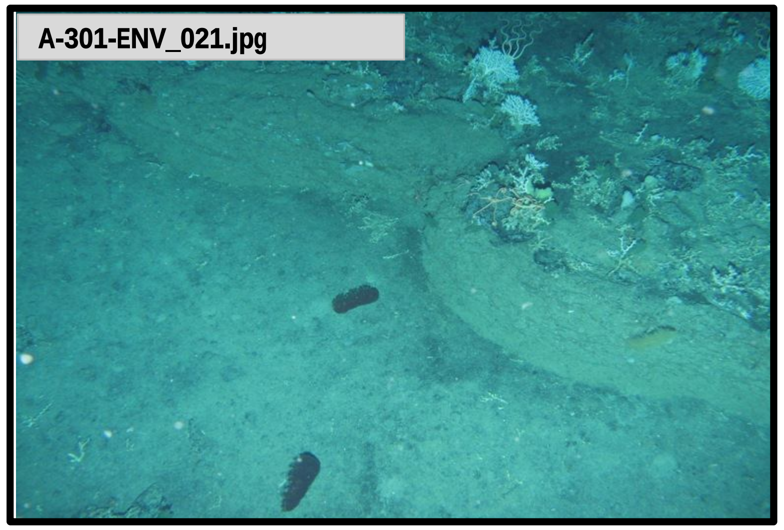
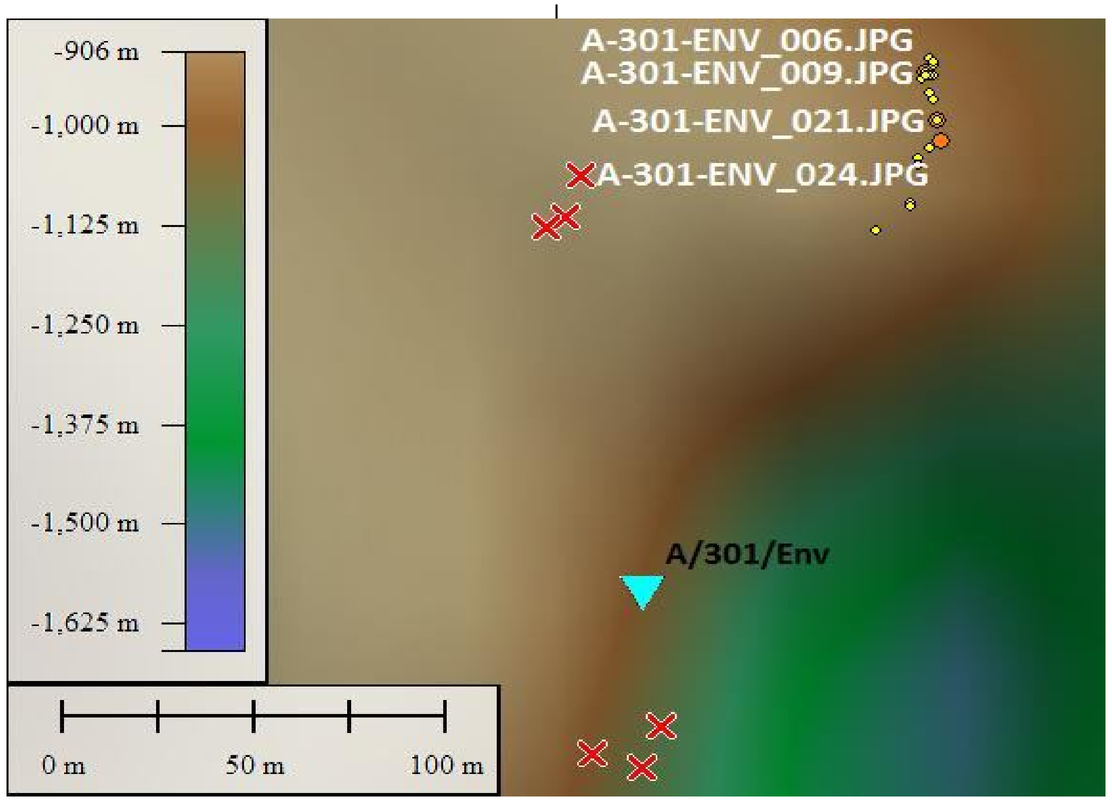


Photo Position: 790834 mE, 4214991 mN



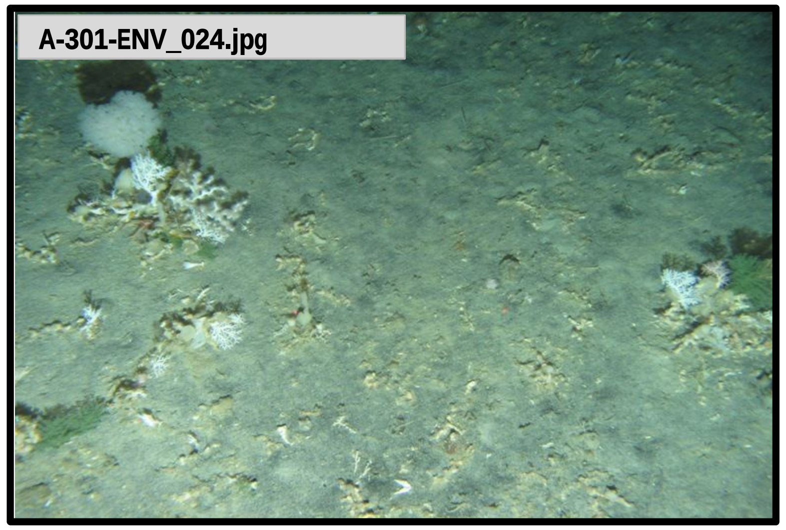


Photo Position: 790835 mE, 4214985 mN

Sediment Example Image

Client

noble energy

Contractor

Benthic Solutions

Benthic Solutions Ltd., Marsh Road,

Sieved Sample Image

Sample Location   UW Photo   UW Photo (featured)

Geodetic Infomation: Datum: WGS84   Projection: Transverse Mercator   Central Meridian: 60° West

Habitat Summary Information: A/302/ENV

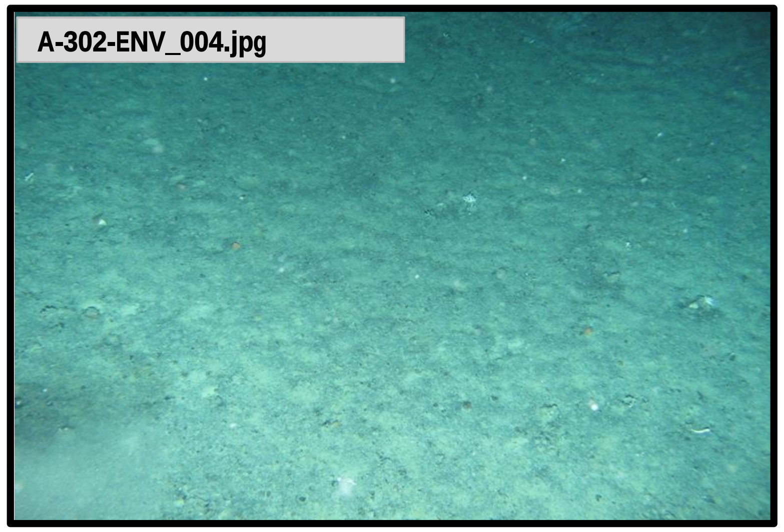


Photo Position: 804643 mE, 4210660 mN

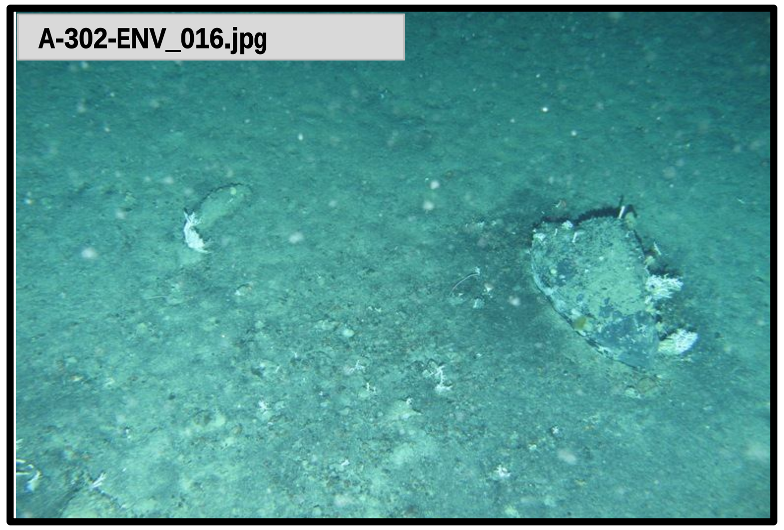


Photo Position: 804631 mE, 4210621 mN

Sediment Example Image

Survey Area: FISA

No. of Stills: 24 **Mins of Video: 22** **Track Length: 92m**

Site Selection Criteria

Regional infill station

Analogue Interpretation

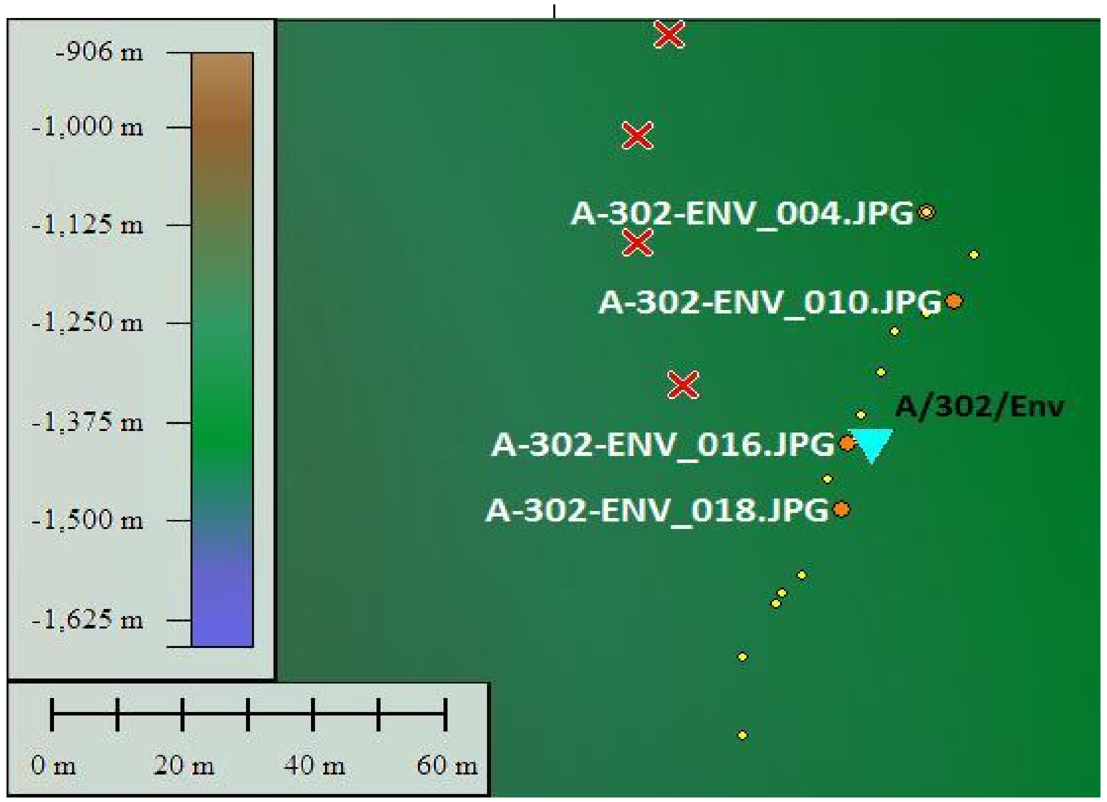
Slightly sloped seabed

Sediment Description

Beige and black sand with gravels, occasional cobbles and evidence of bioturbation

Conspicuous Fauna

Cup Coral: *Flabellum* sp., Branched Stone Coral: *Stylaster* sp., Sea Pen: Pennatulacea, Stone Crab: *Paralomis* sp., Sponge: Porifera sp., Hydroid sp., Nephropidae sp. *Thymops birsteini*, Glass Sponge: Hexactinellida sp., Bryozoa sp.,



Client

Contractor

Benthic Solutions Ltd., Marsh Road,

Sample Location UW Photo UW Photo (featured)

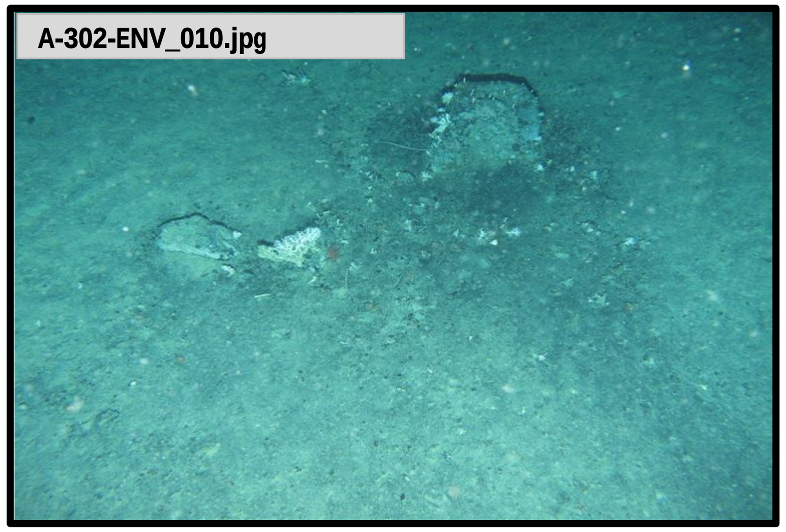


Photo Position: 804647 mE, 4210645 mN

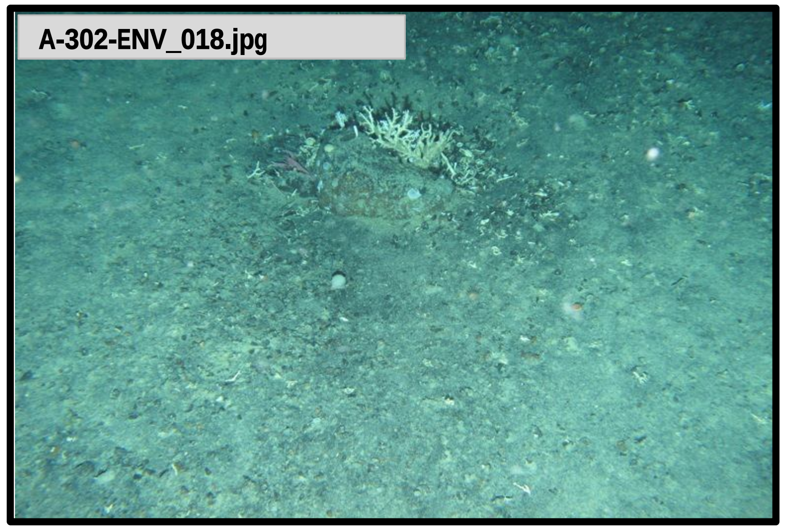


Photo Position: 804630 mE, 4210610 mN

Sieved Sample Image

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

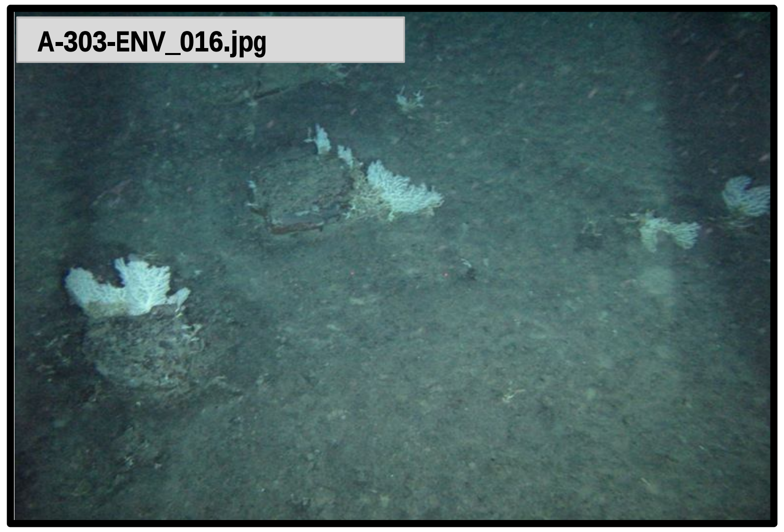


Photo Position: 796078 mE, 4211863 mN

Photo Position: 796089 mE, 4211851 mN

Sediment Example Image

Habitat Summary Information: A/303/ENV

Survey Area: FISA

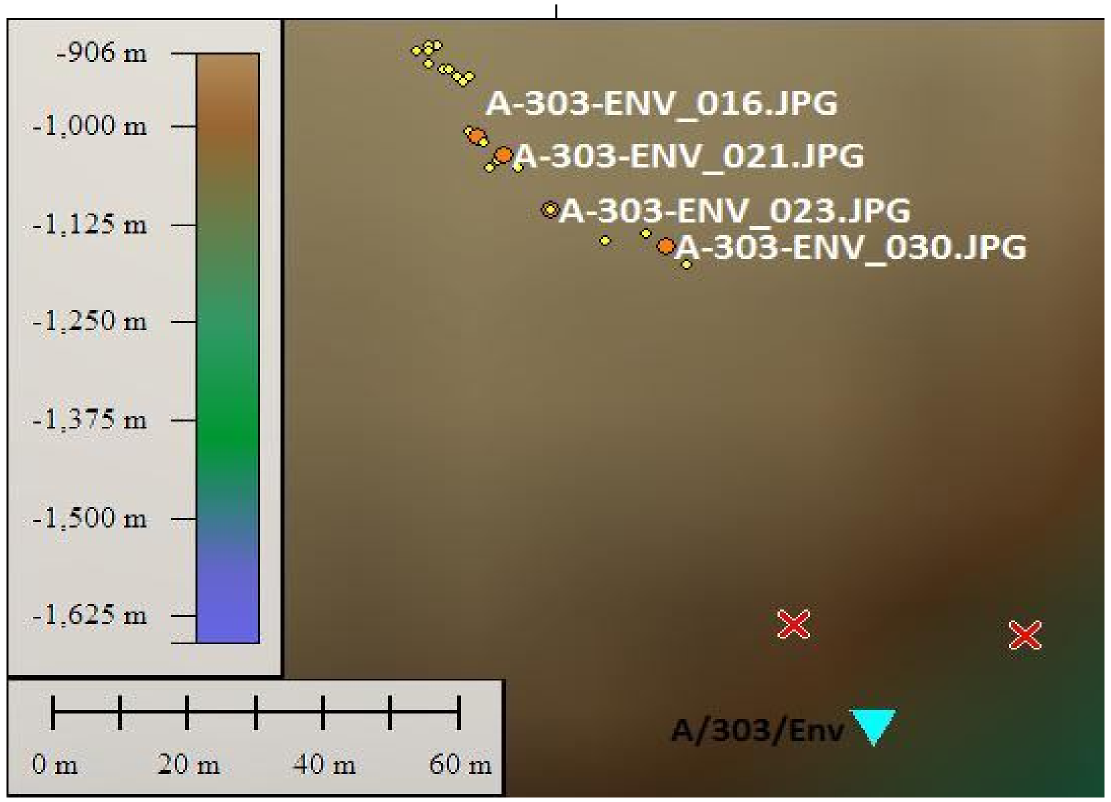
No. of Stills: 31 | **Mins of Video: 34** | **Track Length: 57m**

Site Selection Criteria
Slope feature

Analogue Interpretation
Slightly sloped seabed

Sediment Description
Darker, coarse surface layer over beige fine to medium compact sands

Conspicuous Fauna
Cup Coral: *Flabellum sp.*, Branched Stone Coral: *Stylaster sp.*, Sea Pen: Pennatulacea, Relic *Lophelia sp.* , *Lophelia pertusa*, Glass Sponge: Hexactinellida sp., Brittlestar (Ophiuroid), Sponge: possibly *Suberites sp.* , Bryozoa sp., Tube-building Polychaete, Polychaete sp., Gastropoda sp.,



Client noble energy

Contractor Benthic Solutions
Benthic Solutions Ltd., Marsh Road,

✕ Sample Location ○ UW Photo ● UW Photo (featured)

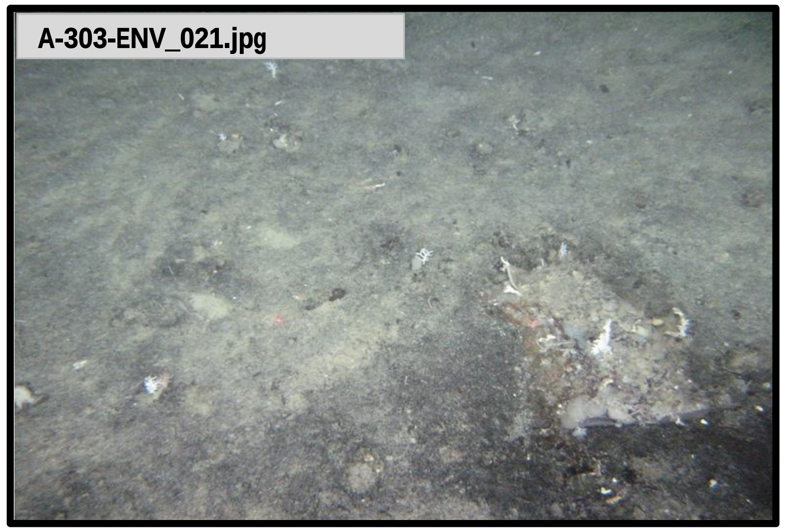


Photo Position: 796082 mE, 4211860 mN

Photo Position: 796106 mE, 4211845 mN

Sieved Sample Image

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

Habitat Summary Information: A/304/ENV

Photo Position: 783332 mE, 4221139 mN

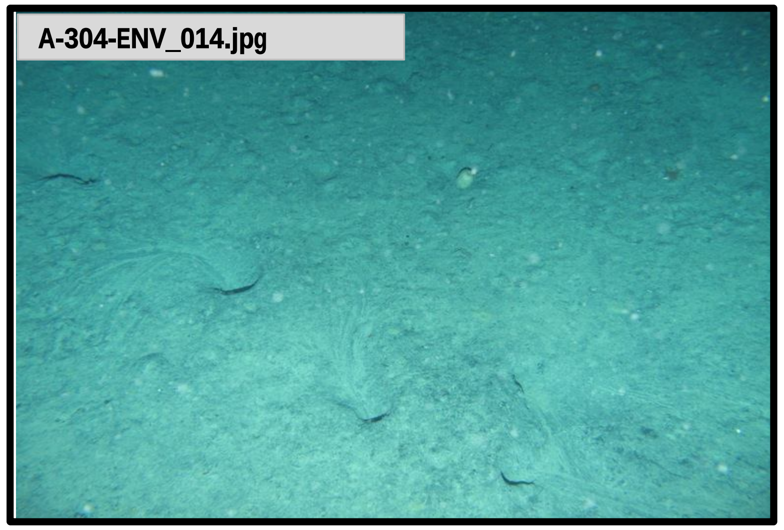


Photo Position: 783301 mE, 4221165 mN

Sediment Example Image

Survey Area: FISA

No. of Stills: 18 **Mins of Video: 21** **Track Length: 78m**

Site Selection Criteria

Regional infill station

Analogue Interpretation

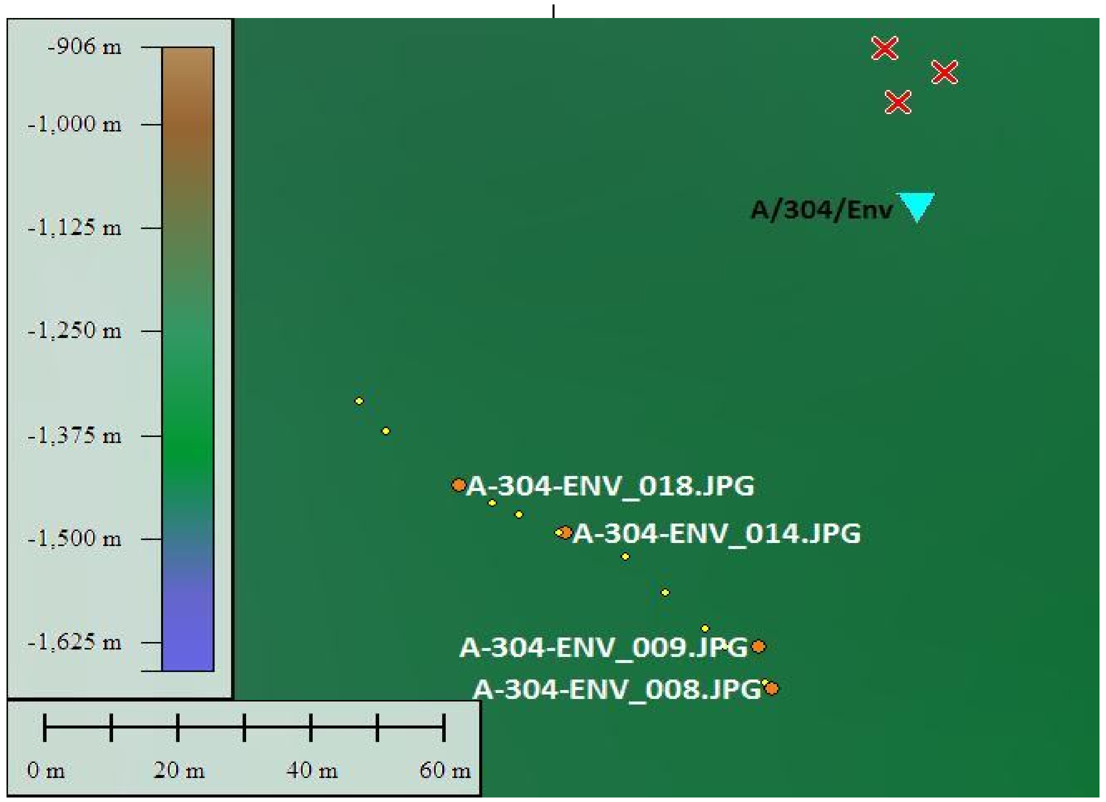
Relatively flat seabed

Sediment Description

Beige with dark flecks, fine to medium sand with occasional fine gravel

Conspicuous Fauna

Stone Crab: *Paralomis sp.*, Branched Stone Coral: *Stylaster sp.*, Sea Pen: Pennatulacea, Relic *Lophelia sp.*, *Lophelia pertusa*, Glass Sponge: Hexactinellida sp., Venus Fly-trap Anemone: *Actinoscyphia sp.*, Anemone: Actiniaria sp., Nephropidae sp. *Thymops birsteini*, Cup Coral: *Flabellum sp.*, Decapod Shrimp sp., Tube-building Polychaete, Polychaete sp., Brittlestar (Ophiuroid), Sea Spider: Pycnogonida sp., Tusk Shell: Scaphopoda sp.,



Client noble energy

Contractor Benthic Solutions

Benthic Solutions Ltd., Marsh Road,

Sample Location UW Photo UW Photo (featured)

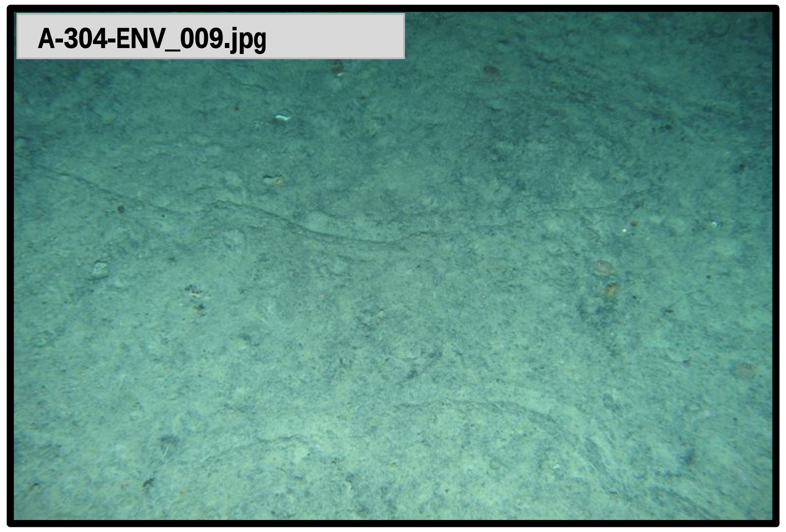


Photo Position: 783330 mE, 4221146 mN

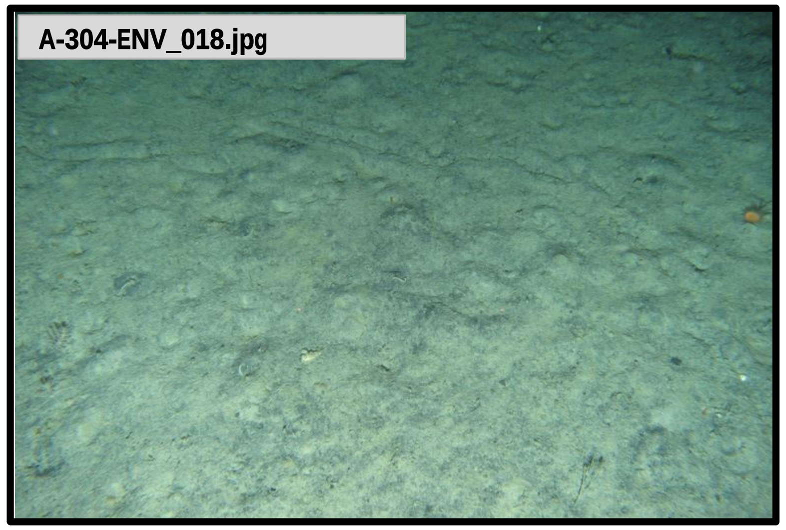


Photo Position: 783285 mE, 4221173 mN

Sieved Sample Image

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

Photo Position: 778086 mE, 4210837 mN

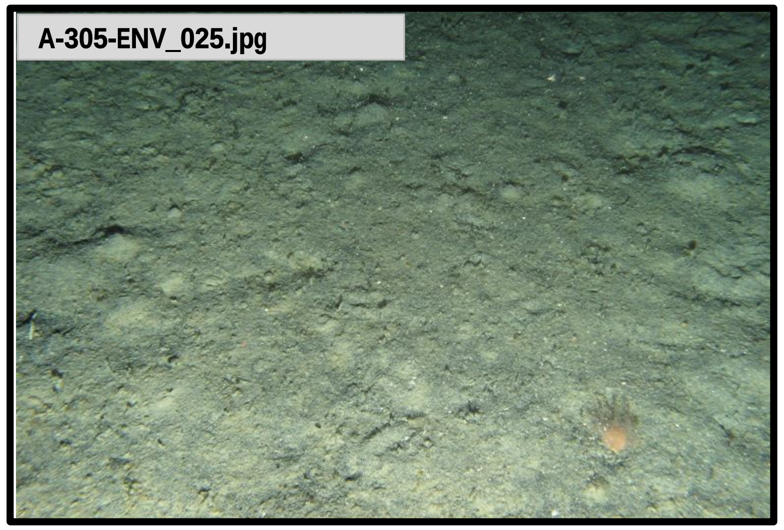


Photo Position: 777955 mE, 4210965 mN

Sediment Example Image

Habitat Summary Information: A/305/ENV

Survey Area: FISA

No. of Stills: 19 | **Mins of Video: 32** | **Track Length: 375m**

Site Selection Criteria

Regional infill station

Analogue Interpretation

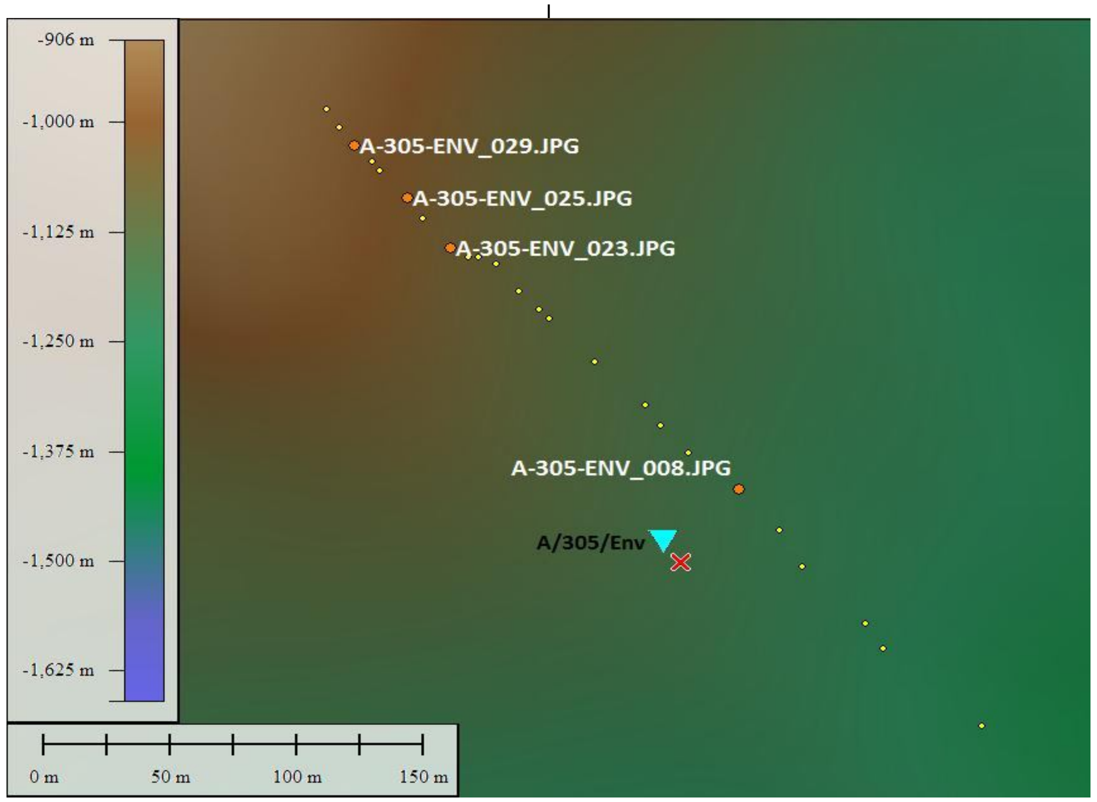
Slightly sloped seabed

Sediment Description

Darker, coarse surface layer over beige fine to medium compact sands

Conspicuous Fauna

Isopod: possibly *Acutiserolis neaera* , Cup Coral: *Flabellum sp.* , Decapod Shrimp sp., Sea Pen: Pennatulacea, Tube-building Polychaete, Polychaete sp.,



Client noble energy

Contractor Benthic Solutions

Benthic Solutions Ltd., Marsh Road,

Sample Location | UW Photo | UW Photo (featured)

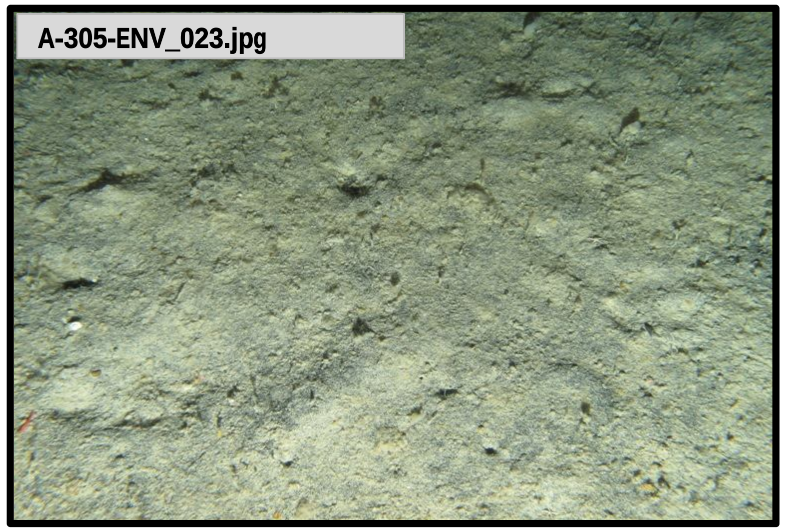


Photo Position: 777972 mE, 4210943 mN

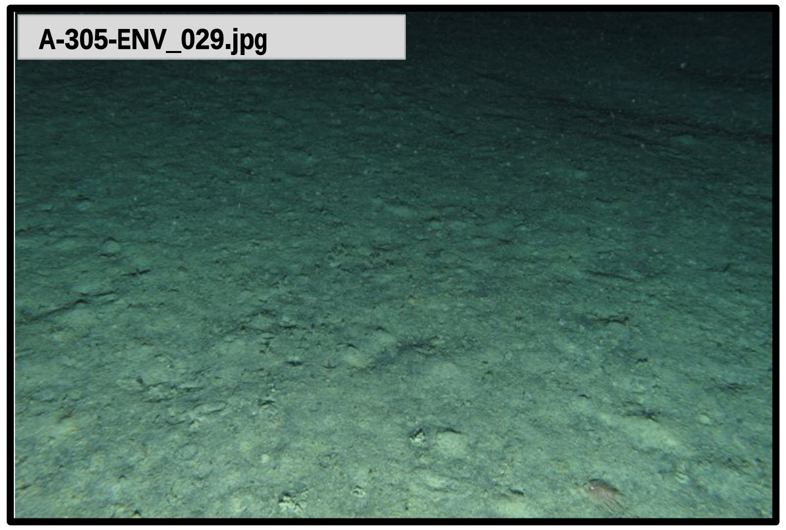


Photo Position: 777934 mE, 4210988 mN

Sieved Sample Image

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

Habitat Summary Information: A/306/ENV

Survey Area: FISA

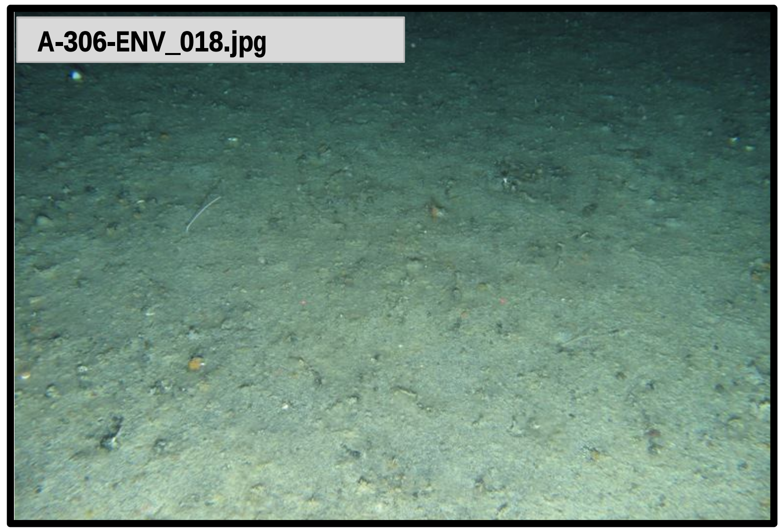
No. of Stills: 32 **Mins of Video: 33** **Track Length: 158m**

Site Selection Criteria
Trench feauture

Analogue Interpretation
Base of trench feature

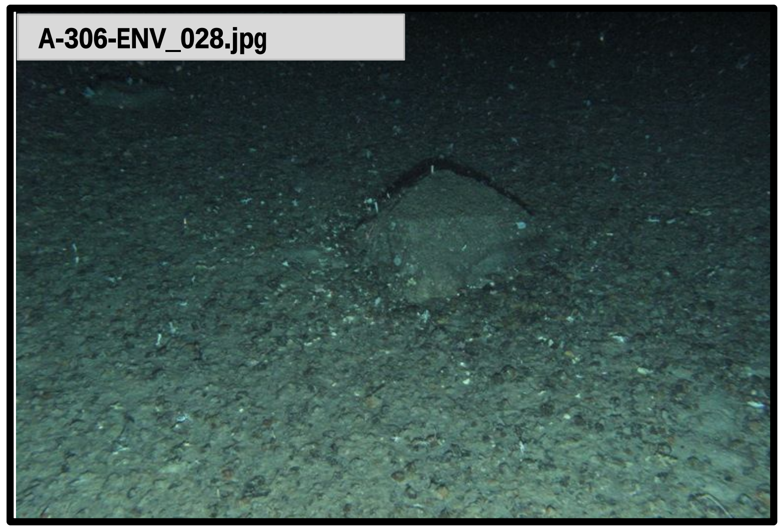
Sediment Description
Coarse pebbles and rocks suspended in clay

Conspicuous Fauna
Cup Coral: *Flabellum sp.* , Sea Pen: Pennatulacea, Hake: possibly *Merluccius hubbsi*, Sponge: Porifera sp., Tube-building Polychaete, Polychaete sp., Decapod Shrimp sp., Relic *Lophelia sp.* , Bryozoa sp., Branched Stone Coral: *Stylaster sp.* , Brittlestar (Ophiuroid),



A-306-ENV_018.jpg

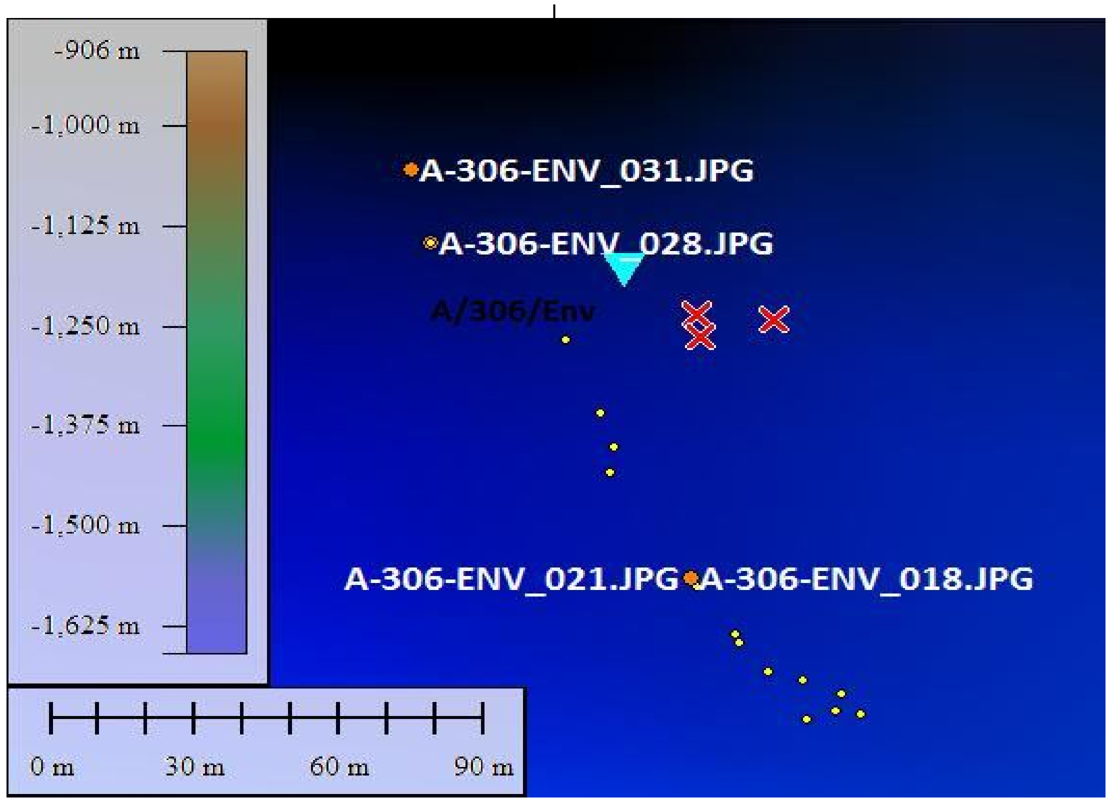
Photo Position: 796857 mE, 4206311 mN



A-306-ENV_028.jpg

Photo Position: 796803 mE, 4206390 mN

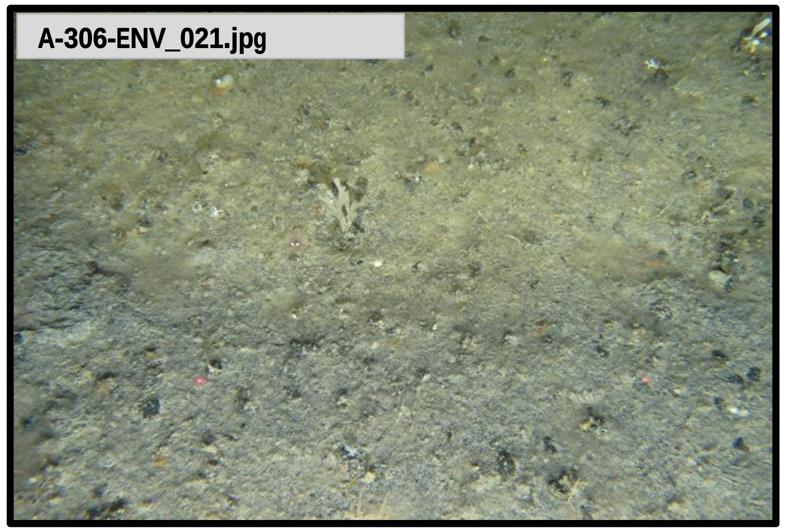
Sediment Example Image



Client noble energy

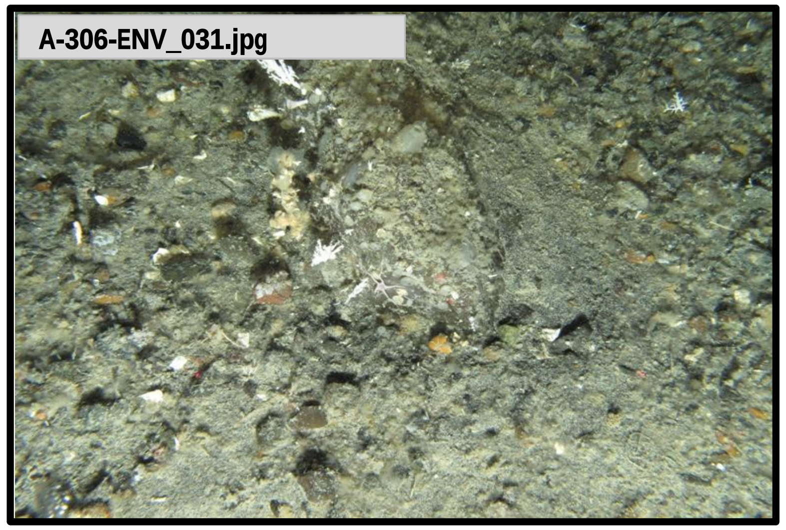
Contractor Benthic Solutions
Benthic Solutions Ltd., Marsh Road,

✕ Sample Location ● UW Photo ● UW Photo (featured)



A-306-ENV_021.jpg

Photo Position: 796857 mE, 4206311 mN



A-306-ENV_031.jpg

Photo Position: 796799 mE, 4206407 mN

Sieved Sample Image

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

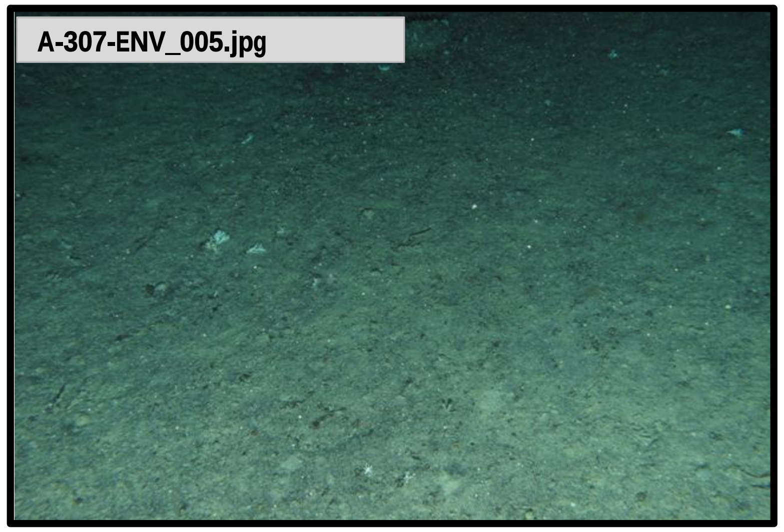


Photo Position: 793337 mE, 4188006 mN

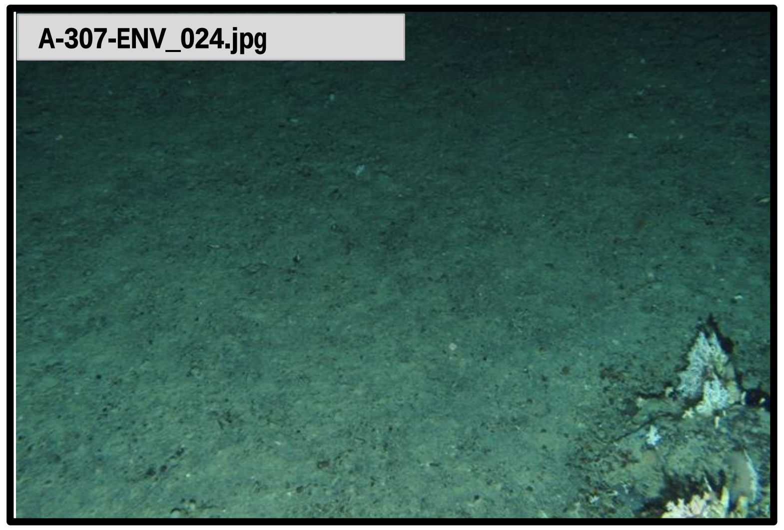


Photo Position: 793246 mE, 4188021 mN

Sediment Example Image

Habitat Summary Information: A/307/ENV

Survey Area: FISA

No. of Stills: 30 **Mins of Video: 30** **Track Length: 142m**

Site Selection Criteria

Regional infill station in deepest area

Analogue Interpretation

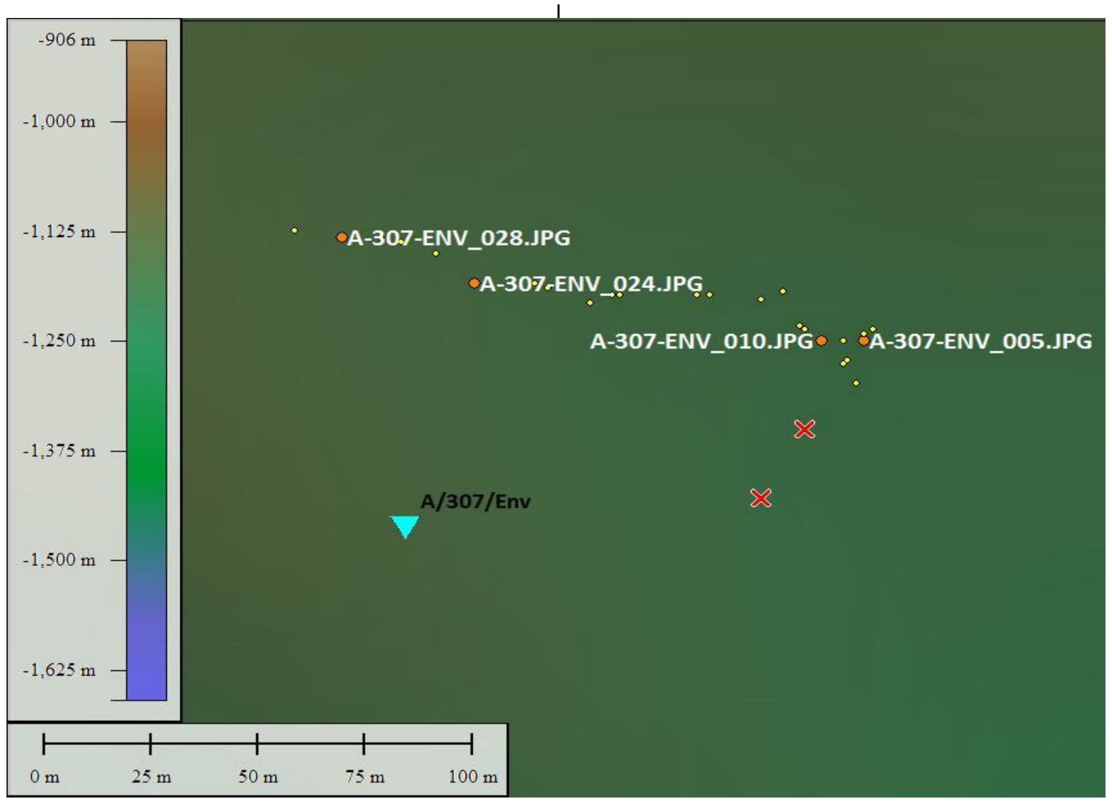
Relatively flat seabed

Sediment Description

Coarse sand, pebbles and rocks suspended in clay with evidence of bioturbation

Conspicuous Fauna

Branched Stone Coral: *Stylaster sp.* , Bryozoa sp., Sponge: Porifera sp., Cup Coral: *Flabellum sp.* , Sea Spider: Pycnogonida sp., Starfish: Asteroidea sp.,



Client

noble energy

Contractor

Benthic Solutions

Benthic Solutions Ltd., Marsh Road,

✕ Sample Location ○ UW Photo ● UW Photo (featured)

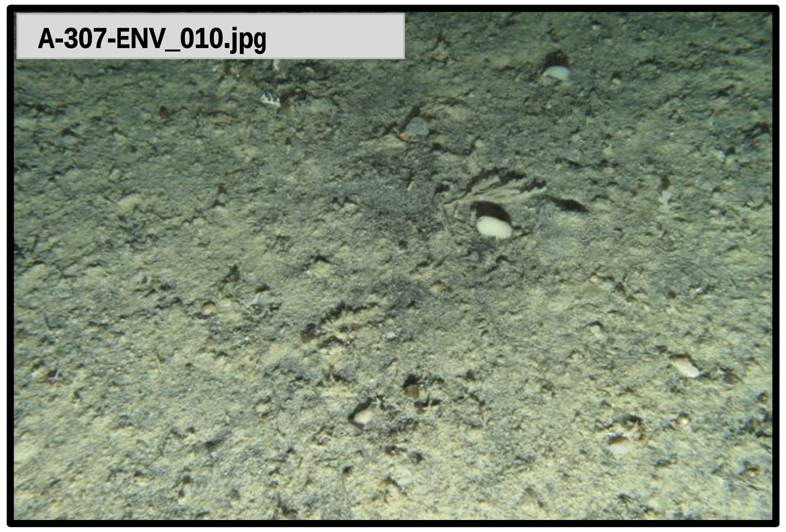


Photo Position: 793327 mE, 4188006 mN

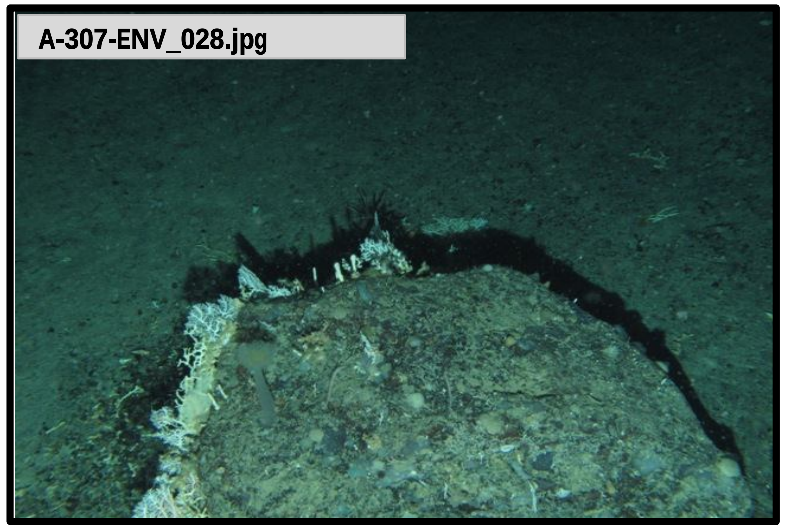


Photo Position: 793215 mE, 4188033 mN

Sieved Sample Image

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

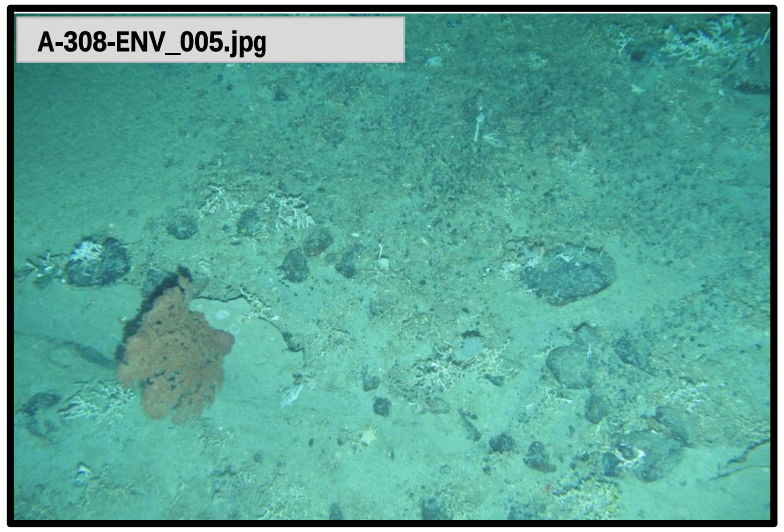


Photo Position: 784240 mE, 4192294 mN

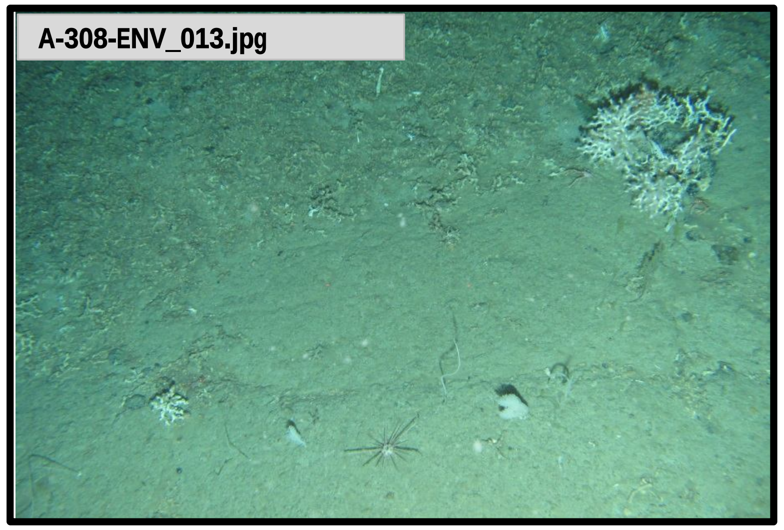


Photo Position: 784252 mE, 4192327 mN

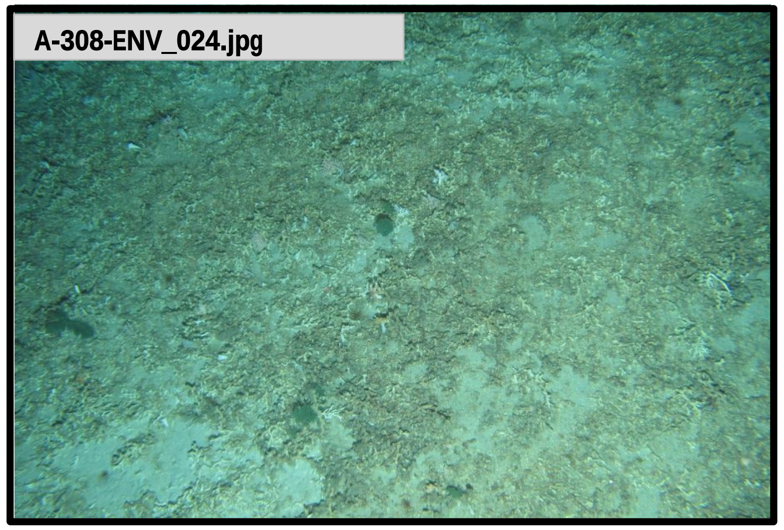


Photo Position: 784287 mE, 4192439 mN

Habitat Summary Information: A/308/ENV

Survey Area: FISA

No. of Stills: 26 **Mins of Video: 24** **Track Length: 217m**

Site Selection Criteria

Slump at base of escarpment

Analogue Interpretation

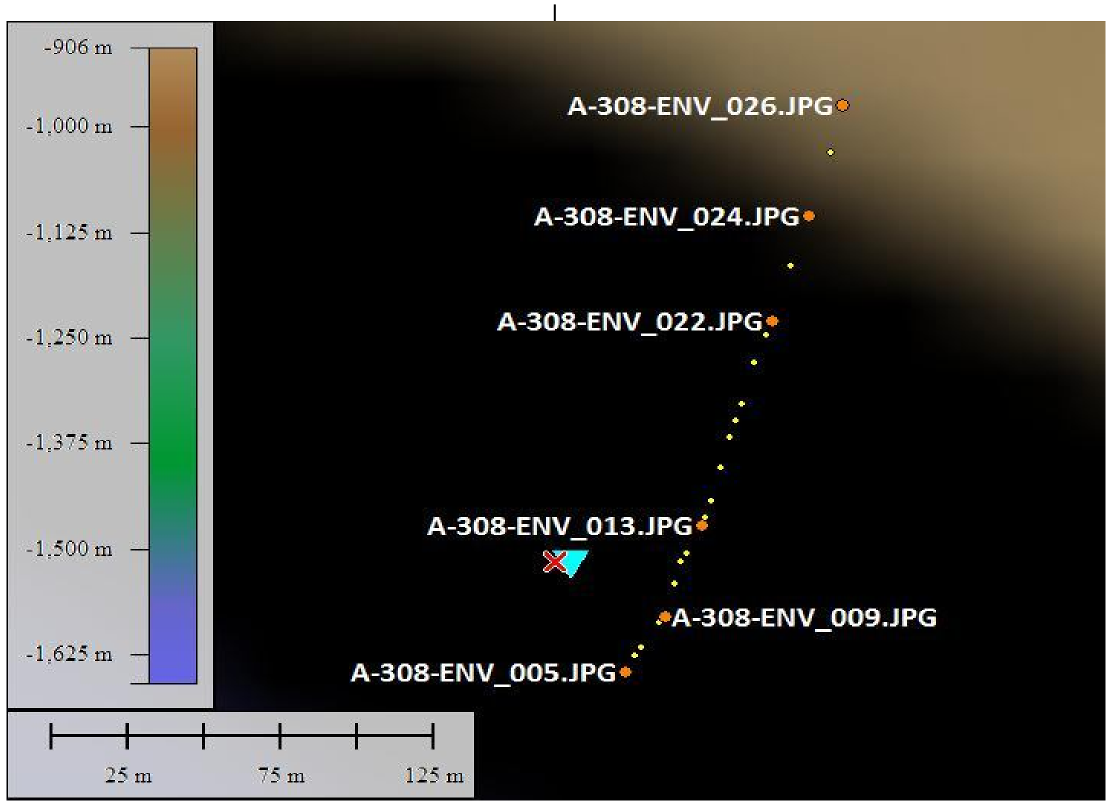
Slump feature

Sediment Description

Coarse pebbles and rocks suspended in clay

Conspicuous Fauna

Lophelia pertusa , Relic *Lophelia sp.*, Sponge: Porifera sp., Branched Stone Coral: *Stylaster sp.* , Sea Pen: Pennatulacea, Gorgonian sp., Starfish: Asteroidea sp., Hydroid sp., Glass Sponge: Hexactinellida sp., Squat Lobster: Galatheidae sp., Bryozoa sp., Decapod Shrimp sp., Sea Pen: Pennatulacea, Moridae sp., Octocoral sp., Branched Bryozoa sp., Brittlestar (Ophiuroid),



Client noble energy

Contractor Benthic Solutions

Benthic Solutions Ltd., Marsh Road,

Sample Location UW Photo UW Photo (featured)

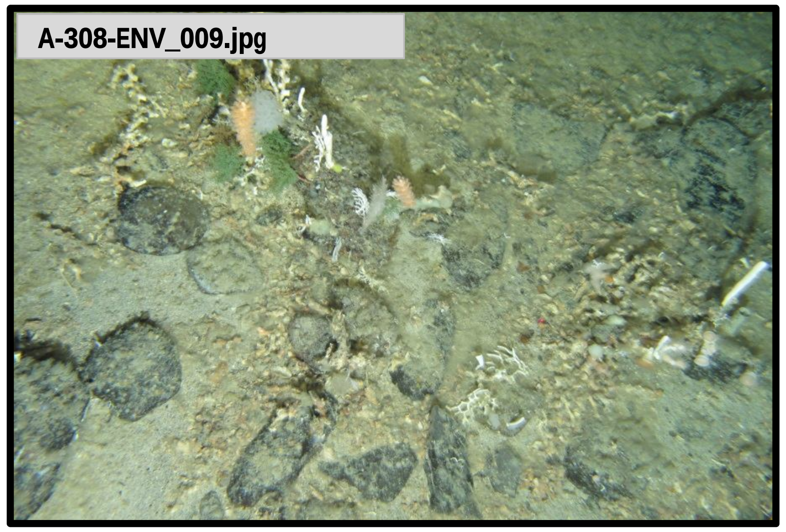


Photo Position: 784240 mE, 4192294 mN

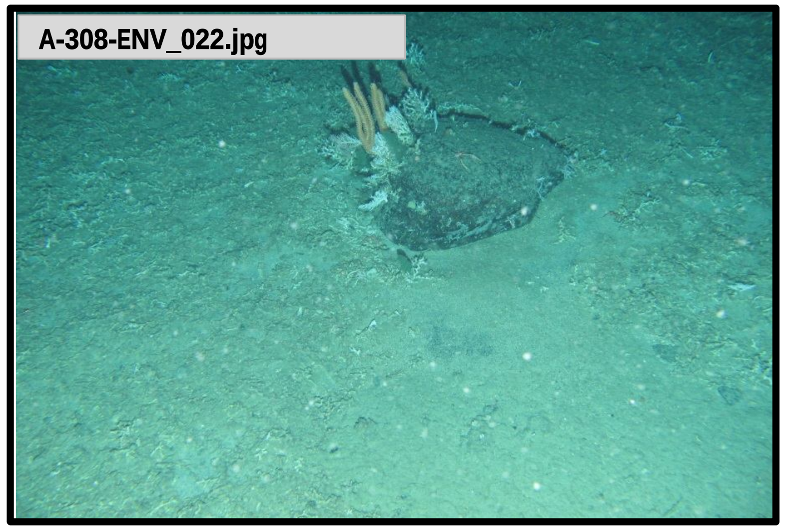


Photo Position: 784275 mE, 4192401 mN

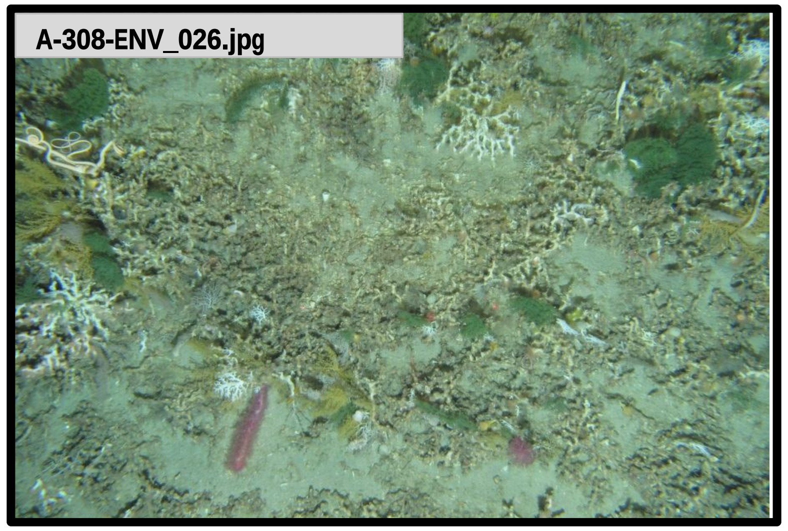


Photo Position: 784298 mE, 4192479 mN

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

Habitat Summary Information: A/309/ENV

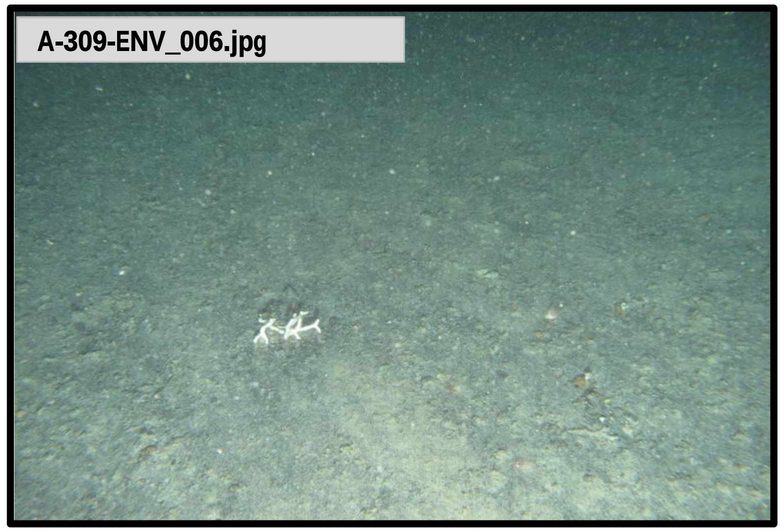


Photo Position: 791040 mE, 4193466 mN

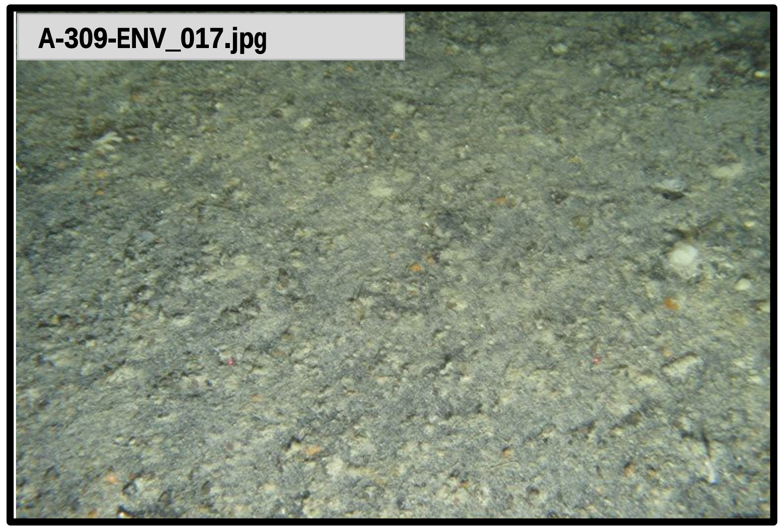


Photo Position: 790980 mE, 4193578 mN


Sediment Example Image

Survey Area: FISA

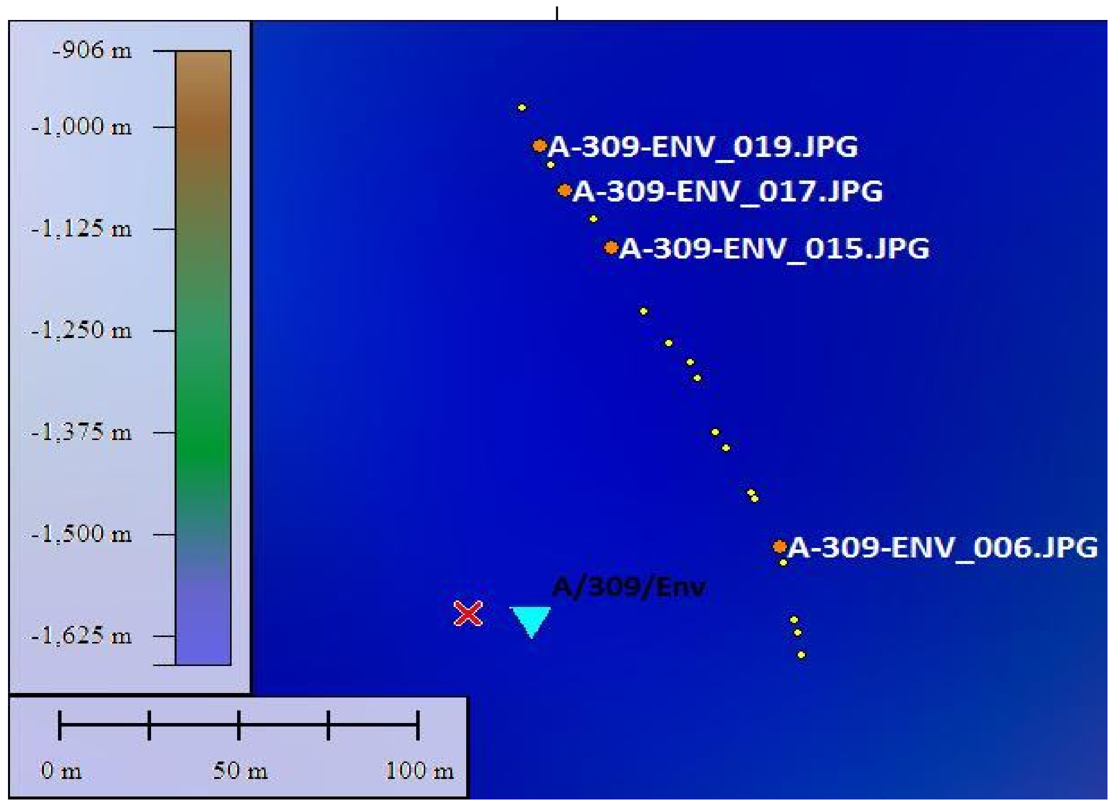
No. of Stills: 20 | Mins of Video: 27 | Track Length: 189m

Site Selection Criteria
Base of trench feature

Analogue Interpretation
Base of trench feature

Sediment Description
Dark compact medium sand

Conspicuous Fauna
Cup Coral: *Flabellum sp.*, Bryozoa sp., Sponge: Porifera sp., Branched Stone Coral: *Stylaster sp.* , Isopod: possibly *Acutiserolis neaera*, Sea Pen: Pennatulacea,



Client noble energy

Contractor Benthic Solutions
Benthic Solutions Ltd., Marsh Road,

✗ Sample Location | ○ UW Photo | ● UW Photo (featured)

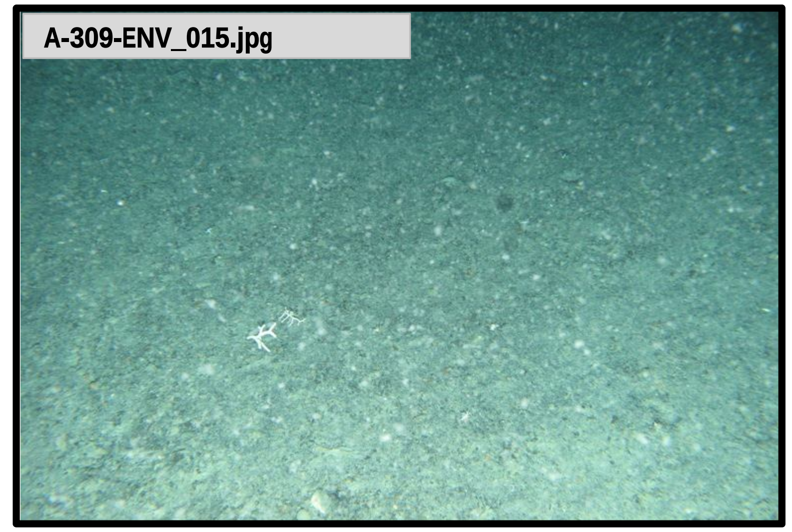


Photo Position: 790993 mE, 4193560 mN

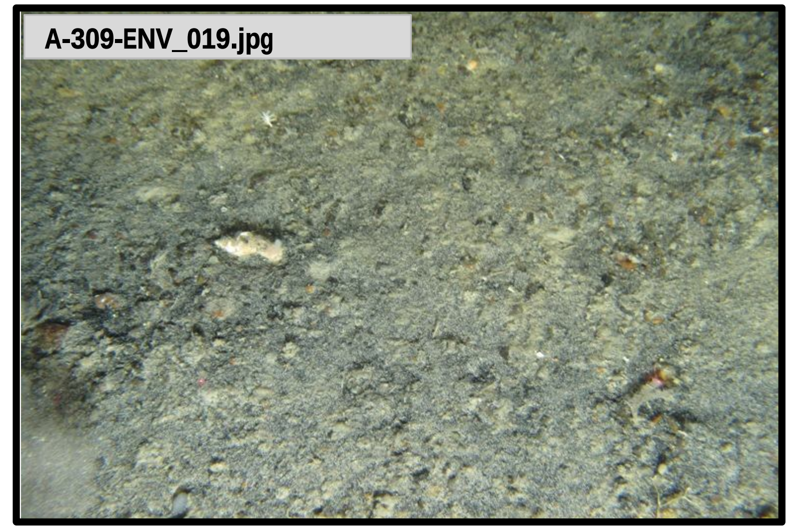


Photo Position: 790973 mE, 4193592 mN


Sieved Sample Image

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

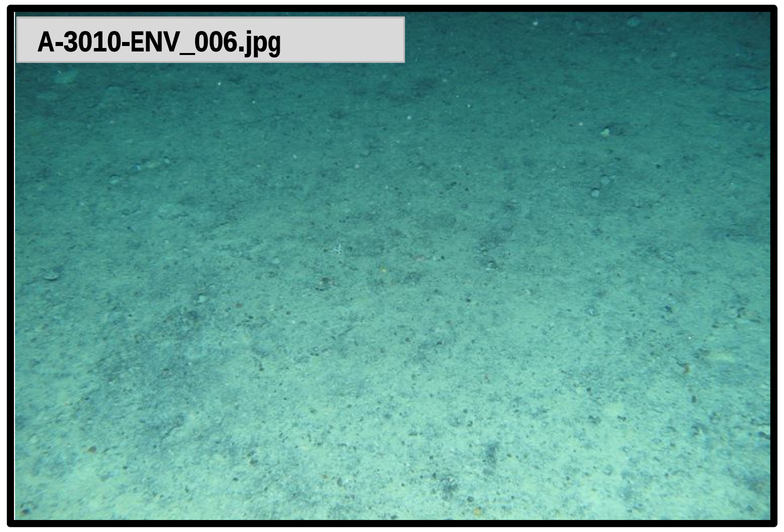


Photo Position: 791040 mE, 4193466 mN

Habitat Summary Information: A/3010/ENV

Survey Area: FISA

No. of Stills: 20 **Mins of Video: 27** **Track Length: 432m**

Site Selection Criteria

Repeat sample from 2011 survey ()8666.1 FOGL Vinson West EBS)

Analogue Interpretation

Undulating seabed

Sediment Description

Olive grey fine to medium sand with fine gravel and a dark surface layer

Conspicuous Fauna

Isopod: possibly *Acutiserolis neaera*, Branched Stone Coral: *Stylaster sp.*, Cup Coral: *Flabellum sp.*, Sponge: Porifera sp., Sea Pen: Pennatulacea,

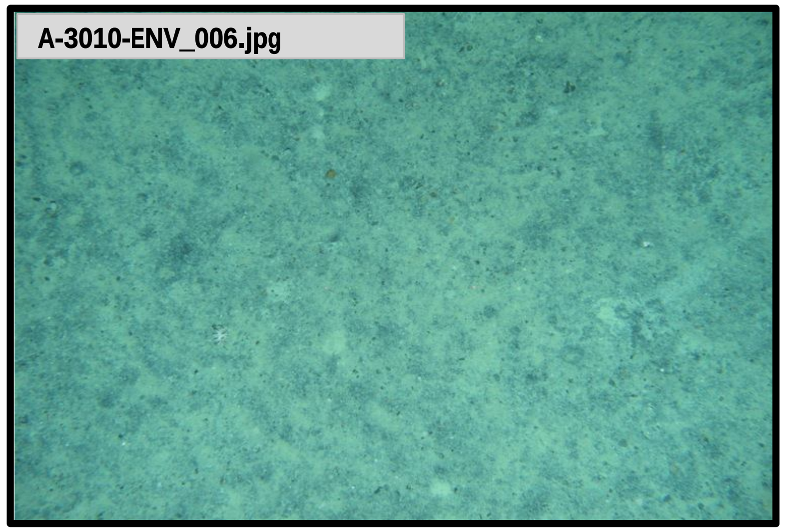


Photo Position: 790993 mE, 4193560 mN

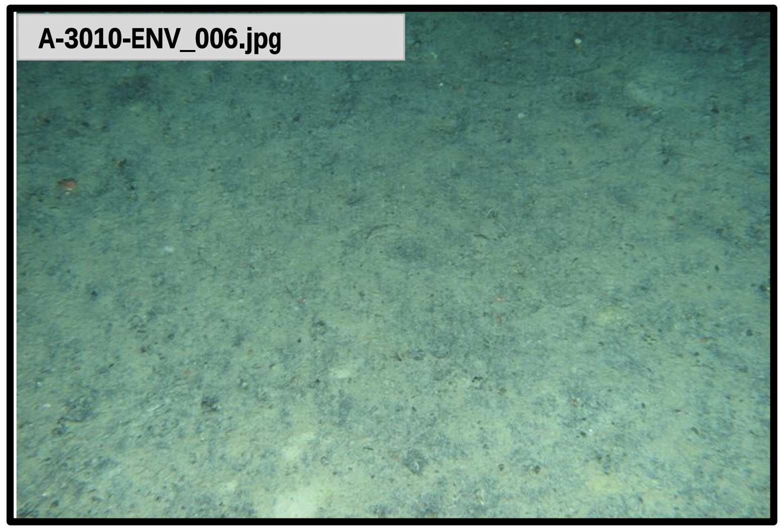
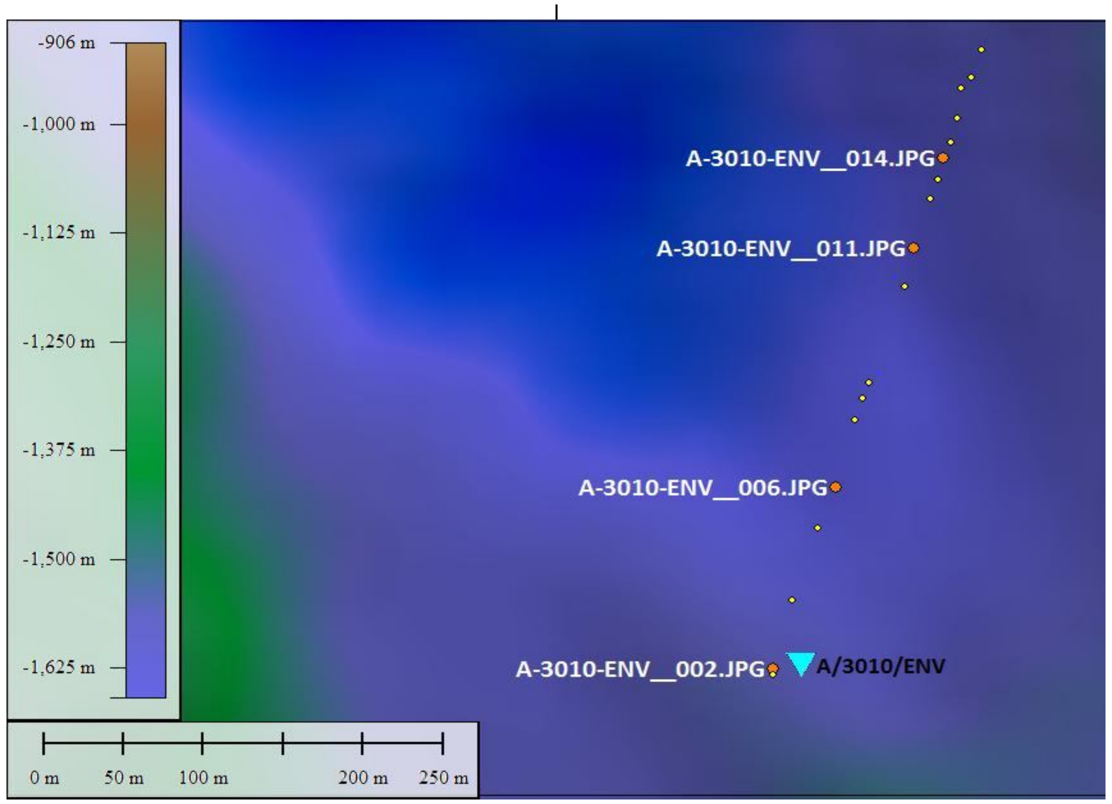


Photo Position: 790980 mE, 4193578 mN



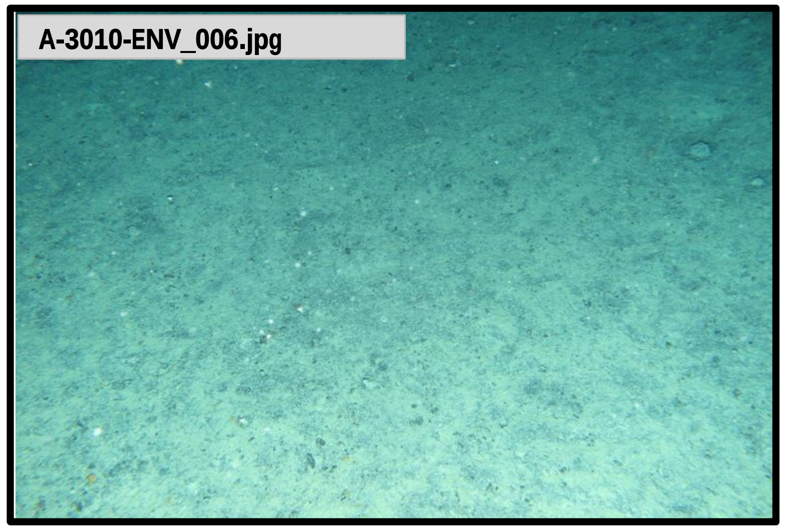


Photo Position: 790973 mE, 4193592 mN

Sediment Example Image

Client noble energy

Contractor Benthic Solutions

Benthic Solutions Ltd., Marsh Road,

Sieved Sample Image

Sample Location   UW Photo   UW Photo (featured)

Geodetic Infomation: Datum: WGS84 Projection: Transverse Mercator Central Meridian: 60° West

APPENDIX IX - SEABED PHOTOGRAPHIC POSITIONS

*Due to hardware limitations (beacon type and behaviour), navigation accuracy varied between sites. The accuracy has been given a rating of 1 to 10. 10 is considered good (under 30seconds between photo being taken and nearest beacon communication), and 0 is considered very bad (no communication with the beacon at all). A rating of 5 would mean around 15 minutes delay of beacon position, so accuracy would be ~100m in this case. Although not ideal – given the scale of the area being covered this inaccuracy is manageable.

Site	Location	Pic Filename	Time	Date	Easting	Northing	Position rating
FISA	A/03/ENV	A-03-ENV//002.JPG	12:15:53	02/02/2014	736983	4188568	10
FISA	A/03/ENV	A-03-ENV//003.JPG	12:17:38	02/02/2014	737011	4188539	10
FISA	A/03/ENV	A-03-ENV//004.JPG	12:19:03	02/02/2014	736997	4188592	10
FISA	A/03/ENV	A-03-ENV//005.JPG	12:22:04	02/02/2014	736999	4188638	10
FISA	A/03/ENV	A-03-ENV//006.JPG	12:27:15	02/02/2014	737023	4188626	10
FISA	A/03/ENV	A-03-ENV//007.JPG	12:28:11	02/02/2014	736960	4188761	10
FISA	A/03/ENV	A-03-ENV//008.JPG	12:29:48	02/02/2014	737024	4188675	10
FISA	A/03/ENV	A-03-ENV//009.JPG	12:31:45	02/02/2014	737007	4188758	10
FISA	A/03/ENV	A-03-ENV//010.JPG	12:32:26	02/02/2014	737005	4188771	10
FISA	A/03/ENV	A-03-ENV//011.JPG	12:36:07	02/02/2014	736967	4188873	10
FISA	A/03/ENV	A-03-ENV//012.JPG	12:37:28	02/02/2014	736998	4188865	10
FISA	A/03/ENV	A-03-ENV//013.JPG	12:38:13	02/02/2014	736677	4188807	10
FISA	A/03/ENV	A-03-ENV//014.JPG	12:39:13	02/02/2014	737018	4188879	10
FISA	A/03/ENV	A-03-ENV//015.JPG	12:40:50	02/02/2014	737030	4188872	10
FISA	A/03/ENV	A-03-ENV//016.JPG	12:41:46	02/02/2014	737012	4188931	10
FISA	A/03/ENV	A-03-ENV//017.JPG	12:42:23	02/02/2014	737018	4188932	10
FISA	A/03/ENV	A-03-ENV//018.JPG	12:43:43	02/02/2014	737020	4188964	10
FISA	A/03/ENV	A-03-ENV//019.JPG	12:45:08	02/02/2014	737020	4188995	10
FISA	A/03/ENV	A-03-ENV//020.JPG	12:46:49	02/02/2014	737003	4189047	10
FISA	A/03/ENV	A-03-ENV//021.JPG	12:48:22	02/02/2014	737031	4189034	10
FISA	A/03/ENV	A-03-ENV//022.JPG	12:49:34	02/02/2014	737019	4189084	10
FISA	A/03/ENV	A-03-ENV//023.JPG	12:50:51	02/02/2014	737009	4189125	10
FISA	A/03/ENV	A-03-ENV//024.JPG	12:52:20	02/02/2014	737022	4189140	10
FISA	A/03/ENV	A-03-ENV//025.JPG	12:53:24	02/02/2014	737026	4189151	10
FISA	A/03/ENV	A-03-ENV//026.JPG	12:54:45	02/02/2014	737018	4189208	10
FISA	A/09/ENV	A-09-ENV/00002.JPG	00:54:20	01/01/2014	774026	4201278	10
FISA	A/09/ENV	A-09-ENV/00003.JPG	00:55:29	01/01/2014	774025	4201276	10
FISA	A/09/ENV	A-09-ENV/00004.JPG	00:57:18	01/01/2014	774027	4201279	10
FISA	A/09/ENV	A-09-ENV/00005.JPG	00:57:51	01/01/2014	774028	4201280	10
FISA	A/09/ENV	A-09-ENV/00006.JPG	00:58:40	01/01/2014	774028	4201281	10
FISA	A/09/ENV	A-09-ENV/00007.JPG	00:59:04	01/01/2014	774028	4201281	10
FISA	A/09/ENV	A-09-ENV/00008.JPG	00:59:59	01/01/2014	774027	4201284	10
FISA	A/09/ENV	A-09-ENV/00009.JPG	01:03:27	01/01/2014	774025	4201300	10
FISA	A/09/ENV	A-09-ENV/00010.JPG	01:05:07	01/01/2014	774025	4201302	10
FISA	A/09/ENV	A-09-ENV/00011.JPG	01:05:10	01/01/2014	774025	4201302	10
FISA	A/09/ENV	A-09-ENV/00012.JPG	01:05:43	01/01/2014	774025	4201304	10
FISA	A/09/ENV	A-09-ENV/00013.JPG	01:07:02	01/01/2014	774027	4201313	10
FISA	A/09/ENV	A-09-ENV/00014.JPG	01:07:38	01/01/2014	774028	4201317	10
FISA	A/09/ENV	A-09-ENV/00015.JPG	01:07:51	01/01/2014	774028	4201318	10
FISA	A/09/ENV	A-09-ENV/00016.JPG	01:08:21	01/01/2014	774028	4201322	10
FISA	A/09/ENV	A-09-ENV/00017.JPG	01:09:03	01/01/2014	774030	4201325	10
FISA	A/09/ENV	A-09-ENV/00018.JPG	01:09:49	01/01/2014	774032	4201330	10
FISA	A/09/ENV	A-09-ENV/00019.JPG	01:10:49	01/01/2014	774035	4201337	10
FISA	A/09/ENV	A-09-ENV/00020.JPG	01:11:37	01/01/2014	774035	4201343	10
FISA	A/09/ENV	A-09-ENV/00021.JPG	01:13:14	01/01/2014	774038	4201361	10
FISA	A/09/ENV	A-09-ENV/00022.JPG	01:14:54	01/01/2014	774039	4201367	10
FISA	A/09/ENV	A-09-ENV/00023.JPG	01:15:00	01/01/2014	774039	4201368	10
FISA	A/09/ENV	A-09-ENV/00024.JPG	01:15:43	01/01/2014	774040	4201374	10
FISA	A/09/ENV	A-09-ENV/00025.JPG	01:16:01	01/01/2014	774042	4201377	10
FISA	A/09/ENV	A-09-ENV/00026.JPG	01:18:11	01/01/2014	774044	4201394	10
FISA	A/1008/ENV	A-1008-ENV/002.JPG	03:42:37	13/01/2014	784320	4202061	10
FISA	A/1008/ENV	A-1008-ENV/003.JPG	03:43:41	13/01/2014	784321	4202062	10

Site	Location	Pic Filename	Time	Date	Easting	Northing	Position rating
FISA	A/1008/ENV	A-1008-ENV/004.JPG	03:44:46	13/01/2014	784322	4202064	10
FISA	A/1008/ENV	A-1008-ENV/005.JPG	03:46:07	13/01/2014	784324	4202064	10
FISA	A/1008/ENV	A-1008-ENV/006.JPG	03:46:39	13/01/2014	784325	4202063	10
FISA	A/1008/ENV	A-1008-ENV/007.JPG	03:47:03	13/01/2014	784325	4202063	10
FISA	A/1008/ENV	A-1008-ENV/008.JPG	03:47:47	13/01/2014	784325	4202062	10
FISA	A/1008/ENV	A-1008-ENV/009.JPG	03:48:20	13/01/2014	784325	4202061	10
FISA	A/1008/ENV	A-1008-ENV/010.JPG	03:50:49	13/01/2014	784327	4202048	10
FISA	A/1008/ENV	A-1008-ENV/011.JPG	03:51:13	13/01/2014	784327	4202049	10
FISA	A/1008/ENV	A-1008-ENV/012.JPG	03:51:45	13/01/2014	784327	4202049	10
FISA	A/1008/ENV	A-1008-ENV/013.JPG	03:52:26	13/01/2014	784327	4202046	10
FISA	A/1008/ENV	A-1008-ENV/014.JPG	03:52:54	13/01/2014	784327	4202043	10
FISA	A/1008/ENV	A-1008-ENV/015.JPG	03:54:31	13/01/2014	784326	4202037	10
FISA	A/1008/ENV	A-1008-ENV/016.JPG	03:55:15	13/01/2014	784325	4202032	10
FISA	A/1008/ENV	A-1008-ENV/017.JPG	03:56:08	13/01/2014	784326	4202029	10
FISA	A/1008/ENV	A-1008-ENV/018.JPG	03:56:36	13/01/2014	784327	4202027	10
FISA	A/1008/ENV	A-1008-ENV/019.JPG	03:58:29	13/01/2014	784327	4202013	10
FISA	A/1008/ENV	A-1008-ENV/020.JPG	03:59:21	13/01/2014	784328	4202009	10
FISA	A/1008/ENV	A-1008-ENV/021.JPG	03:59:46	13/01/2014	784327	4202007	10
FISA	A/1008/ENV	A-1008-ENV/022.JPG	04:01:31	13/01/2014	784326	4201989	10
FISA	A/1008/ENV	A-1008-ENV/023.JPG	04:02:11	13/01/2014	784325	4201981	10
FISA	A/1008/ENV	A-1008-ENV/024.JPG	04:02:39	13/01/2014	784325	4201976	10
FISA	A/1008/ENV	A-1008-ENV/025.JPG	04:03:11	13/01/2014	784324	4201970	10
FISA	A/1008/ENV	A-1008-ENV/026.JPG	04:03:44	13/01/2014	784324	4201966	10
FISA	A/1008/ENV	A-1008-ENV/027.JPG	04:04:52	13/01/2014	784324	4201962	10
FISA	A/1008/ENV	A-1008-ENV/028.JPG	04:05:57	13/01/2014	784324	4201953	10
FISA	A/1008/ENV	A-1008-ENV/029.JPG	04:06:49	13/01/2014	784323	4201941	10
FISA	A/1008/ENV	A-1008-ENV/030.JPG	04:07:42	13/01/2014	784324	4201931	10
FISA	A/1008/ENV	A-1008-ENV/031.JPG	04:09:31	13/01/2014	784322	4201913	10
FISA	A/1008/ENV	A-1008-ENV/032.JPG	04:10:55	13/01/2014	784322	4201900	10
FISA	A/1008/ENV	A-1008-ENV/033.JPG	04:12:24	13/01/2014	784323	4201891	10
FISA	A/1008/ENV	A-1008-ENV/034.JPG	04:13:33	13/01/2014	784323	4201880	10
FISA	A/1008/ENV	A-1008-ENV/035.JPG	04:14:09	13/01/2014	784321	4201870	10
FISA	A/1008/ENV	A-1008-ENV/036.JPG	04:14:49	13/01/2014	784320	4201862	10
FISA	A/1008/ENV	A-1008-ENV/037.JPG	04:16:06	13/01/2014	784320	4201850	10
FISA	A/1008/ENV	A-1008-ENV/038.JPG	04:17:07	13/01/2014	784320	4201840	10
FISA	A/1008/ENV	A-1008-ENV/039.JPG	04:17:47	13/01/2014	784318	4201833	10
FISA	A/1008/ENV	A-1008-ENV/040.JPG	04:18:19	13/01/2014	784318	4201828	10
FISA	A/1008/ENV	A-1008-ENV/041.JPG	04:20:36	13/01/2014	784316	4201800	10
FISA	A/1008/ENV	A-1008-ENV/042.JPG	04:21:21	13/01/2014	784317	4201792	10
FISA	A/1008/ENV	A-1008-ENV/043.JPG	04:21:53	13/01/2014	784317	4201786	10
FISA	A/1011/ENV	A-1011-ENV/002.JPG	12:19:41	05/01/2014	784839	4213104	10
FISA	A/1011/ENV	A-1011-ENV/003.JPG	12:20:53	05/01/2014	784828	4213108	10
FISA	A/1011/ENV	A-1011-ENV/004.JPG	12:23:27	05/01/2014	784828	4213105	10
FISA	A/1011/ENV	A-1011-ENV/005.JPG	12:25:12	05/01/2014	784824	4213107	10
FISA	A/1011/ENV	A-1011-ENV/006.JPG	12:25:56	05/01/2014	784826	4213107	10
FISA	A/1011/ENV	A-1011-ENV/007.JPG	12:27:09	05/01/2014	784823	4213108	10
FISA	A/1011/ENV	A-1011-ENV/008.JPG	12:27:53	05/01/2014	784820	4213112	10
FISA	A/1011/ENV	A-1011-ENV/009.JPG	12:29:30	05/01/2014	784818	4213110	10
FISA	A/1011/ENV	A-1011-ENV/010.JPG	12:31:11	05/01/2014	784805	4213111	10
FISA	A/1011/ENV	A-1011-ENV/011.JPG	12:31:51	05/01/2014	784800	4213111	10
FISA	A/1011/ENV	A-1011-ENV/012.JPG	12:34:49	05/01/2014	784782	4213109	10
FISA	A/1011/ENV	A-1011-ENV/013.JPG	12:35:41	05/01/2014	784774	4213113	10
FISA	A/1011/ENV	A-1011-ENV/014.JPG	12:36:29	05/01/2014	784777	4213115	10
FISA	A/1011/ENV	A-1011-ENV/015.JPG	12:40:31	05/01/2014	784750	4213116	10
FISA	A/1011/ENV	A-1011-ENV/016.JPG	12:41:56	05/01/2014	784734	4213121	10
FISA	A/1011/ENV	A-1011-ENV/017.JPG	12:45:38	05/01/2014	784701	4213123	10
FISA	A/1013/ENV	A-1013-ENV/002.JPG	21:03:33	12/01/2014	790314	4204430	0
FISA	A/1013/ENV	A-1013-ENV/003.JPG	21:03:33	12/01/2014	790314	4204430	1
FISA	A/1013/ENV	A-1013-ENV/004.JPG	21:03:33	12/01/2014	790314	4204430	2

Site	Location	Pic Filename	Time	Date	Easting	Northing	Position rating
FISA	A/1013/ENV	A-1013-ENV/005.JPG	21:03:33	12/01/2014	790314	4204430	2
FISA	A/1013/ENV	A-1013-ENV/006.JPG	21:03:33	12/01/2014	790314	4204430	3
FISA	A/1013/ENV	A-1013-ENV/007.JPG	21:03:33	12/01/2014	790314	4204430	3
FISA	A/1013/ENV	A-1013-ENV/008.JPG	21:03:33	12/01/2014	790314	4204430	4
FISA	A/1013/ENV	A-1013-ENV/009.JPG	21:03:33	12/01/2014	790314	4204430	4
FISA	A/1013/ENV	A-1013-ENV/010.JPG	21:03:33	12/01/2014	790314	4204430	5
FISA	A/1013/ENV	A-1013-ENV/011.JPG	21:03:33	12/01/2014	790314	4204430	5
FISA	A/1013/ENV	A-1013-ENV/012.JPG	21:03:33	12/01/2014	790314	4204430	5
FISA	A/1013/ENV	A-1013-ENV/013.JPG	21:03:33	12/01/2014	790314	4204430	6
FISA	A/1013/ENV	A-1013-ENV/014.JPG	21:03:33	12/01/2014	790314	4204430	6
FISA	A/1013/ENV	A-1013-ENV/015.JPG	21:03:33	12/01/2014	790314	4204430	6
FISA	A/1013/ENV	A-1013-ENV/016.JPG	21:03:33	12/01/2014	790314	4204430	7
FISA	A/1013/ENV	A-1013-ENV/017.JPG	21:03:33	12/01/2014	790314	4204430	7
FISA	A/1013/ENV	A-1013-ENV/018.JPG	21:03:33	12/01/2014	790314	4204430	7
FISA	A/1013/ENV	A-1013-ENV/019.JPG	21:03:33	12/01/2014	790314	4204430	8
FISA	A/1013/ENV	A-1013-ENV/020.JPG	21:03:33	12/01/2014	790314	4204430	8
FISA	A/1013/ENV	A-1013-ENV/021.JPG	21:03:33	12/01/2014	790314	4204430	9
FISA	A/1013/ENV	A-1013-ENV/022.JPG	21:03:33	12/01/2014	790314	4204430	9
FISA	A/1013/ENV	A-1013-ENV/023.JPG	21:03:33	12/01/2014	790314	4204430	9
FISA	A/1013/ENV	A-1013-ENV/024.JPG	21:03:33	12/01/2014	790314	4204430	10
FISA	A/1013/ENV	A-1013-ENV/025.JPG	21:03:33	12/01/2014	790314	4204430	10
FISA	A/1013/ENV	A-1013-ENV/026.JPG	21:04:43	12/01/2014	790290	4204445	10
FISA	A/1015/ENV	A-1015-ENV/002.JPG	08:47:48	13/01/2014	786601	4198433	10
FISA	A/1015/ENV	A-1015-ENV/003.JPG	08:47:48	13/01/2014	786601	4198433	10
FISA	A/1015/ENV	A-1015-ENV/004.JPG	08:48:05	13/01/2014	786601	4198433	10
FISA	A/1015/ENV	A-1015-ENV/005.JPG	08:48:45	13/01/2014	786601	4198432	10
FISA	A/1015/ENV	A-1015-ENV/006.JPG	08:52:07	13/01/2014	786593	4198429	10
FISA	A/1015/ENV	A-1015-ENV/007.JPG	08:54:20	13/01/2014	786592	4198430	10
FISA	A/1015/ENV	A-1015-ENV/008.JPG	08:55:33	13/01/2014	786584	4198429	10
FISA	A/1015/ENV	A-1015-ENV/009.JPG	08:56:37	13/01/2014	786582	4198429	10
FISA	A/1015/ENV	A-1015-ENV/010.JPG	08:56:57	13/01/2014	786581	4198430	10
FISA	A/1015/ENV	A-1015-ENV/011.JPG	08:57:58	13/01/2014	786577	4198431	10
FISA	A/1015/ENV	A-1015-ENV/012.JPG	09:01:24	13/01/2014	786557	4198429	10
FISA	A/1015/ENV	A-1015-ENV/013.JPG	09:03:41	13/01/2014	786545	4198429	10
FISA	A/1015/ENV	A-1015-ENV/014.JPG	09:04:01	13/01/2014	786545	4198430	10
FISA	A/1015/ENV	A-1015-ENV/015.JPG	09:04:53	13/01/2014	786541	4198433	10
FISA	A/1015/ENV	A-1015-ENV/016.JPG	09:09:16	13/01/2014	786502	4198430	10
FISA	A/1015/ENV	A-1015-ENV/017.JPG	09:10:04	13/01/2014	786493	4198431	10
FISA	A/1015/ENV	A-1015-ENV/018.JPG	09:10:36	13/01/2014	786487	4198430	10
FISA	A/1015/ENV	A-1015-ENV/019.JPG	09:11:53	13/01/2014	786477	4198430	10
FISA	A/1015/ENV	A-1015-ENV/020.JPG	09:12:25	13/01/2014	786472	4198430	10
FISA	A/1015/ENV	A-1015-ENV/021.JPG	09:12:45	13/01/2014	786469	4198431	10
FISA	A/1015/ENV	A-1015-ENV/022.JPG	09:13:18	13/01/2014	786464	4198434	10
FISA	A/1015/ENV	A-1015-ENV/023.JPG	09:13:58	13/01/2014	786459	4198437	10
FISA	A/1015/ENV	A-1015-ENV/024.JPG	09:15:11	13/01/2014	786447	4198436	10
FISA	A/1015/ENV	A-1015-ENV/025.JPG	09:16:11	13/01/2014	786435	4198434	10
FISA	A/1015/ENV	A-1015-ENV/026.JPG	09:16:52	13/01/2014	786428	4198434	10
FISA	A/1015/ENV	A-1015-ENV/027.JPG	09:17:36	13/01/2014	786420	4198435	10
FISA	A/1015/ENV	A-1015-ENV/028.JPG	09:18:00	13/01/2014	786415	4198436	10
FISA	A/1015/ENV	A-1015-ENV/029.JPG	09:18:45	13/01/2014	786407	4198436	10
FISA	A/1015/ENV	A-1015-ENV/030.JPG	09:19:13	13/01/2014	786402	4198436	10
FISA	A/1015/ENV	A-1015-ENV/031.JPG	09:20:17	13/01/2014	786386	4198439	10
FISA	A/1015/ENV	A-1015-ENV/032.JPG	09:20:54	13/01/2014	786378	4198440	10
FISA	A/1015/ENV	A-1015-ENV/033.JPG	09:21:34	13/01/2014	786370	4198440	10
FISA	A/1015/ENV	A-1015-ENV/034.JPG	09:22:18	13/01/2014	786361	4198439	10
FISA	A/1015/ENV	A-1015-ENV/035.JPG	09:22:51	13/01/2014	786355	4198439	10
FISA	A/1015/ENV	A-1015-ENV/036.JPG	09:23:11	13/01/2014	786351	4198438	10
FISA	A/1015/ENV	A-1015-ENV/037.JPG	09:24:19	13/01/2014	786334	4198438	10
FISA	A/1015/ENV	A-1015-ENV/038.JPG	09:25:16	13/01/2014	786321	4198438	10

Site	Location	Pic Filename	Time	Date	Easting	Northing	Position rating
FISA	A/1015/ENV	A-1015-ENV/039.JPG	09:25:40	13/01/2014	786315	4198440	10
FISA	A/106/ENV	A-106-ENV/002.JPG	21:14:50	16/01/2014	743498	4180226	10
FISA	A/106/ENV	A-106-ENV/003.JPG	21:14:50	16/01/2014	743498	4180226	10
FISA	A/106/ENV	A-106-ENV/004.JPG	21:18:14	16/01/2014	743498	4180209	10
FISA	A/106/ENV	A-106-ENV/005.JPG	21:27:45	16/01/2014	743339	4180057	10
FISA	A/106/ENV	A-106-ENV/006.JPG	21:29:01	16/01/2014	743323	4180032	10
FISA	A/106/ENV	A-106-ENV/007.JPG	21:29:51	16/01/2014	743304	4180018	10
FISA	A/106/ENV	A-106-ENV/008.JPG	21:31:09	16/01/2014	743285	4179996	10
FISA	A/106/ENV	A-106-ENV/009.JPG	21:32:14	16/01/2014	743262	4179981	10
FISA	A/106/ENV	A-106-ENV/010.JPG	21:34:14	16/01/2014	743229	4179939	10
FISA	A/106/ENV	A-106-ENV/011.JPG	21:34:41	16/01/2014	743221	4179933	10
FISA	A/106/ENV	A-106-ENV/012.JPG	21:36:19	16/01/2014	743193	4179903	10
FISA	A/106/ENV	A-106-ENV/013.JPG	21:37:20	16/01/2014	743180	4179886	10
FISA	A/106/ENV	A-106-ENV/014.JPG	21:38:17	16/01/2014	743162	4179871	10
FISA	A/106/ENV	A-106-ENV/015.JPG	21:38:56	16/01/2014	743149	4179859	10
FISA	A/106/ENV	A-106-ENV/016.JPG	21:39:54	16/01/2014	743133	4179841	10
FISA	A/106/ENV	A-106-ENV/017.JPG	21:40:40	16/01/2014	743119	4179827	10
FISA	A/106/ENV	A-106-ENV/018.JPG	21:41:12	16/01/2014	743112	4179819	10
FISA	A/106/ENV	A-106-ENV/019.JPG	21:41:55	16/01/2014	743101	4179805	10
FISA	A/106/ENV	A-106-ENV/020.JPG	21:42:35	16/01/2014	743088	4179792	10
FISA	A/106/ENV	A-106-ENV/021.JPG	21:44:08	16/01/2014	743075	4179781	10
FISA	A/106/ENV	A-106-ENV/022.JPG	21:46:15	16/01/2014	743055	4179786	10
FISA	A/106/ENV	A-106-ENV/023.JPG	21:48:10	16/01/2014	743056	4179779	10
FISA	A/106/ENV	A-106-ENV/024.JPG	21:48:40	16/01/2014	743053	4179780	10
FISA	A/10/ENV	A-10-ENV/001.JPG	14:31:28	04/01/2014	774452	4205142	10
FISA	A/10/ENV	A-10-ENV/002.JPG	14:32:35	04/01/2014	774452	4205141	10
FISA	A/10/ENV	A-10-ENV/003.JPG	14:34:03	04/01/2014	774452	4205141	10
FISA	A/10/ENV	A-10-ENV/004.JPG	14:35:27	04/01/2014	774452	4205141	10
FISA	A/10/ENV	A-10-ENV/005.JPG	14:36:22	04/01/2014	774453	4205140	10
FISA	A/10/ENV	A-10-ENV/006.JPG	14:38:17	04/01/2014	774449	4205139	10
FISA	A/10/ENV	A-10-ENV/007.JPG	14:39:17	04/01/2014	774447	4205138	10
FISA	A/10/ENV	A-10-ENV/008.JPG	14:40:18	04/01/2014	774445	4205138	10
FISA	A/10/ENV	A-10-ENV/009.JPG	14:41:19	04/01/2014	774443	4205137	10
FISA	A/10/ENV	A-10-ENV/010.JPG	14:42:16	04/01/2014	774439	4205137	10
FISA	A/10/ENV	A-10-ENV/011.JPG	14:43:32	04/01/2014	774435	4205137	10
FISA	A/10/ENV	A-10-ENV/012.JPG	14:45:27	04/01/2014	774426	4205136	10
FISA	A/10/ENV	A-10-ENV/013.JPG	14:47:03	04/01/2014	774419	4205134	10
FISA	A/10/ENV	A-10-ENV/014.JPG	14:47:46	04/01/2014	774415	4205133	10
FISA	A/12/ENV	A-12-ENV/002.JPG	20:21:24	04/01/2014	783898	4203852	10
FISA	A/12/ENV	A-12-ENV/003.JPG	20:22:36	04/01/2014	783898	4203856	10
FISA	A/12/ENV	A-12-ENV/004.JPG	20:22:36	04/01/2014	783898	4203856	10
FISA	A/12/ENV	A-12-ENV/005.JPG	20:22:36	04/01/2014	783898	4203856	9
FISA	A/12/ENV	A-12-ENV/006.JPG	20:26:59	04/01/2014	783879	4203855	10
FISA	A/12/ENV	A-12-ENV/007.JPG	20:26:59	04/01/2014	783879	4203855	10
FISA	A/12/ENV	A-12-ENV/008.JPG	20:30:24	04/01/2014	783878	4203855	9
FISA	A/12/ENV	A-12-ENV/009.JPG	20:30:24	04/01/2014	783878	4203855	10
FISA	A/12/ENV	A-12-ENV/010.JPG	20:30:24	04/01/2014	783878	4203855	10
FISA	A/12/ENV	A-12-ENV/011.JPG	20:30:24	04/01/2014	783878	4203855	10
FISA	A/12/ENV	A-12-ENV/012.JPG	20:32:01	04/01/2014	783871	4203856	10
FISA	A/12/ENV	A-12-ENV/013.JPG	20:32:45	04/01/2014	783868	4203856	10
FISA	A/12/ENV	A-12-ENV/014.JPG	20:32:57	04/01/2014	783867	4203855	10
FISA	A/12/ENV	A-12-ENV/015.JPG	20:36:36	04/01/2014	783851	4203854	9
FISA	A/12/ENV	A-12-ENV/016.JPG	20:38:25	04/01/2014	783838	4203858	9
FISA	A/12/ENV	A-12-ENV/017.JPG	20:42:57	04/01/2014	783806	4203857	9
FISA	A/12/ENV	A-12-ENV/018.JPG	20:42:57	04/01/2014	783806	4203857	10
FISA	A/12/ENV	A-12-ENV/019.JPG	20:42:57	04/01/2014	783806	4203857	10
FISA	A/12/ENV	A-12-ENV/020.JPG	20:42:57	04/01/2014	783806	4203857	10
FISA	A/12/ENV	A-12-ENV/021.JPG	20:43:42	04/01/2014	783799	4203860	10
FISA	A/12/ENV	A-12-ENV/022.JPG	20:43:42	04/01/2014	783799	4203860	10

Site	Location	Pic Filename	Time	Date	Easting	Northing	Position rating
FISA	A/14/ENV	A-14-ENV/002.JPG	14:46:18	13/01/2014	782520	4194696	9
FISA	A/14/ENV	A-14-ENV/003.JPG	14:47:22	13/01/2014	782519	4194696	10
FISA	A/14/ENV	A-14-ENV/004.JPG	14:48:47	13/01/2014	782521	4194699	10
FISA	A/14/ENV	A-14-ENV/005.JPG	14:51:25	13/01/2014	782524	4194716	10
FISA	A/14/ENV	A-14-ENV/006.JPG	14:52:45	13/01/2014	782528	4194723	10
FISA	A/14/ENV	A-14-ENV/007.JPG	14:54:30	13/01/2014	782541	4194740	10
FISA	A/14/ENV	A-14-ENV/008.JPG	14:56:31	13/01/2014	782549	4194761	10
FISA	A/14/ENV	A-14-ENV/009.JPG	14:58:04	13/01/2014	782557	4194775	10
FISA	A/14/ENV	A-14-ENV/010.JPG	14:59:25	13/01/2014	782562	4194782	10
FISA	A/14/ENV	A-14-ENV/011.JPG	15:00:57	13/01/2014	782568	4194797	10
FISA	A/14/ENV	A-14-ENV/012.JPG	15:01:58	13/01/2014	782572	4194810	10
FISA	A/14/ENV	A-14-ENV/013.JPG	15:03:39	13/01/2014	782585	4194830	10
FISA	A/14/ENV	A-14-ENV/014.JPG	15:04:47	13/01/2014	782585	4194838	10
FISA	A/14/ENV	A-14-ENV/015.JPG	15:05:16	13/01/2014	782588	4194846	10
FISA	A/18/ENV	A-18-ENV//002.JPG	13:16:58	01/02/2014	768236	4174063	10
FISA	A/18/ENV	A-18-ENV//003.JPG	13:22:14	01/02/2014	768169	4173962	10
FISA	A/18/ENV	A-18-ENV//004.JPG	13:24:13	01/02/2014	768149	4173917	10
FISA	A/18/ENV	A-18-ENV//005.JPG	13:28:04	01/02/2014	768101	4173839	10
FISA	A/18/ENV	A-18-ENV//006.JPG	13:29:09	01/02/2014	768088	4173816	10
FISA	A/18/ENV	A-18-ENV//007.JPG	13:31:49	01/02/2014	768053	4173757	10
FISA	A/18/ENV	A-18-ENV//008.JPG	13:32:12	01/02/2014	768048	4173748	10
FISA	A/18/ENV	A-18-ENV//009.JPG	13:34:41	01/02/2014	768014	4173690	10
FISA	A/18/ENV	A-18-ENV//010.JPG	13:35:29	01/02/2014	768005	4173670	10
FISA	A/18/ENV	A-18-ENV//011.JPG	13:35:52	01/02/2014	768000	4173664	10
FISA	A/18/ENV	A-18-ENV//012.JPG	13:38:46	01/02/2014	767962	4173601	10
FISA	A/18/ENV	A-18-ENV//013.JPG	13:39:23	01/02/2014	767954	4173587	10
FISA	A/18/ENV	A-18-ENV//014.JPG	13:40:30	01/02/2014	767941	4173567	10
FISA	A/18/ENV	A-18-ENV//015.JPG	13:40:58	01/02/2014	767936	4173558	10
FISA	A/18/ENV	A-18-ENV//016.JPG	13:41:25	01/02/2014	767930	4173550	10
FISA	A/18/ENV	A-18-ENV//017.JPG	13:41:47	01/02/2014	767925	4173540	10
FISA	A/18/ENV	A-18-ENV//018.JPG	13:42:38	01/02/2014	767915	4173524	10
FISA	A/18/ENV	A-18-ENV//019.JPG	13:44:23	01/02/2014	767894	4173482	10
FISA	A/18/ENV	A-18-ENV//020.JPG	13:44:47	01/02/2014	767888	4173473	10
FISA	A/18/ENV	A-18-ENV//021.JPG	13:45:21	01/02/2014	767881	4173461	10
FISA	A/18/ENV	A-18-ENV//022.JPG	13:45:41	01/02/2014	767877	4173453	10
FISA	A/18/ENV	A-18-ENV//023.JPG	13:46:15	01/02/2014	767871	4173444	10
FISA	A/201/ENV	A-201-ENV/002.JPG	04:43:38	15/01/2014	734235	4206721	10
FISA	A/201/ENV	A-201-ENV/003.JPG	04:43:38	15/01/2014	734235	4206721	10
FISA	A/201/ENV	A-201-ENV/004.JPG	04:46:55	15/01/2014	734242	4206712	10
FISA	A/201/ENV	A-201-ENV/005.JPG	04:53:39	15/01/2014	734279	4206707	10
FISA	A/201/ENV	A-201-ENV/006.JPG	04:53:39	15/01/2014	734279	4206707	10
FISA	A/201/ENV	A-201-ENV/007.JPG	04:54:27	15/01/2014	734293	4206706	10
FISA	A/201/ENV	A-201-ENV/008.JPG	04:55:16	15/01/2014	734299	4206707	10
FISA	A/201/ENV	A-201-ENV/009.JPG	04:55:48	15/01/2014	734295	4206709	10
FISA	A/201/ENV	A-201-ENV/010.JPG	04:56:20	15/01/2014	734293	4206712	10
FISA	A/201/ENV	A-201-ENV/011.JPG	04:57:13	15/01/2014	734294	4206713	10
FISA	A/201/ENV	A-201-ENV/012.JPG	04:57:49	15/01/2014	734300	4206714	10
FISA	A/201/ENV	A-201-ENV/013.JPG	04:58:37	15/01/2014	734317	4206713	10
FISA	A/201/ENV	A-201-ENV/014.JPG	04:59:34	15/01/2014	734332	4206712	10
FISA	A/201/ENV	A-201-ENV/015.JPG	05:00:18	15/01/2014	734336	4206711	10
FISA	A/201/ENV	A-201-ENV/016.JPG	05:00:42	15/01/2014	734337	4206711	10
FISA	A/201/ENV	A-201-ENV/017.JPG	05:02:11	15/01/2014	734343	4206708	10
FISA	A/201/ENV	A-201-ENV/018.JPG	05:02:47	15/01/2014	734346	4206707	10
FISA	A/201/ENV	A-201-ENV/019.JPG	05:03:20	15/01/2014	734350	4206708	10
FISA	A/201/ENV	A-201-ENV/020.JPG	05:03:56	15/01/2014	734356	4206710	10
FISA	A/201/ENV	A-201-ENV/021.JPG	05:04:20	15/01/2014	734360	4206710	10
FISA	A/201/ENV	A-201-ENV/022.JPG	05:05:45	15/01/2014	734378	4206710	10
FISA	A/201/ENV	A-201-ENV/023.JPG	05:06:17	15/01/2014	734385	4206709	10
FISA	A/201/ENV	A-201-ENV/024.JPG	05:07:10	15/01/2014	734396	4206709	10

Site	Location	Pic Filename	Time	Date	Easting	Northing	Position rating
FISA	A/201/ENV	A-201-ENV/025.JPG	05:07:38	15/01/2014	734400	4206710	10
FISA	A/201/ENV	A-201-ENV/026.JPG	05:09:03	15/01/2014	734420	4206713	10
FISA	A/201/ENV	A-201-ENV/027.JPG	05:09:39	15/01/2014	734430	4206713	10
FISA	A/201/ENV	A-201-ENV/028.JPG	05:10:03	15/01/2014	734434	4206713	10
FISA	A/201/ENV	A-201-ENV/029.JPG	05:10:48	15/01/2014	734435	4206714	10
FISA	A/201/ENV	A-201-ENV/030.JPG	05:11:40	15/01/2014	734434	4206715	10
FISA	A/201/ENV	A-201-ENV/031.JPG	05:12:20	15/01/2014	734452	4206717	10
FISA	A/201/ENV	A-201-ENV/032.JPG	05:13:05	15/01/2014	734474	4206717	10
FISA	A/201/ENV	A-201-ENV/033.JPG	05:15:18	15/01/2014	734514	4206716	10
FISA	A/201/ENV	A-201-ENV/034.JPG	05:16:26	15/01/2014	734536	4206719	10
FISA	A/201/ENV	A-201-ENV/035.JPG	05:18:23	15/01/2014	734572	4206721	10
FISA	A/201/ENV	A-201-ENV/036.JPG	05:19:07	15/01/2014	734585	4206720	10
FISA	A/201/ENV	A-201-ENV/037.JPG	05:19:56	15/01/2014	734598	4206719	10
FISA	A/201/ENV	A-201-ENV/038.JPG	05:20:40	15/01/2014	734608	4206718	10
FISA	A/201/ENV	A-201-ENV/039.JPG	05:21:29	15/01/2014	734616	4206717	10
FISA	A/201/ENV	A-201-ENV/040.JPG	05:22:01	15/01/2014	734621	4206717	10
FISA	A/202/ENV	A-202-ENV/002.JPG	23:09:13	14/01/2014	754103	4216040	9
FISA	A/202/ENV	A-202-ENV/003.JPG	23:13:23	14/01/2014	754142	4216058	10
FISA	A/202/ENV	A-202-ENV/004.JPG	23:14:08	14/01/2014	754148	4216061	10
FISA	A/202/ENV	A-202-ENV/005.JPG	23:15:12	14/01/2014	754157	4216068	10
FISA	A/202/ENV	A-202-ENV/006.JPG	23:15:52	14/01/2014	754165	4216072	10
FISA	A/202/ENV	A-202-ENV/007.JPG	23:17:57	14/01/2014	754186	4216082	10
FISA	A/202/ENV	A-202-ENV/008.JPG	23:17:57	14/01/2014	754186	4216082	10
FISA	A/202/ENV	A-202-ENV/009.JPG	23:17:57	14/01/2014	754186	4216082	9
FISA	A/202/ENV	A-202-ENV/010.JPG	23:17:57	14/01/2014	754186	4216082	9
FISA	A/202/ENV	A-202-ENV/011.JPG	23:17:57	14/01/2014	754186	4216082	9
FISA	A/202/ENV	A-202-ENV/012.JPG	23:17:57	14/01/2014	754186	4216082	8
FISA	A/202/ENV	A-202-ENV/013.JPG	23:17:57	14/01/2014	754186	4216082	6
FISA	A/202/ENV	A-202-ENV/014.JPG	23:17:57	14/01/2014	754186	4216082	6
FISA	A/202/ENV	A-202-ENV/015.JPG	23:17:57	14/01/2014	754186	4216082	6
FISA	A/202/ENV	A-202-ENV/016.JPG	23:17:57	14/01/2014	754186	4216082	5
FISA	A/202/ENV	A-202-ENV/017.JPG	23:17:57	14/01/2014	754186	4216082	5
FISA	A/202/ENV	A-202-ENV/018.JPG	23:17:57	14/01/2014	754186	4216082	5
FISA	A/202/ENV	A-202-ENV/019.JPG	23:17:57	14/01/2014	754186	4216082	4
FISA	A/202/ENV	A-202-ENV/020.JPG	23:17:57	14/01/2014	754186	4216082	4
FISA	A/202/ENV	A-202-ENV/021.JPG	23:17:57	14/01/2014	754186	4216082	4
FISA	A/202/ENV	A-202-ENV/022.JPG	23:17:57	14/01/2014	754186	4216082	4
FISA	A/202/ENV	A-202-ENV/023.JPG	23:17:57	14/01/2014	754186	4216082	3
FISA	A/202/ENV	A-202-ENV/024.JPG	23:17:57	14/01/2014	754186	4216082	3
FISA	A/202/ENV	A-202-ENV/025.JPG	23:17:57	14/01/2014	754186	4216082	3
FISA	A/202/ENV	A-202-ENV/026.JPG	23:17:57	14/01/2014	754186	4216082	2
FISA	A/202/ENV	A-202-ENV/027.JPG	23:17:57	14/01/2014	754186	4216082	2
FISA	A/202/ENV	A-202-ENV/028.JPG	23:17:57	14/01/2014	754186	4216082	2
FISA	A/202/ENV	A-202-ENV/029.JPG	23:17:57	14/01/2014	754186	4216082	2
FISA	A/202/ENV	A-202-ENV/030.JPG	23:17:57	14/01/2014	754186	4216082	1
FISA	A/202/ENV	A-202-ENV/031.JPG	23:17:57	14/01/2014	754186	4216082	1
FISA	A/202/ENV	A-202-ENV/032.JPG	23:17:57	14/01/2014	754186	4216082	1
FISA	A/203/ENV	A-203-ENV.a/00002.JPG	19:38:55	03/01/2014	787583	4199233	10
FISA	A/203/ENV	A-203-ENV.a/00003.JPG	19:40:44	03/01/2014	787585	4199231	10
FISA	A/203/ENV	A-203-ENV.a/00004.JPG	19:41:09	03/01/2014	787585	4199231	10
FISA	A/203/ENV	A-203-ENV.a/00005.JPG	19:41:33	03/01/2014	787585	4199232	10
FISA	A/203/ENV	A-203-ENV.a/00006.JPG	19:41:41	03/01/2014	787586	4199232	10
FISA	A/203/ENV	A-203-ENV.a/00007.JPG	19:42:33	03/01/2014	787585	4199231	10
FISA	A/203/ENV	A-203-ENV.a/00008.JPG	19:42:45	03/01/2014	787585	4199230	10
FISA	A/203/ENV	A-203-ENV.a/00009.JPG	19:46:19	03/01/2014	787581	4199219	10
FISA	A/203/ENV	A-203-ENV.a/00010.JPG	19:46:39	03/01/2014	787580	4199218	10
FISA	A/203/ENV	A-203-ENV.a/00011.JPG	19:47:44	03/01/2014	787579	4199212	10
FISA	A/203/ENV	A-203-ENV.a/00012.JPG	19:49:33	03/01/2014	787578	4199203	10
FISA	A/203/ENV	A-203-ENV.a/00013.JPG	19:49:49	03/01/2014	787577	4199202	10

Site	Location	Pic Filename	Time	Date	Easting	Northing	Position rating
FISA	A/203/ENV	A-203-ENV.a/00014.JPG	19:50:21	03/01/2014	787575	4199199	10
FISA	A/203/ENV	A-203-ENV.a/00015.JPG	19:51:18	03/01/2014	787573	4199192	10
FISA	A/203/ENV	A-203-ENV.a/00016.JPG	19:51:30	03/01/2014	787573	4199190	10
FISA	A/203/ENV	A-203-ENV.a/00017.JPG	19:51:50	03/01/2014	787572	4199188	10
FISA	A/203/ENV	A-203-ENV.a/00018.JPG	19:52:50	03/01/2014	787570	4199182	10
FISA	A/203/ENV	A-203-ENV.a/00019.JPG	19:53:31	03/01/2014	787568	4199176	10
FISA	A/203/ENV	A-203-ENV.a/00020.JPG	19:54:03	03/01/2014	787566	4199174	10
FISA	A/203/ENV	A-203-ENV.a/00021.JPG	19:54:39	03/01/2014	787566	4199170	10
FISA	A/203/ENV	A-203-ENV.a/00022.JPG	19:55:04	03/01/2014	787565	4199167	10
FISA	A/203/ENV	A-203-ENV.a/00023.JPG	19:55:24	03/01/2014	787564	4199164	10
FISA	A/203/ENV	A-203-ENV.a/00024.JPG	19:55:36	03/01/2014	787563	4199162	10
FISA	A/203/ENV	A-203-ENV.a/00025.JPG	19:56:00	03/01/2014	787562	4199159	10
FISA	A/203/ENV	A-203-ENV.a/00026.JPG	19:56:40	03/01/2014	787560	4199153	10
FISA	A/203/ENV	A-203-ENV.a/00027.JPG	19:57:13	03/01/2014	787558	4199150	10
FISA	A/203/ENV	A-203-ENV.a/00028.JPG	19:57:45	03/01/2014	787557	4199145	10
FISA	A/203/ENV	A-203-ENV.a/00029.JPG	19:57:57	03/01/2014	787557	4199143	10
FISA	A/203/ENV	A-203-ENV.a/00030.JPG	19:58:13	03/01/2014	787556	4199141	10
FISA	A/203/ENV	A-203-ENV.a/00031.JPG	19:58:29	03/01/2014	787556	4199140	10
FISA	A/203/ENV	A-203-ENV.a/00032.JPG	19:58:49	03/01/2014	787555	4199137	10
FISA	A/203/ENV	A-203-ENV.a/00033.JPG	19:59:30	03/01/2014	787553	4199132	10
FISA	A/203/ENV	A-203-ENV.a/00034.JPG	20:00:26	03/01/2014	787551	4199125	10
FISA	A/203/ENV	A-203-ENV.a/00035.JPG	20:01:59	03/01/2014	787544	4199111	10
FISA	A/203/ENV	A-203-ENV.a/00036.JPG	20:02:19	03/01/2014	787543	4199109	10
FISA	A/205/ENV	A-205-ENV//002.JPG	05:13:34	02/02/2014	792365	4178244	9
FISA	A/205/ENV	A-205-ENV//004.JPG	05:14:07	02/02/2014	792341	4178272	10
FISA	A/205/ENV	A-205-ENV//009.JPG	05:19:09	02/02/2014	792239	4178366	10
FISA	A/205/ENV	A-205-ENV//010.JPG	05:19:33	02/02/2014	792218	4178377	10
FISA	A/205/ENV	A-205-ENV//012.JPG	05:19:33	02/02/2014	792218	4178377	8
FISA	A/205/ENV	A-205-ENV//014.JPG	05:19:33	02/02/2014	792218	4178377	7
FISA	A/205/ENV	A-205-ENV//015.JPG	05:19:33	02/02/2014	792218	4178377	7
FISA	A/205/ENV	A-205-ENV//016.JPG	05:19:33	02/02/2014	792218	4178377	6
FISA	A/205/ENV	A-205-ENV//018.JPG	05:19:33	02/02/2014	792218	4178377	5
FISA	A/205/ENV	A-205-ENV//019.JPG	05:19:33	02/02/2014	792218	4178377	5
FISA	A/205/ENV	A-205-ENV//020.JPG	05:19:33	02/02/2014	792218	4178377	4
FISA	A/205/ENV	A-205-ENV//022.JPG	05:19:33	02/02/2014	792218	4178377	3
FISA	A/205/ENV	A-205-ENV//023.JPG	05:19:33	02/02/2014	792218	4178377	1
FISA	A/205/ENV	A-205-ENV//024.JPG	05:19:33	02/02/2014	792218	4178377	1
FISA	A/205/ENV	A-205-ENV//025.JPG	05:19:33	02/02/2014	792218	4178377	0
FISA	A/205/ENV	A-205-ENV//026.JPG	05:19:33	02/02/2014	792218	4178377	0
FISA	A/205/ENV	A-205-ENV//027.JPG	05:19:33	02/02/2014	792218	4178377	0
FISA	A/205/ENV	A-205-ENV//028.JPG	05:19:33	02/02/2014	792218	4178377	-1
FISA	A/206/ENV	A-206-ENV//002.JPG	23:16:57	01/02/2014	776822	4163141	10
FISA	A/206/ENV	A-206-ENV//003.JPG	23:17:05	01/02/2014	776761	4162880	10
FISA	A/206/ENV	A-206-ENV//004.JPG	23:17:21	01/02/2014	776499	4163089	10
FISA	A/206/ENV	A-206-ENV//005.JPG	23:17:42	01/02/2014	776854	4163049	10
FISA	A/206/ENV	A-206-ENV//006.JPG	23:25:09	01/02/2014	776836	4163191	10
FISA	A/206/ENV	A-206-ENV//007.JPG	23:27:02	01/02/2014	776825	4163024	10
FISA	A/206/ENV	A-206-ENV//008.JPG	23:27:27	01/02/2014	776861	4163139	10
FISA	A/206/ENV	A-206-ENV//009.JPG	23:29:03	01/02/2014	776858	4163211	10
FISA	A/206/ENV	A-206-ENV//010.JPG	23:29:48	01/02/2014	776857	4163230	10
FISA	A/206/ENV	A-206-ENV//011.JPG	23:30:12	01/02/2014	776807	4163315	10
FISA	A/206/ENV	A-206-ENV//012.JPG	23:31:29	01/02/2014	776849	4163286	10
FISA	A/206/ENV	A-206-ENV//013.JPG	23:32:33	01/02/2014	776797	4163367	10
FISA	A/206/ENV	A-206-ENV//014.JPG	23:33:22	01/02/2014	776850	4163322	10
FISA	A/206/ENV	A-206-ENV//015.JPG	23:33:54	01/02/2014	776848	4163338	10
FISA	A/206/ENV	A-206-ENV//016.JPG	23:35:47	01/02/2014	776843	4163385	10
FISA	A/206/ENV	A-206-ENV//017.JPG	23:37:07	01/02/2014	776825	4163435	10
FISA	A/206/ENV	A-206-ENV//018.JPG	23:37:24	01/02/2014	776861	4163390	10
FISA	A/206/ENV	A-206-ENV//019.JPG	23:38:00	01/02/2014	776873	4163376	10

Site	Location	Pic Filename	Time	Date	Easting	Northing	Position rating
FISA	A/206/ENV	A-206-ENV//020.JPG	23:39:29	01/02/2014	776867	4163426	10
FISA	A/206/ENV	A-206-ENV//021.JPG	23:40:13	01/02/2014	776850	4163474	10
FISA	A/206/ENV	A-206-ENV//022.JPG	23:40:33	01/02/2014	776869	4163450	10
FISA	A/206/ENV	A-206-ENV//023.JPG	23:41:10	01/02/2014	776857	4163484	10
FISA	A/206/ENV	A-206-ENV//024.JPG	23:44:15	01/02/2014	776870	4163534	10
FISA	A/206/ENV	A-206-ENV//025.JPG	23:44:43	01/02/2014	776870	4163545	10
FISA	A/206/ENV	A-206-ENV//026.JPG	23:45:44	01/02/2014	776873	4163561	10
FISA	A/206/ENV	A-206-ENV//027.JPG	23:46:20	01/02/2014	776884	4163550	10
FISA	A/206/ENV	A-206-ENV//028.JPG	23:47:00	01/02/2014	776881	4163576	10
FISA	A/207/ENV	A-207-ENV/004.JPG	09:37:42	05/01/2014	786705	4209669	10
FISA	A/207/ENV	A-207-ENV/005.JPG	09:39:01	05/01/2014	786694	4209669	10
FISA	A/207/ENV	A-207-ENV/006.JPG	09:39:07	05/01/2014	786694	4209670	10
FISA	A/207/ENV	A-207-ENV/007.JPG	09:40:15	05/01/2014	786691	4209671	10
FISA	A/207/ENV	A-207-ENV/008.JPG	09:40:15	05/01/2014	786691	4209671	9
FISA	A/207/ENV	A-207-ENV/009.JPG	09:45:01	05/01/2014	786683	4209678	9
FISA	A/207/ENV	A-207-ENV/010.JPG	09:45:01	05/01/2014	786683	4209678	10
FISA	A/207/ENV	A-207-ENV/011.JPG	09:45:22	05/01/2014	786682	4209681	10
FISA	A/207/ENV	A-207-ENV/012.JPG	09:45:25	05/01/2014	786681	4209681	10
FISA	A/207/ENV	A-207-ENV/013.JPG	09:47:35	05/01/2014	786674	4209683	10
FISA	A/207/ENV	A-207-ENV/014.JPG	09:47:44	05/01/2014	786673	4209684	10
FISA	A/207/ENV	A-207-ENV/015.JPG	09:48:02	05/01/2014	786670	4209686	10
FISA	A/207/ENV	A-207-ENV/016.JPG	09:48:02	05/01/2014	786670	4209686	10
FISA	A/207/ENV	A-207-ENV/017.JPG	09:48:02	05/01/2014	786670	4209686	10
FISA	A/207/ENV	A-207-ENV/018.JPG	09:48:02	05/01/2014	786670	4209686	9
FISA	A/207/ENV	A-207-ENV/019.JPG	09:48:02	05/01/2014	786670	4209686	9
FISA	A/207/ENV	A-207-ENV/020.JPG	09:48:02	05/01/2014	786670	4209686	9
FISA	A/207/ENV	A-207-ENV/021.JPG	09:55:33	05/01/2014	786606	4209741	9
FISA	A/207/ENV	A-207-ENV/022.JPG	09:55:33	05/01/2014	786606	4209741	9
FISA	A/207/ENV	A-207-ENV/023.JPG	09:55:33	05/01/2014	786606	4209741	9
FISA	A/207/ENV	A-207-ENV/024.JPG	09:55:33	05/01/2014	786606	4209741	10
FISA	A/207/ENV	A-207-ENV/025.JPG	09:55:33	05/01/2014	786606	4209741	10
FISA	A/207/ENV	A-207-ENV/026.JPG	09:55:33	05/01/2014	786606	4209741	10
FISA	A/207/ENV	A-207-ENV/027.JPG	09:58:04	05/01/2014	786607	4209750	10
FISA	A/207/ENV	A-207-ENV/028.JPG	09:58:32	05/01/2014	786602	4209757	10
FISA	A/207/ENV	A-207-ENV/029.JPG	09:59:23	05/01/2014	786592	4209765	10
FISA	A/207/ENV	A-207-ENV/030.JPG	09:59:23	05/01/2014	786592	4209765	10
FISA	A/207/ENV	A-207-ENV/031.JPG	09:59:38	05/01/2014	786591	4209766	10
FISA	A/207/ENV	A-207-ENV/032.JPG	10:00:15	05/01/2014	786590	4209768	10
FISA	A/207/ENV	A-207-ENV/033.JPG	10:00:30	05/01/2014	786588	4209769	10
FISA	A/207/ENV	A-207-ENV/034.JPG	10:00:30	05/01/2014	786588	4209769	10
FISA	A/208/ENV	A-208-ENV/00006.JPG	14:54:56	31/12/2013	773659	4228267	10
FISA	A/208/ENV	A-208-ENV/00007.JPG	14:56:12	31/12/2013	773659	4228267	10
FISA	A/208/ENV	A-208-ENV/00008.JPG	15:03:22	31/12/2013	773671	4228281	10
FISA	A/208/ENV	A-208-ENV/00009.JPG	15:06:24	31/12/2013	773678	4228291	10
FISA	A/208/ENV	A-208-ENV/00010.JPG	15:07:14	31/12/2013	773681	4228293	10
FISA	A/208/ENV	A-208-ENV/00011.JPG	15:07:14	31/12/2013	773681	4228293	10
FISA	A/208/ENV	A-208-ENV/00012.JPG	15:08:57	31/12/2013	773687	4228301	10
FISA	A/208/ENV	A-208-ENV/00013.JPG	15:10:20	31/12/2013	773691	4228304	10
FISA	A/208/ENV	A-208-ENV/00014.JPG	15:11:22	31/12/2013	773694	4228308	10
FISA	A/208/ENV	A-208-ENV/00015.JPG	15:11:57	31/12/2013	773695	4228310	10
FISA	A/208/ENV	A-208-ENV/00016.JPG	15:12:55	31/12/2013	773698	4228315	10
FISA	A/208/ENV	A-208-ENV/00017.JPG	15:14:16	31/12/2013	773702	4228321	10
FISA	A/208/ENV	A-208-ENV/00018.JPG	15:15:06	31/12/2013	773705	4228325	10
FISA	A/208/ENV	A-208-ENV/00019.JPG	15:16:01	31/12/2013	773709	4228330	10
FISA	A/208/ENV	A-208-ENV/00020.JPG	15:18:14	31/12/2013	773717	4228341	10
FISA	A/208/ENV	A-208-ENV/00021.JPG	15:18:50	31/12/2013	773720	4228344	10
FISA	A/208/ENV	A-208-ENV/00022.JPG	15:20:01	31/12/2013	773725	4228350	10
FISA	A/208/ENV	A-208-ENV/00023.JPG	15:20:57	31/12/2013	773729	4228356	10
FISA	A/208/ENV	A-208-ENV/00024.JPG	15:22:46	31/12/2013	773735	4228365	10

Site	Location	Pic Filename	Time	Date	Easting	Northing	Position rating
FISA	A/20/ENV	A-20-ENV/00003.JPG	08:32:27	03/01/2014	791008	4195279	10
FISA	A/20/ENV	A-20-ENV/00004.JPG	08:33:51	03/01/2014	791005	4195279	10
FISA	A/20/ENV	A-20-ENV/00005.JPG	08:34:37	03/01/2014	791006	4195277	10
FISA	A/20/ENV	A-20-ENV/00006.JPG	08:36:04	03/01/2014	791007	4195278	10
FISA	A/20/ENV	A-20-ENV/00007.JPG	08:36:53	03/01/2014	791007	4195277	10
FISA	A/20/ENV	A-20-ENV/00008.JPG	08:41:31	03/01/2014	791009	4195278	10
FISA	A/20/ENV	A-20-ENV/00009.JPG	08:42:17	03/01/2014	791009	4195279	10
FISA	A/20/ENV	A-20-ENV/00010.JPG	08:43:17	03/01/2014	791013	4195281	10
FISA	A/20/ENV	A-20-ENV/00011.JPG	08:44:02	03/01/2014	791016	4195284	10
FISA	A/20/ENV	A-20-ENV/00012.JPG	08:45:15	03/01/2014	791018	4195287	10
FISA	A/20/ENV	A-20-ENV/00013.JPG	08:47:07	03/01/2014	791023	4195293	10
FISA	A/20/ENV	A-20-ENV/00014.JPG	08:47:55	03/01/2014	791026	4195298	10
FISA	A/20/ENV	A-20-ENV/00015.JPG	08:48:35	03/01/2014	791029	4195301	10
FISA	A/20/ENV	A-20-ENV/00016.JPG	08:49:44	03/01/2014	791037	4195305	10
FISA	A/20/ENV	A-20-ENV/00017.JPG	08:50:57	03/01/2014	791042	4195311	10
FISA	A/20/ENV	A-20-ENV/00018.JPG	08:51:54	03/01/2014	791047	4195316	10
FISA	A/20/ENV	A-20-ENV/00019.JPG	08:53:28	03/01/2014	791055	4195320	10
FISA	A/21/ENV	A-21-ENV/004.JPG	02:30:31	14/01/2014	798261	4195360	10
FISA	A/21/ENV	A-21-ENV/005.JPG	02:31:20	14/01/2014	798262	4195362	10
FISA	A/21/ENV	A-21-ENV/006.JPG	02:32:04	14/01/2014	798265	4195360	10
FISA	A/21/ENV	A-21-ENV/007.JPG	02:33:41	14/01/2014	798266	4195359	10
FISA	A/21/ENV	A-21-ENV/008.JPG	02:34:05	14/01/2014	798265	4195359	10
FISA	A/21/ENV	A-21-ENV/009.JPG	02:34:33	14/01/2014	798264	4195360	10
FISA	A/21/ENV	A-21-ENV/010.JPG	02:35:14	14/01/2014	798264	4195363	10
FISA	A/21/ENV	A-21-ENV/011.JPG	02:36:38	14/01/2014	798261	4195369	10
FISA	A/21/ENV	A-21-ENV/012.JPG	02:38:19	14/01/2014	798259	4195370	10
FISA	A/21/ENV	A-21-ENV/013.JPG	02:39:16	14/01/2014	798259	4195371	10
FISA	A/21/ENV	A-21-ENV/014.JPG	02:43:18	14/01/2014	798243	4195385	10
FISA	A/21/ENV	A-21-ENV/015.JPG	02:45:11	14/01/2014	798241	4195397	10
FISA	A/21/ENV	A-21-ENV/016.JPG	02:45:51	14/01/2014	798235	4195401	10
FISA	A/21/ENV	A-21-ENV/017.JPG	02:46:15	14/01/2014	798232	4195403	10
FISA	A/21/ENV	A-21-ENV/018.JPG	02:47:52	14/01/2014	798221	4195410	10
FISA	A/21/ENV	A-21-ENV/019.JPG	02:48:24	14/01/2014	798217	4195412	10
FISA	A/21/ENV	A-21-ENV/020.JPG	02:49:17	14/01/2014	798211	4195416	10
FISA	A/21/ENV	A-21-ENV/021.JPG	02:49:25	14/01/2014	798211	4195416	10
FISA	A/21/ENV	A-21-ENV/022.JPG	02:51:10	14/01/2014	798204	4195421	10
FISA	A/21/ENV	A-21-ENV/023.JPG	02:51:10	14/01/2014	798204	4195421	10
FISA	A/21/ENV	A-21-ENV/024.JPG	02:51:30	14/01/2014	798201	4195423	10
FISA	A/21/ENV	A-21-ENV/025.JPG	02:52:47	14/01/2014	798190	4195434	10
FISA	A/21/ENV	A-21-ENV/026.JPG	02:53:27	14/01/2014	798185	4195439	10
FISA	A/21/ENV	A-21-ENV/027.JPG	02:54:07	14/01/2014	798180	4195442	10
FISA	A/21/ENV	A-21-ENV/028.JPG	02:54:40	14/01/2014	798177	4195445	10
FISA	A/21/ENV	A-21-ENV/029.JPG	02:55:32	14/01/2014	798170	4195452	10
FISA	A/21/ENV	A-21-ENV/030.JPG	02:56:12	14/01/2014	798165	4195457	10
FISA	A/22/ENV	A-22-ENV//002.JPG	18:08:06	01/02/2014	768009	4163221	10
FISA	A/22/ENV	A-22-ENV//003.JPG	18:10:03	01/02/2014	767851	4163299	10
FISA	A/22/ENV	A-22-ENV//004.JPG	18:12:49	01/02/2014	768020	4163207	10
FISA	A/22/ENV	A-22-ENV//005.JPG	18:14:05	01/02/2014	768023	4163219	10
FISA	A/22/ENV	A-22-ENV//006.JPG	18:14:58	01/02/2014	768017	4163242	10
FISA	A/22/ENV	A-22-ENV//007.JPG	18:15:30	01/02/2014	768038	4163200	10
FISA	A/22/ENV	A-22-ENV//008.JPG	18:16:59	01/02/2014	768037	4163237	10
FISA	A/22/ENV	A-22-ENV//009.JPG	18:18:11	01/02/2014	768041	4163255	10
FISA	A/22/ENV	A-22-ENV//010.JPG	18:19:12	01/02/2014	768019	4163321	10
FISA	A/22/ENV	A-22-ENV//011.JPG	18:20:40	01/02/2014	768032	4163339	10
FISA	A/22/ENV	A-22-ENV//012.JPG	18:21:29	01/02/2014	767893	4163428	10
FISA	A/22/ENV	A-22-ENV//013.JPG	18:22:46	01/02/2014	768051	4163350	10
FISA	A/22/ENV	A-22-ENV//014.JPG	18:23:14	01/02/2014	768034	4163389	10
FISA	A/22/ENV	A-22-ENV//015.JPG	18:23:58	01/02/2014	768051	4163383	10
FISA	A/22/ENV	A-22-ENV//016.JPG	18:24:18	01/02/2014	768057	4163230	10

Site	Location	Pic Filename	Time	Date	Easting	Northing	Position rating
FISA	A/22/ENV	A-22-ENV//017.JPG	18:24:59	01/02/2014	768057	4163396	10
FISA	A/22/ENV	A-22-ENV//018.JPG	18:25:43	01/02/2014	768064	4163400	10
FISA	A/22/ENV	A-22-ENV//019.JPG	18:26:03	01/02/2014	768056	4163427	10
FISA	A/22/ENV	A-22-ENV//020.JPG	18:27:04	01/02/2014	768063	4163441	10
FISA	A/22/ENV	A-22-ENV//021.JPG	18:28:32	01/02/2014	768065	4163475	10
FISA	A/22/ENV	A-22-ENV//022.JPG	18:29:29	01/02/2014	768089	4163439	10
FISA	A/22/ENV	A-22-ENV//023.JPG	18:30:13	01/02/2014	768052	4163537	10
FISA	A/22/ENV	A-22-ENV//024.JPG	18:30:42	01/02/2014	768076	4163512	10
FISA	A/22/ENV	A-22-ENV//025.JPG	18:31:50	01/02/2014	768089	4163518	10
FISA	A/22/ENV	A-22-ENV//026.JPG	18:32:18	01/02/2014	768073	4163561	10
FISA	A/22/ENV	A-22-ENV//027.JPG	18:32:51	01/02/2014	768082	4163559	10
FISA	A/26/ENV	A-26-ENV/002.JPG	04:17:38	05/01/2014	783883	4207355	10
FISA	A/26/ENV	A-26-ENV/003.JPG	04:18:25	05/01/2014	783881	4207352	10
FISA	A/26/ENV	A-26-ENV/004.JPG	04:19:54	05/01/2014	783858	4207354	10
FISA	A/26/ENV	A-26-ENV/005.JPG	04:20:26	05/01/2014	783847	4207357	10
FISA	A/26/ENV	A-26-ENV/006.JPG	04:20:52	05/01/2014	783841	4207357	10
FISA	A/26/ENV	A-26-ENV/007.JPG	04:21:10	05/01/2014	783837	4207358	10
FISA	A/26/ENV	A-26-ENV/008.JPG	04:22:23	05/01/2014	783819	4207356	10
FISA	A/26/ENV	A-26-ENV/009.JPG	04:23:15	05/01/2014	783807	4207354	10
FISA	A/26/ENV	A-26-ENV/010.JPG	04:25:01	05/01/2014	783779	4207357	10
FISA	A/26/ENV	A-26-ENV/011.JPG	04:26:36	05/01/2014	783747	4207361	10
FISA	A/26/ENV	A-26-ENV/012.JPG	04:28:03	05/01/2014	783715	4207363	10
FISA	A/26/ENV	A-26-ENV/013.JPG	04:28:33	05/01/2014	783707	4207360	10
FISA	A/26/ENV	A-26-ENV/014.JPG	04:29:07	05/01/2014	783694	4207362	10
FISA	A/26/ENV	A-26-ENV/015.JPG	04:31:07	05/01/2014	783651	4207358	10
FISA	A/26/ENV	A-26-ENV/016.JPG	04:31:32	05/01/2014	783642	4207359	10
FISA	A/26/ENV	A-26-ENV/017.JPG	04:32:36	05/01/2014	783620	4207361	10
FISA	A/26/ENV	A-26-ENV/018.JPG	04:33:19	05/01/2014	783604	4207360	10
FISA	A/26/ENV	A-26-ENV/019.JPG	04:34:04	05/01/2014	783586	4207360	10
FISA	A/27/ENV	A-27-ENV/003.JPG	06:45:03	09/01/2014	792429	4213811	10
FISA	A/27/ENV	A-27-ENV/004.JPG	06:45:13	09/01/2014	792429	4213811	10
FISA	A/27/ENV	A-27-ENV/005.JPG	06:50:15	09/01/2014	792431	4213802	10
FISA	A/27/ENV	A-27-ENV/006.JPG	06:53:45	09/01/2014	792427	4213816	10
FISA	A/27/ENV	A-27-ENV/007.JPG	06:54:36	09/01/2014	792427	4213820	10
FISA	A/27/ENV	A-27-ENV/008.JPG	06:55:04	09/01/2014	792427	4213821	10
FISA	A/27/ENV	A-27-ENV/009.JPG	06:55:36	09/01/2014	792427	4213824	10
FISA	A/27/ENV	A-27-ENV/010.JPG	06:56:12	09/01/2014	792427	4213830	10
FISA	A/27/ENV	A-27-ENV/011.JPG	06:56:57	09/01/2014	792427	4213840	10
FISA	A/27/ENV	A-27-ENV/012.JPG	06:58:34	09/01/2014	792424	4213854	10
FISA	A/27/ENV	A-27-ENV/013.JPG	06:58:34	09/01/2014	792424	4213854	10
FISA	A/27/ENV	A-27-ENV/014.JPG	06:59:08	09/01/2014	792425	4213859	10
FISA	A/27/ENV	A-27-ENV/015.JPG	07:00:08	09/01/2014	792427	4213868	10
FISA	A/27/ENV	A-27-ENV/016.JPG	07:00:10	09/01/2014	792427	4213868	10
FISA	A/27/ENV	A-27-ENV/017.JPG	07:01:03	09/01/2014	792428	4213874	10
FISA	A/27/ENV	A-27-ENV/018.JPG	07:01:53	09/01/2014	792426	4213880	10
FISA	A/27/ENV	A-27-ENV/019.JPG	07:02:52	09/01/2014	792424	4213887	10
FISA	A/27/ENV	A-27-ENV/020.JPG	07:03:22	09/01/2014	792423	4213890	10
FISA	A/27/ENV	A-27-ENV/021.JPG	07:04:04	09/01/2014	792422	4213896	10
FISA	A/27/ENV	A-27-ENV/022.JPG	07:05:17	09/01/2014	792420	4213909	10
FISA	A/27/ENV	A-27-ENV/023.JPG	07:05:47	09/01/2014	792421	4213916	10
FISA	A/27/ENV	A-27-ENV/024.JPG	07:06:34	09/01/2014	792424	4213928	10
FISA	A/27/ENV	A-27-ENV/025.JPG	07:06:34	09/01/2014	792424	4213928	10
FISA	A/27/ENV	A-27-ENV/026.JPG	07:07:36	09/01/2014	792428	4213940	10
FISA	A/27/ENV	A-27-ENV/027.JPG	07:07:36	09/01/2014	792428	4213940	10
FISA	A/3010/ENV	A-3010-ENV//002.JPG	13:47:35	05/02/2014	773456	4162973	10
FISA	A/3010/ENV	A-3010-ENV//003.JPG	13:48:44	05/02/2014	773456	4162969	10
FISA	A/3010/ENV	A-3010-ENV//004.JPG	13:55:03	05/02/2014	773468	4163019	10
FISA	A/3010/ENV	A-3010-ENV//005.JPG	13:58:21	05/02/2014	773484	4163067	10
FISA	A/3010/ENV	A-3010-ENV//006.JPG	13:59:49	05/02/2014	773495	4163094	10

Site	Location	Pic Filename	Time	Date	Easting	Northing	Position rating
FISA	A/3010/ENV	A-3010-ENV//007.JPG	14:02:03	05/02/2014	773507	4163139	10
FISA	A/3010/ENV	A-3010-ENV//008.JPG	14:02:51	05/02/2014	773512	4163153	10
FISA	A/3010/ENV	A-3010-ENV//009.JPG	14:03:23	05/02/2014	773516	4163164	10
FISA	A/3010/ENV	A-3010-ENV//010.JPG	14:06:25	05/02/2014	773538	4163228	10
FISA	A/3010/ENV	A-3010-ENV//011.JPG	14:07:21	05/02/2014	773544	4163253	10
FISA	A/3010/ENV	A-3010-ENV//012.JPG	14:09:02	05/02/2014	773554	4163286	10
FISA	A/3010/ENV	A-3010-ENV//013.JPG	14:09:42	05/02/2014	773559	4163299	10
FISA	A/3010/ENV	A-3010-ENV//014.JPG	14:10:19	05/02/2014	773562	4163313	10
FISA	A/3010/ENV	A-3010-ENV//015.JPG	14:10:47	05/02/2014	773567	4163324	10
FISA	A/3010/ENV	A-3010-ENV//016.JPG	14:11:23	05/02/2014	773571	4163340	10
FISA	A/3010/ENV	A-3010-ENV//017.JPG	14:12:24	05/02/2014	773573	4163360	10
FISA	A/3010/ENV	A-3010-ENV//018.JPG	14:12:44	05/02/2014	773580	4163367	10
FISA	A/3010/ENV	A-3010-ENV//019.JPG	14:13:28	05/02/2014	773586	4163385	10
FISA	A/301/ENV	A-301-ENV/002.JPG	00:24:21	09/01/2014	790831	4215005	8
FISA	A/301/ENV	A-301-ENV/003.JPG	00:24:21	09/01/2014	790831	4215005	8
FISA	A/301/ENV	A-301-ENV/004.JPG	00:24:21	09/01/2014	790831	4215005	9
FISA	A/301/ENV	A-301-ENV/005.JPG	00:24:21	09/01/2014	790831	4215005	9
FISA	A/301/ENV	A-301-ENV/006.JPG	00:24:21	09/01/2014	790831	4215005	9
FISA	A/301/ENV	A-301-ENV/007.JPG	00:24:21	09/01/2014	790831	4215005	9
FISA	A/301/ENV	A-301-ENV/008.JPG	00:24:21	09/01/2014	790831	4215005	10
FISA	A/301/ENV	A-301-ENV/009.JPG	00:24:21	09/01/2014	790831	4215005	10
FISA	A/301/ENV	A-301-ENV/010.JPG	00:24:21	09/01/2014	790831	4215005	10
FISA	A/301/ENV	A-301-ENV/011.JPG	00:25:42	09/01/2014	790830	4215003	10
FISA	A/301/ENV	A-301-ENV/012.JPG	00:26:39	09/01/2014	790832	4215009	10
FISA	A/301/ENV	A-301-ENV/013.JPG	00:28:40	09/01/2014	790833	4215007	10
FISA	A/301/ENV	A-301-ENV/014.JPG	00:30:08	09/01/2014	790833	4215008	10
FISA	A/301/ENV	A-301-ENV/015.JPG	00:31:37	09/01/2014	790833	4215004	10
FISA	A/301/ENV	A-301-ENV/016.JPG	00:31:53	09/01/2014	790833	4215004	10
FISA	A/301/ENV	A-301-ENV/017.JPG	00:32:50	09/01/2014	790832	4215004	10
FISA	A/301/ENV	A-301-ENV/018.JPG	00:33:06	09/01/2014	790831	4215004	10
FISA	A/301/ENV	A-301-ENV/019.JPG	00:34:18	09/01/2014	790832	4214999	10
FISA	A/301/ENV	A-301-ENV/020.JPG	00:34:34	09/01/2014	790833	4214997	10
FISA	A/301/ENV	A-301-ENV/021.JPG	00:36:35	09/01/2014	790834	4214991	10
FISA	A/301/ENV	A-301-ENV/022.JPG	00:36:35	09/01/2014	790834	4214991	10
FISA	A/301/ENV	A-301-ENV/023.JPG	00:39:09	09/01/2014	790835	4214985	10
FISA	A/301/ENV	A-301-ENV/024.JPG	00:39:09	09/01/2014	790835	4214985	10
FISA	A/301/ENV	A-301-ENV/025.JPG	00:39:41	09/01/2014	790832	4214983	10
FISA	A/301/ENV	A-301-ENV/026.JPG	00:40:21	09/01/2014	790829	4214980	10
FISA	A/301/ENV	A-301-ENV/027.JPG	00:40:46	09/01/2014	790829	4214978	10
FISA	A/301/ENV	A-301-ENV/028.JPG	00:40:46	09/01/2014	790829	4214978	10
FISA	A/301/ENV	A-301-ENV/029.JPG	00:40:46	09/01/2014	790829	4214978	10
FISA	A/301/ENV	A-301-ENV/030.JPG	00:43:27	09/01/2014	790827	4214967	10
FISA	A/301/ENV	A-301-ENV/031.JPG	00:43:27	09/01/2014	790827	4214967	10
FISA	A/301/ENV	A-301-ENV/032.JPG	00:43:35	09/01/2014	790827	4214966	10
FISA	A/301/ENV	A-301-ENV/033.JPG	00:46:00	09/01/2014	790818	4214959	10
FISA	A/301/ENV	A-301-ENV/034.JPG	00:46:00	09/01/2014	790818	4214959	10
FISA	A/302/ENV	A-302-ENV/002.JPG	20:22:16	09/01/2014	804643	4210660	8
FISA	A/302/ENV	A-302-ENV/003.JPG	20:22:16	09/01/2014	804643	4210660	9
FISA	A/302/ENV	A-302-ENV/004.JPG	20:22:16	09/01/2014	804643	4210660	9
FISA	A/302/ENV	A-302-ENV/005.JPG	20:22:16	09/01/2014	804643	4210660	9
FISA	A/302/ENV	A-302-ENV/006.JPG	20:22:16	09/01/2014	804643	4210660	10
FISA	A/302/ENV	A-302-ENV/007.JPG	20:25:22	09/01/2014	804650	4210653	10
FISA	A/302/ENV	A-302-ENV/008.JPG	20:27:23	09/01/2014	804647	4210645	10
FISA	A/302/ENV	A-302-ENV/009.JPG	20:27:23	09/01/2014	804647	4210645	10
FISA	A/302/ENV	A-302-ENV/010.JPG	20:27:23	09/01/2014	804647	4210645	10
FISA	A/302/ENV	A-302-ENV/011.JPG	20:28:52	09/01/2014	804643	4210643	10
FISA	A/302/ENV	A-302-ENV/012.JPG	20:28:52	09/01/2014	804643	4210643	10
FISA	A/302/ENV	A-302-ENV/013.JPG	20:30:25	09/01/2014	804638	4210640	10
FISA	A/302/ENV	A-302-ENV/014.JPG	20:31:57	09/01/2014	804636	4210633	10

Site	Location	Pic Filename	Time	Date	Easting	Northing	Position rating
FISA	A/302/ENV	A-302-ENV/015.JPG	20:33:10	09/01/2014	804633	4210626	10
FISA	A/302/ENV	A-302-ENV/016.JPG	20:33:54	09/01/2014	804631	4210621	10
FISA	A/302/ENV	A-302-ENV/017.JPG	20:35:07	09/01/2014	804628	4210615	10
FISA	A/302/ENV	A-302-ENV/018.JPG	20:36:28	09/01/2014	804630	4210610	10
FISA	A/302/ENV	A-302-ENV/019.JPG	20:38:12	09/01/2014	804624	4210599	10
FISA	A/302/ENV	A-302-ENV/020.JPG	20:39:05	09/01/2014	804621	4210596	10
FISA	A/302/ENV	A-302-ENV/021.JPG	20:39:49	09/01/2014	804620	4210594	10
FISA	A/302/ENV	A-302-ENV/022.JPG	20:41:34	09/01/2014	804615	4210585	10
FISA	A/302/ENV	A-302-ENV/023.JPG	20:42:31	09/01/2014	804615	4210572	10
FISA	A/303/ENV	A-303-ENV/002.JPG	13:17:26	09/01/2014	796072	4211878	10
FISA	A/303/ENV	A-303-ENV/003.JPG	13:17:32	09/01/2014	796072	4211878	10
FISA	A/303/ENV	A-303-ENV/004.JPG	13:18:11	09/01/2014	796071	4211878	10
FISA	A/303/ENV	A-303-ENV/005.JPG	13:20:52	09/01/2014	796069	4211877	10
FISA	A/303/ENV	A-303-ENV/006.JPG	13:21:58	09/01/2014	796071	4211877	10
FISA	A/303/ENV	A-303-ENV/007.JPG	13:22:19	09/01/2014	796071	4211877	10
FISA	A/303/ENV	A-303-ENV/008.JPG	13:23:02	09/01/2014	796071	4211875	10
FISA	A/303/ENV	A-303-ENV/009.JPG	13:24:33	09/01/2014	796073	4211874	10
FISA	A/303/ENV	A-303-ENV/010.JPG	13:25:06	09/01/2014	796074	4211874	10
FISA	A/303/ENV	A-303-ENV/011.JPG	13:26:24	09/01/2014	796075	4211873	10
FISA	A/303/ENV	A-303-ENV/012.JPG	13:26:49	09/01/2014	796075	4211873	10
FISA	A/303/ENV	A-303-ENV/013.JPG	13:27:46	09/01/2014	796077	4211873	10
FISA	A/303/ENV	A-303-ENV/014.JPG	13:28:35	09/01/2014	796076	4211872	10
FISA	A/303/ENV	A-303-ENV/015.JPG	13:30:27	09/01/2014	796077	4211864	10
FISA	A/303/ENV	A-303-ENV/016.JPG	13:30:48	09/01/2014	796078	4211863	10
FISA	A/303/ENV	A-303-ENV/017.JPG	13:31:21	09/01/2014	796079	4211862	10
FISA	A/303/ENV	A-303-ENV/018.JPG	13:31:21	09/01/2014	796079	4211862	10
FISA	A/303/ENV	A-303-ENV/019.JPG	13:34:50	09/01/2014	796080	4211858	10
FISA	A/303/ENV	A-303-ENV/020.JPG	13:35:14	09/01/2014	796081	4211859	10
FISA	A/303/ENV	A-303-ENV/021.JPG	13:36:08	09/01/2014	796082	4211860	10
FISA	A/303/ENV	A-303-ENV/022.JPG	13:37:54	09/01/2014	796084	4211858	10
FISA	A/303/ENV	A-303-ENV/023.JPG	13:38:43	09/01/2014	796089	4211851	10
FISA	A/303/ENV	A-303-ENV/024.JPG	13:38:43	09/01/2014	796089	4211851	10
FISA	A/303/ENV	A-303-ENV/025.JPG	13:38:43	09/01/2014	796089	4211851	10
FISA	A/303/ENV	A-303-ENV/026.JPG	13:38:43	09/01/2014	796089	4211851	9
FISA	A/303/ENV	A-303-ENV/027.JPG	13:42:48	09/01/2014	796097	4211846	10
FISA	A/303/ENV	A-303-ENV/028.JPG	13:42:48	09/01/2014	796097	4211846	10
FISA	A/303/ENV	A-303-ENV/029.JPG	13:43:45	09/01/2014	796103	4211847	10
FISA	A/303/ENV	A-303-ENV/030.JPG	13:45:19	09/01/2014	796106	4211845	10
FISA	A/303/ENV	A-303-ENV/031.JPG	13:46:11	09/01/2014	796109	4211842	10
FISA	A/304/ENV	A-304-ENV/003.JPG	16:04:16	08/01/2014	783331	4221140	9
FISA	A/304/ENV	A-304-ENV/005.JPG	16:04:16	08/01/2014	783331	4221140	9
FISA	A/304/ENV	A-304-ENV/006.JPG	16:04:16	08/01/2014	783331	4221140	10
FISA	A/304/ENV	A-304-ENV/007.JPG	16:04:16	08/01/2014	783331	4221140	10
FISA	A/304/ENV	A-304-ENV/008.JPG	16:05:28	08/01/2014	783332	4221139	10
FISA	A/304/ENV	A-304-ENV/009.JPG	16:09:51	08/01/2014	783330	4221146	10
FISA	A/304/ENV	A-304-ENV/010.JPG	16:10:47	08/01/2014	783325	4221146	10
FISA	A/304/ENV	A-304-ENV/011.JPG	16:12:08	08/01/2014	783322	4221149	10
FISA	A/304/ENV	A-304-ENV/012.JPG	16:13:20	08/01/2014	783316	4221155	10
FISA	A/304/ENV	A-304-ENV/013.JPG	16:14:21	08/01/2014	783310	4221161	10
FISA	A/304/ENV	A-304-ENV/014.JPG	16:15:54	08/01/2014	783301	4221165	10
FISA	A/304/ENV	A-304-ENV/015.JPG	16:16:06	08/01/2014	783300	4221165	10
FISA	A/304/ENV	A-304-ENV/016.JPG	16:16:50	08/01/2014	783294	4221168	10
FISA	A/304/ENV	A-304-ENV/017.JPG	16:17:14	08/01/2014	783290	4221170	10
FISA	A/304/ENV	A-304-ENV/018.JPG	16:17:43	08/01/2014	783285	4221173	10
FISA	A/304/ENV	A-304-ENV/019.JPG	16:19:23	08/01/2014	783274	4221182	10
FISA	A/304/ENV	A-304-ENV/020.JPG	16:20:04	08/01/2014	783270	4221187	10
FISA	A/305/ENV	A-305-ENV/003.JPG	06:59:48	12/01/2014	778182	4210733	10
FISA	A/305/ENV	A-305-ENV/004.JPG	07:04:16	12/01/2014	778143	4210767	10
FISA	A/305/ENV	A-305-ENV/005.JPG	07:05:06	12/01/2014	778136	4210778	10

Site	Location	Pic Filename	Time	Date	Easting	Northing	Position rating
FISA	A/305/ENV	A-305-ENV/006.JPG	07:07:19	12/01/2014	778111	4210803	10
FISA	A/305/ENV	A-305-ENV/007.JPG	07:08:31	12/01/2014	778102	4210819	10
FISA	A/305/ENV	A-305-ENV/008.JPG	07:10:14	12/01/2014	778086	4210837	10
FISA	A/305/ENV	A-305-ENV/009.JPG	07:11:42	12/01/2014	778066	4210853	10
FISA	A/305/ENV	A-305-ENV/010.JPG	07:12:36	12/01/2014	778055	4210865	10
FISA	A/305/ENV	A-305-ENV/011.JPG	07:13:35	12/01/2014	778049	4210874	10
FISA	A/305/ENV	A-305-ENV/012.JPG	07:14:59	12/01/2014	778029	4210893	10
FISA	A/305/ENV	A-305-ENV/016.JPG	07:16:41	12/01/2014	778011	4210912	10
FISA	A/305/ENV	A-305-ENV/017.JPG	07:17:04	12/01/2014	778007	4210916	10
FISA	A/305/ENV	A-305-ENV/018.JPG	07:17:48	12/01/2014	777999	4210924	10
FISA	A/305/ENV	A-305-ENV/020.JPG	07:18:45	12/01/2014	777990	4210936	10
FISA	A/305/ENV	A-305-ENV/021.JPG	07:19:17	12/01/2014	777983	4210939	10
FISA	A/305/ENV	A-305-ENV/022.JPG	07:19:53	12/01/2014	777979	4210939	10
FISA	A/305/ENV	A-305-ENV/023.JPG	07:20:19	12/01/2014	777972	4210943	10
FISA	A/305/ENV	A-305-ENV/024.JPG	07:21:10	12/01/2014	777961	4210956	10
FISA	A/305/ENV	A-305-ENV/025.JPG	07:21:48	12/01/2014	777955	4210965	10
FISA	A/305/ENV	A-305-ENV/027.JPG	07:22:51	12/01/2014	777944	4210977	10
FISA	A/305/ENV	A-305-ENV/028.JPG	07:23:09	12/01/2014	777941	4210981	10
FISA	A/305/ENV	A-305-ENV/029.JPG	07:23:38	12/01/2014	777934	4210988	10
FISA	A/305/ENV	A-305-ENV/030.JPG	07:24:29	12/01/2014	777928	4210996	10
FISA	A/305/ENV	A-305-ENV/031.JPG	07:25:00	12/01/2014	777923	4211004	10
FISA	A/306/ENV	A-306-ENV/002.JPG	13:43:46	12/01/2014	796888	4206284	10
FISA	A/306/ENV	A-306-ENV/003.JPG	13:44:34	12/01/2014	796892	4206279	10
FISA	A/306/ENV	A-306-ENV/004.JPG	13:44:34	12/01/2014	796892	4206279	10
FISA	A/306/ENV	A-306-ENV/005.JPG	13:48:32	12/01/2014	796887	4206280	9
FISA	A/306/ENV	A-306-ENV/006.JPG	13:48:32	12/01/2014	796887	4206280	10
FISA	A/306/ENV	A-306-ENV/007.JPG	13:48:32	12/01/2014	796887	4206280	10
FISA	A/306/ENV	A-306-ENV/008.JPG	13:48:44	12/01/2014	796887	4206280	10
FISA	A/306/ENV	A-306-ENV/009.JPG	13:50:37	12/01/2014	796881	4206278	10
FISA	A/306/ENV	A-306-ENV/010.JPG	13:54:07	12/01/2014	796880	4206287	9
FISA	A/306/ENV	A-306-ENV/011.JPG	13:54:07	12/01/2014	796880	4206287	10
FISA	A/306/ENV	A-306-ENV/012.JPG	13:54:07	12/01/2014	796880	4206287	10
FISA	A/306/ENV	A-306-ENV/013.JPG	13:54:07	12/01/2014	796880	4206287	10
FISA	A/306/ENV	A-306-ENV/014.JPG	13:56:08	12/01/2014	796873	4206289	10
FISA	A/306/ENV	A-306-ENV/015.JPG	13:57:04	12/01/2014	796867	4206296	10
FISA	A/306/ENV	A-306-ENV/016.JPG	13:57:21	12/01/2014	796866	4206298	10
FISA	A/306/ENV	A-306-ENV/017.JPG	13:59:18	12/01/2014	796858	4206309	10
FISA	A/306/ENV	A-306-ENV/018.JPG	13:59:34	12/01/2014	796857	4206311	10
FISA	A/306/ENV	A-306-ENV/019.JPG	13:59:34	12/01/2014	796857	4206311	10
FISA	A/306/ENV	A-306-ENV/020.JPG	13:59:34	12/01/2014	796857	4206311	10
FISA	A/306/ENV	A-306-ENV/021.JPG	13:59:34	12/01/2014	796857	4206311	9
FISA	A/306/ENV	A-306-ENV/022.JPG	14:04:04	12/01/2014	796840	4206336	9
FISA	A/306/ENV	A-306-ENV/023.JPG	14:04:04	12/01/2014	796840	4206336	10
FISA	A/306/ENV	A-306-ENV/024.JPG	14:04:40	12/01/2014	796841	4206342	10
FISA	A/306/ENV	A-306-ENV/025.JPG	14:05:41	12/01/2014	796838	4206350	10
FISA	A/306/ENV	A-306-ENV/026.JPG	14:07:26	12/01/2014	796831	4206367	10
FISA	A/306/ENV	A-306-ENV/027.JPG	14:07:26	12/01/2014	796831	4206367	10
FISA	A/306/ENV	A-306-ENV/028.JPG	14:11:12	12/01/2014	796803	4206390	9
FISA	A/306/ENV	A-306-ENV/029.JPG	14:11:12	12/01/2014	796803	4206390	10
FISA	A/306/ENV	A-306-ENV/030.JPG	14:11:12	12/01/2014	796803	4206390	10
FISA	A/306/ENV	A-306-ENV/031.JPG	14:12:00	12/01/2014	796799	4206407	10
FISA	A/307/ENV	A-307-ENV/002.JPG	07:05:45	14/01/2014	793335	4187995	10
FISA	A/307/ENV	A-307-ENV/003.JPG	07:08:15	14/01/2014	793332	4188000	10
FISA	A/307/ENV	A-307-ENV/004.JPG	07:08:35	14/01/2014	793333	4188001	10
FISA	A/307/ENV	A-307-ENV/005.JPG	07:09:23	14/01/2014	793337	4188006	10
FISA	A/307/ENV	A-307-ENV/006.JPG	07:10:28	14/01/2014	793339	4188009	10
FISA	A/307/ENV	A-307-ENV/007.JPG	07:10:28	14/01/2014	793339	4188009	10
FISA	A/307/ENV	A-307-ENV/008.JPG	07:11:16	14/01/2014	793337	4188008	10
FISA	A/307/ENV	A-307-ENV/009.JPG	07:11:53	14/01/2014	793332	4188006	10

Site	Location	Pic Filename	Time	Date	Easting	Northing	Position rating
FISA	A/307/ENV	A-307-ENV/010.JPG	07:12:21	14/01/2014	793327	4188006	10
FISA	A/307/ENV	A-307-ENV/011.JPG	07:13:13	14/01/2014	793323	4188009	10
FISA	A/307/ENV	A-307-ENV/012.JPG	07:14:54	14/01/2014	793322	4188010	10
FISA	A/307/ENV	A-307-ENV/013.JPG	07:17:15	14/01/2014	793318	4188019	10
FISA	A/307/ENV	A-307-ENV/014.JPG	07:17:40	14/01/2014	793318	4188019	10
FISA	A/307/ENV	A-307-ENV/015.JPG	07:18:52	14/01/2014	793313	4188017	10
FISA	A/307/ENV	A-307-ENV/016.JPG	07:18:52	14/01/2014	793313	4188017	10
FISA	A/307/ENV	A-307-ENV/017.JPG	07:20:09	14/01/2014	793301	4188018	10
FISA	A/307/ENV	A-307-ENV/018.JPG	07:20:25	14/01/2014	793298	4188018	10
FISA	A/307/ENV	A-307-ENV/019.JPG	07:22:18	14/01/2014	793280	4188018	10
FISA	A/307/ENV	A-307-ENV/020.JPG	07:22:46	14/01/2014	793278	4188018	10
FISA	A/307/ENV	A-307-ENV/021.JPG	07:24:03	14/01/2014	793273	4188016	10
FISA	A/307/ENV	A-307-ENV/022.JPG	07:25:27	14/01/2014	793263	4188020	10
FISA	A/307/ENV	A-307-ENV/023.JPG	07:26:24	14/01/2014	793260	4188021	10
FISA	A/307/ENV	A-307-ENV/024.JPG	07:28:01	14/01/2014	793246	4188021	10
FISA	A/307/ENV	A-307-ENV/025.JPG	07:29:05	14/01/2014	793237	4188029	10
FISA	A/307/ENV	A-307-ENV/026.JPG	07:29:46	14/01/2014	793229	4188032	10
FISA	A/307/ENV	A-307-ENV/027.JPG	07:30:06	14/01/2014	793224	4188033	10
FISA	A/307/ENV	A-307-ENV/028.JPG	07:30:50	14/01/2014	793215	4188033	10
FISA	A/307/ENV	A-307-ENV/029.JPG	07:32:11	14/01/2014	793204	4188035	10
FISA	A/308/ENV	A-308-ENV/002.JPG	18:20:31	13/01/2014	784226	4192274	10
FISA	A/308/ENV	A-308-ENV/003.JPG	18:20:31	13/01/2014	784226	4192274	10
FISA	A/308/ENV	A-308-ENV/004.JPG	18:21:15	13/01/2014	784227	4192274	10
FISA	A/308/ENV	A-308-ENV/005.JPG	18:21:47	13/01/2014	784227	4192274	10
FISA	A/308/ENV	A-308-ENV/006.JPG	18:23:32	13/01/2014	784230	4192280	10
FISA	A/308/ENV	A-308-ENV/007.JPG	18:24:04	13/01/2014	784232	4192283	10
FISA	A/308/ENV	A-308-ENV/008.JPG	18:25:55	13/01/2014	784238	4192292	10
FISA	A/308/ENV	A-308-ENV/009.JPG	18:26:20	13/01/2014	784240	4192294	10
FISA	A/308/ENV	A-308-ENV/010.JPG	18:27:32	13/01/2014	784243	4192306	10
FISA	A/308/ENV	A-308-ENV/011.JPG	18:28:23	13/01/2014	784245	4192314	10
FISA	A/308/ENV	A-308-ENV/012.JPG	18:28:55	13/01/2014	784247	4192317	10
FISA	A/308/ENV	A-308-ENV/013.JPG	18:30:14	13/01/2014	784252	4192327	10
FISA	A/308/ENV	A-308-ENV/014.JPG	18:30:38	13/01/2014	784253	4192330	10
FISA	A/308/ENV	A-308-ENV/015.JPG	18:31:04	13/01/2014	784255	4192336	10
FISA	A/308/ENV	A-308-ENV/016.JPG	18:31:48	13/01/2014	784258	4192348	10
FISA	A/308/ENV	A-308-ENV/017.JPG	18:32:37	13/01/2014	784261	4192359	10
FISA	A/308/ENV	A-308-ENV/018.JPG	18:33:03	13/01/2014	784263	4192365	10
FISA	A/308/ENV	A-308-ENV/019.JPG	18:33:33	13/01/2014	784265	4192371	10
FISA	A/308/ENV	A-308-ENV/020.JPG	18:34:34	13/01/2014	784269	4192386	10
FISA	A/308/ENV	A-308-ENV/021.JPG	18:35:24	13/01/2014	784273	4192396	10
FISA	A/308/ENV	A-308-ENV/022.JPG	18:35:55	13/01/2014	784275	4192401	10
FISA	A/308/ENV	A-308-ENV/023.JPG	18:37:11	13/01/2014	784281	4192421	10
FISA	A/308/ENV	A-308-ENV/024.JPG	18:38:20	13/01/2014	784287	4192439	10
FISA	A/308/ENV	A-308-ENV/025.JPG	18:39:37	13/01/2014	784294	4192462	10
FISA	A/308/ENV	A-308-ENV/026.JPG	18:40:35	13/01/2014	784298	4192479	10
FISA	A/309/ENV	A-309-ENV/002.JPG	22:11:39	13/01/2014	791046	4193432	10
FISA	A/309/ENV	A-309-ENV/003.JPG	22:13:15	13/01/2014	791045	4193439	10
FISA	A/309/ENV	A-309-ENV/004.JPG	22:14:08	13/01/2014	791044	4193443	10
FISA	A/309/ENV	A-309-ENV/005.JPG	22:17:09	13/01/2014	791041	4193461	10
FISA	A/309/ENV	A-309-ENV/006.JPG	22:18:14	13/01/2014	791040	4193466	10
FISA	A/309/ENV	A-309-ENV/007.JPG	22:20:39	13/01/2014	791033	4193481	10
FISA	A/309/ENV	A-309-ENV/008.JPG	22:20:55	13/01/2014	791032	4193483	10
FISA	A/309/ENV	A-309-ENV/009.JPG	22:22:48	13/01/2014	791025	4193497	10
FISA	A/309/ENV	A-309-ENV/010.JPG	22:23:08	13/01/2014	791022	4193502	10
FISA	A/309/ENV	A-309-ENV/011.JPG	22:24:37	13/01/2014	791017	4193519	10
FISA	A/309/ENV	A-309-ENV/012.JPG	22:25:14	13/01/2014	791015	4193524	10
FISA	A/309/ENV	A-309-ENV/013.JPG	22:26:02	13/01/2014	791009	4193530	10
FISA	A/309/ENV	A-309-ENV/014.JPG	22:27:02	13/01/2014	791002	4193540	10
FISA	A/309/ENV	A-309-ENV/015.JPG	22:28:51	13/01/2014	790993	4193560	10

Site	Location	Pic Filename	Time	Date	Easting	Northing	Position rating
FISA	A/309/ENV	A-309-ENV/016.JPG	22:29:40	13/01/2014	790988	4193569	10
FISA	A/309/ENV	A-309-ENV/017.JPG	22:30:24	13/01/2014	790980	4193578	10
FISA	A/309/ENV	A-309-ENV/018.JPG	22:31:13	13/01/2014	790976	4193586	10
FISA	A/309/ENV	A-309-ENV/019.JPG	22:31:49	13/01/2014	790973	4193592	10
FISA	A/309/ENV	A-309-ENV/020.JPG	22:32:45	13/01/2014	790968	4193604	10

APPENDIX X - AQC CERTIFICATION OF LABORATORIES

Schedule of Accreditation

issued by

United Kingdom Accreditation Service

21 - 47 High Street, Feltham, Middlesex, TW13 4UN, UK

UKAS TESTING 1252 Accredited to ISO/IEC 17025:2005	**ENVIRONMENTAL SCIENTIFICS GROUP LIMITED** **Trading as ESG Environmental Chemistry** **Issue No:** 059 **Issue date:** 30 July 2012	
	Environmental Chemistry **PO Box 100** **Bretby Business Park** **Burton-on-Trent** **Staffordshire** **DE15 0XD**	**Contact: Mr Andy Peirce** **Tel: +44 (0)1283 554542** **Fax: +44 (0)1283 554422** **E-Mail: andy.peirce@esgl.co.uk** **Website:**
Testing performed at the above address only		

DETAIL OF ACCREDITATION

Materials/Products tested	Type of test/Properties measured/Range of measurement	Standard specifications/ Equipment/Techniques used
	Chemical Tests	
SILICACIOUS MATERIALS	Oxides of: Aluminium Calcium Iron Magnesium Manganese Phosphorus Potassium Silicon Sodium Sulphur Titanium	Documented In-House Method based on Analyst:June 1985: Vol 110 by ICP-OES, No ICPASH
	Chemical Tests	
SOILS, SEDIMENTS and SLUDGES	Aluminium Arsenic Cadmium Chromium Cobalt Copper Iron Lead Manganese Molybdenum Nickel Vanadium Zinc	Documented In-House Method based on Blue Book Methods for the Examination of Waters and Associated Materials. Determination of Metals in Soils, Sediments and Sewage Sludge and Plants using ICP-OES, No ICPSOIL

1252 Accredited to ISO/IEC 17025:2005	**Schedule of Accreditation** issued by **United Kingdom Accreditation Service** 21 - 47 High Street, Feltham, Middlesex, TW13 4UN, UK **ENVIRONMENTAL SCIENTIFICS GROUP LIMITED** **Trading as ESG Environmental Chemistry** **Issue No:** 059 **Issue date:** 30 July 2012

Testing performed at main address only

Materials/Products tested	Type of test/Properties measured/Range of measurement	Standard specifications/ Equipment/Techniques used
SOILS, SEDIMENTS and SLUDGES (cont'd)	Chemical Tests (cont'd)	
SOILS ONLY (includes made ground)	Calcium Magnesium Sodium Potassium Strontium Phosphorus	
SOILS ONLY	Antimony Arsenic Cadmium Chromium Cobalt Copper Lead Manganese Mercury Molybdenum Nickel Selenium Thallium Uranium Vanadium Zinc	Documented In-House Method using ICPMS, No ICPMSS
MARINE SEDIMENTS	Arsenic Tin Lead Copper	Documented in house method: ICPSEDEXT - Hydrofluoric acid digestion followed by ICPMSSED analysis by ICPMS
	Lithium Aluminium Barium Iron Manganese Strontium Chromium Nickel Vanadium Zinc	Documented in house method: ICPSEDEXT - Hydrofluoric acid digestion followed by ICPSED analysis by ICPOES

United Kingdom Accreditation Service

ACCREDITATION CERTIFICATE

UKAS
UNITED KINGDOM ACCREDITATION SERVICE

TESTING LABORATORY
No. 1205

Environmental Scientifics Group Limited
Trading as TES Bretby

is accredited in accordance with the recognised International Standard ISO/IEC 17025:2005
General Requirements for the competence of testing and calibration laboratories.

This accreditation demonstrates technical competence for a defined scope as detailed in and at the locations specified in the schedule to this certificate, and the operation of a laboratory quality management system (refer joint ISO-ILAC-IAF Communiqué dated 18 June 2005).

The schedule to this certificate is an essential accreditation document and from time to time may be revised and reissued by the United Kingdom Accreditation Service. The most recent issue of the schedule of accreditation, which bears the same accreditation number as this certificate, is available from the UKAS website www.ukas.org.

This accreditation is subject to continuing conformity with United Kingdom Accreditation Service requirements. The absence of a schedule on the UKAS website indicates that the accreditation is no longer in force.

R Beltson

Accreditation Manager, United Kingdom Accreditation Service

Initial Accreditation date
12 October 1992

This certificate issued on
01 November 2010

The Department for Innovation, Universities and Skills (DIUS) has entered into a memorandum of understanding with the United Kingdom Accreditation Service (UKAS) through which UKAS is recognised as the national body responsible for assessing and accrediting the competence of organisations in the fields of calibration, testing, inspection and certification of systems, products and persons

Aquatic Environments
Quarry Bank Cottage
Harehope Quarry
Frosterley
Weardale
Co. Durham
DL13 2SG

Tel: 01388 528 015 / 528599 or 07813786503
tom@aquatic-environments.co.uk

Benthic Solutions Limited
Elanco Works
Marsh Road
Hoveton
Norfolk, NR12 8UH
Tel: +44 (0) 1603 784726
Mobile: +44 (0) 7786 361136

31/08/14

Dear Ian,

Please find below the results of the Falklands macrobenthic sample AQC process.

R.E. Falklands AQC Results

Benthic Solutions' sample code	Taxa found by Aquatic Environments	Aquatic Environments comments
A18	1x Copepoda	Very clean sample, well sorted.
A202	Nothing	Very clean sample, well sorted.
A302	1x Melinninae 1x Syllidae	Very small specimens. Very clean sample well sorted.
T10	1x Copepod 1x Ostracoda 1x Gastropoda	Very clean sample well sorted. Gastropod similar size to a UK Hydrobia.
T301	1x Copepoda	Very clean sample, well sorted.
T305	Nothing	Very clean sample, well sorted.

Yours sincerely

Tom Mercer
Principal Consultant

APPENDIX XI – PEARSONS CORRELATION

Pearson Product Moment Correlation Coefficient	Aluminium ($mg.g^{-1}$)	Arsenic	Barium	Chromium	Copper	Iron ($mg.g^{-1}$)	Lead	Mercury	Nickel	Vanadium	Zinc	Parent to derivative ratio	Total Oil ($ug.g^{-1}$)	Total n alkanes ($ug.g^{-1}$)	Carbon Preference Index	P/B Ratio	Proportion of Alkanes (%)	Total PAHs	NPD PAHs (ng.g-1)	Total Organic Carbon (% dwt)
A/09/ENV	26	11	306	136.7	16.8	118	5.6	0.02	9.8	77.2	69.8	0.18	2.5	0.19	1.37	0.81	7.50	53.53	28.96	0.11
A/12/ENV	25	10.2	291	133	13.9	112	6.1	0.01	15.3	76.2	139.9	0.22	5.8	0.44	1.24	0.76	7.51	102.85	52.88	0.21
A/14/ENV	25	11.1	250	136.3	14.5	131	6.2	0.01	10.6	74.8	70.7	0.18	2.2	0.21	1.25	0.80	9.47	56.73	29.77	0.17
A/18/ENV	21	11.1	253	140.2	15.7	135	5.9	0.01	10	72.5	74	0.18	3.1	0.32	1.23	0.81	10.46	88.86	46.42	0.23
A/20/ENV	23	9.6	285	144.5	19.6	116	5.9	0.01	13.2	75.4	83.7	0.23	2.6	0.25	1.25	0.88	9.36	68.09	37.41	0.15
A/202/ENV	22	13.2	279	113.9	16.2	134	6.1	0.01	9.3	75	70.4	0.08	1.6	0.16	1.30	0.72	9.46	37.73	22.11	0.22
A/204/ENV	27	3.2	529	34.9	17	25	4.2	0.02	10.2	52.7	43.3	0.23	7.1	0.73	1.22	0.88	10.27	207.65	108.08	0.15
A/21/ENV	28	8.9	327	156.8	13.7	117	6.9	0.01	14.2	76.3	86.2	0.18	1.8	0.27	1.48	0.76	15.13	74.94	37.36	0.19
A/22/ENV	23	10.1	508	126.1	14.7	122	6.2	0.01	10.1	70	71	0.17	3.3	0.31	1.21	0.76	9.32	82.32	40.34	0.24
A/26/ENV	33	6.4	414	92.4	17.1	49	5.9	0.02	12.2	69.4	64.3	0.18	5.3	0.36	1.25	0.83	6.76	105.83	55.93	0.40
A/27/ENV	27	10.9	313	110.1	15.8	102	6.1	0.01	10.5	74	71.5	0.19	4.0	0.40	1.34	0.78	10.04	103.85	53.35	0.21
A/3/ENV	28	12.3	415	89.4	15.5	95	7.4	0.03	10.1	72.1	69.6	0.19	5.4	0.51	1.30	0.91	9.44	147.35	80.28	0.32
A/301/ENV	26.7	7.6	321	127.9	20.1	93.80	6.3	0.03	17.6	71.6	88	0.05	1.2	0.15	1.29	0.7	12.50	35.18	21.02	0.24
A/302/ENV	23.5	9.1	268	170.1	17.2	116.00	5.2	0.01	14.9	82.4	84.5	0.20	2.9	0.25	1.31	0.84	8.71	71.06	37.49	0.15
A/304/ENV	25.5	10.1	311	147.5	14.3	121.00	5.2	0.01	10.4	77.4	72.7	0.17	2.7	0.23	1.34	0.84	8.47	60.21	31.72	0.17
A/305/ENV	25.9	11.3	317	143.1	11.8	118.00	6.6	0.01	10.9	78.1	75.4	0.18	2.5	0.35	1.46	0.76	14.04	91.01	46.03	0.17
A/306/ENV	31.5	7.3	338	140.3	18.1	89.50	5.8	0.02	20.4	89.4	85	0.16	2.1	0.19	1.39	0.73	9.03	57.21	31.21	0.24
A/307/ENV	25	9.9	442	148.9	15.9	128.00	6.1	0.01	12.9	80.9	78.5	0.17	2.2	0.24	1.03	0.78	10.97	59.49	32.52	0.23
A/10/ENV	27	11.1	340	143.2	11.2	10.70	4.9	0.01	10.6	84.1	73	0.19	4.7	0.46	1.38	0.83	9.84	138.09	72.24	0.32
A/1008/ENV	25.1	8.6	351	132.3	17.4	93.90	5.4	0.01	14.4	84	88.4	0.18	1.9	0.23	1.29	0.86	12.27	63.84	33.35	0.21
A/1011/ENV	25.8	11.4	296	130.3	13.5	104.00	6.1	0.02	11.6	83.8	78.6	0.12	1.4	0.14	1.30	0.69	10.09	39.88	23.08	0.28
A/1013/ENV	24.3	4.7	365	74.1	15.8	37.80	6.7	0.02	12.6	63.2	57.9	0.19	4.4	0.42	1.36	0.78	9.70	118.88	65.76	0.27
A/1015/ENV	38.2	6.8	338	82.6	19	55.70	13.3	0.02	14.9	80.3	73.2	0.18	3.1	0.39	1.43	0.77	12.79	108.79	57.94	0.31
A/3010/ENV	21.1	12.1	233	158.4	15.6	137.00	6.6	0.01	11.1	84.5	81.8	0.20	2.4	0.27	1.16	0.89	11.15	76.12	38.88	0.11
A/303/ENV	27.1	10.3	290	130.1	12.8	102.00	5.8	0.02	12	85.3	80.8	0.11	1.9	0.18	1.33	0.74	9.19	40.26	22.63	0.2
A/309/ENV	21.1	10.3	245	185.9	18.3	128.00	5.3	0.02	13.9	87.9	83.9	0.19	2.4	0.24	1.29	0.93	9.95	62.21	31.96	0.08
Aluminium ($mg.g^{-1}$)		-0.450	0.319	-0.465	0.142	-0.557	0.605	0.428	0.356	-0.005	-0.107	-0.042	0.205	0.233	0.445	-0.235	0.106	0.261	0.275	0.589
Arsenic			-0.510	0.570	-0.424	0.667	-0.080	-0.343	-0.417	0.493	0.285	-0.194	-0.385	-0.421	-0.073	-0.021	-0.051	-0.439	-0.450	-0.194
Barium				-0.620	0.025	-0.489	-0.033	0.229	-0.112	-0.570	-0.423	0.151	0.521	0.554	-0.220	0.036	-0.021	0.567	0.567	0.394
Chromium					-0.133	0.658	-0.248	-0.427	0.209	0.752	0.516	-0.061	-0.625	-0.659	-0.026	0.050	0.087	-0.664	-0.693	-0.471
Copper						-0.006	0.204	0.377	0.480	-0.106	-0.053	-0.040	-0.103	-0.127	-0.181	0.205	-0.050	-0.106	-0.082	-0.099
Iron ($mg.g^{-1}$)							-0.089	-0.366	-0.083	0.361	0.377	-0.171	-0.601	-0.630	-0.255	-0.063	0.055	-0.679	-0.701	-0.553
Lead								0.202	0.172	0.084	0.022	-0.050	-0.093	0.051	0.305	-0.202	0.376	0.041	0.053	0.341
Mercury									0.257	-0.176	-0.214	-0.343	0.128	0.099	0.142	-0.038	-0.081	0.131	0.178	0.311
Nickel										0.362	0.509	-0.136	-0.245	-0.255	0.168	-0.247	0.170	-0.260	-0.251	0.057
Vanadium											0.474	-0.175	-0.610	-0.622	0.149	-0.068	0.078	-0.606	-0.615	-0.153
Zinc												0.001	-0.165	-0.283	-0.043	-0.192	-0.021	-0.362	-0.378	-0.137
Parent to derivative ratio													0.597	0.601	-0.089	0.674	-0.147	0.608	0.581	-0.210
Total Oil ($ug.g^{-1}$)														0.917	-0.122	0.399	-0.372	0.907	0.906	0.293
Total n alkanes ($ug.g^{-1}$)															-0.006	0.394	-0.007	0.989	0.983	0.222
Carbon Preference Index																-0.243	0.315	0.019	0.018	0.097
P/B Ratio																	-0.171	0.432	0.424	-0.302
Proportion of Alkanes (%)																		-0.022	-0.039	-0.092
Total PAHs																			0.997	0.261
NPD PAHs (ng.g-1)																				0.291
Total Organic Carbon (% dwt)																				
Water depth (m)																				
Mean (mm)																				
Mean(Phi)																				
Sorting																				
Skewness																				
Kurtosis																				
% Fines																				
% Gravel																				
Number of Species per $0.2m^2$ (S)																				
Number of Individuals per $0.2m^2$ (N)																				
Richness (Margalef)		Pearson correlation >0.497 (p=0.01, 99% significant)																		
Evenness (Pielou's Evenness)		Pearson correlation >0.389 (p=0.05, 95% significant)																		
Shannon-Wiener Diversity																				
Simpsons Diversity																				

Pearson Product Moment Correlation Coefficient	Water depth (m)	Mean (mm)	Mean(Phi)	Sorting	Skewness	Kurtosis	% Fines	% Gravel	Number of Species per $0.2m^2$ (S)	Number of Individuals per $0.2m^2$ (N)	Richness (Margalef)	Evenness (Pielou's Evenness)	Shannon-Wiener Diversity	Simpsons Diversity
A/09/ENV	1260	0.143	2.81	2.8	0.29	1.32	28.73	8.49	50	108	0.962	0.9	5.081	10.47
A/12/ENV	1280	0.224	2.16	3.61	0.12	1.43	26.47	15.98	22	25	0.99	0.988	4.404	6.524
A/14/ENV	1316	0.144	2.8	2.66	0.43	1.13	27.64	5.67	47	123	0.935	0.854	4.744	9.559
A/18/ENV	1415	0.149	2.75	2.58	0.45	1.06	27.25	3.82	41	64	0.972	0.934	5.002	9.618
A/20/ENV	1350	0.131	2.93	2.31	0.59	1.04	26.34	1.75	11	31	0.718	0.708	2.451	2.912
A/202/ENV	1153	0.088	3.51	2.6	0.47	0.78	40.47	0.15	50	117	0.963	0.895	5.052	10.29
A/204/ENV	1302	0.082	3.61	3.12	0.29	1.04	40.03	7.36	51	130	0.936	0.853	4.84	10.27
A/21/ENV	1430	0.214	2.23	2.33	0.23	2.3	17.27	9.03	39	96	0.937	0.869	4.594	8.325
A/22/ENV	1522	0.245	2.03	4.06	-0.08	1.78	26.49	17.85	24	47	0.948	0.913	4.187	5.974
A/26/ENV	1260	0.084	3.58	6.08	-0.58	2.62	66.71	16.53	50	83	0.98	0.95	5.359	11.09
A/27/ENV	1260	0.086	3.54	2.47	0.45	0.82	38.52	1.09	55	107	0.948	0.886	5.123	11.56
A/3/ENV	1134	0.045	4.48	2.68	0.06	0.78	56.11	1.20	51	102	0.97	0.921	5.224	10.81
A/301/ENV	1250	0.11	3.18	2.44	0.51	0.96	31.14	2.84	18	27	0.943	0.925	3.856	5.158
A/302/ENV	1330	0.177	2.5	2.73	0.27	1.85	22.18	11.94	39	124	0.875	0.774	4.092	7.883
A/304/ENV	1250	0.08	3.65	2.27	0.47	0.86	37.79	1.26	44	98	0.973	0.938	5.119	9.378
A/305/ENV	1267	0.073	3.77	2.6	0.31	0.86	42.79	1.78	41	84	0.962	0.919	4.922	9.028
A/306/ENV	1350	0.098	3.36	2.87	0.31	1.19	33.65	6.36	36	101	0.936	0.865	4.471	7.584
A/307/ENV	1400	0.16	2.65	2.89	0.3	1.44	25.32	11.73	34	55	0.972	0.944	4.801	8.235
A/10/ENV	1261	0.104	3.27	2.88	0.29	1.09	35.77	6.80	44	95	0.953	0.889	4.851	9.443
A/1008/ENV	1280	0.141	2.82	2.56	0.57	0.96	27.87	0.95	44	89	0.953	0.899	4.907	9.58
A/1011/ENV	1325	0.117	3.1	2.48	0.46	0.97	30.57	1.16	34	67	0.964	0.925	4.708	7.848
A/1013/ENV	1350	0.094	3.41	3.18	0.22	1.12	37.93	12.62	24	41	0.951	0.918	4.211	6.193
A/1015/ENV	1358	0.354	1.5	4.13	-0.03	0.8	27.63	27.30	51	94	0.979	0.942	5.343	11.01
A/3010/ENV	1540	0.148	2.76	2.39	0.52	1.05	25.87	3.71	39	78	0.966	0.933	4.932	8.722
A/303/ENV	1285	0.125	3	2.52	0.57	0.97	29.26	3.74	32	50	0.98	0.965	4.823	7.924
A/309/ENV	1395	0.167	2.58	1.97	0.56	1.65	20.07	1.05	16	33	0.896	0.867	3.467	4.29
Aluminium ($mg.g^{-1}$)	-0.258	0.222	-0.028	0.538	-0.562	0.067	0.369	0.526	0.391	0.256	0.284	0.234	0.407	0.412
Arsenic	-0.103	-0.086	0.054	-0.423	0.337	-0.241	-0.134	-0.458	0.080	0.023	0.075	0.090	0.117	0.090
Barium	0.000	-0.050	0.161	0.491	-0.545	0.192	0.386	0.373	0.144	0.081	0.171	0.128	0.170	0.155
Chromium	0.331	0.158	-0.323	-0.472	0.420	0.217	-0.583	-0.293	-0.380	-0.227	-0.248	-0.193	-0.351	-0.405
Copper	0.044	0.161	-0.149	0.089	0.016	0.030	-0.069	0.117	-0.204	-0.111	-0.435	-0.371	-0.391	-0.249
Iron ($mg.g^{-1}$)	0.244	0.130	-0.224	-0.450	0.405	-0.002	-0.440	-0.341	-0.202	-0.136	-0.114	-0.053	-0.165	-0.209
Lead	0.100	0.617	-0.406	0.272	-0.310	-0.170	-0.038	0.554	0.153	-0.019	0.186	0.245	0.228	0.194
Mercury	-0.334	-0.204	0.318	0.133	-0.190	-0.102	0.369	0.015	-0.058	-0.133	0.151	0.201	0.017	-0.034
Nickel	0.129	0.272	-0.297	0.025	0.008	0.185	-0.286	0.218	-0.430	-0.283	-0.181	-0.116	-0.381	-0.434
Vanadium	0.141	0.203	-0.273	-0.327	0.338	-0.043	-0.405	-0.177	-0.137	-0.092	-0.015	0.016	-0.055	-0.140
Zinc	0.063	0.362	-0.424	-0.115	0.132	0.113	-0.420	0.063	-0.461	-0.465	-0.017	0.155	-0.279	-0.396
Parent to derivative ratio	0.276	0.150	-0.121	0.139	-0.217	0.208	-0.040	0.249	0.072	0.133	-0.305	-0.327	-0.109	0.037
Total Oil ($ug.g^{-1}$)	-0.205	-0.142	0.260	0.483	-0.532	0.114	0.507	0.324	0.236	0.132	0.128	0.097	0.191	0.266
Total n alkanes ($ug.g^{-1}$)	-0.110	-0.076	0.223	0.310	-0.396	-0.042	0.387	0.276	0.289	0.199	0.119	0.052	0.216	0.303
Carbon Preference Index	-0.292	0.026	0.075	-0.090	-0.047	-0.074	0.067	0.006	0.206	0.272	0.037	-0.076	0.125	0.161
P/B Ratio	0.072	-0.133	0.152	-0.086	0.024	0.079	0.093	-0.160	0.077	0.135	-0.339	-0.343	-0.136	0.022
Proportion of Alkanes (%)	0.248	0.234	-0.192	-0.341	0.251	-0.155	-0.322	-0.087	-0.001	-0.004	0.032	0.005	0.021	-0.008
Total PAHs	-0.104	-0.110	0.257	0.327	-0.421	-0.017	0.423	0.268	0.328	0.258	0.092	0.000	0.226	0.329
NPD PAHs (ng.g-1)	-0.142	-0.138	0.290	0.325	-0.416	-0.045	0.449	0.258	0.325	0.252	0.087	0.001	0.222	0.326
Total Organic Carbon (% dwt)	-0.287	-0.049	0.194	0.643	-0.646	0.105	0.603	0.377	0.232	-0.023	0.369	0.390	0.376	0.312
Water depth (m)		0.544	-0.640	0.006	0.021	0.347	-0.600	0.314	-0.383	-0.317	-0.146	-0.071	-0.285	-0.380
Mean (mm)			-0.953	0.230	-0.209	0.254	-0.615	0.713	-0.184	-0.201	0.012	0.073	-0.101	-0.154
Mean(Phi)				-0.127	0.055	-0.322	0.759	-0.605	0.304	0.274	0.070	0.002	0.221	0.279
Sorting					-0.917	0.510	0.517	0.744	0.193	-0.006	0.282	0.313	0.293	0.260
Skewness						-0.584	-0.539	-0.734	-0.252	-0.092	-0.305	-0.283	-0.329	-0.302
Kurtosis							-0.023	0.441	-0.142	-0.084	-0.061	-0.077	-0.131	-0.140
% Fines								-0.047	0.453	0.255	0.281	0.251	0.446	0.481
% Gravel									0.021	-0.068	0.205	0.219	0.129	0.073
Number of Species per $0.2m^2$ (S)										0.870	0.483	0.182	0.863	0.982
Number of Individuals per $0.2m^2$ (N)											0.167	-0.216	0.576	0.768
Richness (Margalef)												0.909	0.839	0.603
Evenness (Pielou's Evenness)													0.642	0.344
Shannon-Wiener Diversity														0.928
Simpsons Diversity														

APPENDIX XII - SERVICE WARRANTY

This report, with its associated works and services, has been designed solely to meet the requirements of the contract agreed with you, our client. If used in other circumstances, some or all of the results may not be valid and we can accept no liability for such use. Such circumstances include different or changed objectives, use by third parties, or changes to, for example, site conditions or legislation occurring after completion of the work. In case of doubt, please consult Benthic Solutions Limited.

Appendix L: FISA12 and FIST13 MetOcean Study Report

RPS | Falkland Islands (Blocks FISA12 and FIST13). Preliminary MetOcean Study

ASA Team: Stefanie Zamorski, Eric Comerma (PM)

Table of Contents

List of Figures

List of Tables

1. Geographic Location - Area of Interest

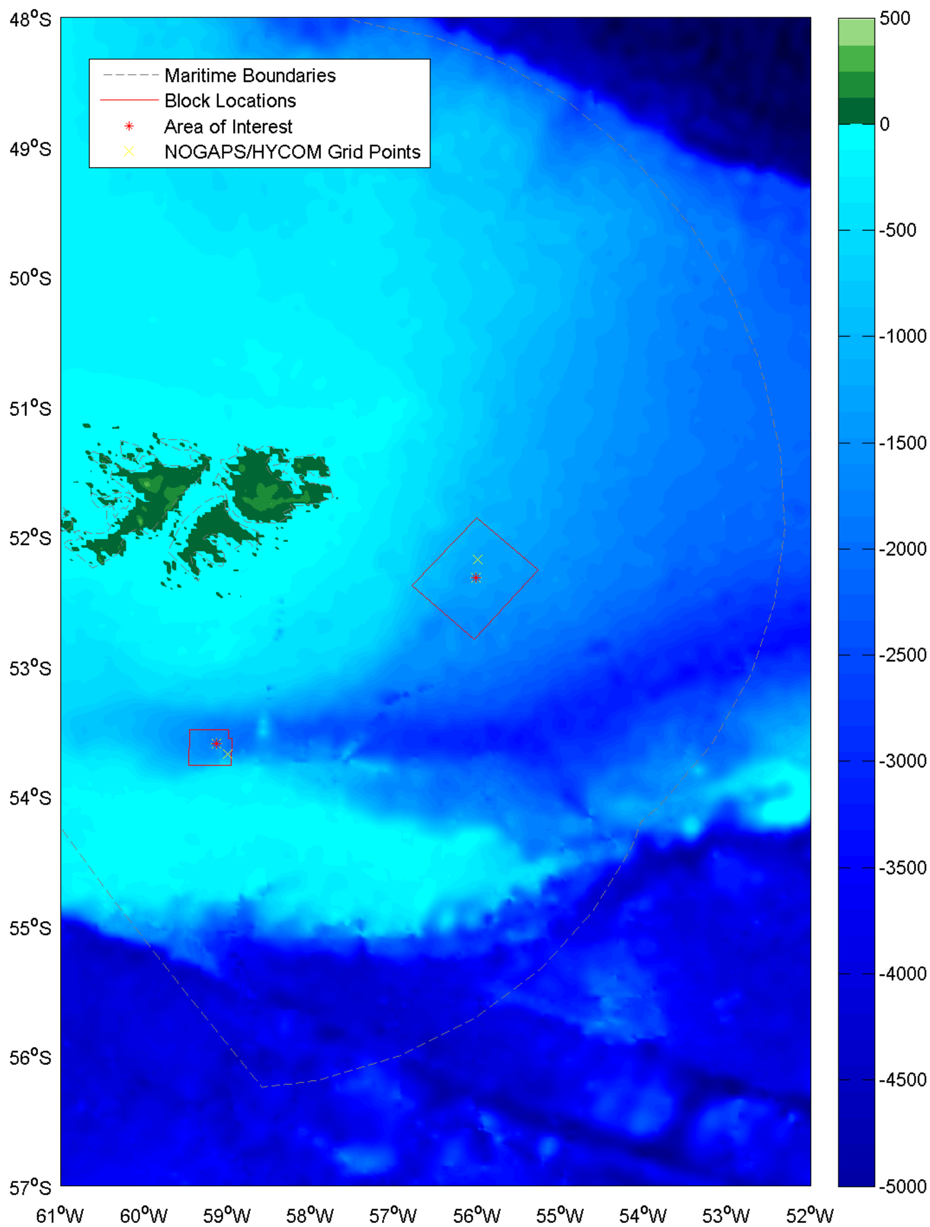


Figure 1. Location of the sites of interest with bathymetry (m).

Table 1. Coordinates of the sites of interest.

Site Name	Type / Block	Latitude	Longitude	Approximate Distance from land (km)	Approximate Water Depth (m)
FISA12	Block center	52.3228° S	56.0229° W	137 (Cape Pembroke)	1,177
FIST13	Block center	53.6032° S	59.135° W	76 (Beauchene Island)	1,527

2. Environmental Data Analysis

2.1. Bathymetry

The Falkland Islands are situated on a projection of the Patagonian continental shelf that is bounded to the north by a steep slope, called the Falklands Escarpment. The continental shelf extends around 200 km beyond the Falklands coast to the north, about 50 km to the south-west, and approximately 50-100 km offshore on the eastern side (Otley, 2008). The North Falklands Basin is a gradually north-eastward sloping area between the Falkland Islands and the Falklands Escarpment, with depths between 150 and 1,500 m (Figure 2). The South Falkland Basin is located about 200 km south of the Falkland Islands and 600 km east of the southeastern coast of South America. It lies at the southern edge of the Falkland Plateau, which is a shallow continental promontory (Bry, 2004). The Falkland Plateau extends about 1,800 km east of the Falkland Islands, bordered by the Falklands Escarpment to the north and the North Scotia Ridge to the south. The Falkland Trough lies between the plateau and the ridge, which begins as a slight depression in the continental shelf and deepens to 3,700 m (Ludwig, 1983).

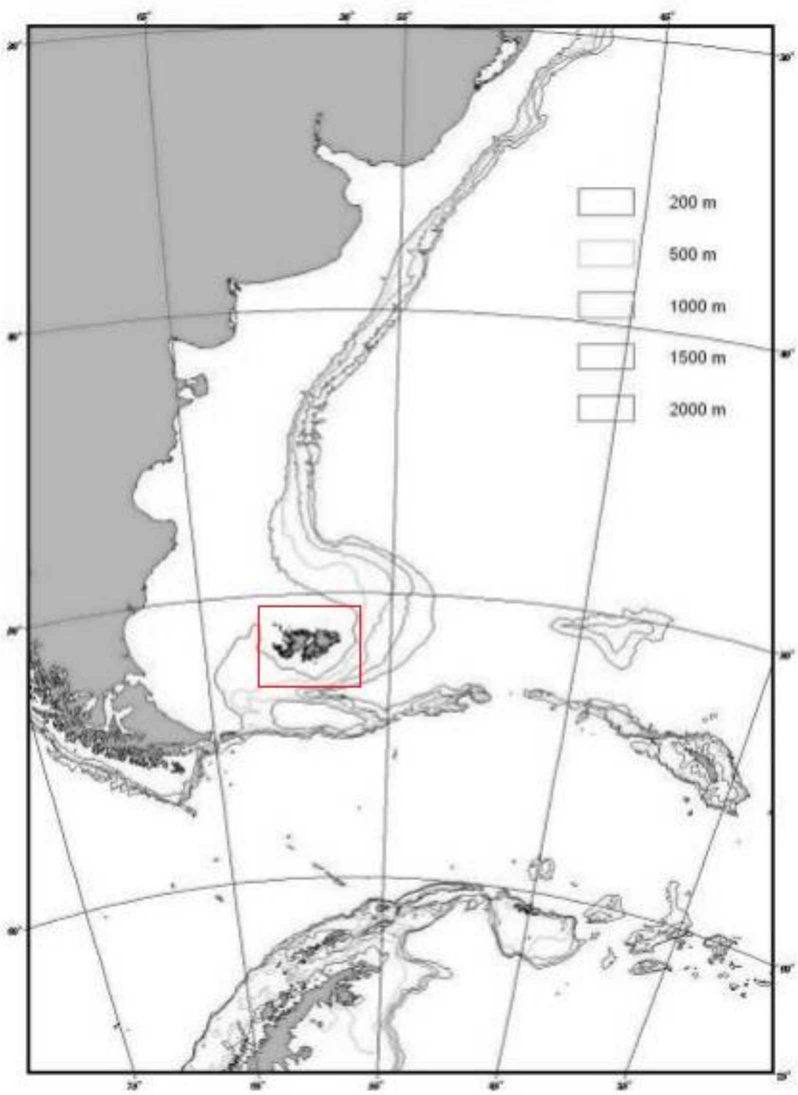


Figure 2. The location of Falkland Islands relative to South America, South Georgia and Antarctica (Otley, 2008).

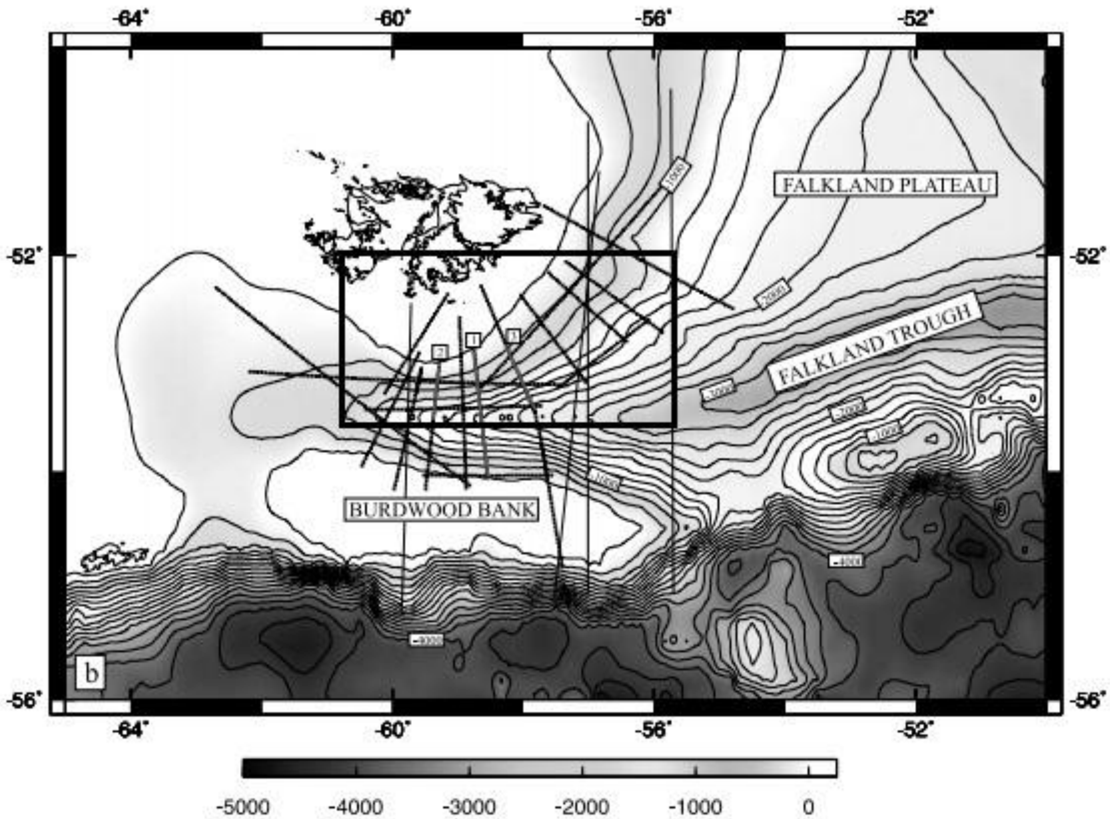


Figure 3. Bathymetry surrounding the Falkland Islands and notable bathymetry features. The South Falkland Basin is indicated by the black box (Source: Bry, 2004).

2.2. Seasonality

The weather regime in the Falkland Islands is influenced by the close proximity of the Andes to the west, the surrounding waters, particularly the cold East Falkland current moving northwards, and the presence of the Antarctic Peninsula over 1,000 km to the south. The annual mean maximum temperature is approximately 10°C and annual mean minimum temperature is approximately 3°C. The predominant wind direction is westerly, however, depressions and associated fronts move through the area frequently with wind speeds greater than 30 knots, thus causing variability in the regime. The prevailing wind direction falls in a broad arc from south-southwesterly to north-northwesterly for about 70% of the time (Upton and Shaw, 2002). When low pressure troughs accelerate towards the Falkland Islands, this leads to strong northerly winds and enhanced precipitation. This occurs more commonly during austral winter months. In general, the precipitation rate in the Falkland Islands is low, with around 625 mm annually.

2.3. Wind Dataset – NOGAPS

For this study, in the absence of an extended spatial coverage of long term observed winds, wind data was obtained from the output of the U.S. Navy Operational Global Atmospheric Prediction System (NOGAPS). The version of the NOGAPS dataset used for this modeling study is originally derived from the publically available version hosted by the U.S. Global Ocean Data Assimilation Experiment (GODAE) and subsequently has a QuikSCAT correction applied by the HYCOM Consortium. This dataset of winds at 10 m above the surface is provided at 0.5 degree horizontal resolution with a 3-hour time step provided from 2009 through 2012. NOGAPS winds were also included as one of the main driving forces used in HYCOM, the global hydrodynamic currents dataset also used in this study (Section 2.5, Current Dataset – *HYCOM Hindcast*)

Figure 4 illustrates the spatial variability of the yearly average NOGAPS wind field represented by rose diagrams. Overall, wind direction is primarily from the west and fluctuates between southwest to northwesterly winds. Wind speeds tend to be greater than 15 knots, decreasing slightly closer to the Falkland Islands.

Figure 5 provides monthly wind speed statistics (average and 95th percentile) between 2009 and 2012 for the NOGAPS wind grid point at an offshore location in the center of the FISA12 block. This site shows average monthly wind speeds between 16-21 knots, reaching peak speeds in June. The highest wind speeds occur during late austral fall-winter, with lesser values throughout austral summer. Annual and monthly wind roses for years 2009 through 2012 for the selected location in Block FISA12 are shown in Figure 6 and Figure 7. Analysis of the wind roses at this site indicates little seasonality the wind regime. The wind direction throughout the year is primarily westerly, expanding in a northwest and southwesterly arc, with an average speed around 18.5 knots. The strongest monthly winds occur in late austral fall through winter (April-August) with speeds averaging 18-20 knots and average maximum monthly values reaching 48 knots during this time. Winds weaken during the spring and summer.

The same monthly wind speed statistics (average and 95th percentile) were performed for a central grid point in the southern block, FIST13. The same trend as the northern site is seen in Figure 8. Yearly (Figure 9) and monthly (Figure 10) wind roses at the southern site show wind direction primarily from the west-northwest with a yearly average of 18.7 knots. Similar seasonality is seen compared with the northern site. Winds are stronger during the winter and predominantly from the west, with northwesterly and southwesterly components as well. During the summer (December-February), monthly averaged speeds decrease and shift direction to predominantly westerly and southwesterly. The highest monthly averages are during April through August (18.5-20 knots).

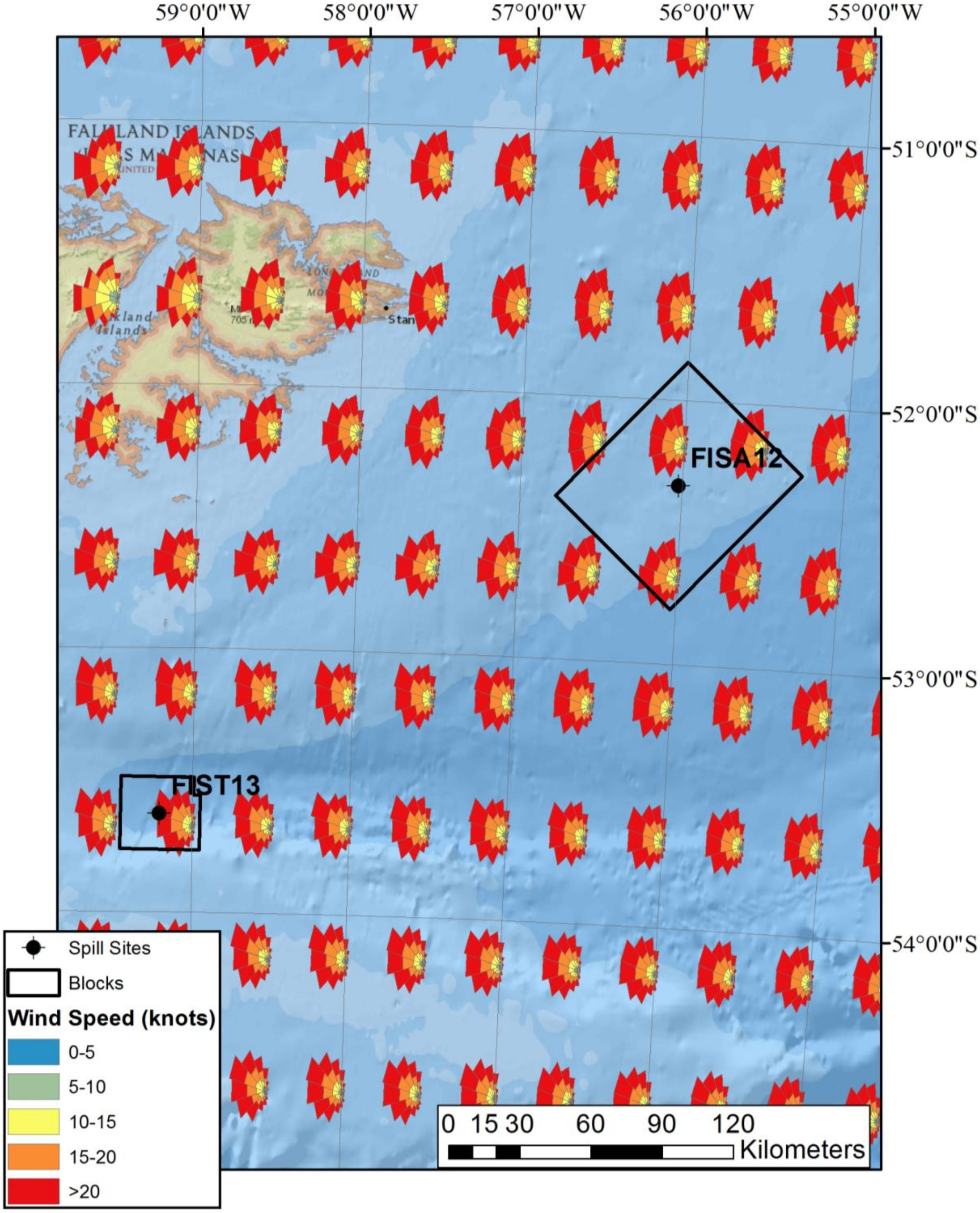


Figure 4. Spatial variability of the average NOGAPS wind field represented by rose diagrams; wind speeds in knots, using meteorological convention (i.e. direction wind is coming from).

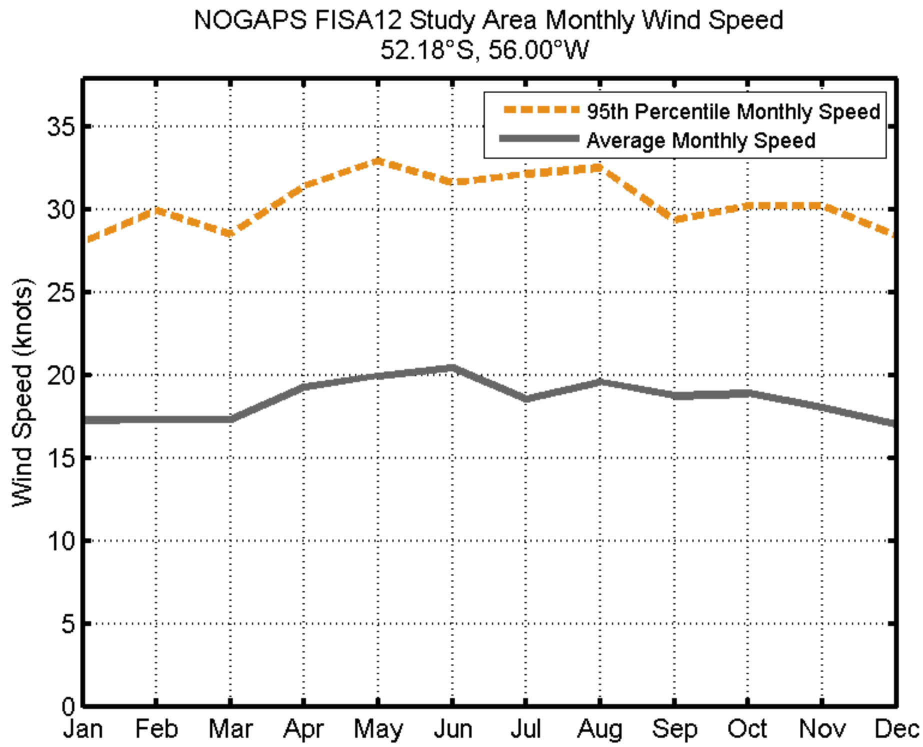


Figure 5. NOGAPS wind speed statistics: monthly average (grey solid) and 95th Percentile (orange dashed) wind speed in the FISA12 block offshore Falklands for the period of 2009-2012.

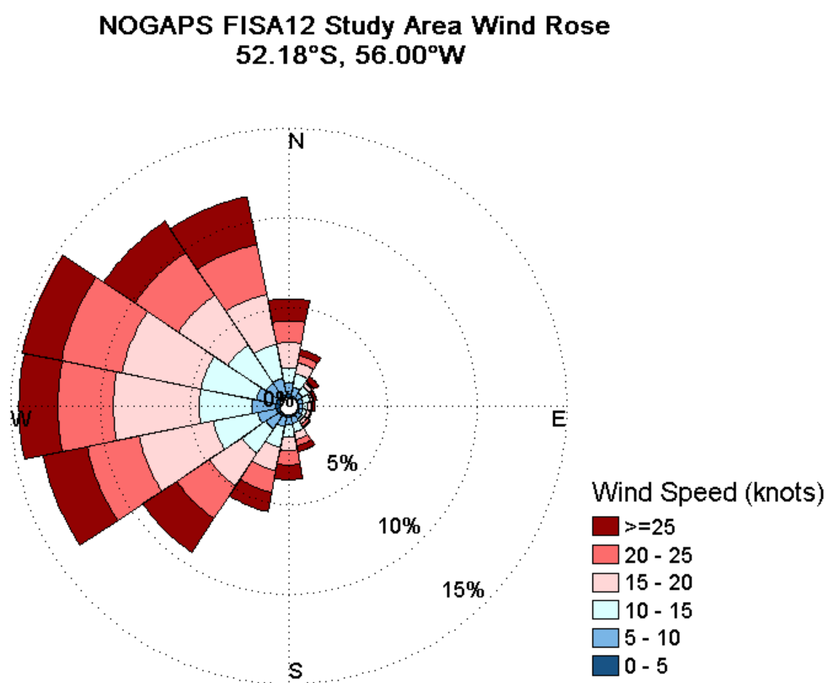


Figure 6. Yearly NOGAPS wind roses in FISA12 block offshore Falklands. Wind speeds are in knots, using meteorological convention (i.e., direction wind is coming from).

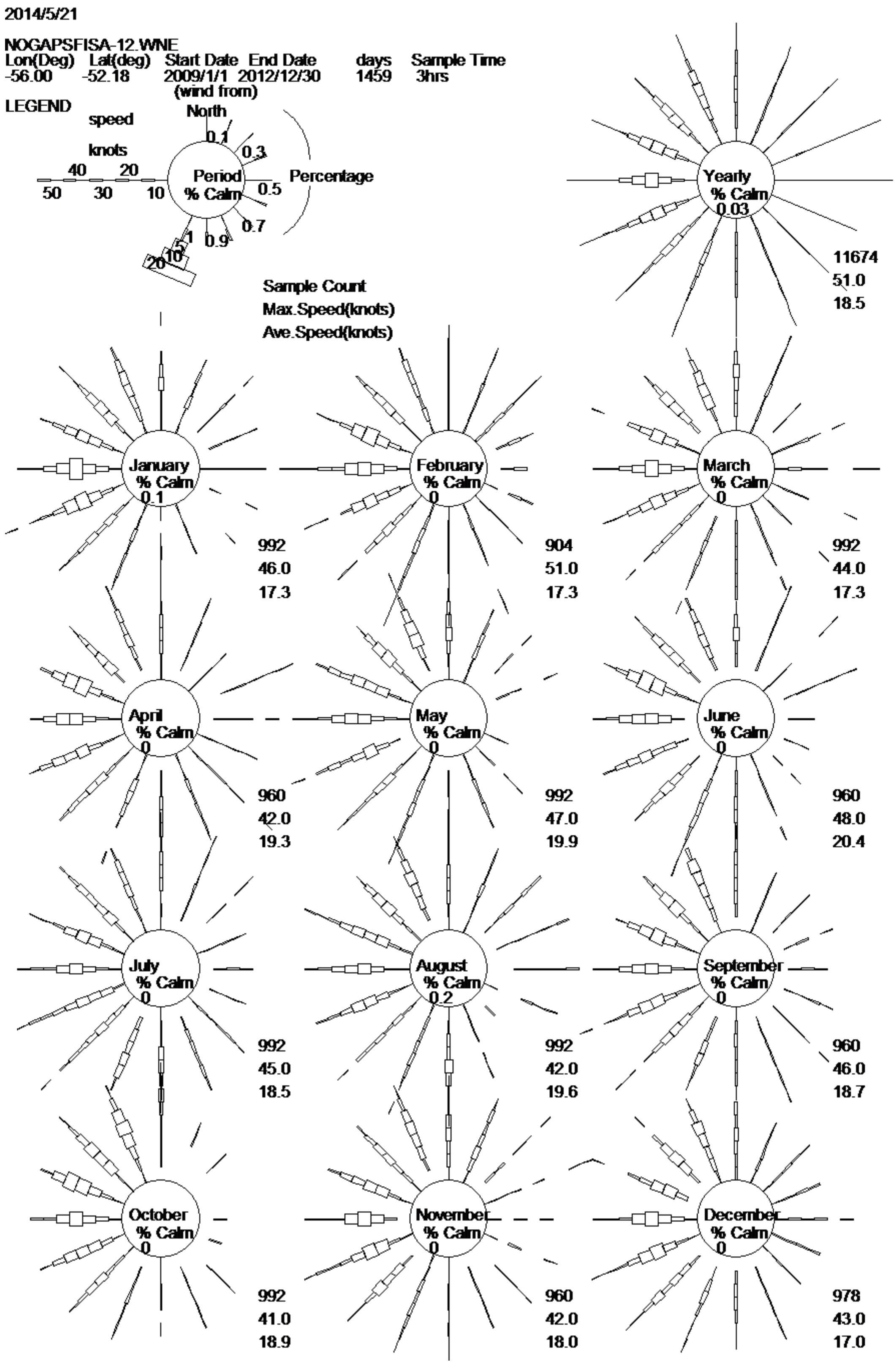


Figure 7. NOGAPS monthly and yearly wind roses for the northern grid point in FISA12 block offshore Falklands. Wind speeds are in knots, using meteorological convention (i.e., direction wind is coming from).

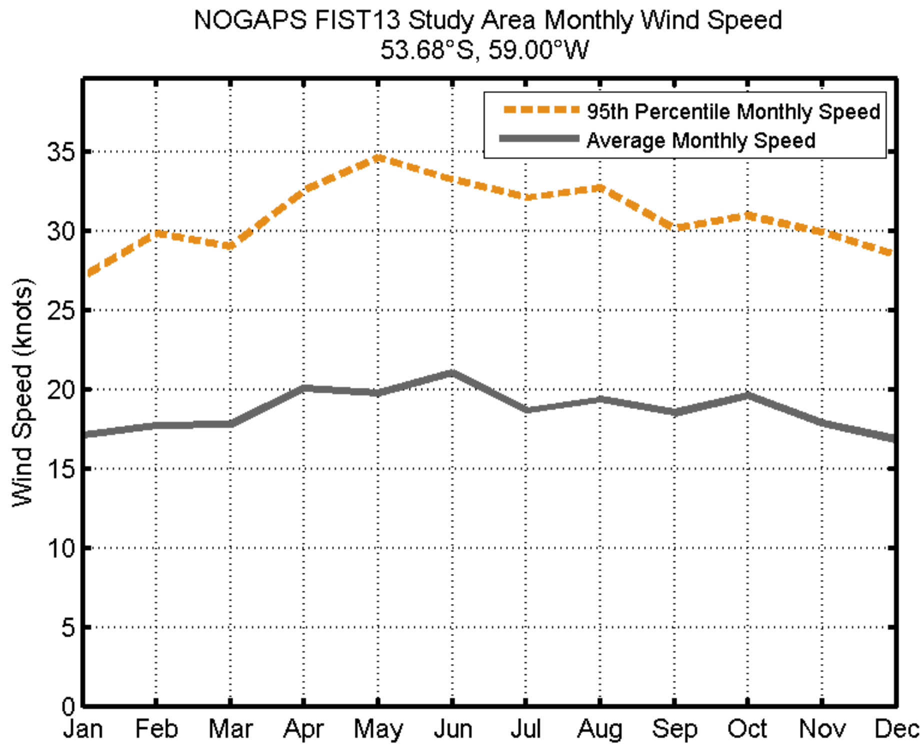


Figure 8. NOGAPS wind speed statistics: monthly average (grey solid) and 95th Percentile (orange dashed) wind speed in the FIST13 block offshore Falklands for the period of 2009-2012.

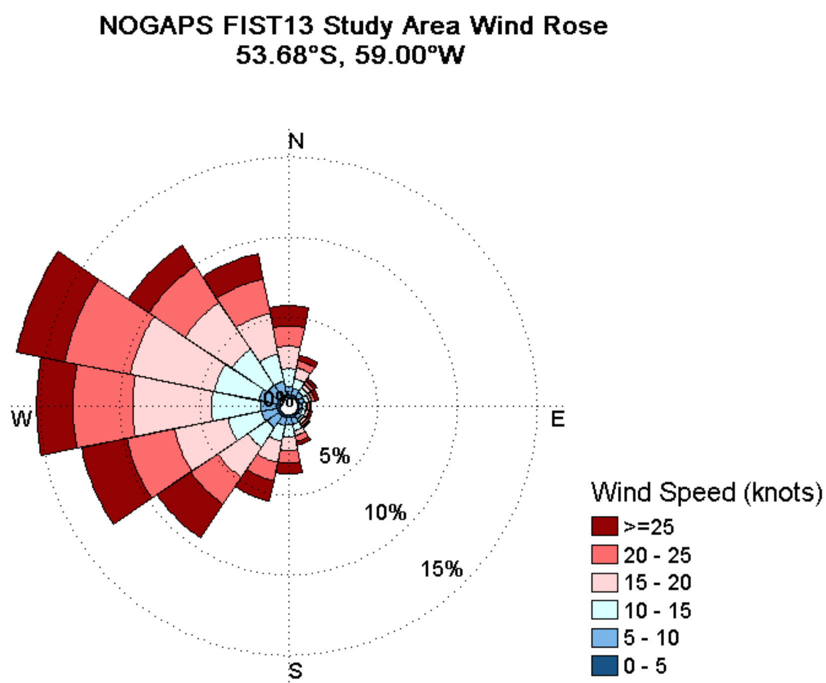


Figure 9. Yearly NOGAPS wind roses in FIST13 block offshore Falklands. Wind speeds are in knots, using meteorological convention (i.e., direction wind is coming from).

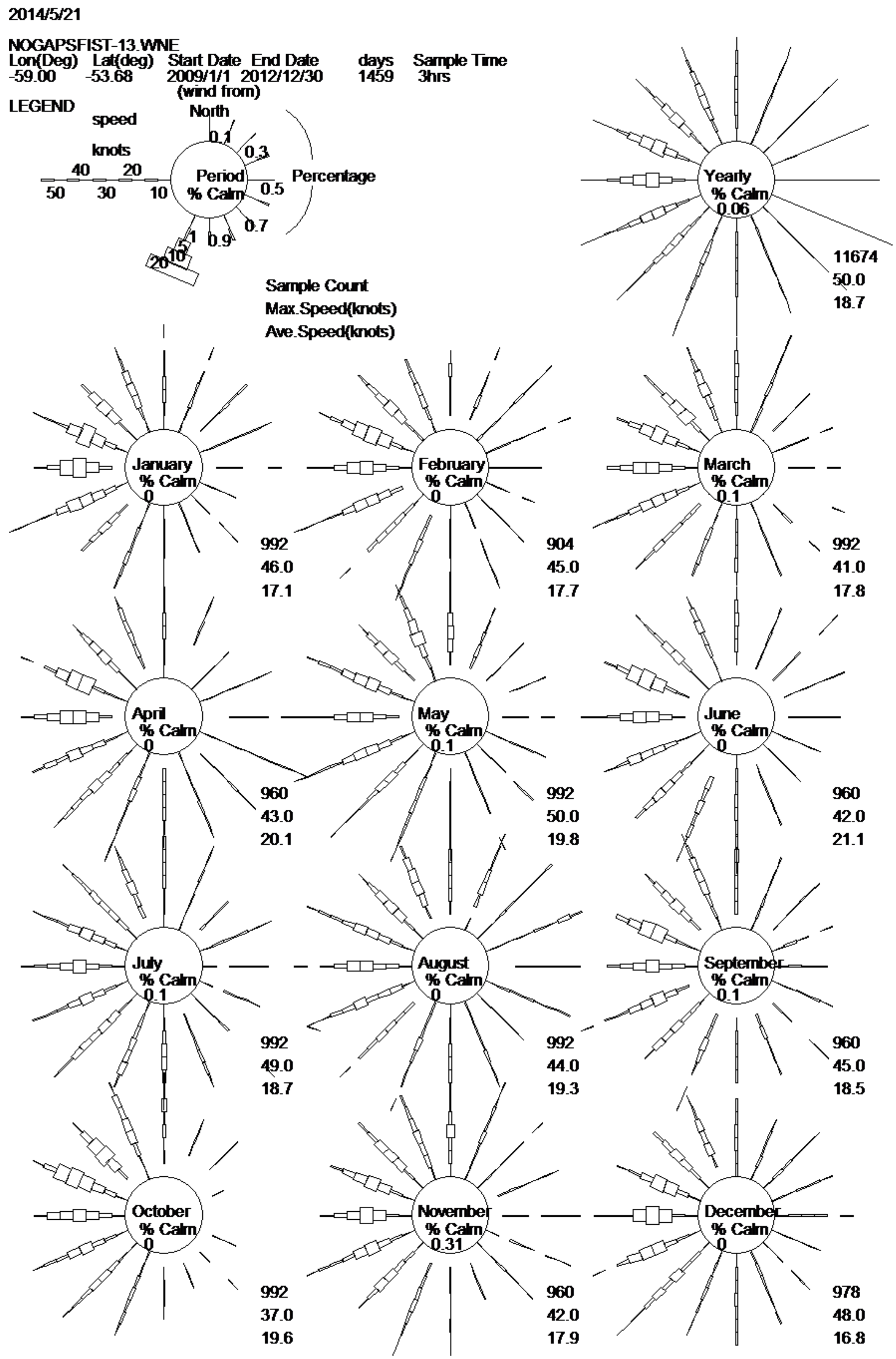


Figure 10. NOGAPS monthly and yearly wind roses for the northern grid point in FIST13 block offshore Falklands. Wind speeds are in knots, using meteorological convention (i.e., direction wind is coming from).

2.4. Ocean Circulation and Physical Attributes

The Falkland Islands consist of two large Islands (East and West Falkland) and at least 780 smaller islands and islets (Otley, 2008). Circulation off the Falkland Islands is primarily influenced by the Falkland, or Malvinas, Current (Figure 11). The Falkland Current is strong, relatively fresh (typically between 33.5-34.5 psu), and cold with sea-surface temperatures ranging from around 2-6°C in austral winter, to 10-14°C during austral summer (Brandini et al., 2000). The Falkland Current is a branch of the Antarctic Circumpolar Current (ACC) that flows northwards along the continental shelf of Argentina until it reaches the Brazil Current. The Brazil Current is a poleward (southward) flowing current that branches off from the South Equatorial Current around 8-10°S.

The Antarctic Polar Front (APF) forms the boundary between the cold Antarctic surface water and the warmer-sub-Antarctic water (Otley, 2008). This convergence zone marks the location where Antarctic surface waters moving northward sink below sub-Antarctic waters (Moore, 1999). Although the boundaries vary, typically this occurs between 50-60°S and is defined by water at 200 m depth with temperatures around 2°C (Park et al., 1993). The water between the APF and the sub-Antarctic Front is defined as the Antarctic Polar Frontal Zone (APFZ), which lies to the south and southeast of the Falkland Islands. The ACC diverts sharply northwards after Cape Horn and at the Burdwood Bank and the Falkland Islands splits into two branches. The larger current branch passes to the east of the islands and propagates northward along the continental shelf. North of the Falkland Islands, an anti-cyclonic (counter-clockwise) ring typically forms. The East and West Falkland Currents meet again around 49°S, where the current continues northward roughly parallel to the 200 m isobath around 0.5 knots and 100 km width.

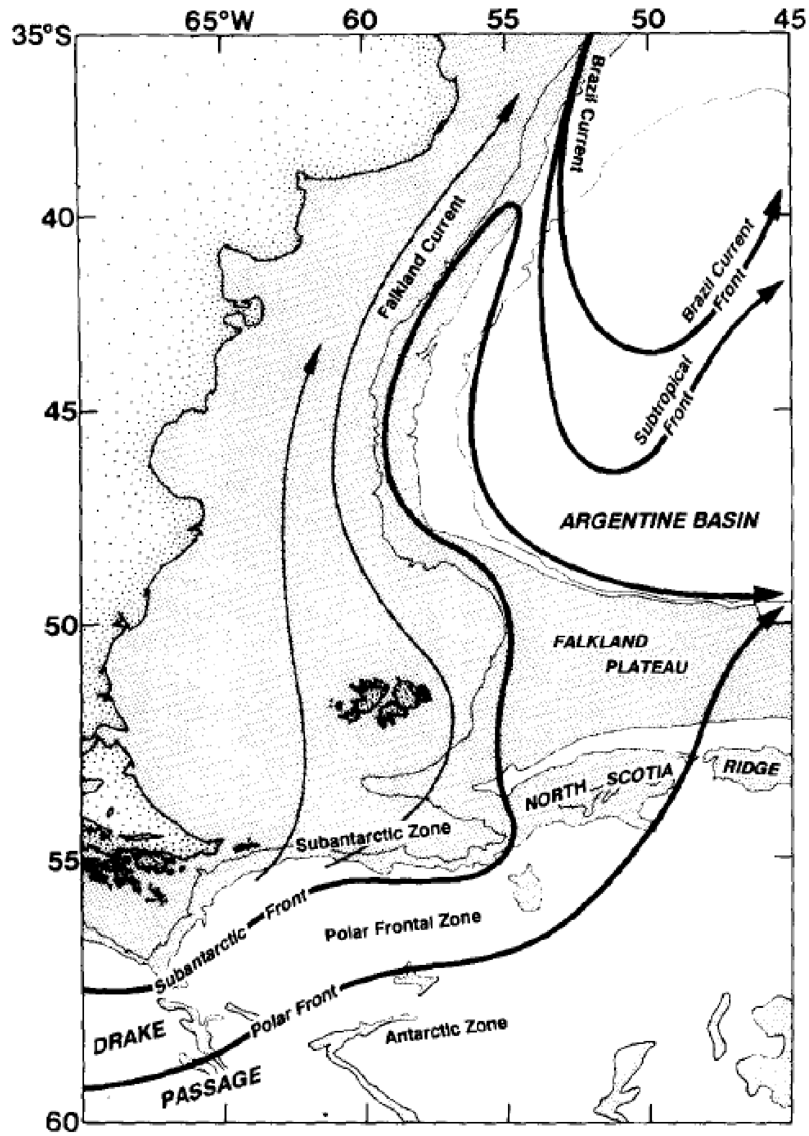


Figure 11. A schematic of the large-scale geostrophic currents and fronts in the southwestern South Atlantic Ocean. Depths less than 3,000 m are shaded (Source: Peterson and Stramma, 1990).

When the warm Brazil Current reaches around 33-38°S, it collides with the cold, northward flowing Falkland Current, thus causing a sharp temperature and salinity gradient and diverging both currents offshore (Otley, 2008). The Brazil Current is then deflected to the east into the region known as the Brazil-Malvinas Confluence Zone (Brazil-Falkland Confluence Zone), which is one of the most energetic regions in all the oceans (Figure 12) (Sarceno et al., 2004). The confluence varies meridionally, and is farthest north during austral winter and spring. This seasonality is presumed to be related to the general seasonal shift of wind systems and seasonal meridional shift of the subtropical gyre (Peterson and Stramma, 1990). After the Brazil Current reaches the confluence region, it bifurcates into two branches; one turning northward forming a recirculation cell, while the other continues southward and veers northeast around 45°S to become the South Atlantic Current (Boebel et al., 1999). At this confluence zone, the northward flowing Falkland Current retroflects cyclonically back toward the south, while the lesser portions continue north along the inner portions of the shelf. On the eastern side of the cyclonic trough is the combined southward flow of the Falkland and Brazil Current that extend to about 45°S before turning east and north to form the poleward limits of the subtropical gyre. The Falkland waters continue south to the southern margin of the Argentine Basin (49°S) before turning east with the circumpolar regime (Campos, 1995). The warm-core eddies formed from the poleward extension of the Brazil current can be up to 300-400 km in diameter, and they transport heat and salt to the northern realm of the ACC.

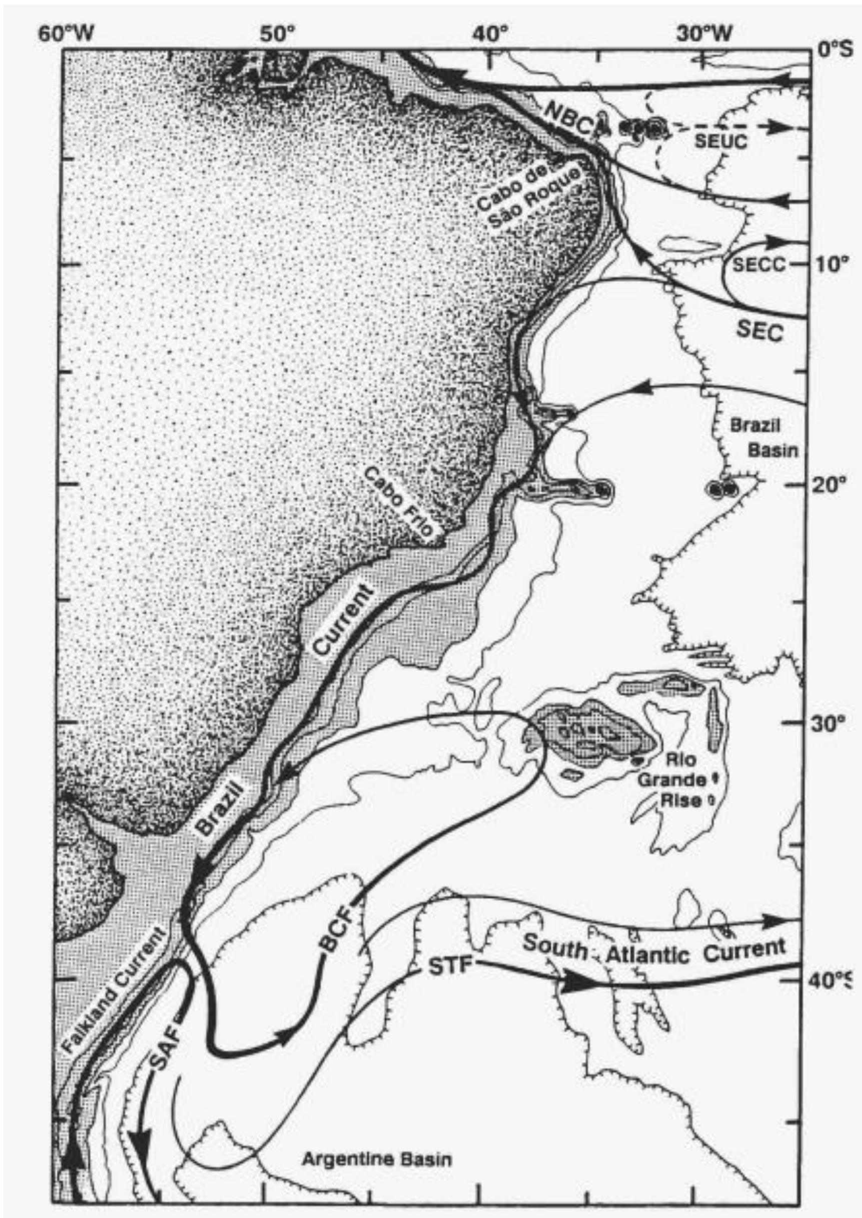


Figure 12. Schematic of flow in the South West Atlantic. At mid-latitudes are the Brazil and Falkland (or Malvinas) Currents along the western boundary and the South Atlantic Current in the interior. Equatorial current systems are also indicated. The bathymetry contour interval is 1,000 m (Source: Campos, 1995).

There are few direct measurements of the velocity of the Falkland Current. Peterson (1992) deployed surface drifters in the Falkland Current and found speeds around 40 cm/s. The along-shelf flow of the Falkland Current is variable year to year with no distinct seasonal cycle. However, the cross-shelf flow exhibits an annual cycle that is associated with the position of the sub-Antarctic front (Gyory, 2013, Vivier and Provost, 1999).

A 2009 FUGRO report and accompanying data has been provided to ASA by the client. The data consist of real-time current measurements from two Acoustic Doppler Current Profilers (ADCP) that were collected offshore the Falkland islands between December 6th, 2008 and October 21st, 2009. The two data collection locations and time periods are listed in Table 2 (Figure 13). The site locations were chosen in relation to the Falklands (Malvinas) Current. Loligo was positioned in deeper water that was in the predominantly northward flow of the Falklands Current. This site experienced higher current speeds than Toroa (about 25% higher) and several eddy events that lasted from days to weeks. The more southern site, Toroa, was positioned to the southwest of Loligo in shallower water along the shelf slope. Here, there were weaker currents, smaller scale eddy events and some influence from tidal current streams. At Loligo, the current direction was predominantly north to northeast, while Toroa was primarily northeastward. At both sites, the water column was well-mixed and had little annual variation in temperature (FUGRO, 2009).

Table 2. ADCP locations, depth and time period.

Site Name	Latitude	Longitude	Approximate Water Depth (m)	Time Period
Loligo	51.2372° S	54.6978° W	1,421	2008-12-09 to 2009-10-21
Toroa	53.0327° S	57.9527° W	691	2009-05-02 to 2009-10-20

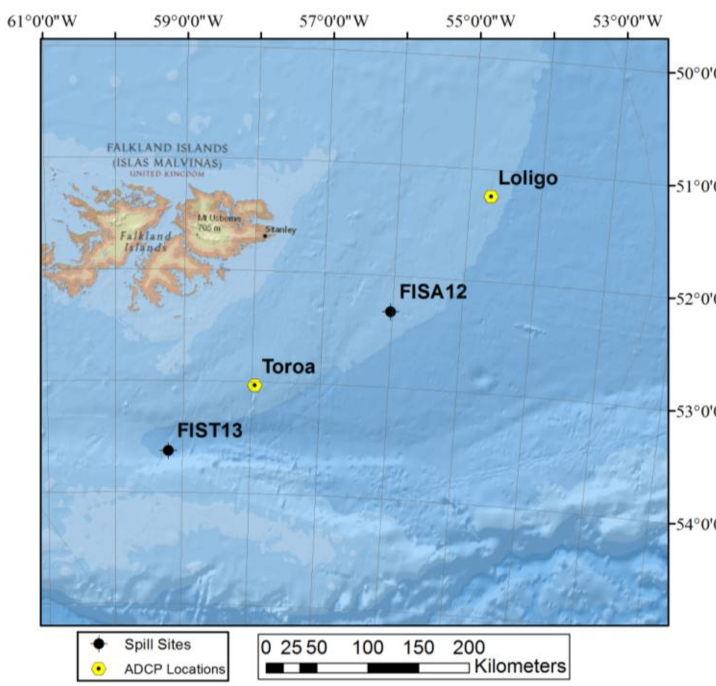


Figure 13. ADCP locations and FISA12 and FIST13 center points.

2.5. Current Dataset – *HYCOM Hindcast*

For this study, regional currents for the area were obtained from a hindcast analysis using inputs from the HYCOM (HYbrid Coordinate Ocean Model) 1/12 degree global simulation assimilated with NCODA (Navy Coupled Ocean Data Assimilation) from the U.S. Naval Research Laboratory (http://www.hycom.org). The model domain has a spatial resolution defined by a 1/12 degree grid in the horizontal direction and a daily temporal resolution, which for this study was obtained for the period of 2009-2012.

Comparisons between HYCOM data and supplied ADCP data (mentioned previously) were performed and demonstrated good agreement between the two data sources (Figure 14). Both the HYCOM and the ADCP data indicated the current speed increases to the north, as seen by the lower current speeds at the FIST13 site (Figure 15). The dominant direction is generally northeastward around 15-30 cm/s.

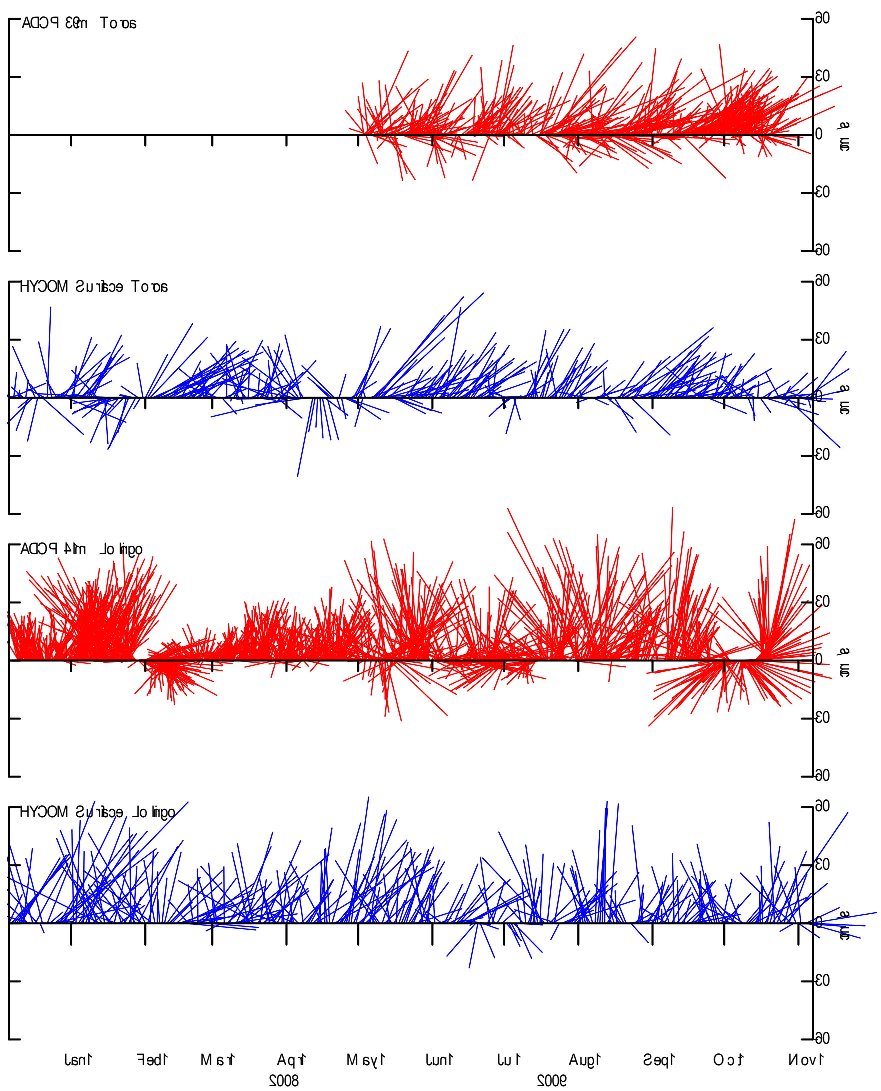


Figure 14. Comparisons of HYCOM and ADCP data at Toroa and Loliga locations.

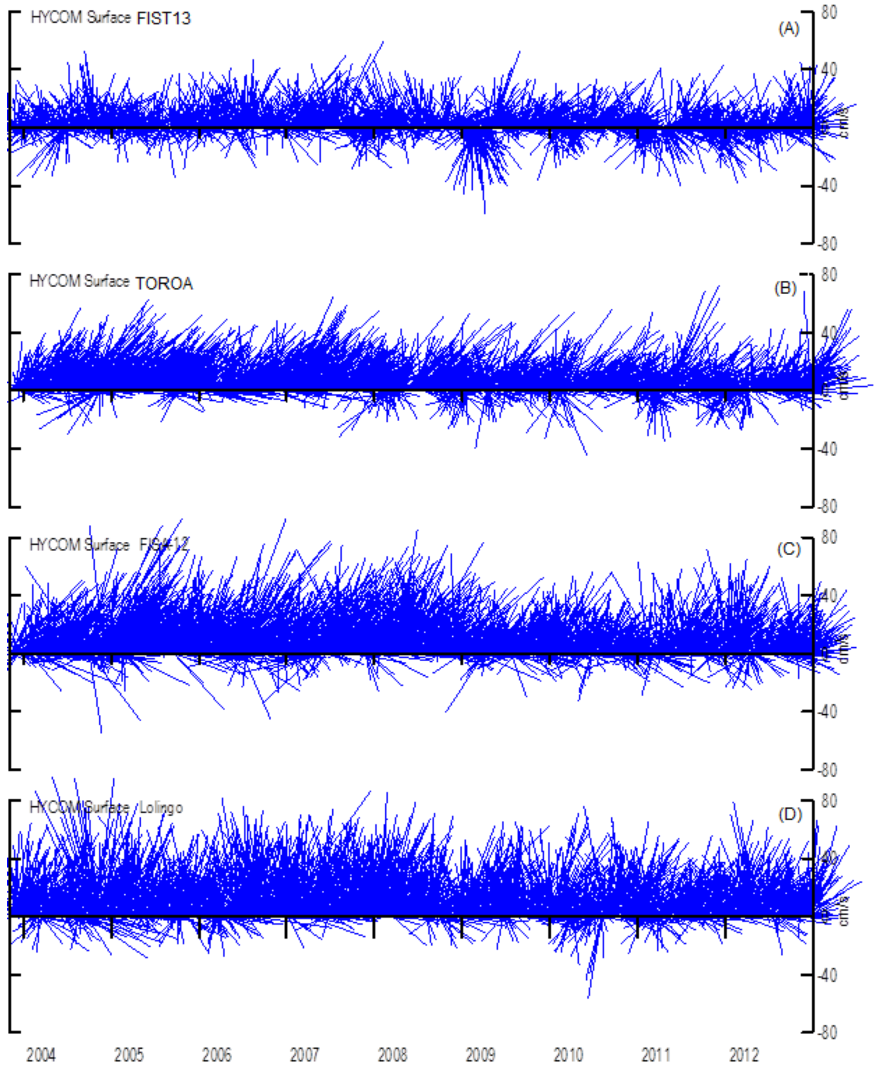


Figure 15. HYCOM surface velocities for FIST13 (A), TOROA (B), FISA12 (C) AND LOLIGO (D). Velocities are in cm/s.

2.6. Monthly Statistics

Figure 16 presents monthly statistics (average and 95th percentile) of the HYCOM current speeds at the surface and 1,500 m depth for a central site in FISA12. Throughout the period of interest, average monthly surface currents vary between 20-30 cm/s, while currents expectantly decrease with depth. Monthly averaged surface currents reach a maximum in August with average speeds around 30 cm/s, and a slightly lesser peak in June around 28 cm/s. The current decreases rapidly after its maximum to a minimum in October around 20 cm/s. Subsequently, current speeds increase to near 30 cm/s in January, with some variability in the following months. At depth, around 1,500 m, current speeds are fairly consistent, varying between 0.7-1.5 cm/s (Figure 16).

Figure 17 presents HYCOM monthly statistics in a central location of the southern block, FIST13. There are differences in the seasonality at this site based on the monthly statistics. In general, current speeds are lower and less variable at this site. The minimum occurs in March, around 14 cm/s, while the first maximum occurs in May around 20 cm/s, with a slightly smaller peak in October, near 19 cm/s. At depth, around 1,500 m, the current speeds are consistently around 2 cm/s throughout the year.

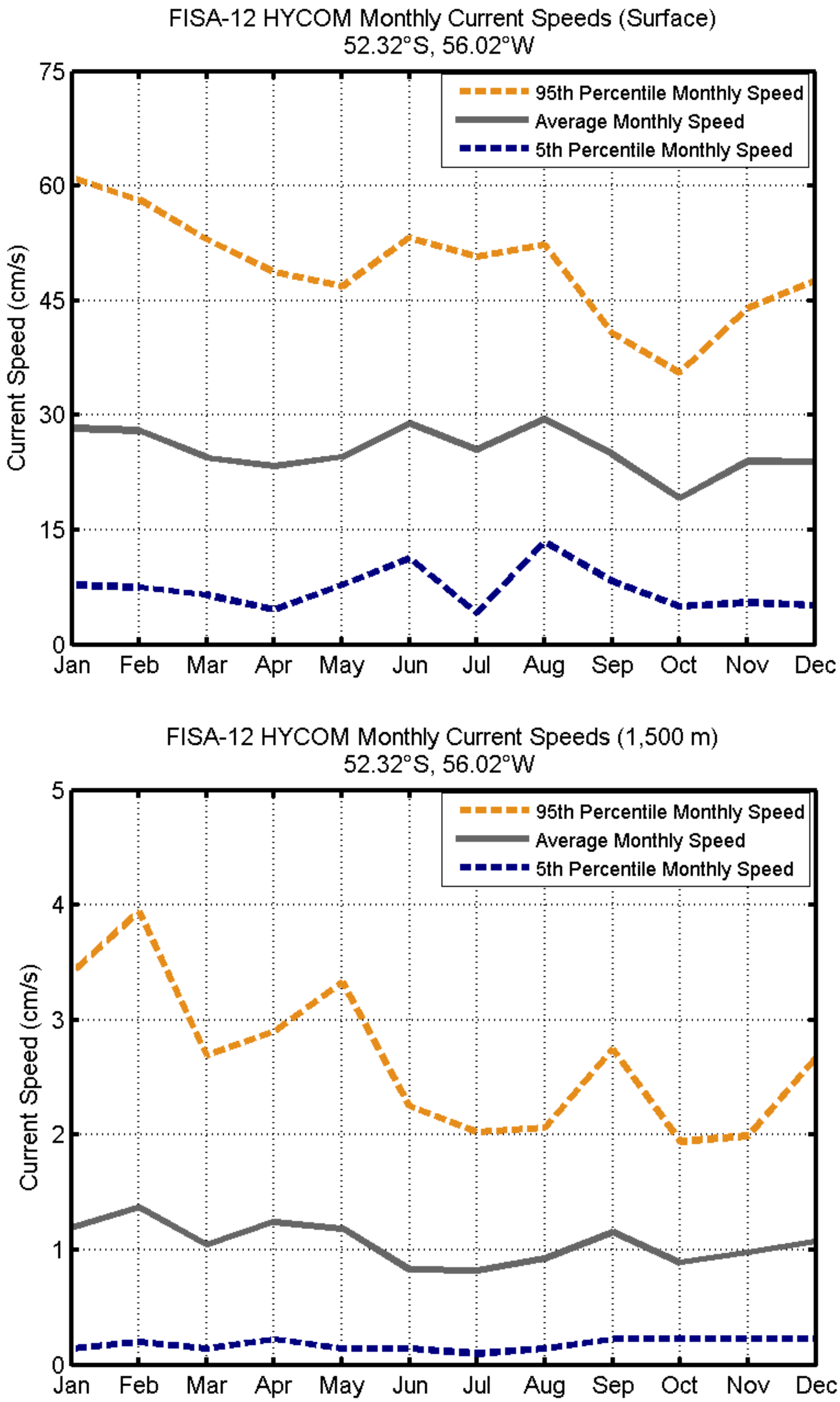


Figure 16. HYCOM current statistics: monthly average (grey solid) and 95th percentile (orange) current speed at the surface (top) and 1,500 m (bottom) in the center of the FISA12 block for the period of 2009-2012.

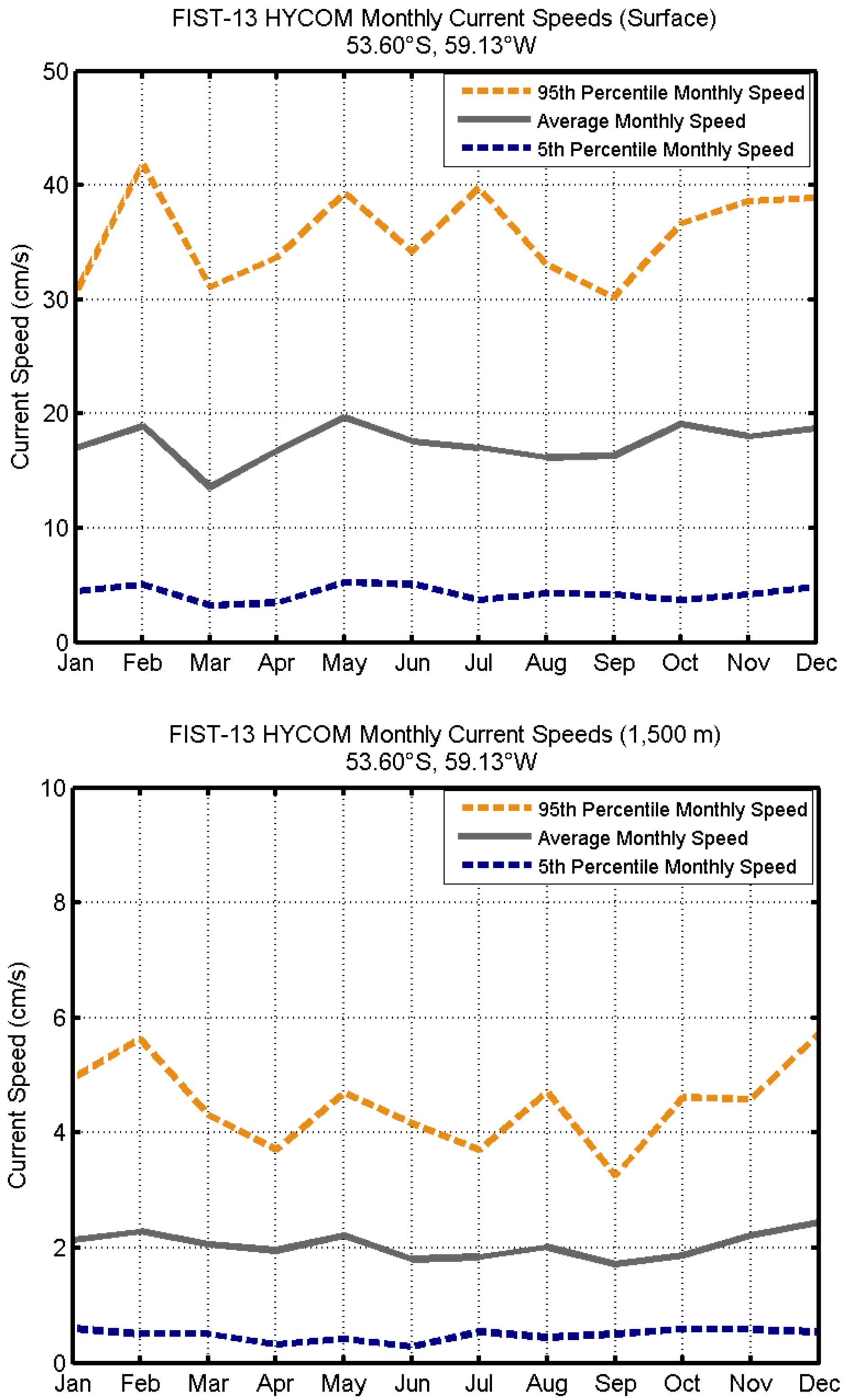


Figure 17. HYCOM current statistics: monthly average (grey solid) and 95th percentile (orange) current speed at the surface (top) and 1,500 m (bottom) in the center of the FIST13 block for the period of 2009-2012.

2.7. Current Roses

Figure 18 illustrates the spatial variability of the yearly average HYCOM current field represented by rose diagrams. Overall, current direction is primarily east-northeastwards. Current speeds are variable and differ depending on the location of interest. Offshore, there is a strong north-northeastward current with speeds frequently greater than 60 cm/s. Moving west towards Falklands, speeds are more commonly between 15-30 cm/s, and increase slightly as you near the eastern coast.

Figure 19 presents HYCOM current roses in the center of FISA12 averaged over the period of interest, for both the surface and 1,500 m water depths. The yearly surface current rose illustrates that the flow is predominantly northeastward between 15-30 cm/s. Currents at 1,500 m are typically less than 2 cm/s with a predominantly east-northeastward flow. Monthly current roses for the surface illustrate some slight seasonality in the area (Figure 20). Currents have a more northward component during summer through early fall (December-May). During winter and spring (June through October), direction is primarily to the northeast.

At the FIST13 site, direction is primarily northeastward with slightly more variability in direction, with a southeastward component observed as well (Figure 21). At depth, flow is dominated by both westward and eastward movement, with average speeds between 2-3 cm/s that can reach over 5 cm/s. The seasonality seen in the monthly surface current roses in Figure 22 illustrates changes in direction rather than speed. During mid-summer through early fall (January-April), the dominant flow is to the south. From May through winter and spring (June-October), the flow regime shifts to northeastward with speeds between 15-30 cm/s.

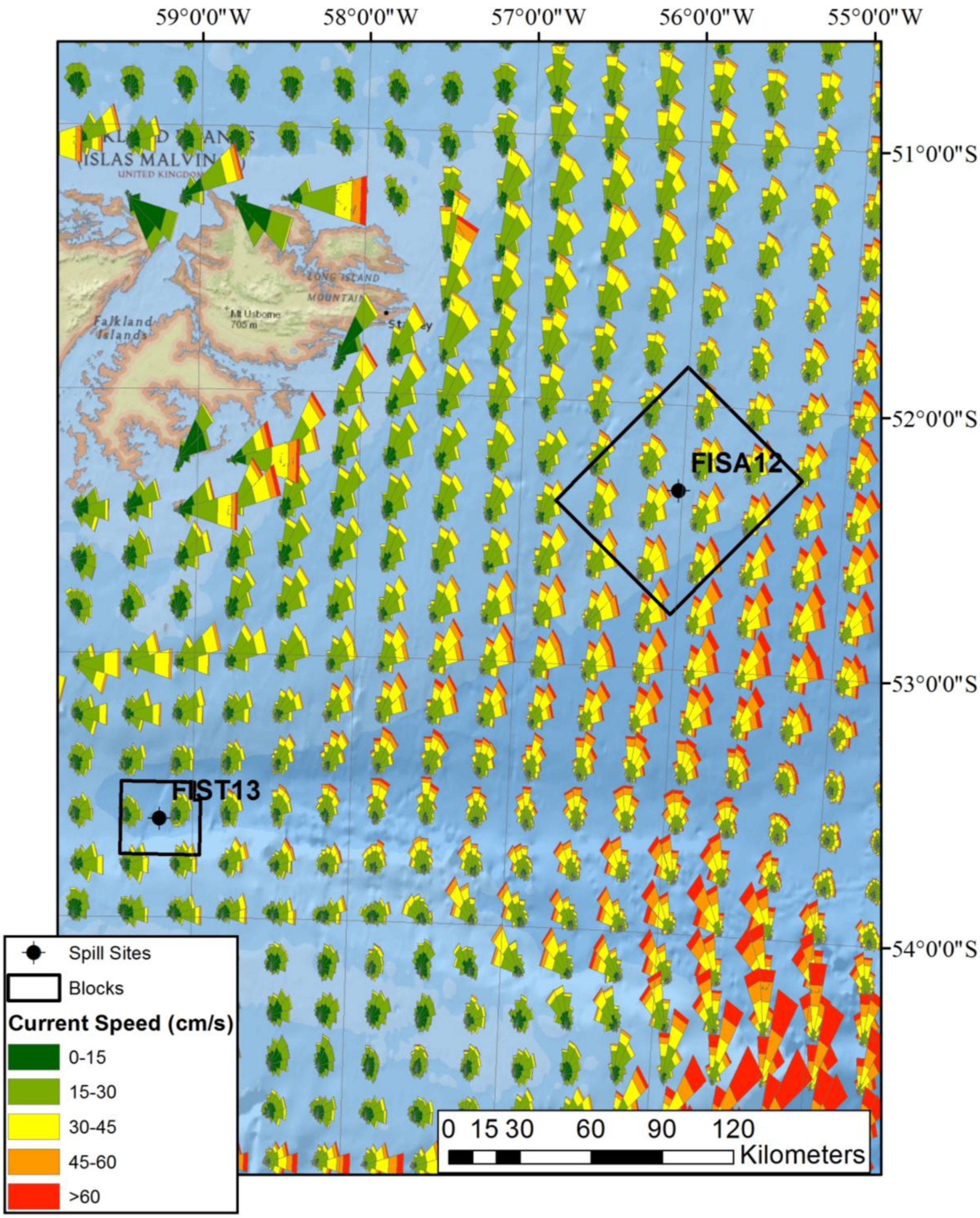
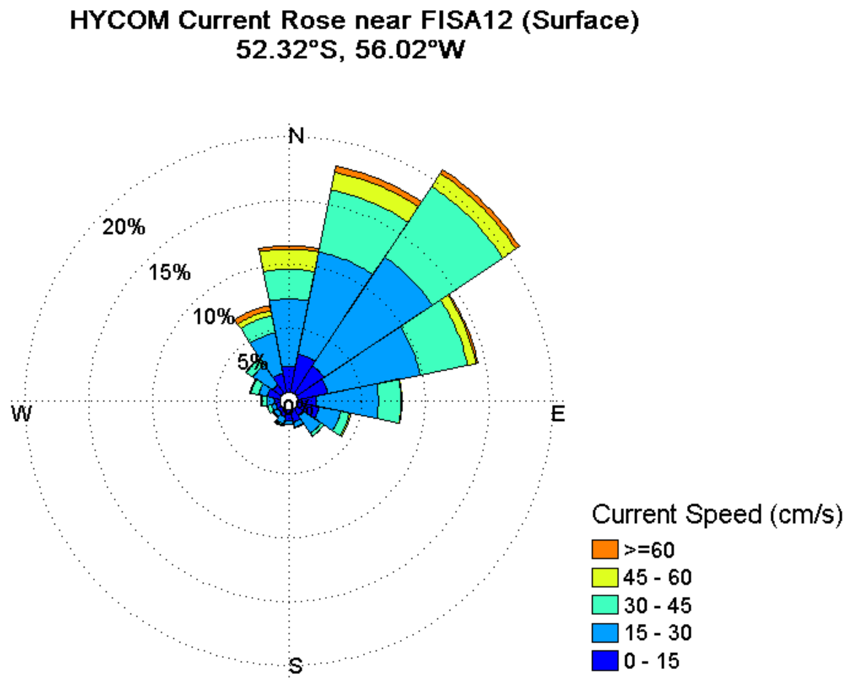


Figure 18. Spatial variability of the average HYCOM current field represented by rose diagrams; current speed is in cm/s, using standard convention (i.e. direction currents are going to).



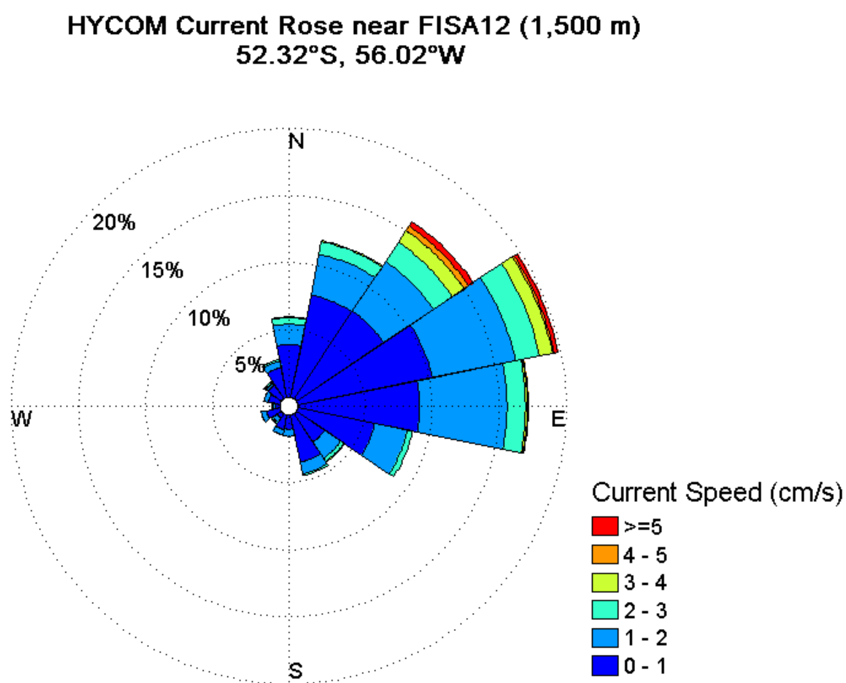


Figure 19. HYCOM current roses in the center of the FISA12 block averaged over the period of 2009-2012. Current roses presented for the surface (top) and 1,500 m (bottom) water depths. Direction convention is standard (i.e., direction currents are moving to).

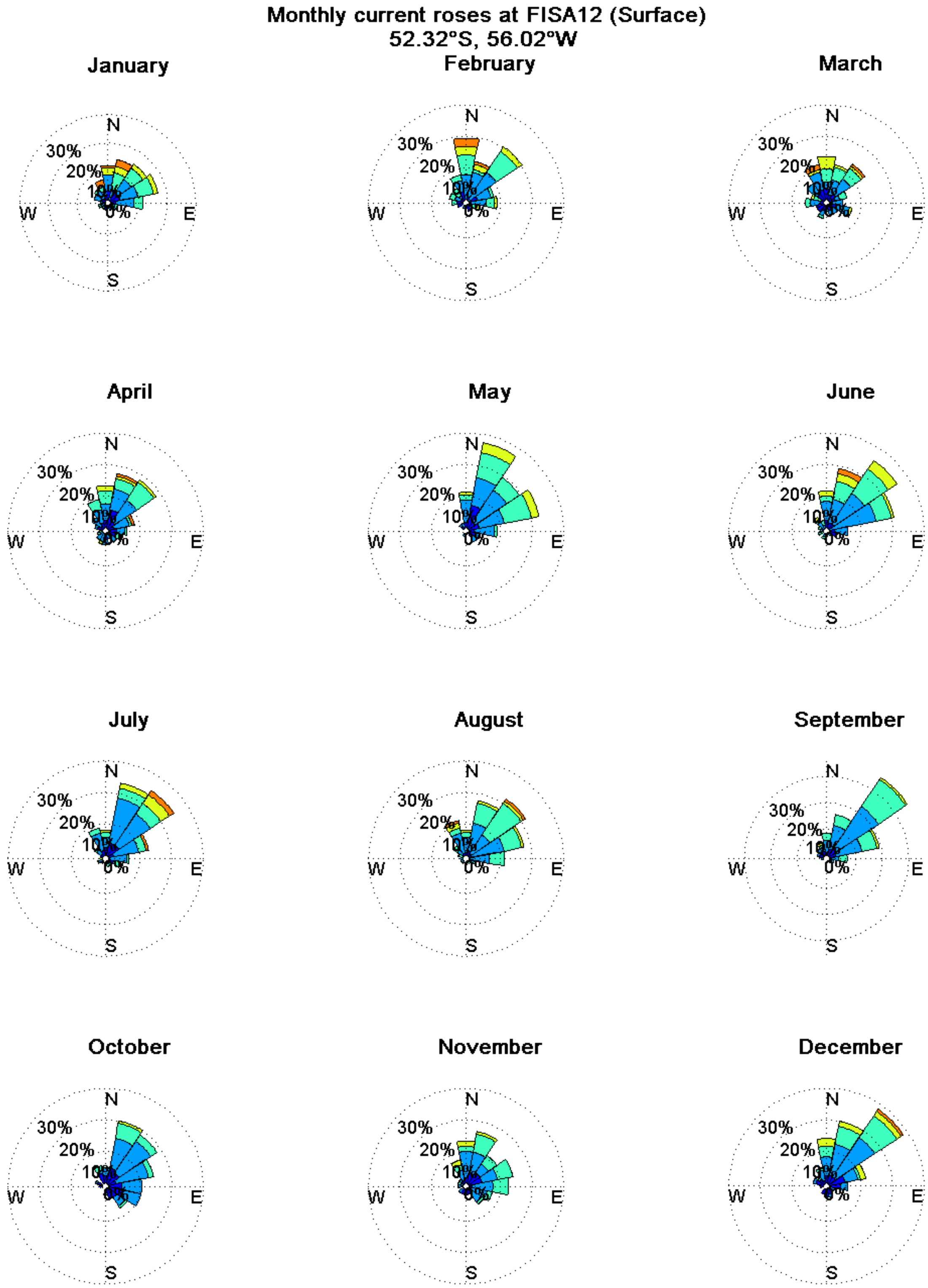
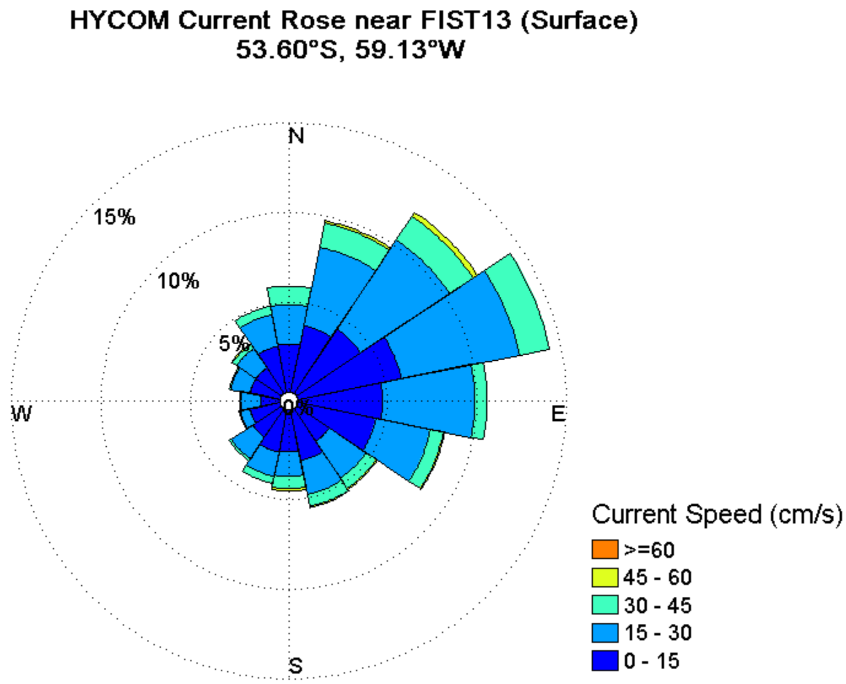


Figure 20. HYCOM monthly averaged surface current roses in the center of the FISA12 block averaged over the period of 2009-2012. Direction convention is standard (i.e., direction currents are moving to).



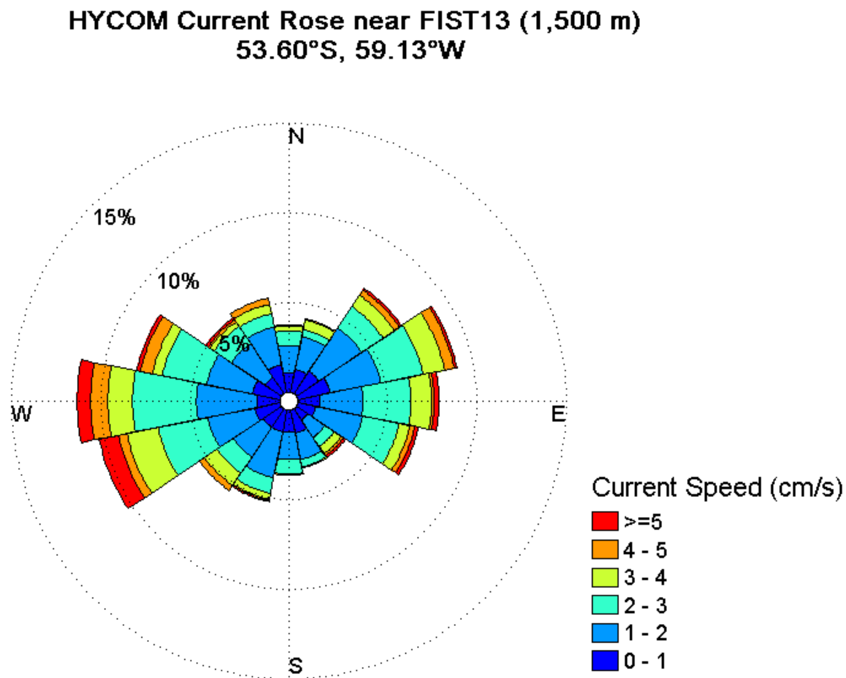


Figure 21. HYCOM current roses in the center of the FIST13 block averaged over the period of 2009-2012. Current roses presented for the surface (top) and 1,500 m (bottom) water depths. Direction convention is standard (i.e., direction currents are moving to).

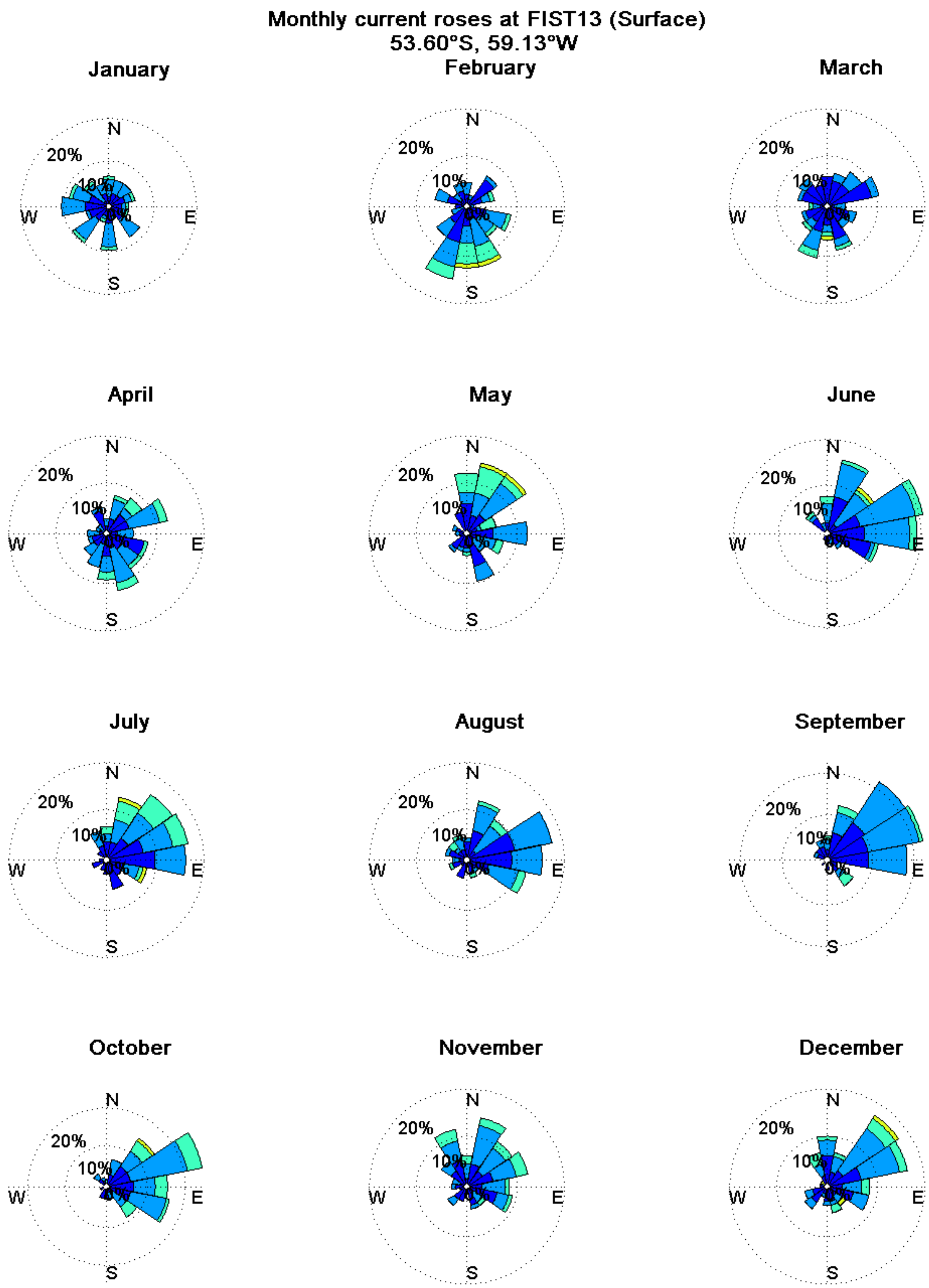


Figure 22. HYCOM monthly averaged surface current roses in the center of the FIST13 block averaged over the period of 2009-2012. Direction convention is standard (i.e., direction currents are moving to).

2.8. Mapped Current Fields

Figure 23 shows a spatial view of HYCOM mean surface currents for years 2009-2012. These figures clearly indicate the edge of the strong, eastward flowing branch of the ACC south of the areas of interest. As discussed above, the current that separates from the polar current to flow northward is known as the Falklands Current, and propagates northeastward through the FISA12 block. The FIST13 block does not appear to be directly impacted by the sub-polar northward current.

Around the coastal areas of the Falkland Islands, current speeds vary largely between 5-35 cm/s. The current direction around the southern part of the Islands is eastward, shifting northeastward as currents round the eastern side of the Islands. Current speeds near the coast are typically less than offshore. Monthly spatial maps for 2009-2012 are seen in Figure 24. Overall, the monthly averages look similar, though the northwards Falklands Current changes zonal position based on the season. It shifts westward, towards the Falkland Islands, during austral summer, which can cause an increase in current velocity through FISA12. Yearly averaged surface currents are seen in Figure 25 through Figure 28. Flow through the FIST13 block is primarily east-northeastward each year with consistent speeds. Within FISA12, current direction is primarily northeastward each year, with some slight changes in speed depending on the northward current location and if it passes directly through the block. After the current passes through the areas of interest, propagation is northward until around 49°S, where part of the current flows westward, while also branching eastward.

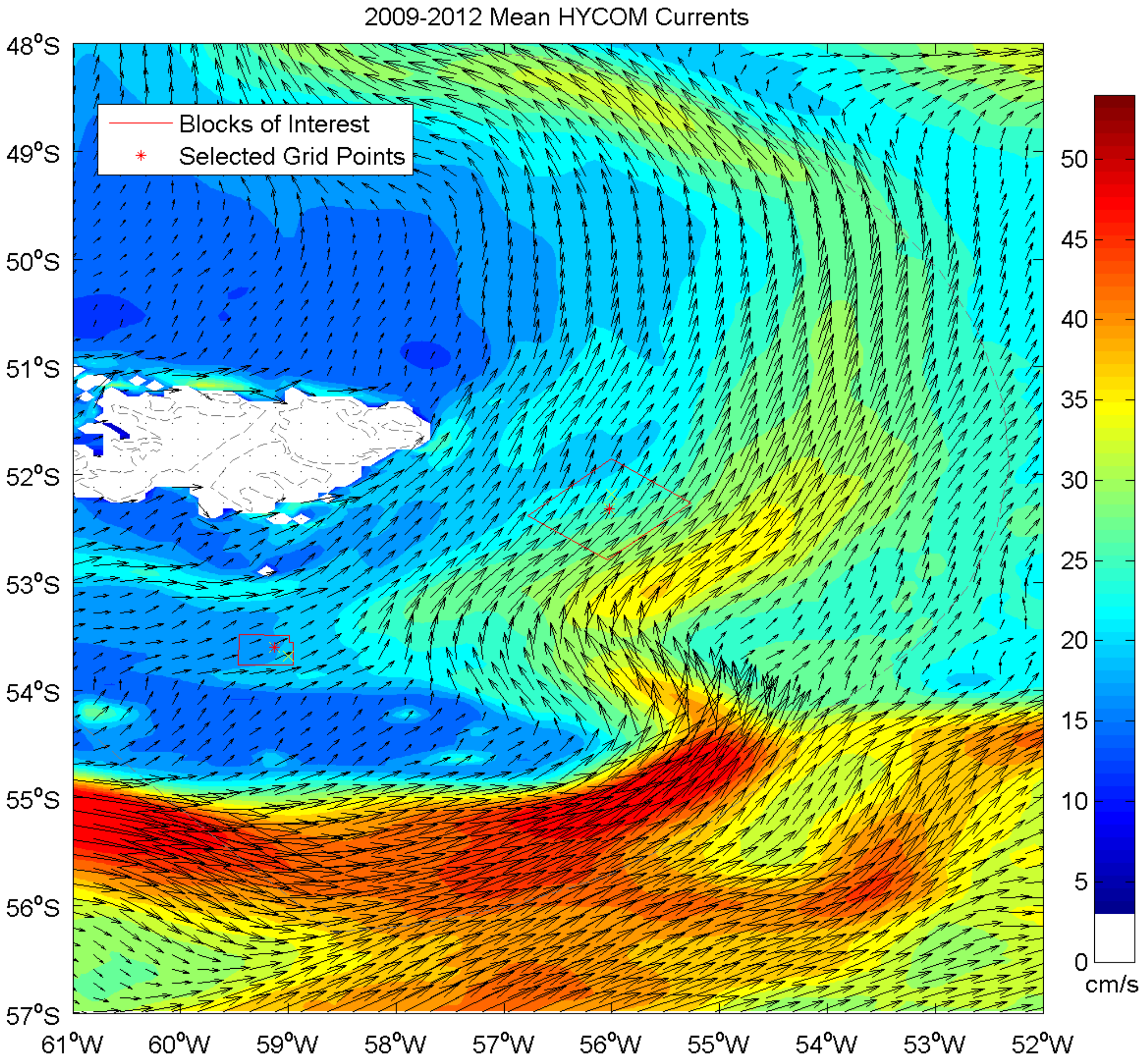


Figure 23. Mean HYCOM surface currents from 2009-2012. The blocks of interest are outlined in red and red stars indicate points selected for analysis.

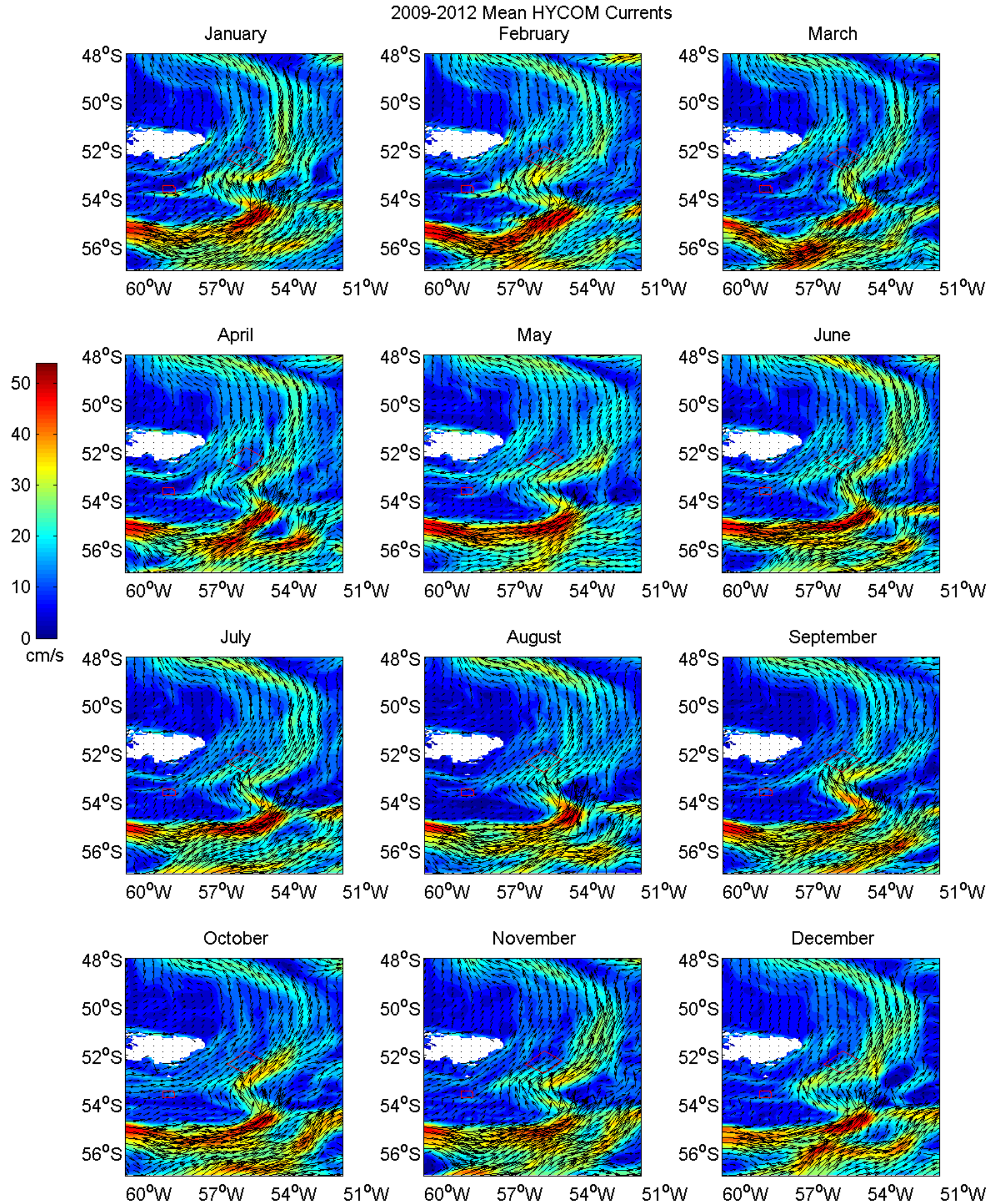


Figure 24. Monthly mean HYCOM surface currents from 2009-2012. Blocks of interest are outlined in red. Red stars indicate points selected for analysis.

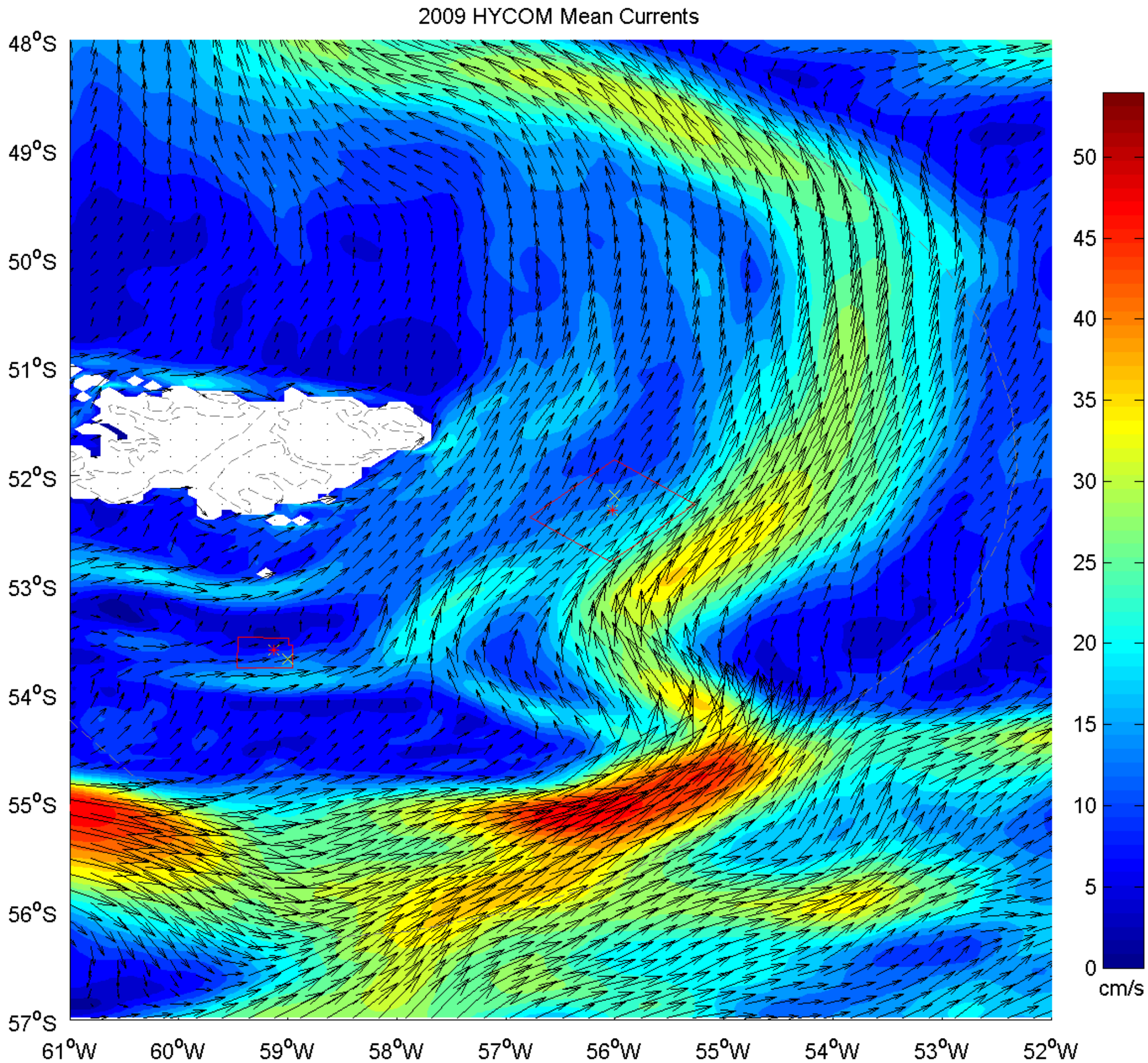


Figure 25. 2009 mean HYCOM surface currents. Blocks of interest are outlined in red. Red stars indicate points selected for analysis.

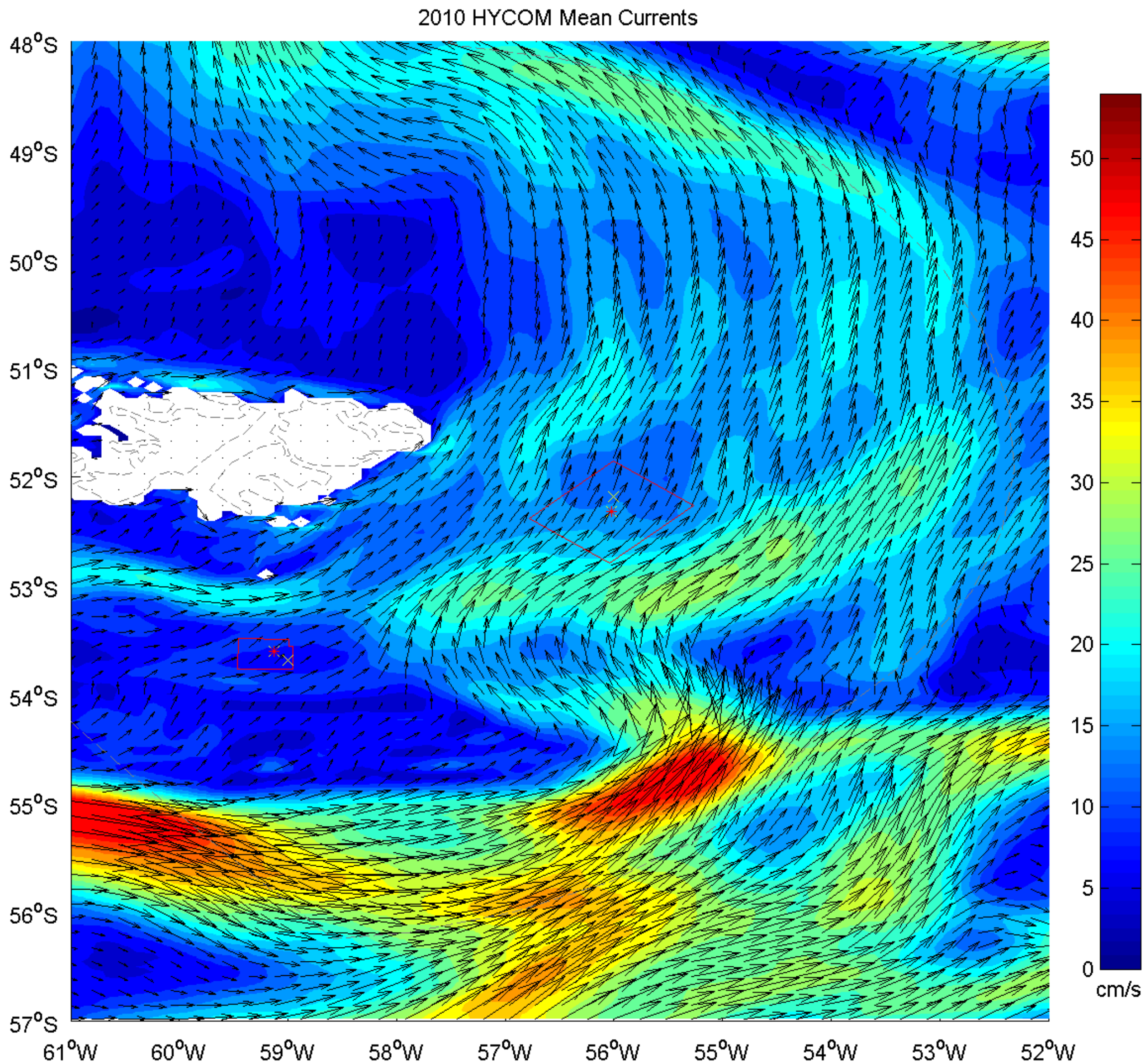


Figure 26. 2010 mean HYCOM surface currents. Blocks of interest are outlined in red. Red stars indicate points selected for analysis.

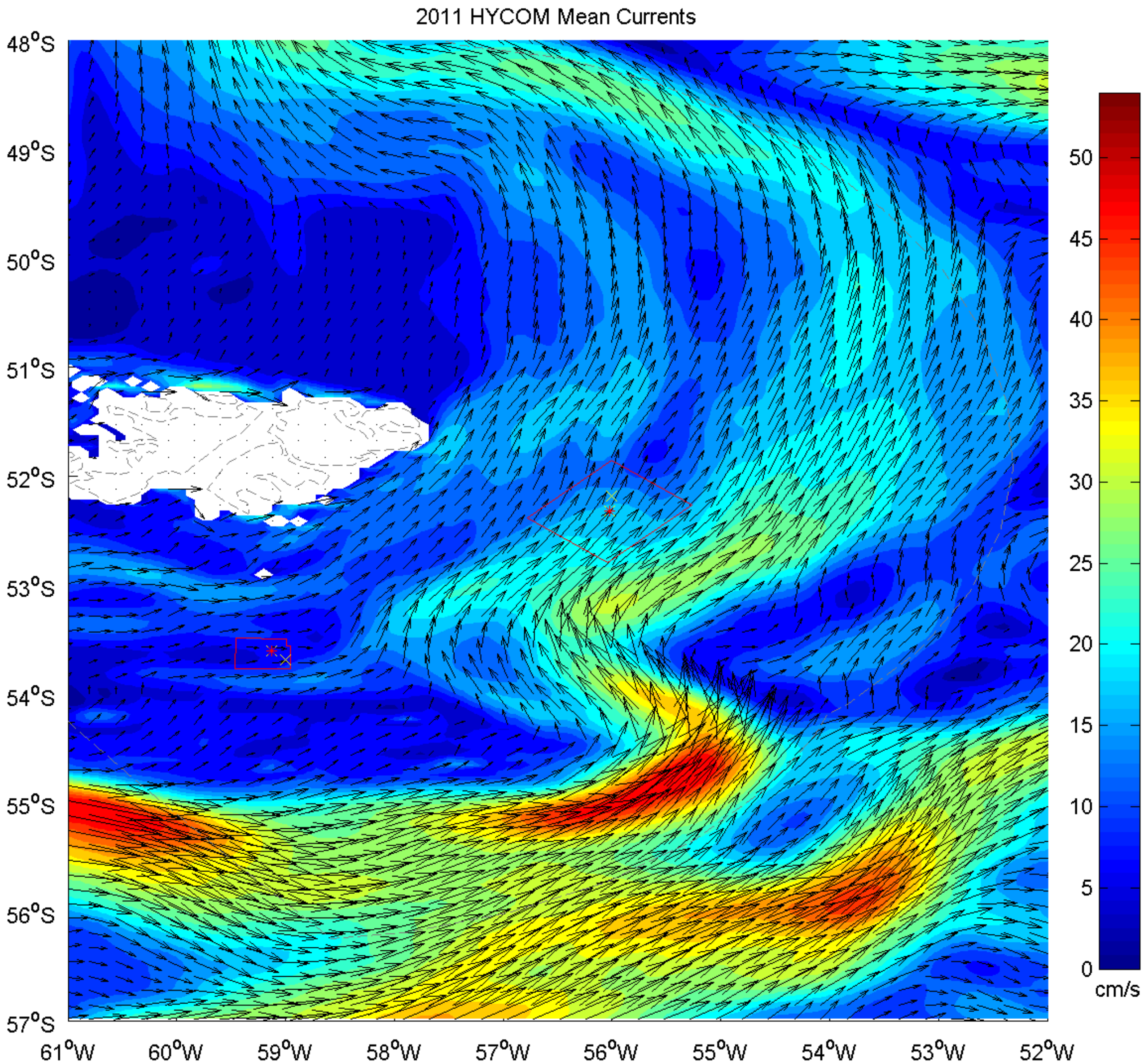


Figure 27. 2011 mean HYCOM surface currents. Blocks of interest are outlined in red. Red stars indicate points selected for analysis.

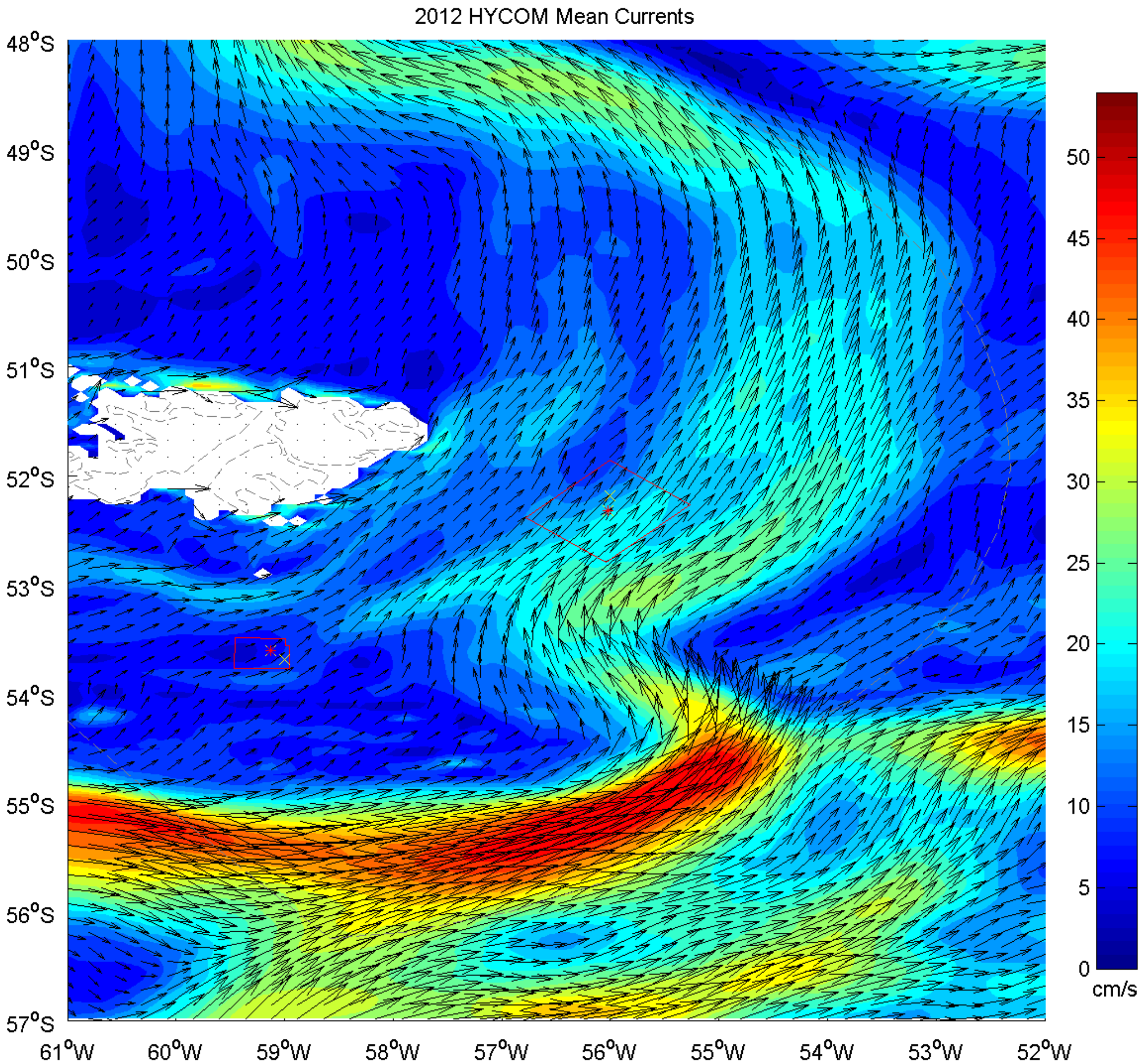


Figure 28. 2012 mean HYCOM surface currents. Blocks of interest are outlined in red. Red stars indicate points selected for analysis.

2.9. Water Column Vertical Structure

Figure 29 shows the vertical profile of currents obtained from the HYCOM model outputs for the area of interest averaged from 2009 through 2012 (FISA12 site). Near the surface, the current velocity can exceed 50 cm/s. On average, however, surface speeds are around 25 cm/s. Velocity decreases with depth to a minimum of about 1 cm/s near the seabed. In the FIST13 block, currents at the surface exceed 35 cm/s, but typically average 17 cm/s (Figure 30). Near the bottom, the current flows around 2-3 cm/s.

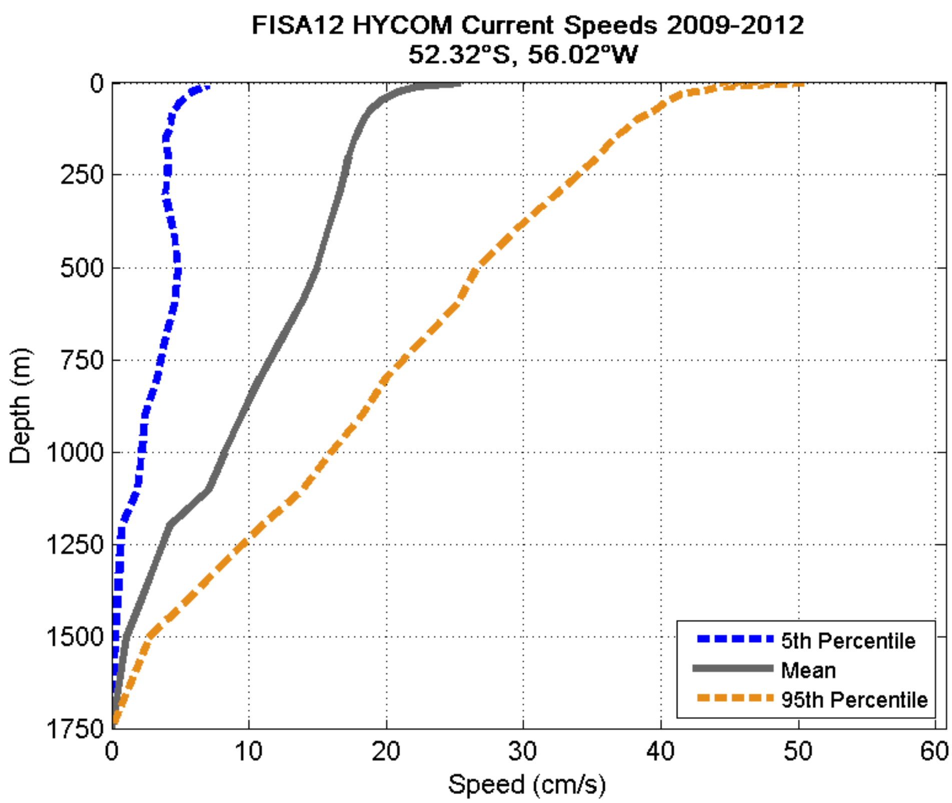


Figure 29. HYCOM 5th percentile (blue), average (solid grey), and 95th percentile (dashed orange) current speed with depth in FISA12 block for the period of 2009-2012.

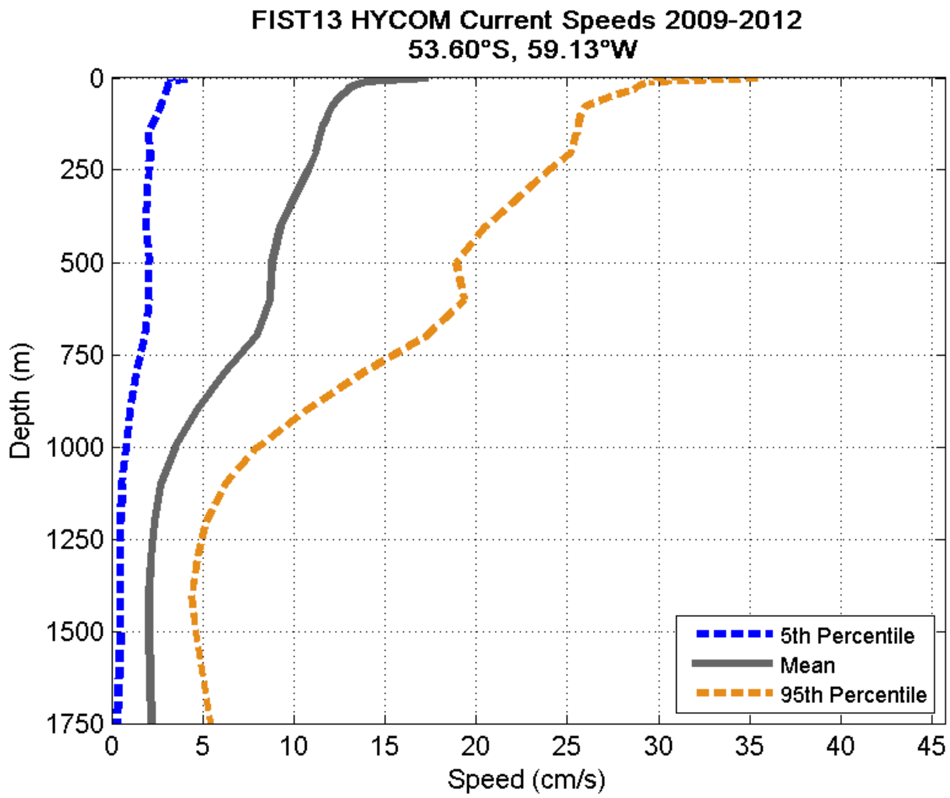


Figure 30. HYCOM 5th percentile (blue), average (solid grey), and 95th percentile (dashed orange) current speed with depth in FIST13 block for the period of 2009-2012.

Figure 31 and Figure 32 illustrate the yearly-averaged vertical profile of temperature, salinity, and density near the locations of interest. Temperature and salinity data were obtained from the World Ocean Atlas NODC NOAA data product (Levitus, 1982). Surface temperatures at the FISA12 site are approximately 6.5°C and decline gradually before reaching a minimum of approximately 3°C at depth. Salinity values are steady, with an average of about 34 psu at the water surface and increase slightly to 34.25 psu at depth. Density is around 26.7 kg/m^3 at the surface and increases to 28 kg/m^3 at depth. At the FIST13 site the water column properties are similar, with surface temperatures are near 6.5°C at the surface and less than 2.5°C at depth. Salinity values are around 34 psu at the surface and increase to over 34.5 psu at depth. Density is around 26.7 kg/m^3 at the surface and increases to 28.5 kg/m^3 at depth.

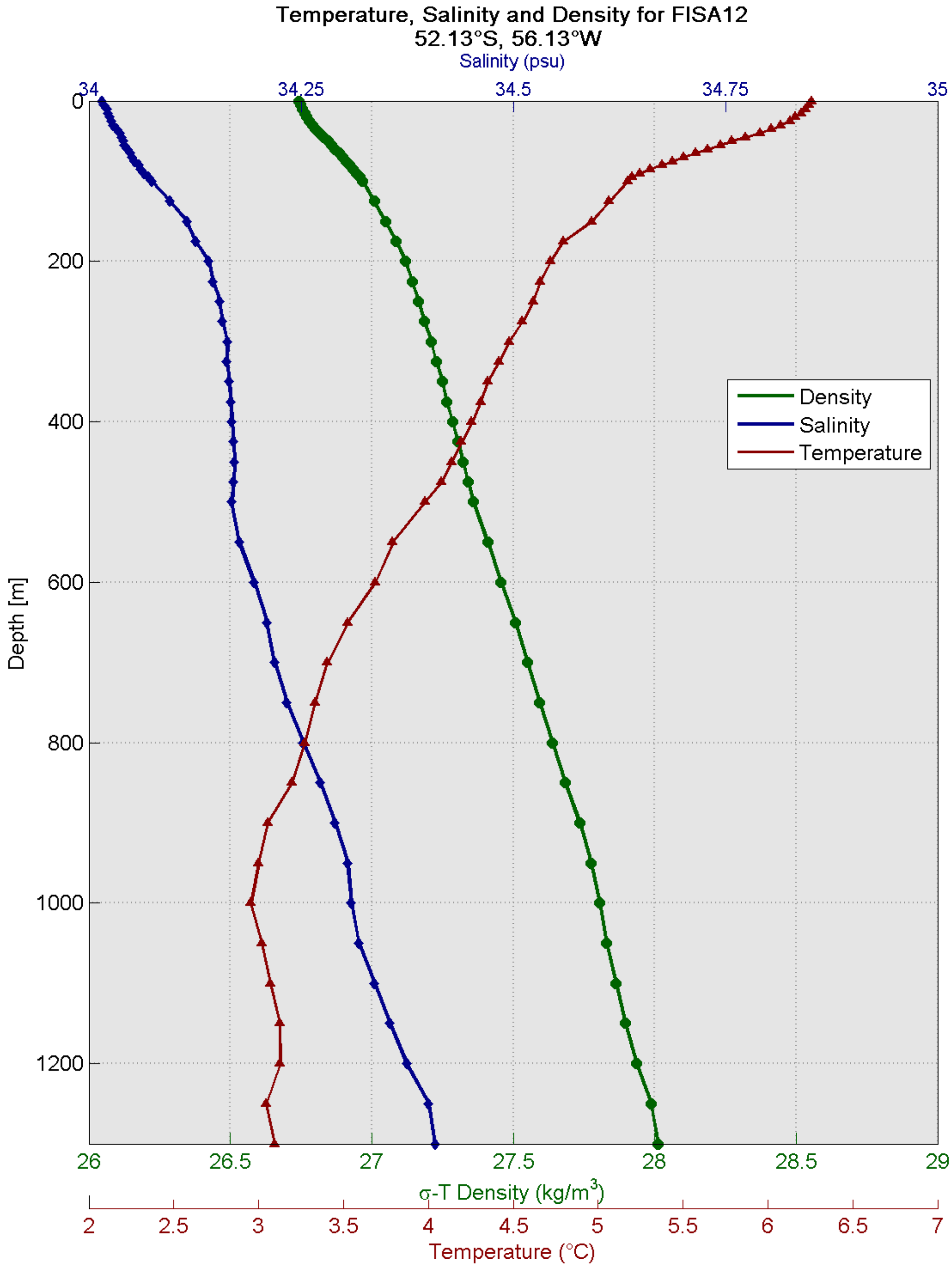


Figure 31. Yearly averaged temperature and salinity vertical profiles in the center of the FISA12 block.

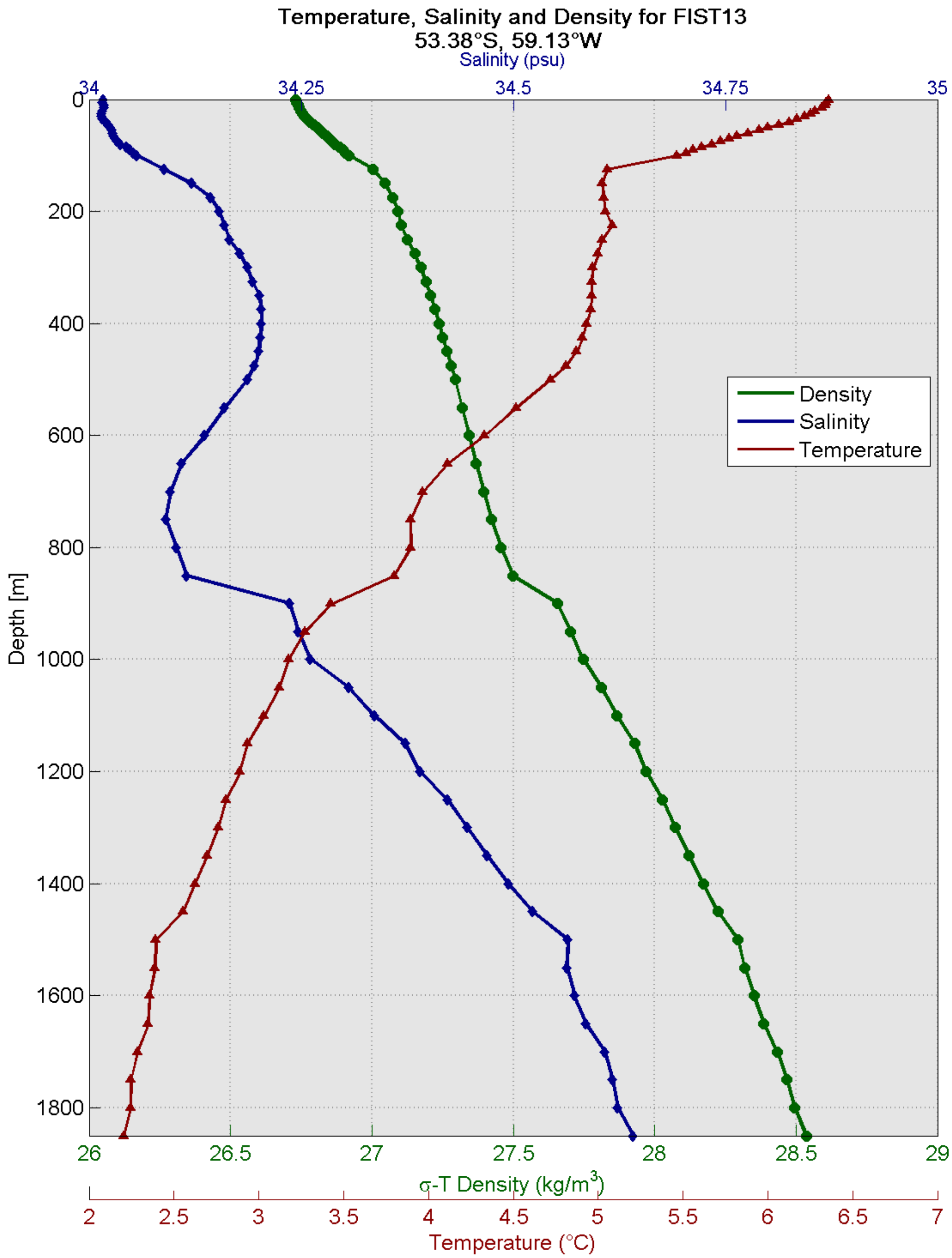


Figure 32. Yearly averaged temperature and salinity vertical profiles in the center of the FIST13 block.

3. References

Brandini, F.P., D. Boltovskoy, A. Piola, S. Kocmur, R. Rottgers, P.C. Abreu, and R.M. Lopes, 2000: Multiannual trends in fronts and distribution of nutrients and chlorophyll in the southwestern Atlantic (30-62 ° S). *Deep-Sea Research Part I*, **47**, 1015-1033.

Bry, M., N. White, S. Singh, R. England and C. Trowell, 2004: Anatomy and formation of oblique continental collision: South Falkland Basin, *Tectonics*, **23**, TC4011.

Boebel, O., C. Schmid, G. Podesta and W. Zenk, 1999: Intermediate water in the Brazil-Malvinas Confluence Zone: A Lagrangian view. *Journal of Geophysical Research*, **104** (C9), 21,063-21,082.

Campos, E. J. D., J. Miller, T. J. Muller and R. G. Peterson, 1995: Physical Oceanography of the Southwest Atlantic Ocean. *Oceanography*, **8,** No. 3.

FUGRO, 2009, "Metocean Measurements for the Loligo and Toroa Prospects, Phase 1 & Phase 2." Report Number C16360/5769/R2.

Levitus, S. 1982. Climatological Atlas of the World Ocean, NOAA Professional Paper 13. U.S. Government Printing Office, Washington, D.C.

Ludwig, W. J., 1983: Geologic framework of the Falkland Plateau, in Ludwig, W. J., Krasheninikov, V. A., et al., Initial Reports of the Deep Sea Drilling Project, **71**, part 1, 281-293.

Gyory, J., Arthur J. Mariano, Edward H. Ryan, 2013: "The Malvinas Current." Ocean Surface Currents. http://oceancurrents.rsmas.miami.edu/atlantic/malvinas.html.

Moore, K., M. R. Abbott, and J. G. Richman, 1999: Location and dynamics of the Antarctic Polar Front from satellite sea surface temperature data, *Journal of Geophysical Research* **104,** C2, 3059-3073.

Otley, H., G. Munro, A. Clausen and B. Ingham, 2008: Falkland Islands State of the Environment Report 2008. *Falkland Islands Government and Falklands Conservation*, Stanley.

Park, Y.H., L. Gamberoni and E. Charriaud, 1993: Frontal structure, water masses, and circulation in the Crozet Basin. *Journal of Geophysical Research,* **98**: 12361-12385.

Peterson, R.G. and L. Stramma, 1990: Upper-level circulation in the South Atlantic Ocean. *Progress in Oceanography*, **26**, 1-73.

Peterson, R.G., 1992: The boundary currents in the western Argentine Basin. *Deep-Sea Research*, **39**, 623-644.

Saraceno, M., C. Provost, A.R. Piola, J. Bava, and A. Gagliardini, 2004: Brazil Malvinas Frontal System as seen from 9 years of advanced very high resolution radiometer data. *Journal of Geophysical Research*, **109** (C5).

Upton, J. and C.J. Shaw: 2002. An overview of the oceanography and meteorology of the Falkland Islands, *Aquatic Conservation and Freshwater Ecosystems* **12**: 15-25

Vivier, F. and C. Provost, 1999a: Direct velocity measurements in the Malvinas Current. *Journal of Geophysical Research*, **104**, 21083-21103.

Appendix M: MMO Monitoring Reports

PROTECTED SPECIES MONITORING REPORT

Noble Energy Falklands Ltd.

PGS Ramform Sterling

PON3

Falkland Islands Southern Phase A 2012 & Falkland Islands Southern Tilt 2013 (FIST13)

East Falkland Island Basin & Southern Tilt Falkland Island Basin

29 November 2012 – 4 June 2013

Project No.	**UOS01285M**	**RPS**
Report No.	**1**	**411 N Sam Houston Parkway E**
Authors	**Lynn Henneberger / Heidi Ingram / Megan McManus / Lacey Price**	**Houston, Texas 77060**
	Greggo Seward / Emily Ellis / Jessica Mucci	**USA**
	Monica Arancibia-Colgain/ Tatiana Moreno/ Alexandria Denby	**Tel: (281) 448-6188**
Reviewer(s)	**Jessica Mucci**	**Fax : (281) 448-6189**
Submittal Date	**10 July 2013**	**E-mail: Jessica.Mucci@rpsgroup.com** **Web: www.rpsgroup.com**

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

Figure	*Description*	*Page*

Table	*Description*	*Page*

Appendices	*Description*
Appendix A	**JNCC guidelines for minimizing the risk of injury and disturbance to marine mammals from seismic surveys**
Appendix B	**Marine Mammal Recording Forms- Visual**
Appendix C	**Acoustic Observer Logs**
Appendix D	**Record of Operations**
Appendix E	**Location and Effort**
Appendix F	**Project Photos**

1. EXECUTIVE SUMMARY

The following report details the protected species monitoring and seismic survey operations undertaken during the Falkland Islands Southern Phase A 2012 and Falkland Islands Southern Tilt 3D surface seismic surveys aboard the Ramform Sterling from 29 November 2012 through 4 June 2013. This survey was conducted by PGS Geophysical for Noble Energy Falkland Islands Ltd., operated within a permitted area as mentioned in Falklands Islands permit Petroleum Operations Notice 3 (PON3).

Two trained visual protected species observers (PSOs) and a dedicated passive acoustic monitoring (PAM) operator, contracted through RPS, were on board to fulfill the regulatory requirements and reporting mandated by the Joint Nature Conservation Committee. Mitigation measures were to be implemented to minimize potential impacts to marine mammals throughout the duration of the survey. Mitigation measures included the use of PSOs for both visual and acoustic monitoring, establishment of safety radii, and implementation of ramp-up delays if necessary.

The PAM system was utilized during night time hours as well as for exclusion zone clearance during periods of extreme fog as outlined within the PGS Geophysical/Noble Energy Falklands Limited Project Plan section 9.3 the Environmental Management Plan (EMP). Mitigation guidelines for this project are set forth in the Joint Nature Conservation Committee's current *JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys,* August 2010.

On 8 December 2012, the vessel began airgun testing prior to commencing on the Southern Phase A survey on 10 December 2012. The Southern phase A survey was completed on 10 May 2013 at which time the vessel recovered all seismic gear and transited to port for crew change. Upon completion of crew change the vessel transited to the second survey area, the Southern Tilt 2013 survey. This survey began with gun testing just prior to production on 19 May 2013. The Southern Tilt survey was completed on 4 June 2013 and seismic gear began being recovered on this day. All seismic gear was recovered and stored on deck by 5 June 2013.

PSOs undertook a combination of visual and acoustic watches, conducting a total of 1723 hours 32 minutes of visual observations and 732 hours 21 minutes of acoustic monitoring over the course of the survey.

This visual monitoring effort produced a project total of 231 protected species detection records; 228 for cetaceans and three for pinnipeds. Of the 228 cetacean records collected, 101 records were collected for mysticetes, 98 records of odontocetes, 28 records of unidentified large whales, and one record of an unidentified cetacean. All three pinniped detections were of unidentified pinnipeds. There were no detections of sea turtles during the survey. There was one acoustic detection using the passive acoustic monitoring (PAM) system of an unidentified Delphinid. There were no correlating visual and acoustic detections.

On 19 January 2013, there was intent for airgun testing immediately after completion of the survey line during an unmonitored period at night. However, there was delay due to technicalities of changing airgun configurations for testing which resulted in the airguns going silent for duration of four minutes between survey line and airgun testing.

Detections of protected species resulted in two mitigation actions being implemented. On 25 March 2013 a soft start was delayed eight minutes due to long-finned pilot whales (detection 198) being observed within the exclusion zone during the pre-soft start survey. The soft start was being performed prior to testing the airguns so the mitigation action did not result in any production loss. The second mitigation action occurred on 19 May 2013, a soft start prior to gun testing was delayed 15 minutes due to Sei whales (detection 210) heading toward the exclusion zone. The soft start was being performed prior to testing the airguns so the mitigation action did not result in any production loss.

1.1. PROJECT LOCATION AND OPERATION PARAMETERS

There were two prospect areas surveyed during this period. The first prospect area was the Falkland Islands Southern Phase A 2012 Survey located in the East Falkland Islands basin, where water depths ranged from approximately 900 to 1,700 meters (Figure 1). The survey consisted of 109 survey lines with a grid orientation of northeast. The survey was of the Southern Quadrants 52 (block numbers 3-5, 7-10, 12-15, 18-20, and 24-25) and 53 (block numbers 1-3, 6-9, 11-14, 16-17 and 21) covering 2,808 square kilometers. The survey lines were 79 kilometers long with line spacing of 720 meters. Line changes were approximately three to four hours in duration. The *Ramform Sterling* worked with two support vessels, acting as both chase and occasional supply boats, the *Windward* and the *Christina Debora.* On 12 February the *Christina Debora* was replaced by the *Thor Pioneer*.

The second prospect area was the Falkland Islands Southern Tilt 2013 Survey located in the Southern Falkland Islands basin, where water depths ranged from approximately 660 to 2,100 meters (Figure 1). The survey was positioned in the Southern Quadrants 60 (block numbers 13a-15a, 18a-19a, 18b-19b, 20, 23, 24a-25a and 24b-25b) and 61 (block numbers 11, 16 and 21) covering 1,160 square kilometres. The survey consisted of 49 survey lines shot in the East to West direction, averaging 32 kilometres in length with line spacing of 720 meters. Line changes were approximately three to five hours in duration.

The *Ramform Sterling* towed two airgun arrays, separated by 60 meters, each comprised of three sub-arrays, separated by 8 meters. Each sub-array consisted of ten (2 strings) to twelve airguns ranging in volume from 40 in^3 to 250 in^3. Each string was equipped with one spare airgun. The airguns were towed at an average depth of 7 meters. The full source included a total of 62 airguns, alternating arrays for a maximum source volume of 4130 in^3 and a pressure of 2000 psi. Intensity of the source was 69 bar meters at a towed depth of 7 meters. The frequency range is a broadband frequency from 0-240 Hz with an intent to survey at 10-70 Hz. The center of the seismic source array was 750 meters from the vessel reference point (VRP) which was located above the PSO viewing station. The shot point interval was 25 meters or approximately every 10.4 seconds. The vessel towed 12 streamers of 6,600 meters in length, each separated by 120 meters and towed at a depth of approximately 10 meters.

Soft starts were conducted by firing the smallest airgun, and then gradually adding airguns until the airguns reached full power. Current JNCC regulations required all soft starts to be completed within 20 to 40 minutes. The mitigation source is the continuous firing of the smallest airgun at the same shot point interval as production shots. During this survey, the mitigation source was not utilized. Except during the occasional airgun testing after the end of line, airguns were immediately silenced after completion of survey lines. As per the JNCC, during periods of airgun silence lasting less than 10 minutes no soft start is required to return to full power, providing that PSOs are monitoring continuously (visual or PAM) throughout the silence and no protected species are observed within the exclusion zone.

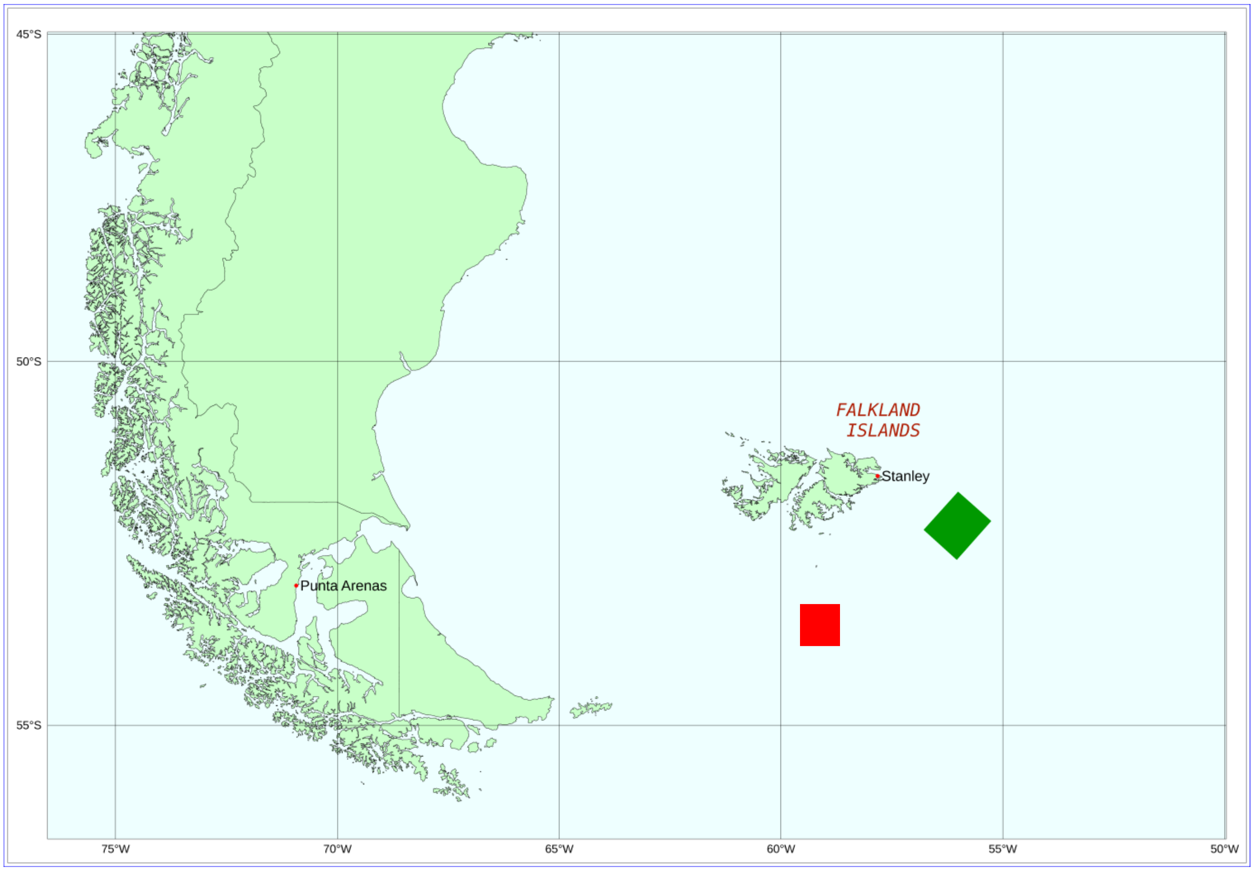


Figure 1: General location of the surveys in relation to the Falkland Islands. The green square represents the Southern Phase A 2012 survey and the red square represents the Southern Tilt 2013 survey.

1.2. PASSIVE ACOUSTIC MONITORING (PAM)

A *Seiche Measurements* PAM system was installed by the first PAM operator to join the vessel shortly after the start up meeting in Punta Arenas, Chile on 25 November 2012. The PAM system was onboard during all survey operations and was uninstalled by the PAM operator upon completion of the survey on 4 June 2013.

The PAM system consisted of two 250m conventional array cable, three 20m airgun-towed (AGT) array cables (one in use with two spares), two 100m deck cables (one for each type of array), a data processing unit with a computer, dual monitors, an acoustic analysis software package, headphones for aural monitoring, various leads and adapters, and a complete spare set of electronics and other hardware (other than cables).

The distance between the area of deployment and the monitoring station are often greater than the length of hydrophone tow cable that remains after deployment and the deck cable serves as an extension that directly interfaces with the data processing unit and the hydrophone tow cable.

The data processing unit processes the raw data from the hydrophones through two external sound cards, a *National Instruments DAQ* card and an *ASIO Fireface* card (contained within a *RME Fireface 800* unit). *National Instruments DAQ* sound cards sample raw audio at 500kHz and are used to detect beaked whale, *Kogia* species, porpoise, and delphinid (echolocation) clicks up to up to 250kHz. *ASIO Fireface* sound cards sample audio at 96kHz and are used to detect mysticete, delphinid, and non-delphinid odontocetes (including sperm whale) vocalizations up to 48kHz. The data processing unit also contains a *Measurements and Computing* data logger for the depth gauge, digital signal amplifiers, an *UltraLink Pro* audio mixer, and an *UltraCurve Pro* graphic equalizer.

The two sound cards supply low and high frequency digital audio feeds to a computer that contains a suite of software for monitoring cetacean acoustics. *Pamguard* (*Beta version 1.11.02*) is the primary software utilized on this survey. The International Federation on Animal Welfare (IFAW) software including *Logger 2000*, *Rainbow Click*, *Whistle*, and *Rainbow Click Porpoise* is the secondary software and will only be used if the *Pamguard* software fails.

The computer receives both the raw audio from the *National Instruments DAQ* sound card as well as the raw audio from the *ASIO Fireface* sound card. *Pamguard* modules including a high and low frequency click detector, whistle and moan detector, spectrogram, map with a direct GPRMC GPS feed from the *Ramform Sterling's* navigation system, and high and low frequency sound recorder.

Raw audio from the *ASIO Fireface* sound card is monitored aurally with *Sennheiser* headphones.

The 250m conventional array cable was installed by the PAM operator and seismic personnel, and was used as a backup means of PAM in the event that the AGT cable became damaged or the gun string it was attached to was brought onboard for maintenance, preventing acoustic monitoring. The conventional array was first deployed and monitored on 06 January 2013 after the second AGT cable was damaged. On 18 January 2013 the conventional array was audibly damaged and subsequently retrieved. It became apparent that the free end of the array had wrapped around the lead in and caused damage to the wiring. The conventional became entangled with the lead in on 17 March 2013 and was snapped during retrieval. The second conventional cable was installed with more p-links to prevent future entanglement. On 25 March 2013 the second conventional array cable was entangled around 2 separate lead ins, with the possibility of an additional entanglement around a third lead in under the water's surface. The cable snapped above the p-links during retrieval. During this time, the first conventional cable was repaired for future deployments.

The 20m AGT array cable was installed by the PAM operator and airgun mechanics on gun string 3, aft of the guns and float, and was first used on 09 December 2012 at the start of seismic survey operations. The cable remained deployed until it became kinked on 01 January 2012. The deployment method was revised and a second cable was installed in place of the first. The second cable was damaged on 05 January and was replaced with the third cable. The third cable became damaged on 10 January in much the same manner as the second cable. The deployment method was reverted to the original plan, but with additional spiral wrap and tape for support, and the first array (since repaired) was deployed. The repaired cable remained deployed and was undamaged for the rest of the survey.

1.3. VISUAL SURVEY METHODOLOGY

There were two trained and experienced PSOs on board to visually monitor for marine mammals, record and report on observations, and request mitigation actions in accordance with the *JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys,* August 2010. The PSOs on board held certifications from a recognized JNCC course and approved Bureau of Ocean Management (BOEM) course. From the beginning of the project Lynn Henneberger was on board as the Lead PSO and Monica Arancibia-Colgain as the support PSO. On 23 January 2013 there was a crew change and Heidi Ingram (Lead) and Tatiana Moreno (support) joined the vessel. On 3 April 2013 Megan McManus joined the vessel as Lead PSO and Alexandria Denby as support PSO. On 16 May 2013 Lacey Price joined the vessel as Lead PSO and Monica Arancibia-Colgain returned as support PSO until the completion of the project on 4 June 2013. Visual monitoring was carried out from the "sky lounge" located above the bridge, approximately 22.4 meters above the water surface which provided the PSOs with a 360° viewpoint around the acoustic source.

Binoculars (7x50 and 10x30 magnifications) were used for visual monitoring in addition to the naked eye. Inside the "sky lounge" the PSOs used a laptop for data collection as well as a telephone for communication. There was also a monitor that displayed current information about the vessel's position, speed, and heading, along with water depth, and source activity. Wind speed and direction were obtained from the ship's instrumentation on the bridge. PSOs were on a rotating schedule. Watches varied in duration, ranging from two to four hours.

When a protected species was observed range estimations were made using reticle binoculars, the naked eye, and by relating the animal to an object at a known distance, such as the acoustic array located 750 meters from the PSO observation deck. Specific species identifications were made whenever distance, length of sighting, and visual observation conditions allowed. PSOs observed physical features of animals sighted and noted behavior of the animal or group. From late January to early April photographs were taken during most sightings. Sometimes photographs were not taken due to the brevity of a sighting. The camera used was a Canon EOS 60D with a 300 millimeter telephoto lens. Marine mammal identification manuals were consulted and photos were examined during visual watch breaks to confirm identifications.

During each sighting event PSOs recorded the position, time at first and last sighting, number of animals present (adults and juveniles), the initial and any subsequent behaviors observed, the initial range, bearing and movement of the animal(s), the source activity at the initial and final detections and any mitigation measures that were applied. Specific information regarding the animal(s) closest approach to the vessel, acoustic source and the acoustic source output at the closest approach were recorded. Additionally, the vessel position, water depth, vessel speed, the wind speed and direction, Beaufort scale, swell level, visibility, glare, and precipitation were recorded every hour at minimum or every time environmental conditions or seismic activity changed. Each sighting event was linked to an entry on a datasheet such that environmental conditions were available for each sighting event.

The PSOs communicated with the seismic crew in the instrument room via internal ship's phone. Communication through the internal phone system directly to the instrument room has assisted in prompt, clear communication of any changes in airgun activity or in the event a mitigation action needed to be implemented. The support vessels could also be reached by both UHF and VHF two-way radio communication.

When the acoustic source was activated from silence, PSOs maintained watch for 60 minutes prior to the activation of the source. Visual watches commenced each day before sunrise, beginning as soon as the exclusion zone was visible, and continued past sunset until the exclusion zone became obscured. Start of observation times ranged from 7:17 to 10:40 UTC, while end of observation times ranged from 20:00 to 00:45 UTC.

1.4. PASSIVE ACOUSTIC MONITORING (PAM) SURVEY METHODOLOGY

This project utilized PAM operators to acoustically monitor during the night and during times of reduced daytime visibility; in order to clear the exclusion zone prior to ramp-up when applicable.

The PAM system was monitored on a nightly basis with a start time ranging from 20:30-00:15 UTC and an end time ranging from 07:45-11:20 UTC. PAM monitoring began on the night of 09 December 2012 and continued for the duration of operations ending on 04 June 2013.

Acoustic surveys were conducted by the PAM operator in two to four hour shifts separated by one to two hour breaks. Acoustic monitoring overlapped visual monitoring during the periods just before sunset and just after sunrise. The overlap allowed for continuous monitoring of the exclusion zone for protected species and would permit operations to resume with minimal lost production time in the event of a late operational delay. In addition, the overlap of acoustic and visual monitoring allowed for potential correlations between acoustic and visual detections.

Acoustic monitoring for marine mammals was completed aurally with *Sennheiser* headphones and visually with *Pamguard Beta 1.11.02*. Delphinid whistles, clicks, and burst pulses as well as sperm whale clicks may be viewed on a spectrogram display within *Pamguard*. Sperm whale, beaked whale, *Kogia* species, and delphinid echolocation clicks may be viewed on low and high frequency click detector displays.

Distances for acoustic detections are primarily based upon a noise or detection score system developed by Gannier *et al* (2002). Gannier *et al* monitored sperm whales (*Physeter macrocephalus*) in the Mediterranean both visually and acoustically. A subjective scale was developed based upon the strength or intensity of the sperm whale clicks at various distances that were measured visually when the sperm whales surfaced. Although the scale is subjective and sounds produced in marine environments will vary according to local conditions, the scale provides a measure for approximating distances when using a single, linear hydrophone array.

Another method to determine range of an animal was to use the *Pamguard* Map module along with the Click Detector in the LF *Pamguard* configuration file. In order to successfully utilize this function of *Pamguard* the detection needs to be several minutes long, and the successful determination and selection of "click trains" in the Click Detector module. Due to the ambient noise levels and minimal hydrophone separation, the PAM operator was not able to utilize this function of *Pamguard.*

During a detection of a vocalizing animal, information regarding position, distance, heading of vessel, water depth, and range of animal, if applicable, was recorded, along with any recordings of vocalizations. A detection report was completed, utilizing information gathered from not only the navigation department, but also from the *Pamguard* modules. All information gathered was input into the Detection Report forms and the Daily Passive Acoustic Forms. This information is available in Appendix B, and Appendix C respectively. All detections were reported on a daily basis to onboard client representatives and the vessel Party Chief. Details of these detections were submitted in Weekly Reports along with the combined visual MMO data, and can be found in Appendix B. Recordings made of detections have a corresponding word document that describes the conditions, and details of the recording.

1.5. SURVEY DATA SUMMARY

The *Ramform Sterling* departed Punta Arenas, Chile on 29 November, 2012 for the Southern Phase A 2012 survey area near the Falkland Islands. The seismic gear was deployed and use of the acoustic source commenced at 23:48 UTC on 8 December 2012 and continued until the prospect was completed at 00:17 UTC on 10 May 2013. Gun operations commenced on the second survey, the Southern Tilt 2013 survey, at 11:44 UTC on 19 May 2013 and continued until 16:57 UTC on 4 June 2013 when the project was completed. All seismic gear began being brought on board on 4 June 2013 and was stored and secured on deck by 5 June 2013.

The acoustic source was active throughout the two surveys, with multiple periods of source silence, for a total of 1515 hours 12 minutes of source activity. This includes ramp-up of the airguns, full power and partial power firing both online and during airgun testing (Figure 2). Full power source operations, while online, accounted for 88 percent (1345 hours 37 minutes) of airgun activity during the project. There was 54 hours 45 minutes of non-production full-volume firing, and 27 hours 32 minutes of airgun testing. Additionally, the airguns were active for a total of 87 hours 18 minutes during ramp ups. There was a total of 2948 hours and 48 minutes of airgun silence throughout the survey.

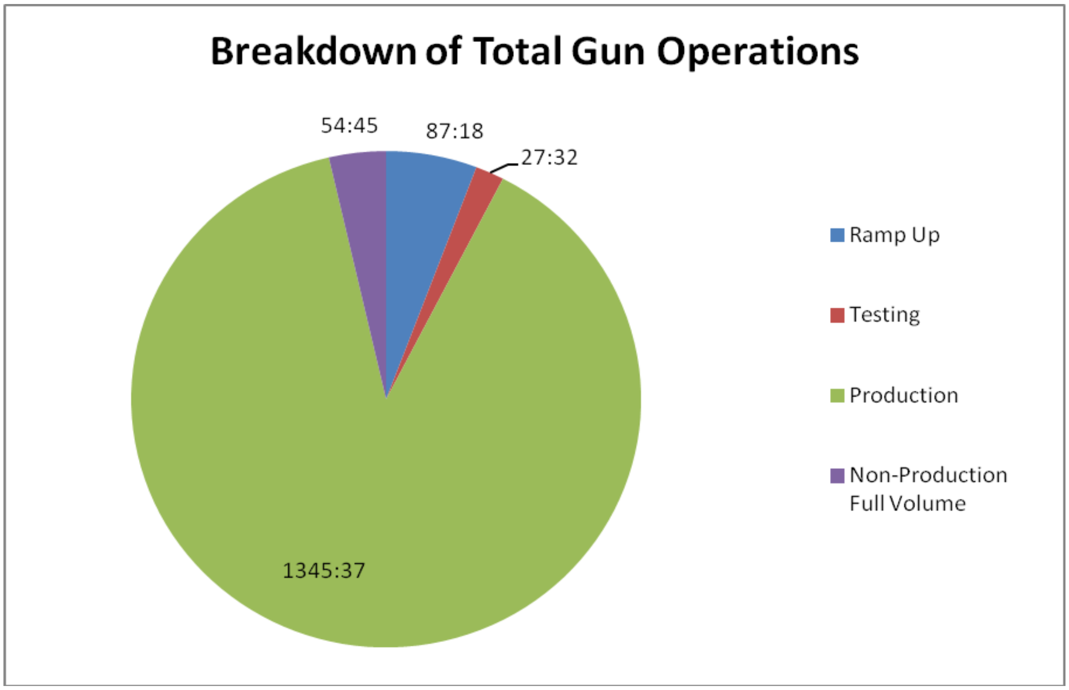


Figure 2: Breakdown of airgun operations.

There were 263 soft starts performed over the course of the survey in order to commence full power survey operations. The soft start ranged from 21 to 37 minutes in duration; with four soft starts being abandoned midway due to computer or compressor problems or bad weather. Nineteen soft starts were performed prior to airgun testing with the remaining soft starts performed to resume production after periods of airgun silence. The soft starts were conducted using an automated gun controller program, which adds guns sequentially to achieve full source over the required period of time. Prior to soft starts and airgun testing the area was monitored for 60 minutes either visually, during daytime, or acoustically, during nighttime or periods of limited visibility. The exclusion zone was cleared prior to airgun activity 139 times through visual monitoring and 124 times through PAM (Table 1).

Table 1. Total acoustic source operations during the Falkland Islands Southern Phase A & Southern Tilt 2013.

Acoustic Source Operations	Number	Duration (hh:mm)
Airgun Tests		**27:32**
Soft start	**263**	**87:18**
Day time ramp-ups cleared by visual observation	**139**	
Day time soft starts cleared by PAM	**14**	
Night time soft starts cleared by PAM	**110**	
Full power survey acquisition		**1345:37**
Full power non-production		**54:45**
Total time acoustic source was active		**1515:12**

1.5.1. Visual Monitoring Survey Summary

Visual monitoring was conducted by two PSOs each day between just before dawn until just after dusk, when it was too dark for the entire safety radius to be visible. The duration of daily observations ranged from approximately 8 hours 40 minutes to 17 hours 19 minutes. Observation times were adjusted as required for seasonal changes in available daylight, as well as daily changes due to cloud cover and fog. Over the course of the project a total of 1723 hours 32 minutes of visual observation were conducted. The acoustic source was active during 902 hours 3 minutes (52%) during visual monitoring and silent during 821 hours 29 minutes (48%) of visual monitoring, as shown in Figure 3. However, when visibility was reduced and the exclusion zone was not visible during daylight hours due to thick fog, passive acoustic monitoring was used to grant clearance prior to soft starts. Daytime PAM was used to clear the exclusion zone 14 times over the course of the project.

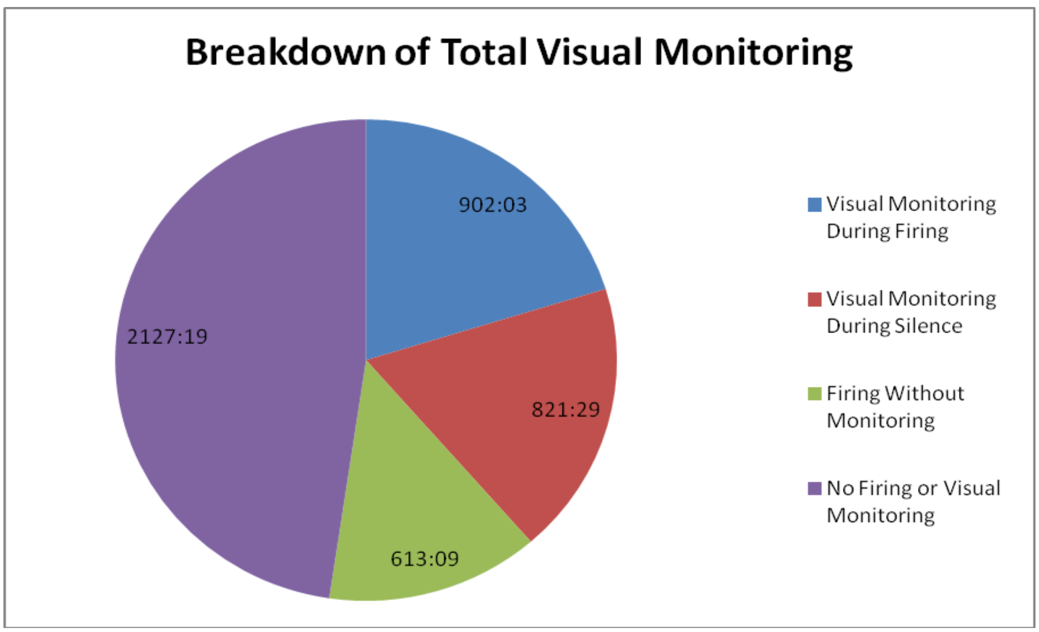


Figure 3: Breakdown of visual monitoring.

1.5.2. Acoustic Monitoring Survey Summary

Acoustic monitoring began on 09 December at 00:15 for pre-watch prior to and during a series of airgun tests and continued throughout the project with the PAM operator monitoring the hydrophones aurally and monitoring the *Pamguard* detection software. Acoustic monitoring for the project ended at 11:30 UTC on 4 June 2013 when acquisition of the final survey line was completed and the hydrophone cable was retrieved. Over the course of the project, the PAM operator and PSOs conducted 732 hours 21 minutes of acoustic monitoring. The acoustic source was active during 424 hours 42 minutes (58%) during acoustic monitoring and silent during 307 hours 39 minutes (42%) of acoustic monitoring (Figure 4).

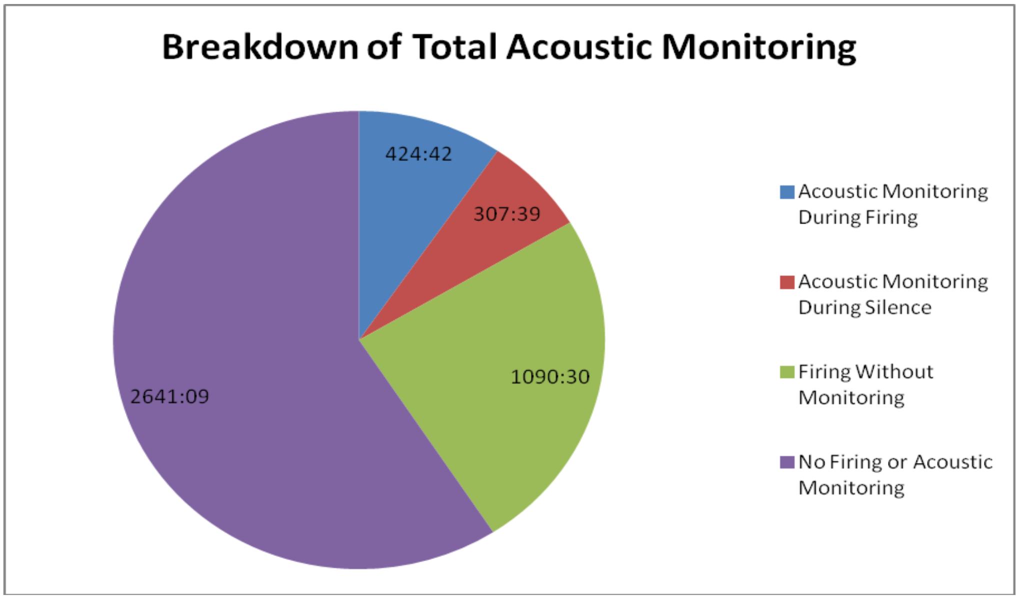


Figure 4: Breakdown of acoustic monitoring.

1.6. MITIGATION ACTIONS

There were two mitigation actions implemented during the Falkland Islands Southern Phase A & Southern Tilt seismic surveys. On 25 March 2013 (detection 198) a pod of long-finned pilot whales were observed approximately 250 meters from the acoustic source during the one hour survey period prior to soft start. The soft start was delayed by eight minutes to ensure the animals had been outside of the exclusion zone for 20 minutes before the airguns were activated. Hourglass dolphins were also observed with the pilot whales but were not observed inside the exclusion zone. The soft start was conducted prior to an airgun test so there was no loss of production due to the mitigation action.

The second mitigation action occurred on 19 May 2013, a soft start prior to gun testing was delayed 15 minutes due to Sei whales (detection 210) heading toward the exclusion zone. The soft start was being performed prior to testing the airguns so the mitigation action did not result in any production loss.

Passive acoustic monitoring was implemented during this project to clear soft starts during times of limited visibility including episodes of heavy fog, in addition to, the night-time operations.

2. WILDLIFE SUMMARY

2.1. VISUAL DETECTIONS

Visual monitoring conducted during the Falkland Islands Southern Phase A 2012 and Southern Tilt 2013 surveys resulted in the collection of 231 records of detection for protected species. Forms describing each detection can be found in Appendix B. Twelve species of marine mammal were positively identified, along with unidentified baleen whales, unidentified whales, unidentified cetaceans, unidentified dolphins, and unidentified pinnipeds. The total number of detection events and total number of animals recorded by species is described in Table 2 and shown in figures 5-7.

The wildlife detections from this project can be separated into two categories: birds and fish. A single sighting of an unidentified shark occurred during a feeding frenzy on 17 February in close proximity to a pod of long-fined pilot whales and hourglass dolphins. Birds from a total of 12 families, including 32 positively identified species, were observed over the course of this project. The most abundant species observed throughout the project was the cape petrel (*Daption capense*), although this is due to a particularly dense number observed in the month of December with numbers tapering dramatically proceeding that month. Other species with similar observation patterns are the giant petrel (*Macronectes giganteus*), southern fulmar (*Fulmarus glacialoides*), and the black-browed albatross (*Thalassarche melanophrys*). The latter of which has its highest number of observed individuals in December and January. The species most regularly observed throughout the project is the black-browed albatross, followed by the wandering albatross (*Diomedea exulans*). Outliers include sooty albatross (*Phoebetria fusca*), gray-headed albatross (*Thalassarche chrysostoma*), Chilean skua (*Stercorarius chilensis*), white-bellied storm-petrel (*Fregetta grallaria*), black-chinned siskin (*Carduelis barbata*), an unidentified penguin species, and an unidentified tern species, each of which represents one to two individuals observed on one to two days.

A complete list of bird species and other marine life observed and identified in addition to the approximate number of individuals observed and the number of days on which they were observed can be found in Tables 4-6.

Table 2. Number of visual detection records recorded for each protected species.

	Total Number of Detection Records	Total Number of Animals Recorded
Cetaceans		
Unidentified whale	28	33
Unidentified cetacean	1	1
Mysticetes		
Fin whale	25	54
Sei whale	21	47
Minke whale	8	10
Southern right whale	5	5
Humpback whale	1	1
Unidentified baleen whale	42	66
Odontocetes		
Sperm whale	1	2
Orca	2	2
Long-finned pilot whale	14	431

Hourglass dolphin	58	797
Peale's dolphin	4	54
Dusky dolphin	1	1
Commerson's dolphin	1	7
Unidentified dolphin	16	106
Pinnipeds		
Unidentified pinniped	3	3
TOTAL	**231**	**1621**

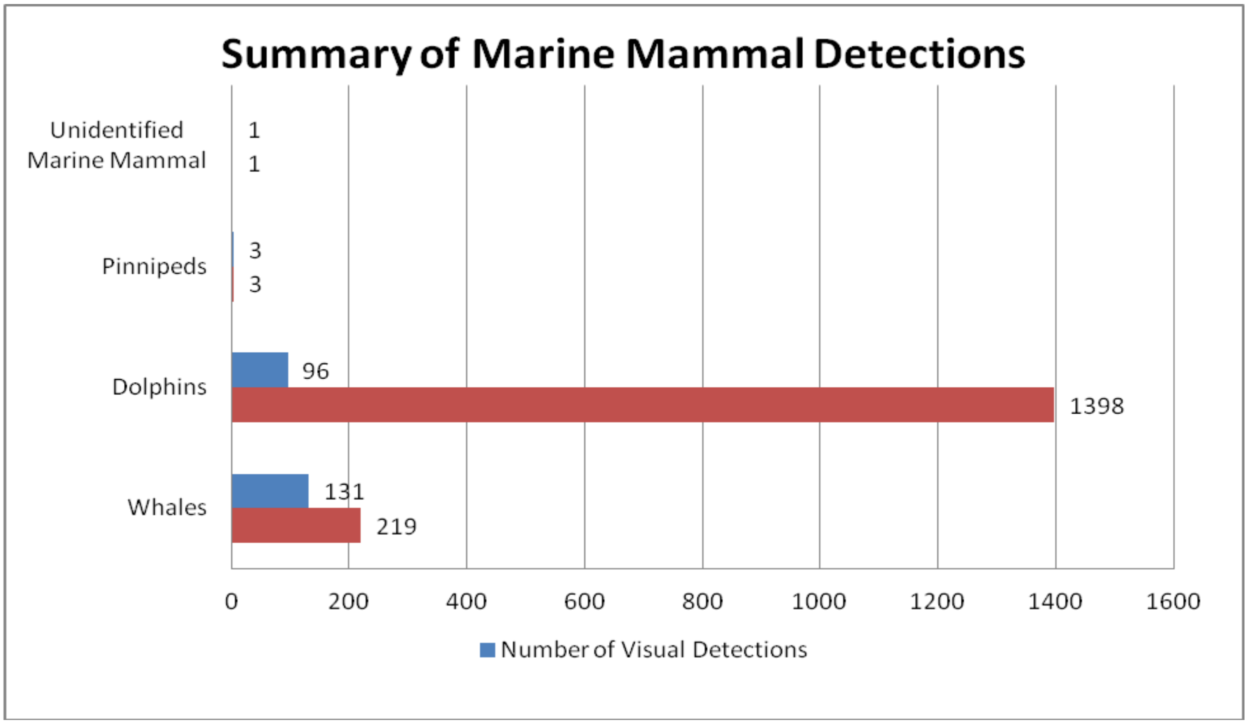


Figure 5: Breakdown of protected species detected.

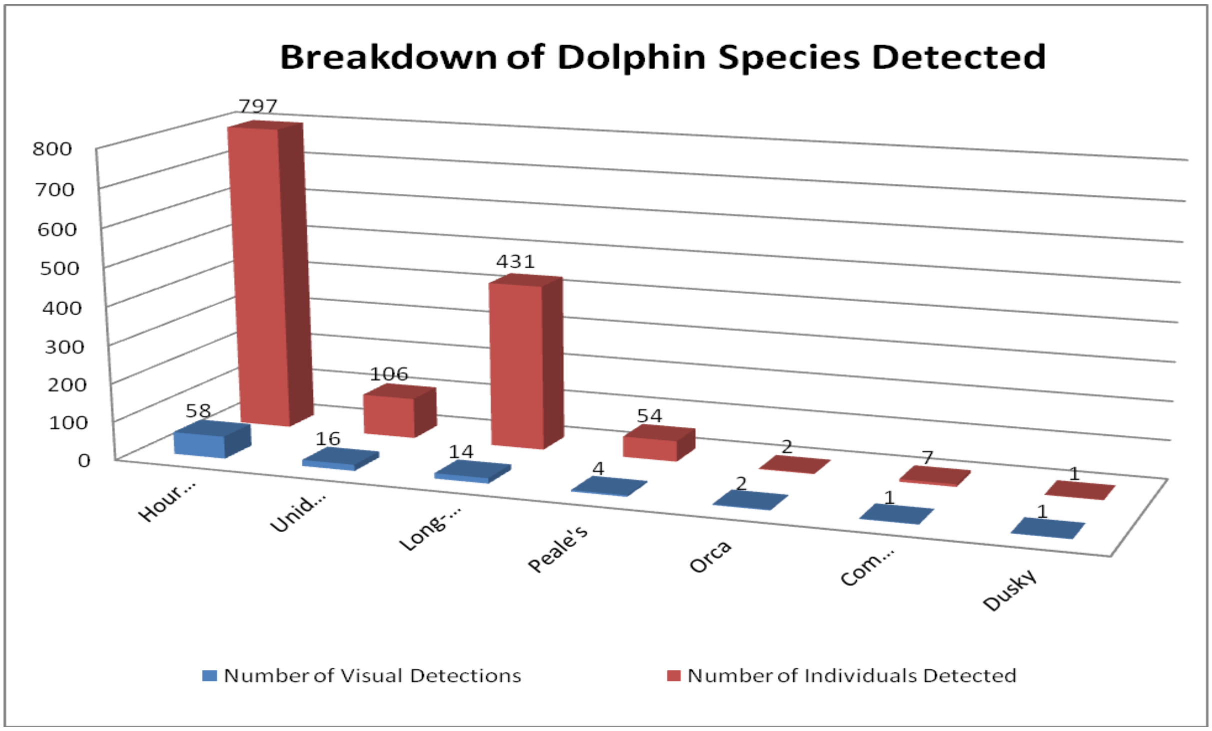


Figure 6: Breakdown of dolphin species detected.

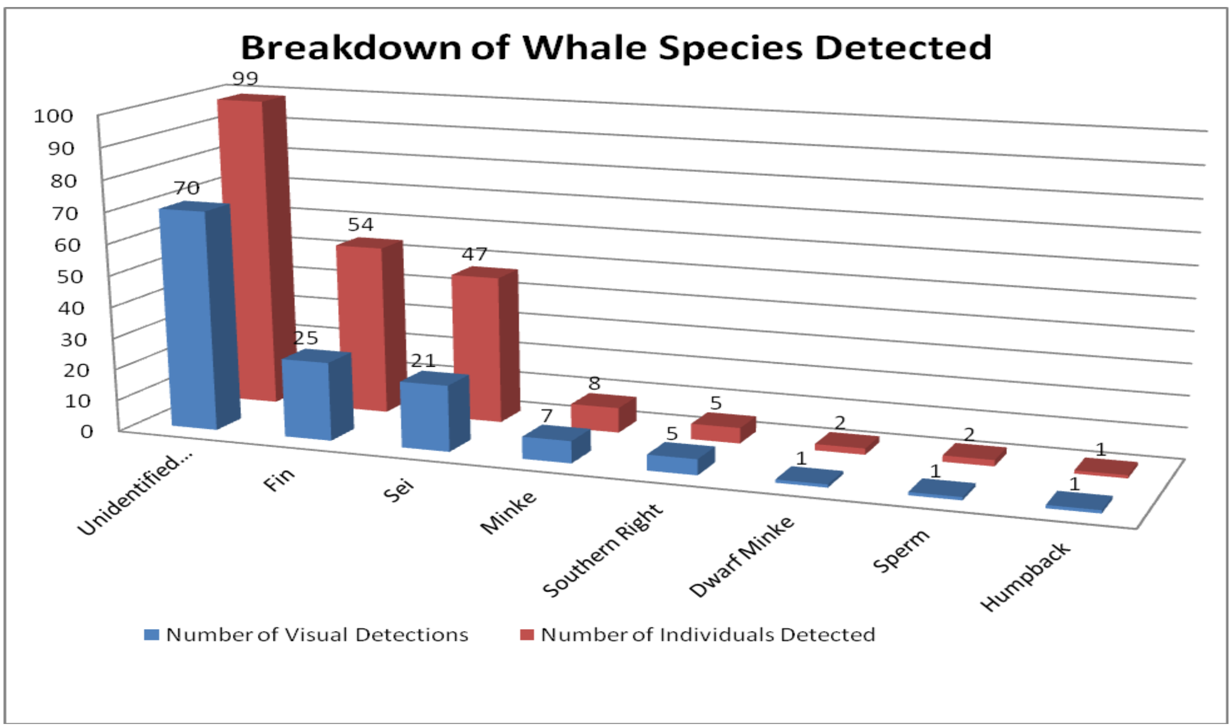


Figure 7. Breakdown of whale species detected during the survey.

Of the 231 visual protected species detection events during the survey, 130 detections occurred while the acoustic source was active and 101 detections occurred while the acoustic source was silent. Table 3 demonstrates the average closest approach of each species to the source at various source volumes. Figure 8 shows the average closest distance of each category of marine mammals to the source while firing and during silence.

Table 3. Average closest approach of protected species to the acoustic source at various volumes.

Species Detected	Full Power (4130 in³)		Soft start		Reduced power		Not Firing	
	Number of detections	Average closest approach to source (meters)	Number of detections	Average closest approach to source (meters)	Number of detections	Average closest approach to source (meters)	Number of detections	Average closest approach to source (meters)
Fin whale	17	1208	-	-	-	-	8	1356
Sei whale	7	1160	-	-	-	-	14	2300
Minke whale	5	913	-	-	-	-	2	1100
Dwarf minke whale	-	-	-	-	-	-	1	20
Southern right whale	4	968	-	-	-	-	1	800
Humpback whale	-	-	-	-	-	-	1	100
Sperm whale	1	5000	-	-	-	-	-	-
Orca	1	800	-	-	-	-	1	250
Long-finned pilot whale	4	513	-	-	-	-	10	293
Hourglass dolphin	31	1145	1	1500	-	-	26	925
Peale's dolphin	-	-	-	-	-	-	4	481
Dusky dolphin	-	-	-	-	-	-	1	50
Commerson's dolphin	1	850	-	-	-	-	-	-
Unidentified baleen whale	26	2240	1	1200	1	1500	14	2083
Unidentified whale	17	2303	3	1083	-	-	8	2413
Unidentified dolphin	8	1634	-	-	-	-	8	1586
Unidentified cetacean	1	895	-	-	-	-	-	-
Unidentified pinniped	3	838	-	-	-	-	-	-

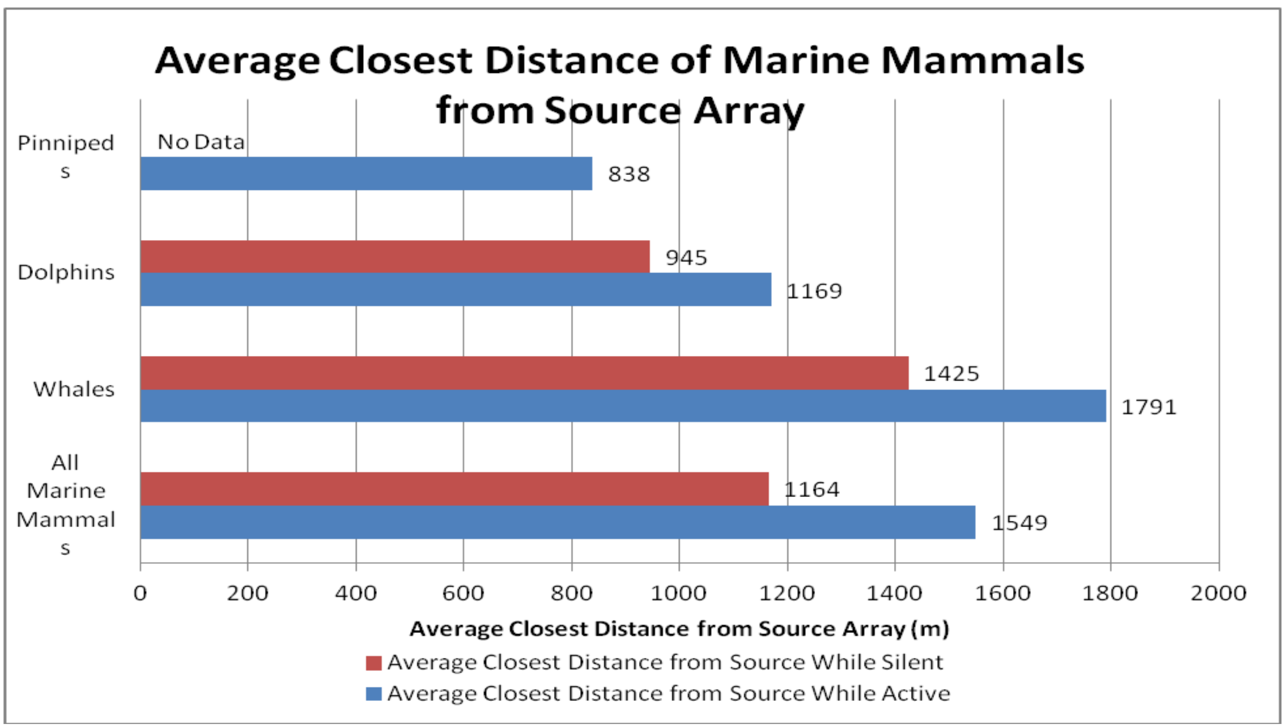


Figure 8. Average closest distance of protected species to source array.

2.1.1. Cetacean Detections

2.1.1.1. Sei whale

There were 21 visual detections of sei whales (*Balaenoptera borealis*) totalling 47 animals, five of the animals were identified as juveniles. The sightings occurred in water depths ranging from 160 to 1,941 meters and were observed in group sizes ranging from one to five animals. The majority of detections (11 detections) occurred during the end of November and December. During one sighting two sei whales were observed with a pod of hourglass dolphins.

2.1.1.2. Fin whale

There were 25 visual detections of fin whales (*Balaenoptera physalus*) totalling 54 animals; observed in group sizes ranging from one to eight animals. Three of the animals were identified as juveniles. The majority of fin whale detections (19 detections) occurred during the end of November through January. The sightings occurred in water depths ranging from 128 to 1,994 meters.

2.1.1.3. Dwarf minke whale

There was one visual detection of two dwarf minke whales (*Balaenoptera acutorostrata*). This sighting occurred at 560 meters of water depth. The whales were observed with a pod of long-finned pilot whales.

2.1.1.4. Minke whale

There were seven visual detections of Antarctic minke whales (*Balaenoptera bonaerensis*) totalling nine animals, observed in group sizes of one to two animals. The sightings occurred in water depths ranging from 482 to 1,641 meters.

2.1.1.5. Humpback whale

There was one visual detection of a humpback whale (*Balaenoptera novaeangliae*). This sighting occurred at 500 meters of water depth.

2.1.1.6. Sperm whale

There was one visual detection of two sperm whales (*Physeter macrocephalus*). This sighting occurred at 1,413 meters of water depth.

2.1.1.7. Southern right whale

There were five visual detections of Southern right whales (*Eubalaena australis*), all sightings of individual animals. All sightings of Southern right whales occurred in February and March. The sightings occurred in water depths ranging from 1,318 to 1,606 meters. During one sighting a pod of five hourglass dolphins were observed swimming alongside the whale.

2.1.1.8. Orca

There were two visual detections of orcas (*Orcinus orca*), both sightings of individual animals. Both sightings occurred in the month of December. The sightings occurred in water depths of 727 and 1,321 meters.

2.1.1.9. Long-finned pilot whale

There were 14 visual detections of long-finned pilot whales (*Globicephela melas*) totalling 431 animals, observed in group sizes of eight to 50 animals. Twenty-three of the animals were identified as juveniles. The sightings occurred in water depths ranging from 305 to 1,754 meters. During five of the detections the pilot whales were observed with other species such as a dwarf minke whale, an unidentified baleen whale, and hourglass dolphins.

2.1.1.10.Peale's dolphin

There were four visual detections of Peale's dolphins (*Lagenorhynchus australis*) totalling 54 animals. The sightings occurred in water depths ranging from 129 to 918 meters.

2.1.1.11. Hourglass dolphin

Hourglass dolphins (*Lagenorhynchus cruciger*) were the most abundant species observed with 58 detections totalling 797 animals. The majority of hourglass dolphin sightings (48 detections) occurred in February and March. The dolphins were observed in group sizes of two to 80 animals, with one sighting of a large pod of approximately 250 animals. Twenty three of the animals were identified as juveniles. The sightings occurred in water depths ranging from 291 to 1,980 meters. Hourglass dolphins were frequently observed bowriding; they were also observed on one occasion with a Southern right whale and on three occasions with long-finned pilot whales.

2.1.1.12.Dusky dolphin

There was one visual detection of a single dusky dolphin (*Lagenorhynchus obscurus*). This sighting occurred at a water depth of 1,786 meters.

2.1.1.13. Commerson's dolphin

There was one visual detection of Commerson's dolphins (*Cephalorhynchus commersonii*) totalling seven animals. This sighting occurred at a water depth of 1,547 meters.

2.1.1.14. Unidentified baleen whale

There were 42 visual detections of unidentifiable baleen whales, totalling 66 animals. Two of the animals were identified as juveniles. The animals in six of these sightings were identified as being either fin or sei whales.

2.1.1.15. Unidentified whale

There were 28 visual detections of unidentifiable whales, totalling 33 animals. One of the animals was identified as a juvenile. During the majority of these sightings only the blow was observed.

2.1.1.16. Unidentified dolphin

There were 16 visual detections of unidentifiable dolphins, totalling 106 animals. One of the animals was identified as a juvenile. Additionally, there was one sighting of a single unidentifiable cetacean.

2.1.2. Pinniped Detections

2.1.2.1. Unidentified pinniped

There were three visual detections of unidentifiable pinnipeds. The sightings occurred at water depths of 981 to 1,247 meters.

2.2. ACOUSTIC DETECTIONS

There was one acoustic detection during this survey. On 27 December 2012 at 01:40 an unidentified delphinid species was detected acoustically. Low frequency whistles were noted aurally as well as via Pamguard's spectrogram software. The dominant frequencies of the whistles were observed at 3-4 kHz, with harmonics peaking above 60 kHz. Lack of overlapping vocalizations suggest that only one animal was both present and vocal. The detection lasted for two minutes and ended at 01:42.

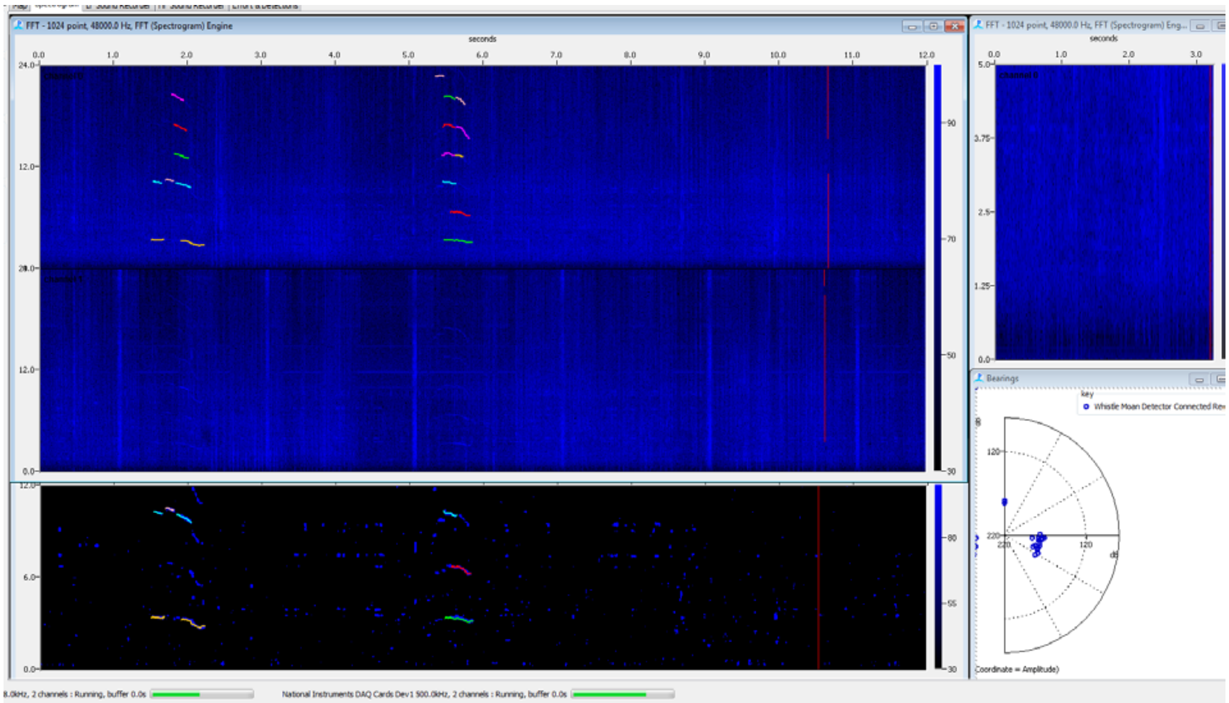


Figure 9. Screen capture of unidentified delphined detection on Pamguard.

2.3. ENVIRONMENTAL CONDITIONS

Visual observations were often hindered by poor environmental conditions. During visual observation the Beaufort scale ranged from zero to nine, with the vast majority of observations occurred with a Beaufort scale of four to six. Wind speed was quite variable from around 1 knot to 45 knots. Sea conditions were greatly affected by the wind changes; the sea state during the majority of watch was slight to choppy. The majority of visual observations were conducted with swells lower than two meters and a significant amount of observations were conducted with moderate swells, ranging from two to four meters. Visibility was good for the majority of visual observations, although there were significant periods of time of dense fog and precipitation, sometimes lasting for several days. Due to frequent cloud cover there was no glare present during the majority of watch with only a few days on glare inhibited sighting conditions.

2.4. WILDLIFE SUMMARY TABLES

2.4.1. Marine Mammals

Table 4: Protected species observed during visual and/or acoustic monitoring.

Date	Common Name	Scientific Name (Genus species)	Family	Detection Method	Sighting Description	Mitigation Actions
29/11/2012	Sei Whale	*Balaenoptera borealis*	Balaenopteridae	Visual	Four surfaced together	None
30/11/2012	Peale's Dolphin	*Lagenorhynchus australis*	Delphinidae	Visual	two barely surfaced and were circling the paravane	None
30/11/2012	Fin Whale	*Balaenoptera physalus*	Balaenopteridae	Visual	3 blew in sequence, toward vessel then away	None
01/12/2012	Sei Whale	*Balaenoptera borealis*	Balaenopteridae	Visual	Fast swim, approach vssl, swam bw p-vane and vssl	None
01/12/2012	Long-finned pilot whale	*Globicephala melas*	Delphinidae	Visual	Head out surfacing, ind spread out til last sight	None
01/12/2012	Sei Whale	*Balaenoptera borealis*	Balaenopteridae	Visual	Mill, then away	None
01/12/2012	Sei Whale	*Balaenoptera borealis*	Balaenopteridae	Visual	Mill, then 2 approached w/in 200m	None
01/12/2012	Unidentified whale	*n/a*	*n/a*	Visual	Traveling slow, surfacing ~8-11 minutes	None
01/12/2012	Sei Whale	*Balaenoptera borealis*	Balaenopteridae	Visual	Appeared to be milling, then dove	None
01/12/2012	Sei Whale	*Balaenoptera borealis*	Balaenopteridae	Visual	Blew once then 40 seconds later again, then dove	None
02/12/2012	Fin Whale	*Balaenoptera physalus*	Balaenopteridae	Visual	Surfaced in breaking wave near bow	None
03/12/2012	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	Blow off stbd side, then blow at 09:20 stbd ahead	None
05/12/2012	Long-finned pilot whale	*Globicephala melas*	Delphinidae	Visual	tight grp trvl fast frm bow to pside, frq srfcng	None
05/12/2012	Humpback whale	*Megaptera novaeangliae*	Balaenopteridae	Visual	qk head lob headed W, blow 2-3x, head NE	None
06/12/2012	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	Three blows observed spread out over 8 minutes	None
07/12/2012	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	Blows were in a tight group from different animals	None
07/12/2012	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	Blows only	None
09/12/2012	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	Blows only	None
09/12/2012	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	Blows only	None
09/12/2012	Orca	*Orcinus orca*	Delphinidae	Visual	Crashing through wave	None
09/12/2012	Dwarf Minke whale	*Balaenoptera acutorostrata*	Balaenopteridae	Visual	body surfaced @ P Bow, then blew @ S by lines	None

09/12/2012	Long-finned pilot whale	*Globicephala melas*	Delphinidae	Visual	Lrg. Grp. Spread out by vess.	None
10/12/2012	Long-finned pilot whale	*Globicephala melas*	Delphinidae	Visual	jmpg clear of lrg waves on star side of vessel	None
10/12/2012	Unidentified whale	*n/a*	*n/a*	Visual	Tight group of blows hdg parallel away	None
10/12/2012	Sei Whale	*Balaenoptera borealis*	Balaenopteridae	Visual	1 blow smaller nxt to larger; trvl rapid opp dir	None
10/12/2012	Fin Whale	*Balaenoptera physalus*	Balaenopteridae	Visual	Blow 2-3x every 7-10 min milling	None
10/12/2012	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	2 separate blows at once, blow 2-3x every 5 min.	None
11/12/2012	Unidentified Delphinidae	*n/a*	Delphinidae	Visual	brief head when surfacing,1 lingered w/dorsal vis	None
11/12/2012	Unidentified whale	*n/a*	*n/a*	Visual	One blow sighted	None
11/12/2012	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	1 grp appchd bow then NE; othr stayd ptsd parallel	None
11/12/2012	Fin Whale	*Balaenoptera physalus*	Balaenopteridae	Visual	2 milling, blow 2-3x/6-8 min.	None
11/12/2012	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	Shallow dive, then surfacd & blows hdg away	None
11/12/2012	Unidentified Pinniped	*n/a*	*n/a*	Visual	leaping near bow 3x	None
11/12/2012	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	passed perpend. To boat NE to SW, leaping	None
11/12/2012	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	passed perpend. To boat NE to SW, leaping	None
11/12/2012	Fin Whale	*Balaenoptera physalus*	Balaenopteridae	Visual	milling ~200-500 m from vess.	None
11/12/2012	Fin Whale	*Balaenoptera physalus*	Balaenopteridae	Visual	3-5 animals, prob feed (lg bubbles)	None
11/12/2012	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	Approached w/in 400m then turned perpendicular	None
11/12/2012	Fin Whale	*Balaenoptera physalus*	Balaenopteridae	Visual	2 anim 1 much lrger than othr, sim behav Blow/mill	None
12/12/2012	Unidentified whale	*n/a*	*n/a*	Visual	1 blow near stbd stern, then 1 blow off sdbd bow	None
12/12/2012	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	consistent blows every2-3 min heading ne	None
12/12/2012	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	2-3 blows/ 5-7 min, heading SW rapidly	None
12/12/2012	Sei Whale	*Balaenoptera borealis*	Balaenopteridae	Visual	2-3 blows/5-7 min, heading NE rapidly	None
12/12/2012	Fin Whale	*Balaenoptera physalus*	Balaenopteridae	Visual	Mult blows spread over km around vssl -min 8 ind	None
13/12/2012	Minke Whale	*Balaenoptera bonaerensis*	Balaenopteridae	Visual	Swimming away, then parallel same	None
13/12/2012	Unidentified baleen whale	*n/a*	Balaenopterida e	Visual	3 heading 155; 2 off ptsd; 1 ahead pt	None
13/12/2012	Minke Whale	*Balaenoptera bonaerensis*	Balaenopteridae	Visual	headed paralell w/ vess then away SW	None
13/12/2012	Unidentified baleen whale	*n/a*	Balaenopterida e	Visual	Mill as vssl passed,surfacing w/blow & lg splash	None
14/12/2012	Unidentified baleen whale	*n/a*	Balaenopterida e	Visual	same dir as vess then perpend to NE	None

14/12/2012	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	Blows (2 to 3 ind together, 1 farther)	None
14/12/2012	Unidentified Delphinidae	*n/a*	Delphinidae	Visual	barely broke surf w/leaps, move to vess then away	None
14/12/2012	Fin Whale	*Balaenoptera physalus*	Balaenopteridae	Visual	Traveld behnd floats & off pt monowng (not EZ)	None
14/12/2012	Unidentified Whale	*n/a*	*n/a*	Visual	ind. blows ~4 min apart, trvl quickly awy frm vess	None
14/12/2012	Minke Whale	*Balaenoptera bonaerensis*	Balaenopteridae	Visual	head awy frm vess NE, blow ~4-5 min 2x	None
14/12/2012	Fin Whale	*Balaenoptera physalus*	Balaenopteridae	Visual	2 animals near vssl swam bw streamers; blows ~5min	None
15/12/2012	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	Crossing ahead	None
15/12/2012	Unidentified whale	*n/a*	*n/a*	Visual	1:blws only;2:closr paralel vssl,turnd away thn bk	None
16/12/2012	Long-finned pilot whale	*Globicephala melas*	Delphinidae	Visual	porpoising off stbd bow against vess	None
17/12/2012	Unidentified whale	*n/a*	*n/a*	Visual	blew 1-2x every 4-5 min. mill	None
17/12/2012	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	One blow sighted	None
17/12/2012	Unidentified cetacean	*n/a*	*n/a*	Visual	Surfaced 2X b4 porpoising twds vssl	None
18/12/2012	Long-finned pilot whale	*Globicephala melas*	Delphinidae	Visual	var heading near vess. Spread out	None
18/12/2012	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	blow, v. lrg body	None
18/12/2012	Long-finned pilot whale	*Globicephala melas*	Delphinidae	Visual	tight group heading away frm boat	None
18/12/2012	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	Grp split,appchd w/in 50m;pod alngsde 500m	None
18/12/2012	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	surfacing around whales	None
18/12/2012	Sei Whale	*Balaenoptera borealis*	Balaenopteridae	Visual	Whitewater when surfacing, blows	None
18/12/2012	Fin whale	*Balaenoptera physalus*	Balaenopteridae	Visual	8-10 min,then blow,2 min blow,repeat 8-10 min	None
18/12/2012	Fin whale	*Balaenoptera physalus*	Balaenopteridae	Visual	Slowly crossing ahead	None
18/12/2012	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	Both spyhopped together, blows together	None
22/12/2012	Dusky Dolphin	*Lagenorhynchus obscurus*	Delphinidae	Visual	Slowly submerged off the bow heading towards stern	None
24/12/2012	Unidentified Delphinidae	*n/a*	Delphinidae	Visual	Porpoising parallel creating large splashes	None
27/12/2012	Unidentified Delphinidae	*n/a*	Delphinidae	Acoustic		None
27/12/2012	Unidentified whale	*n/a*	n/a	Visual	Blows sighted, travelling fast	None

27/12/2012	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	Body sighted surfacing off stbd, then 2 blows after it had passed streamers	None
28/12/2012	Orca	*Orcinus orca*	Delphinidae	Visual	porpoised once off stbd side, no blows	None
28/12/2012	Minke whale	*Balaenoptera bonaerensis*	Balaenopteridae	Visual	Rapid surfacing all around vessel	None
28/12/2012	Fin whale	*Balaenoptera physalus*	Balaenopteridae	Visual	slow-moving, 2 off stbd,1 new or old sighted ptsd	None
28/12/2012	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	Blows sighted off stbd deflector (poss 2 animals)	None
29/12/2012	Unidentified Delphinidae	*n/a*	Delphinidae	Visual	porpoising ~2-3 min	None
29/12/2012	Unidentified whale	*n/a*	*n/a*	Visual	water disturbance, fast srfcing, no blows	None
29/12/2012	Sei whale	*Balaenoptera borealis*	Balaenopteridae	Visual	2 blows, simt. Water dist	None
29/12/2012	Sei whale	*Balaenoptera borealis*	Balaenopteridae	Visual	Multiple blows, erratic water disturbance w/2 ind	None
31/12/2012	Peale's dolphin	*Lagenorhynchus australis*	Delphinidae	Visual	porpoising rapidly	None
31/12/2012	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	Lg whiteH2O created,head briefly observed w/1 blow	None
31/12/2012	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	Blows, 3 ind side-by-side,1 blow tiny in relation	None
31/12/2012	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	Blows, animals near each other	None
01/01/2013	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	Blows observed, no body sighted	None
01/01/2013	Fin whale	*Balaenoptera physalus*	Balaenopteridae	Visual	approachd bw streamers 8&9,then bw vessl & source	None
01/01/2013	Fin whale	*Balaenoptera physalus*	Balaenopteridae	Visual	Blows~3 min; parallel, away,cut across chase vssl	None
01/01/2013	Unidentified large baleen whale	*n/a*	Balaenopteridae	Visual	Large whiteH2O created, multiple blows	None
01/01/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	Light splashing, sighted off stbd milling	None
01/01/2013	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	One blow sighted	None
01/01/2013	Unidentified Delphinidae	*n/a*	Delphinidae	Visual	Light splashing, then jumping ~700m stbd	None
04/01/2013	Long-finned pilot whale	*Globicephala melas*	Delphinidae	Visual	milling @ port, move to stbd ~500m, port stern	None
04/01/2013	Commerson's dolphin	*Cephalorhynchus commersonii*	Delphinidae	Visual	Splashes,birds over, vssl approachd, riding waves	None
05/01/2013	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	Blows	None
05/01/2013	Long-finned pilot whale	*Globicephala melas*	Delphinidae	Visual	Logging spread out as vessel approached	None
05/01/2013	Unidentified Delphinidae	*n/a*	Delphinidae	Visual	Porpoising dolphins	None

05/01/2013	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	1-2 tall blows every 4-6 min	None
06/01/2013	Unidentified Delphinidae	*n/a*	Delphinidae	Visual	Splashes on wave crests,1 surfacing sighted	None
07/01/2013	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	Lrg blows sighted ptsd; blended w/fog & lost sight	None
07/01/2013	Unidentified whale	*n/a*	*n/a*	Visual	Blows sighted off bow as vessel passed ind	None
07/01/2013	Unidentified Delphinidae	*n/a*	Delphinidae	Visual	Breach mult xs, then porpoising twds vssl	None
08/01/2013	Fin whale	*Balaenoptera physalus*	Balaenopteridae	Visual	Partial breach, head out of water splashing	None
15/01/2013	Fin whale	*Balaenoptera physalus*	Balaenopteridae	Visual	whiteH2O ahead of blow;blow then lg dorsl exposed	None
15/01/2013	Unidentified whale	*n/a*	*n/a*	Visual	blows sighted;hdg slightly parallel to angled away	None
15/01/2013	Fin whale	*Balaenoptera physalus*	Balaenopteridae	Visual	surfaced exposing dorsal	None
16/01/2013	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	sequential blows far apart, tall columnar, no body	None
17/01/2013	Unidentified whale	*n/a*	*n/a*	Visual	Milling, blows obs every 1-2min, then every 4	None
19/01/2013	Sei whale	*Balaenoptera borealis*	Balaenopteridae	Visual	srfcd w/o blow, head awy frm ship blw ~3-5min	None
19/01/2013	Minke whale	*Balaenoptera bonaerensis*	Balaenopteridae	Visual	Multiple full body breaches	None
19/01/2013	Unidentified whale	*n/a*	*n/a*	Visual	Blows obs side-by-side, & then ~300m apart	None
20/01/2013	Unidentified Delphinidae	*n/a*	Delphinidae	Visual	Splashes, breaches and extremely high jumps	None
20/01/2013	Unidentified Pinniped	*n/a*	*n/a*	Visual	Surfacd,swam undr,surfacd-repeatd creatd v in H2O	None
21/01/2013	Unidentified whale	*n/a*	*n/a*	Visual	one lrg blow then disappeared	None
21/01/2013	Fin Whale	*Balaenoptera physalus*	Balaenopteridae	Visual	hdg parallel opp, shallow, right under surface	None
24/01/2013	Sperm Whale	*Physeter macrocephalus*	Physeteridae	Visual	2 blows side by side traveling away from vessel	None
27/01/2013	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	2 blows every 2/3 min, crossing behind vssl	None
31/01/2013	Unidentified whale	*n/a*	*n/a*	Visual	3 blows observed, one every 6 minutes	None
09/02/2013	Small unidentified whale	*n/a*	*n/a*	Visual	2 blows ~12 seconds apart	None
10/02/2013	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	one blow observed	None
10/02/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	swimming quickly, changing course frequently, porpoising occasionally	None
14/02/2013	Unidentified large baleen whale	*n/a*	Balaenopteridae	Visual	1-2 blows every several minutes, traveling parallel in the opposite direction before turning and traveling away from the vessel	None

14/02/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	swam slowly crossing bow before turning and swimming parallel to the vessel, turned and swam towards stern before traveling quickly away from vessel creating a lot of spray	None
15/02/2013	Unidentified whale	*n/a*	*n/a*	Visual	three blows observed ~10 seconds apart	None
15/02/2013	Fin whale	*Balaenoptera physalus*	Balaenopteridae	Visual	16:09 two blows 1 km off bow, 16:13 one blow dive towards vessel 200m off stbd, 16:15 one blow 300m behind stbd stern, 16:18 one blow whale changed direction traveling same as ship near streamers, 16:21 one blow 150m outside of streamers	None
15/02/2013	Unidentified whale	*n/a*	*n/a*	Visual	18:58 one blow observed 900m off port bow, another within a minute. Two more blows seen side-by-side at 19:08 2km off port stern. One blow significantly larger than the other suggesting a juvenile	None
15/02/2013	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	First blow observed at 19:26 2.5 km from port bow. Blows seen every 2-3min. Traveled parallel to the vessel, in the opposite direction. Last seen at 19:33	None
15/02/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	swam quickly towards vessel, disappeared below bow for 7 minutes, observed swimming away from bow	None
16/02/2013	Unidentified small whale	*n/a*	*n/a*	Visual	first blow low and bushy, subsequent blows every 20-30 seconds very diffuse, barely visible	None
16/02/2013	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	First blow observed 2.2 km off bow, 15 minutes later another blow was observed 1.8 km directly off port side	None
16/02/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	briefly observed off stbd bow porpoising towards vessel	None
16/02/2013	Unidentified whale	*n/a*	*n/a*	Visual	1-2 blows observed every 3-4 minutes	None
17/02/2013	Unidentified whale	*n/a*	*n/a*	Visual	One blow observed 3 km off bow. One more blow observed at 9:56. Not seen again	None
17/02/2013	Long-finned pilot whale	*Globicephala melas*	Delphinidae	Visual	16+ swimming slowly towards vssl. Appear to be herding bait ball. Swam btwn streamer buoys. 650m from guns	None
17/02/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	Swimming quickly towards vessel.	None

17/02/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	sighted swimming quickly towards bow (20:03), bow riding for a few minutes, swam away from vessel in same direction approached. Last seen at 20:18	None
17/02/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	Observed off stbd bow swimming towards vessel, rarely breaking water surface, crossed bow of vessel not seen again.	None
20/02/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	dolphins briefly observed porpoising towards vessel, creating lots of spray	None
21/02/2013	Unidentified whale	*n/a*	*n/a*	Visual	observed 3.5km off port stern. 2-3 blows every 7-10 minutes. Last seen 18:49	None
21/02/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	observed off stbd, swimming quickly at surface in various directions, traveled up towards bow, then away from vessel.	None
21/02/2013	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	multiple blows observed from 21:47 to 21:50 (every 15-20 seconds), resurfaced 3.5 km away observed several more blows	None
22/02/2013	Minke whale	*Balaenoptera bonaerensis*	Balaenopteridae	Visual	multiple blows observed from 16:16-16:18, observed surfacing at 16:24, last seen 16:25	None
22/02/2013	Southern right whale	*Eubalaena australis*	Balaenidae	Visual	originally observed splashes, 17:01 head of whale visible observed two blows, remained at surface of water before diving at 17:04, did not show flukes	None
23/02/2013	Unidentified dolphin	*n/a*	Delphinidae	Visual	animals briefly observed porpoising while traveling quickly, creating a lot of spray	None
23/02/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	animals swam quickly towards vessel, creating a lot of spray, ~300m from vessel animals turned and began traveling parallel to vessel	None
23/02/2013	Unidentified dolphin	*n/a*	Delphinidae	Visual	First observed by FRC crew, following them. Swam towards stern of vssl. 550m closest to guns. Drifted back and off port.	None
23/02/2013	Unidentified whale	*n/a*	Balaenopteridae	Visual	Large, dark whale observed at 14:55, logging for several minutes. No blow observed, no dorsal visible. Last seen at 15:00	None
23/02/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	Dolphins observed swimming slowly in the same direction as the vessel but angled away	None
23/02/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	Traveling parallel to vessel towards port bow. Swimming quickly & porpoising. Last seen at 18:38 UTC	None
23/02/2013	Southern right whale	*Eubalaena australis*	Balaenidae	Visual	Two breaths every time animal surfaced. First obs 3km off bow, travelled parallel to vssl in opp direction. Dove at 18:49, reappeared then dove and showed flukes at 18:57 2km off port stern. Observed with hrglass dolphins	None

23/02/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	5 appeared alongside right whale bowing and flipping, then traveled towards the vessel. Lost in severe glare at 18:51.	None
23/02/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	Pod trvlng towards bow from 2.5km off port at 18:55. Very acrobatic. Converged with another pod while bowriding then trvld perp, away from vssl. Last seen 19:26	None
23/02/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	Obsvd 18:55 trvlng twds bow from 11 o'clock. Very acrobatic. Converged with other pod while bow riding. Split into two groups. 8 cont bowrdng, the rest swam 800 m from stbd bow, circling as if feeding. Regrouped & traveld away from bow lost at 19:36	None
23/02/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	Obs at 20:51 traveling parallel to vessel, then perpendicular, away from vessel. Lots of splashing and appear to be circling. Last observed at 20:56.	None
23/02/2013	Unidentified whale	*n/a*	Balaenopteridae	Visual	Multiple blows observed from 21:20 to 21:23 (every 10-18 seconds), shallow dive, surfaced 21:31. Last seen 21:33	None
23/02/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	Observed off bow swimming quickly towards vessel, before reaching vessel turned and swam away from vessel off port bow	None
24/02/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	Observed briefly at bow before swimming quickly away from vessel off stbd bow	None
25/02/2013	Unidentified whale	*n/a*	*n/a*	Visual	only one blow observed off bow	None
25/02/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	dolphins observed swimming slowly with only dorsal fins above the water	None
25/02/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	dolphins appeared to be feeding, leaping and spinning, briefly began porpoising towards vessel	None
25/02/2013	Unidentified dolphin	*n/a*	Delphinidae	Visual	observed porpoising parallel in the opposite direction of the vessel creating a lot of spray	None
25/02/2013	Southern right whale	*Eubalaena australis*	Balaenidae	Visual	surfaced ~200m from port bow swimming away from vessel, dove just below surface - still visible from water disturbance, surfaced again just before streamers, last seen surfacing between two streamers	None
25/02/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	5 indiv obs at 19:58 ~700m from vessel, swimming parallel in the same direction. Changed direction as if crossing in front of vssl. Lost at 20:07 off pt bow. Seen 2km off port bow at 20:14 jumping and breaching. Last obs at 20:30, 500m off port bow	None

26/02/2013	Long-finned pilot whale	*Globicephala melas*	Delphinidae	Visual	Multiple groups of ~8-15 animals spread out over ~3 km. One group sighted just off bow traveling in the opposite direction down the port side of the vessel. Other groups remained ~2 km away from the vessel.	None
26/02/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	Sighted with pilot whales. Swam parallel in the same direction as the vessel just off port side briefly before turning and continuing in same direction as pilot whales.	None
27/02/2013	Sei whale	*Balaenoptera borealis*	Balaenopteridae	Visual	observed blowing regularly making remaining near surface of water, traveling in opposite direction of vessel. Adult and juvenile ahead whit second adult following ~600m behind	None
27/02/2013	Peale's dolphin	*Lagenorhynchus australis*	Delphinidae	Visual	dolphins observed porpoising towards vessel to bowride, lost sight of them at bow	None
28/02/2013	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	whales observed in inlet near Stanley, observed blowing 1-3X every 3-6 minutes.	None
02/03/2013	Sei whale	*Balaenoptera borealis*	Balaenopteridae	Visual	11:25 one tall blow observed, 11:28 two blows observed, lost sight of whale in severe glare. Whale re-sighted 11:52 on other side of glare, blowing 3-5x every 5-9 minutes	None
02/03/2013	Unidentified dolphin	*n/a*	Delphinidae	Visual	dolphins briefly observed porpoising	None
02/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	dolphins swimming quickly changing course frequently	None
02/03/2013	Unidentified dolphin	*n/a*	Delphinidae	Visual	dolphins swimming quickly creating spray	None
02/03/2013	Minke whale	*Balaenoptera bonaerensis*	Balaenopteridae	Visual	observed blowing 2-3x every 2-7 minutes	None
02/03/2013	Unidentified dolphin	*n/a*	Delphinidae	Visual	porpoising creating spray	None
02/03/2013	Unidentified whale	*n/a*	*n/a*	Visual	three low blows observed	None
02/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	traveling fast, porpoising, creating a lot of spray	None
02/03/2013	Sei whale	*Balaenoptera borealis*	Balaenopteridae	Visual	Sei Whale observed 900m off port bow at 18:52 UTC. Crossed ahead of vessel, within 800m of bow. Last seen at 19:19 UTC.	None
03/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	dolphins observed briefly porpoising at bow before traveling away ahead of the vessel.	None
04/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	dolphins observed bowriding for several minutes before swimming away from vessel off port side	None
07/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	Dolphins observed off port bow porpoising towards vessel, bowrode briefly before continuing away from vessel off stbd bow	None

08/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	Dolphins observed off stbd bow porpoising towards vessel. Swam along stbd side briefly before traveling away from vessel off stbd bow.	None
08/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	3 dolphins observed at 13:35, 150m off port bow porpoising towards bow for about a minute. Not seen again	None
09/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	dolphins observed off stbd bow leaping high out of water traveling in the same direction as vessel	None
09/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	large pod of dolphins bow riding, broke up into several groups spread out over several km, some dolphins remained bow riding for ~1.5 hrs	None
09/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	dolphins observed 2km off port bow traveling in an unknown direction. Last seen at 13:08	None
09/03/2013	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	Blow was observed 2km off stbd stern, bearing 40 deg. Later obs 1.6km bearing 25 deg. Last obs 1km at bearing 70 deg.	None
09/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	approx 4 dolphins obs at 14:08 900m off port stern traveling towards vessel. Quickly changed direction to swim away from vessel. Last seen at 14:10 headed away from vessel.	None
10/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	dolphins observed just under surface of water swimming quickly towards vessels bow, observed bowriding for several minutes	None
10/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	dolphins leaping high out of water creating large splashes	None
11/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	dolphin swimming away from vessel off stbd bow, rarely breaking surface of water, two animals turned and traveled parallel in the opposite direction	None
11/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	dolphins swimming quickly towards port bow of vessel, bowriding for several minutes before swimming away off port stern	None
12/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	dolphins observed briefly swimming towards bow of vessel, not seen again	None
13/03/2013	Fin whale	*Balaenoptera physalus*	Balaenopteridae	Visual	whale originally observed traveling slowly parallel in the opposite direction of the vessel, as vessel passed whale turned and began traveling in same direction. Last seen 700m off port stern	None
14/03/2013	Unidentified whale	*n/a*	n/a	Visual	1-2 blows observed every 3-4 minutes	None
15/03/2013	Southern right whale	*Eubalaena australis*	Balaenidae	Visual	surfaced 600m off stbd stern at 10:25, traveling parallel to the vssl, in same direction. Traveled further from vessel, then turned to swim parallel away from vssl. Last obs 10:35 2km away.	None

15/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	dorsal fins observed 500m off port bow swimming towards vessel. Last observed ~400 m from bow	None
15/03/2013	Unidentified whale	*n/a*	n/a	Visual	1-3 blows observed every 3-6 minutes	None
16/03/2013	Southern right whale	*Eubalaena australis*	Balaenidae	Visual	whale originally observed 1.6 km off port bow crossing ahead of the vessel, 8 minutes later whale 100m from bow directly ahead of vessel, last seen just off stbd bow of vessel	None
16/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	dolphins observed bowriding for several minutes before swimming away from vessel off stbd bow	None
17/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	very large active pod feeding, trailing several km, dolphins often observed leaping repeatedly and landing on side, many dolphins bowriding	None
18/03/2013	Unidentified dolphin	*n/a*	Delphinidae	Visual	large splashes and dorsal fins briefly sighted	None
21/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	dolphins observed just off stbd bow, bowrode for several minutes before swimming away from vessel directly off bow	None
21/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	3 dolphins initially obs swimming towards vssl. One swam down along port side, then back twds bow before traveling away. 19:47 total of 6 dolphins observed traveling parallel in the same direction as the vessel at 2km off port. Last seen at 19:51	None
24/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	dolphins observed swimming quickly towards stern of vessel before turning and swimming quickly away then traveling parallel to vessel, porpoising several times	None
24/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	dolphins swam towards bow of vessel then away from vessel off stbd bow, changing course frequently	None
25/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	8 dolphins observed traveling towards vessel, came within 20m of vessel before turning to travel with pilot whales, 3 dolphins 1200m from vessel traveling with pilot whales, observed leaping landing on side	None
25/03/2013	Long-finned pilot whale	*Globicephala melas*	Delphinidae	Visual	large pod spread out over ~1.5 km, animals closest approached to vessel ~100m, as animals approached floats on streamers they turned and swam to the outside of the gear	Delay soft start
27/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	swimming quickly just under surface creating a lot of spray, one animal briefly porpoising, traveling away from vessel off stbd bow	None
29/03/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	dolphins observed swimming next to vessel for several minutes changing course frequently, swam quickly away from vessel off port bow	None

01/04/2013	Fin whale	*Balaenoptera physalus*	Balaenopteridae	Visual	whales observed ~4 km off stbd bow, one whale ~1 km away from the other two but joined together as vessel passed, traveling parallel, in opposite direction as vessel, angled away, 2-4 blows observed every several minutes, last seen ~3km off stbd stern	None
01/04/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	dolphins observed porpoising off port bow, one dolphin observed leaping multiple times landing on side	None
01/04/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	dolphins observed quickly traveling towards bow, then towards stern along port side. Began swimming in various directions before traveling 1km away	None
02/04/2013	Fin whale	*Balaenoptera physalus*	Balaenopteridae	Visual	10:54 two blows observed directly ahead of vessel, whale crossing ahead of vessel, 11:05 two blows ~2 km off stbd side, whale now traveling parallel same direction as vessel, 11:07 one blow observed	None
02/04/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	dolphins briefly observed swimming quickly away from vessel off port bow	None
14/04/2013	Long-finned pilot whale	*Globicephala melas*	Delphinidae	Visual	16:56 UTC a pod of 25 long-finned pilot whales observed porpoising 150m off port bow, behavior consistent during sighting, last seen at 17:09UTC 500m from port guns	None
15/04/2013	Hourglass dolphin	*Lagenorhynchus cruciger*	Delphinidae	Visual	Dolphins observed off the port bow porpoising and jumping in a stationary position. Dolphins behavior did not change through the entirety of the sighting. The boat was turning so the dolphins were last sighted off the port beam	None
16/04/2013	Unidentified Pinniped	*n/a*	Pinniped	Visual	Pinniped occasionally surfacing for breaths	None
7/05/2013	Peale's Dolphin	*Lagenorhynchus australis*	Delphinidae	Visual	Dolphins observed bow-riding, porpoising, tail slapping and jumping around the bow of the ship.	None
19/05/2013	Sei whale	*Balaenoptera borealis*	Balaenopteridae	Visual	consistent blows every 5-7 minutes heading towards the gear	Delayed Soft Start
19/05/2013	Sei whale	*Balaenoptera borealis*	Balaenopteridae	Visual	Regular blows from a single whale were seen every 30s-2mins from 1302-1322 UTC. Whale out of sight until 1346 UTC then 3 whales seen off stbd beam blowing and swimming quickly at surface. Last noted 2km off stbd bow at 1406 UTC.	None
27/05/2013	Fin whale	*Balaenoptera physalus*	Balaenopteridae	Visual	A total of five tall, narrow column like blows from a single whale were sighted off the starboard beam ~500m. Whale remained fairly stationary as the vessel moved away from it in the opposite direction.	None

28/05/2013	Long-finned pilot whale	*Globicephala melas*	Delphinidae	Visual	Boat approached pod, pod scattered and formed two separate groups around different pieces of gear, surfacing ~2min then never resurfaced after 12:04	None
28/05/2013	Sei whale	*Balaenoptera borealis*	Balaenopteridae	Visual	3 whales seen blowing at the surface every 1-2 mins showing the top portion of their bodies & fins from 1531-1545 UTC as they travelled parallel in the opposite direction of the vessel. Re-sighted at 1558 UTC. Last detected at 1602 UTC.	None
30/05/2013	Sei whale	*Balaenoptera borealis*	Balaenopteridae	Visual	1 whale made a large splash close to boat then appeared 100m from first sighting with head and dorsal fin coming out of the water at the same time, travelling rapidly parallel to vessel	None
31/05/2013	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	A blow was observed 1km off of the forward starboard area and continued to blow every 2-3 minutes with some intermittent longer periods.	None
1/06/2013	Fin whale	*Balaenoptera physalus*	Balaenopteridae	Visual	Blows observed off starboard side with two animals, one around 4k and one around 5k off of the boat with consistent blows every 2-5 minutes. Third whale blow observed off starboard stern ~3k with consistent blows every 2-5 minutes, first travelled toward vessel then away.	None
1/06/2013	Sei whale	*Balaenoptera borealis*	Balaenopteridae	Visual	One whale was seen 800m off the stbd stern blowing regularly every 1-2mins. Two additional whales (1 juv.) were seen four mins later 500m off the stbd bow. The juv. approached the bow 200m off. All continued heading N blowing at the surface.	None
2/06/2013	Sei whale	*Balaenoptera borealis*	Balaenopteridae	Visual	Whale was seen blowing ~2km off the port bow every 1-3 minutes. The whales crossed ahead of the bow from port to starboard and proceeded down the starboard side of the vessel continuing to blow regularly.	None
3/06/2013	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	Whale was seen blowing ~1500m off starboard side ~every 4-7 minutes in about the same area. Normal blows were observed without dorsal or body visible, except brief appearance of body with blow one time	None
3/06/2013	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	Whale was seen behind starboard side of vessel travelling away from vessel blowing approximately every 3-5 minutes	None
4/06/2013	Unidentified baleen whale	*n/a*	Balaenopteridae	Visual	A single blow was seen off the starboard bow ~2km followed by disturbances of the water as the whale surfaced. A small portion of dorsal fin was seen just briefly as the whale surfaced.	None

2.4.2. Fish

Table 5: Fish species observed during visual monitoring.

Common Name	Class	Order	Family	Genus	Species	Number of Individuals Observed	Number of Days Observed
Unidentified shark	Chondrichthyes	n/a	n/a	*n/a*	*n/a*	1	1

2.4.3. Birds

Table 6: Bird species observed during visual monitoring.

Common Name	Class	Order	Family	Genus	Species	Number of Individuals Observed	Number of Days Observed
Black-browed albatross	Aves	Procellariiformes	Diomedeidae	*Thalassarche*	*melanophris*	522	121
Unidentified royal albatross	Aves	Procellariiformes	Diomedeidae	*Diomeda*	*n/a*	32	19
Northern royal albatross	Aves	Procellariiformes	Diomedeidae	*D. e.*	*sanfordi*	7	4
Southern royal albatross	Aves	Procellariiformes	Diomedeidae	*D. e.*	*epomophora*	12	8
Wandering albatross	Aves	Procellariiformes	Diomedeidae	*Diomeda*	*exulans*	266	84
Snowy wandering albatross	Aves	Procellariiformes	Diomedeidae	*D. e.*	*exulans*	4	2
Unidentified great albatross	Aves	Procellariiformes	Diomedeidae	*Diomeda*	*n/a*	80	28
Light-mantled sooty albatross	Aves	Procellariiformes	Diomedeidae	*Phoebetria*	*palpebrata*	15	11
Sooty albatross	Aves	Procellariiformes	Diomedeidae	*Phoebetria*	*fusca*	2	2
Gray-headed albatross	Aves	Procellariiformes	Diomedeidae	*Thalassarche*	*chrysostoma*	3	3
Cattle egret	Aves	Ciconiiformes	Ardeidae	*Bubulcus*	*ibis*	56	13
Southern fulmar	Aves	Procellariiformes	Procellariidae	*Fulmarus*	*glacialoides*	109	21
Antarctic petrel	Aves	Procellariiformes	Procellariidae	*Thalassoica*	*antarctica*	1	1
Atlantic petrel	Aves	Procellariiformes	Procellariidae	*Pterodroma*	*lessonii*	63	8
Grey petrel	Aves	Procellariiformes	Procellariidae	*Procellaria*	*cinerea*	15	7
Cape petrel	Aves	Procellariiformes	Procellariidae	*Daption*	*capense*	805	57
Northern giant petrel	Aves	Procellariiformes	Procellariidae	*Macronectes*	*Halli*	80	32
Southern giant petrel	Aves	Procellariiformes	Procellariidae	*Macronectes*	*giganteus*	188	52
Southern giant petrel (white morph)	Aves	Procellariiformes	Procellariidae	*Macronectes*	*giganteus*	12	7
Unidentified giant petrel	Aves	Procellariiformes	Procellariidae	*Macronectes*	*n/a*	331	66
Soft-plumaged petrel	Aves	Procellariiformes	Procellariidae	*Pterodroma*	*mollis*	86	31
White-chinned petrel	Aves	Procellariiformes	Procellariidae	*Procellaria*	*aequinoctialis*	125	44
Grey-backed storm-petrel	Aves	Procellariiformes	Hydrobatidae	*Oceanites*	*nereis*	9	4

Wilson's storm-petrel	Aves	Procellariiformes	Hydrobatidae	*Oceanites*	*oceanicus*	81	24
White-bellied storm-petrel	Aves	Procellariiformes	Hydrobatidae	*Fregetta*	*grallaria*	2	2
Unidentified storm-petrel	Aves	Procellariiformes	Hydrobatidae	*n/a*	*n/a*	16	11
Slender-billed prion	Aves	Procellariiformes	Procellariidae	*Pachyptila*	*belcheri*	3	2
Unidentified prion	Aves	Procellariiformes	Procellariidae	*Pachyptila*	*n/a*	241	43
Unidentified penguin	Aves	Sphenisciformes	Spheniscidae	*n/a*	*n/a*	1	1
Great shearwater	Aves	Procellariiformes	Procellariidae	*Puffinus*	*gravis*	792	58
Sooty shearwater	Aves	Procellariiformes	Procellariidae	*Puffinus*	*griseus*	21	12
Unidentified shearwater	Aves	Procellariiformes	Procellariidae	*Puffinus*	*n/a*	3	3
Snowy sheathbill	Aves	Charadriiformes	Chionididae	*Chionis*	*albus*	116	35
Black-chinned siskin	Aves	Passeriformes	Fringillidae	*Carduelis*	*barbata*	1	1
Brown (Subantarctic) skua	Aves	Charadriiformes	Stercorariidae	*Stercorarius*	*antarcticus*	24	17
Chilean skua	Aves	Charadriiformes	Stercorariidae	*Stercorarius*	*chilensis*	9	7
Unidentified skua	Aves	Charadriiformes	Stercorariidae	*Stercorarius*	*n/a*	3	3
Unidentified swallow	Aves	Passeriformes	Hirundinidae	*n/a*	*n/a*	1	1
Sooty tern	Aves	Charadriiformes	Sternidae	*Sterna*	*fuscata*	8	1
Kelp gull	Aves	Charadriiformes	Laridae	*Larus*	*dominicanus*	3	2
Peregrine Falcon	Aves	Falconiformes	Falconidae	*Falco*	*peregrinus*	4	4

3. DATA FORMS

3.1. BASIC DATA FORM

BASIC DATA FORM			
Project Number		UOS01285M	
Seismic Contractor		PGS Geophysical	
Client		Noble Energy Falklands Ltd.	
Geographical coordinates of the survey area:		**Latitude**	**Longitude**
	between	55.21673°S	52.76204°W
	and	56.81693°S	51.88380°W
Survey Type		3D	
Vessel and/or Rig Name		*Ramform Sterling*	
Permit Number		PON3	
Location / Distance of Airgun Deployment		Astern 700m	
Water Depth	**Min**	900	
	Max	1700	
Dates of project		29 Nov 2012	THROUGH
Dates included in reporting period		29 November 2012 through 4 June 2013	
Total time airguns operating – all power levels:		1515:12	
Amount of time airguns operating at full power:		1400:22	
Time airguns operating at full power on a survey line:		1345:37	
Time airguns operating at full power approaching survey line:		54:45	
Amount of time compliance gun operations:		00:00	
Amount of time in ramp up:		87:18	
Number daytime ramp ups:		153	
Number of night time ramp ups:		110	
Number of ramp ups from mitigation source:		0	
Number of ramp ups from PAM system:		124	
Amount of time conducted in airgun testing:		27:32	
Duration of visual observations:		1723:32	
Duration of observations while airguns firing:		902:03	
Duration of observation during airgun silence:		821:29	
Duration of acoustic monitoring:		732:21	
Duration of acoustic monitoring while airguns firing:		424:42	
Duration of acoustic monitoring during airgun silence:		307:39	
Visual Observers:		Lynn Henneberger (29 Nov 12- 23 Jan 13) / Heidi Ingram (23 Jan - 3 Apr 2013) / Megan McManus (3 Apr-16 May 13) / Lacey Price (16 May-4 June 13)	
		Monica Arancibia-Colgain (29 Nov 12- 23 Jan 13, 16 May-4 June 13) / Tatiana Moreno (23 Jan 13 – 3 Apr 13), Alexandria Denby (3 April-15 May 13)	
Acoustic Observers:		Greggo Seward (29 Nov 12- 23 Jan 13, 3 Apr -16 May 13) / Emily Ellis (23 Jan 13 – 3 Apr 13), Jessica Mucci (16 May-4 June 13)	
Number of Marine Mammals Visually Detected:		231 Detections (1620 Individuals)	
Number of Marine Mammals Acoustically Detected:		1	
Number of acoustic detections confirmed by visual sighting:		0	
Number of visual sighting confirmed by acoustic detection:		0	
Number of Pinnipeds detected:		3	
List Mitigation Actions (eg. shutdowns, ramp up delays, turtle pauses)		Ramp up delays (25 Mar & 19 May)	
Duration of operational downtime due to mitigation:		None	
Flagged Data Forms (list sheet & date)		None	

3.2. COVER DATA SHEET

Regulatory reference number (e.g. DECC no., MMS permit no., OCS lease no., etc.) **PON3**	**4. COUNTRY** Falkland Islands, UK	**Ship/ platform name** ***Ramform Sterling***
Client **Noble Energy Falklands Ltd**	**Contractor** **PGS**	**Survey type** ☐ site ☐ 4C ☐ 2D ☐ VSP X 3D ☐ WAZ ☐ 4D ☐ other ☐ OBC
Start date **29 November 2012**	**End date** **4 June 2013**	

Number of source vessels	**Type of source** (e.g. airguns)	**Number of airguns** (only if airguns used)	**Source volume** (cu. in.)
1	**Airguns**	**62**	**4130**
Source depth (metres) **7**	**Frequency** (Hz) 70	**Intensity** (dB re. 1µPa or bar metres) **69 bar meters**	**Shot point interval** (seconds) **10.4**

Method of soft start

X increase number of guns ☐ increase pressure ☐ increase frequency ☐ other

Visual monitoring equipment used (e.g. binoculars, big eyes, etc.)	**Magnification of optical equipment** (e.g. binoculars)	**Height of eye** (metres)	**How was distance of animals estimated?**
Binoculars	7x50; 10x30	22.4	X by eye ☐ with laser rangefinder ☐ with rangefinder stick/ callipers X with reticle binoculars X by relating to object at known distance ☐ other

Number of dedicated MMOs	**Training of MMOs**
2	X JNCC approved MMO induction course for UK waters X PSO training course for the Gulf of Mexico ☐ MMO training course for Irish waters ☐ other ☐ none
Was PAM used? X yes ☐ no	**Number of PAM operators** **1**

Description of PAM equipment

20 m airgun towed array

Range of PAM hydrophones from airguns (metres)	**Bearing of PAM hydrophones from airguns** (relative to direction of travel)	**Depth of PAM hydrophones** (metres)
15	**180**	**6.5**

5. REFERENCES

Carwardine, Mark. *Whales, Dolphins and Porpoises.* Smithsonian Handbooks. Ed. Evans, P., and Weinrich, M., Illustrated by Camm, M., Dorling Kindersley Publishing, Inc. (1995).

Harrison, Peter. *Seabirds An Identification Guide.* (1983). Fwd by Peterson, R.T., Rev. Ed. Houghton Mifflin Company (1985).

Joint Nature Conservation Committee, (2010). JNCC Guidelines for minimizing the risk of disturbance and injury to marine mammals from seismic surveys. JNCC Aberdeen, United Kingdom.

Petroleum Operations Notice 3 Notification of Geophysical Surveys Form. Dept. of Mineral Resources, Stanley, Falkland Islands.

Project Plan PGS Geophysical Ramform Sterling Project No 2012132 and Noble Energy Falklands Limited East Falkland Basin version 2. PGS Geophysical, Norway.

Shirihai, H. and Jarrett, B. *Whales Dolphins and Other Marine Mammals of the World.* Princeton Field Guides. Princeton University Press (2006).

Woods, Robin W. and Woods, Anne. *Birds and Mammals of the Falkland Islands.* Wild Guides. Wild Guides Ltd. (2006).

Todd, Frank. *Birds & Mammals of the Antarctic, Subantarctic, & Falkland Islands*. Ibis Publishing Company (2004).

RPS

Protected Species Observer Report

Prepared for: PGS

PGS
Ramform Titan
East Falkland Basin (FINA13)
05 November 2013 – 18 February 2014

Project No.: UMS04150

Authors: Breanna Evans and Lynn Henneberger

Reviewer(s): Jessica Mucci

411 N. Sam Houston Pkwy. E.
Suite 400
Houston, TX 77060 USA

Tel: (281) 448-6188
Fax: (281) 448-6189

Email:
Jessica.Mucci@rpsgroup.com

Table of Contents

List of Figures

List of Tables

List of Appendices

1 Executive Summary

PGS Geophysical conducted this 3D seismic survey for Noble Energy Falkland Islands Ltd., operated within a permitted area as mentioned in Falklands Islands permit Petroleum Operations Notice 3 (PON3) executed on 22 October 2013. The ensuing report reviews the protected species monitoring activities and seismic survey operations undertaken on the *Ramform Titan* for the period of 5 November 2013 through 18 February 2014. The information supplied in this report is in reference to the mitigation guidelines set forth in the Joint Nature Conservation Committee's August 2010 *JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys*.

Two trained visual marine mammal observers (MMOs), contracted through Vision Project Services, and a dedicated passive acoustic monitoring (PAM) operator, contracted through RPS, were onboard to fulfill the regulatory requirements and reporting mandated by the Joint Nature Conservation Committee. Mitigation measures were implemented to minimize potential impacts to marine mammals throughout the duration of the survey.

Mitigation measures included the use of MMOs during daylight hours and PAM during night-time hours to provide clearance of the 500 meter exclusion zone and implement delays in soft start, if necessary. PAM was also utilized as a mitigation tool to allow for soft starts from source silence during periods of reduced visibility, such as episodes of fog or inclement weather, when visual monitoring for protected species could not be conducted fully as outlined within the PGS Geophysical/Noble Energy Falklands Limited Project Plan section 9.3 the Environmental Management Plan (EMP).

Deployment of seismic equipment began the morning of 1 November 2013. Initial airgun testing commenced on 5 November. Production of Noble Energy Falkland LTD survey began at 14:38 UTC on 6 November 2013. On 24 November 2013 production ceased when inclement weather damaged the spread and the seismic gear was retrieved. The *Ramform Titan* continued at anchor in Berkeley sound until after crew change, 4 December 2013, after which the seismic streamers were redeployed and production resumed on 10 December 2013. After which, there was only minor downtime due to weather during the remainder of the survey.

There were a total of three soft starts of 19 minutes in duration which occurred on 22 January, 16 February and 18 February. On 2 February, from 11:35 through 11:47 there was an episode of unplanned auto-firing. The pre-watch was cleared prior to auto-firing by visual MMOs from 10:35 to 10:40 prior to losing visibility due to fog. Daytime PAM began at 10:50, resulting in a total of unplanned clearance period of 45 minutes in duration through PAM. The entire clearance period prior to auto-firing was 50 minutes in duration.

PAM Operators undertook acoustic watches, accumulating a total of 452 hours and 39 minutes of acoustic monitoring over the course of the survey, 312 hours and 26 minutes of which were completed while the acoustic source was active. There were 14 necessary joint pre-searches which required a combination of passive acoustics and visual protected species observation. In addition to the joint pre-surveys, there was a total of 70 passive acoustic watches conducted prior to the commencement of source operations.

The acoustic monitoring effort detected a project total of eight protected species detection records which included three baleen whales, four Delphinidae and one sperm whale detection. There were no correlated visual and acoustic detections during this project.

Acoustic detections of protected species resulted in no mitigation actions.

2 Introduction

A *Marine Mammal Observer* report was prepared by the Vision Project Services marine mammal observers detailing the Noble Energy Falklands LTD survey operations, with a focus on visual monitoring effort, protected species detections and mitigation actions implemented over the course of the survey. This *Passive Acoustic Monitoring and Mitigation* report was prepared by RPS to inform in detail the operation of the PAM system during the Noble Energy Falkland Island marine 3D seismic survey and source operations during this project. As such, survey specifics not pertaining to the PAM system are not discussed in detail but may be found in the *Marine Mammal Observer* report.

2.1 Project Location and Operation Parameters

The East Falkland Island Basin project was located approximately 230 kilometres northeast of Port Stanley, Falkland Islands (Figure 1), in the Southern Quadrants 30 (block numbers 7, 11-15 and 16-30) 31 (block number 16) and 42 (block numbers 1-4 and 7-8). The prospect covered 8,858 square kilometres in water depths ranging from 1000 to 1650 meters. It consisted of 96 survey lines spaced at 720 meter intervals with line changes varying from three to seven hours. PGS's *Ramform Titan* along with two support vessels, the *Falcon Explorer* and *M/V Fellowship*, executed this survey.

Figure 1: Location of the survey in relation to the Falkland Islands.

The *Ramform Titan* towed two airgun arrays, separated by 60 meters, both sources comprised of three sub-arrays, separated by eight meters and towed at seven meters ± 1 meter. Each sub-array consisted of ten (1 string) to twelve (2 strings) airguns and all were equipped with one spare airgun. The sources alternated with a shot point interval of 25 meters. The full source included a total of 34 airguns, ranging in volume from 40 in^3 to 250 in^3, with a maximum source volume of 4130 in^3 and a pressure of 2000 psi. Intensity of the source was 69.78 bar meters and the frequency range was a broadband frequency from 0 to 214 hertz. The center of source was 545 meters from the vessel reference point (VRP), which was located above the PSO viewing station. In addition to the seismic source, the vessel towed 12 streamers of 7,050 meters in length, each separated by 120 meters and towed at a depth of approximately 20 meters (Figure 2).

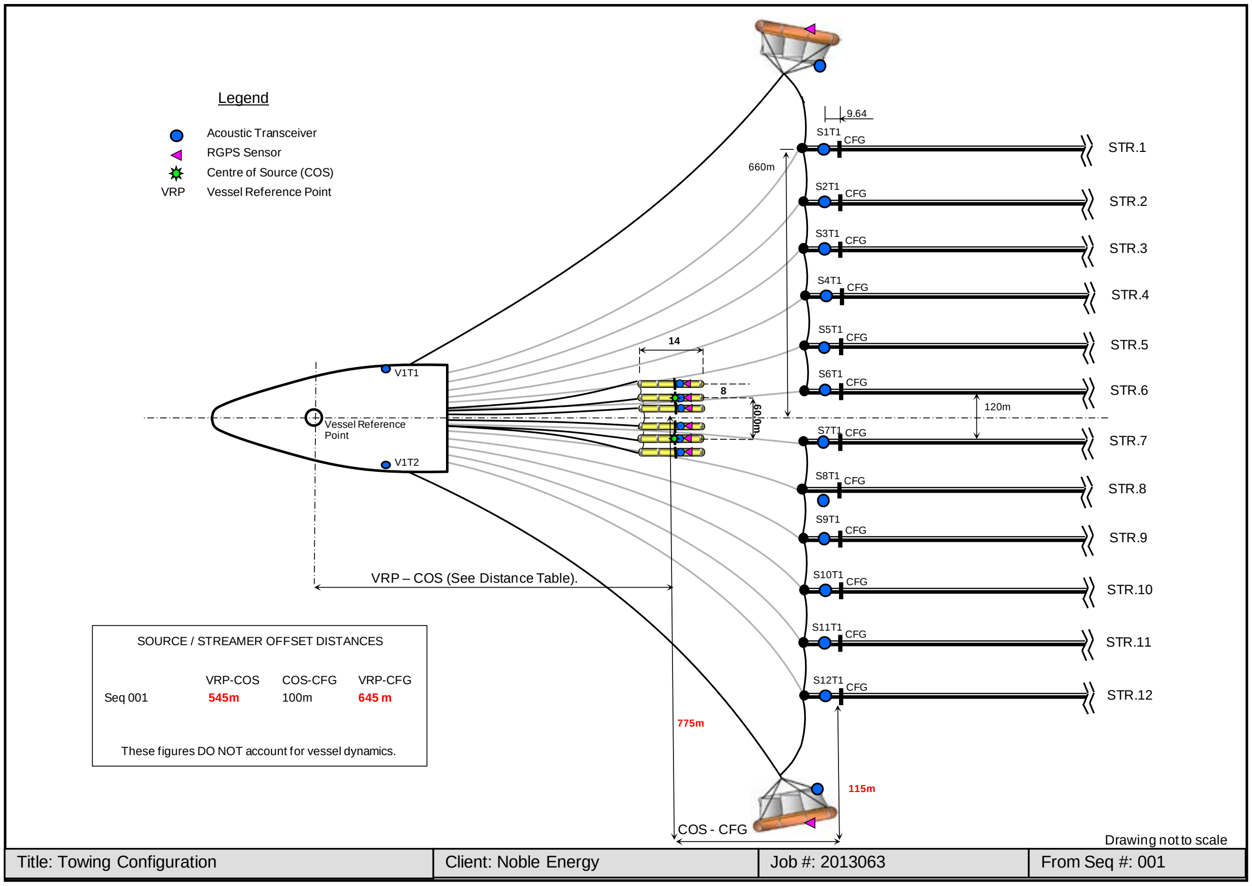


Figure 2: Tow configuration of *Ramform Titan*.

JNCC regulatory requirements for the East Falkland Basin were understood and respected by the *Ramform Titan's* crew. All pre-watch surveys, visual and acoustic, were conducted for one hour before planned activation of the seismic source, as the project was continually in waters deeper then 200 meters. Soft starts were conducted within 20 to 40 minutes by triggering the smallest airgun and then gradually adding airguns until the source reached full power. During the project, there were three episodes of 19 minute soft starts. The mitigation source (smallest airgun firing at survey shot point interval) was not utilized due to all line changes exceeding 20 minutes. Reduced power output only occurred during airgun testing and auto-firing. If any protected species entered the mitigation zone a 20 minute delay of commencement of source was abided by; however, there were no source delays through passive acoustic monitoring.

2.2 Passive Acoustic Monitoring (PAM) Parameters

A *Seiche Measurements* PAM system was installed by *Seiche Measurements Limited* in dock in Bergen, Norway on 2 October 2013 before the *Ramform Titan* transited to the Falkland Islands. The PAM system was onboard during all operations until the end of the Noble Energy Falklands Limited survey and remained onboard for the following PGS survey.

The PAM system consisted of a 250 meter conventional towed array, 100 meter deck cable, a 20 meter airgun-towed array, a data processing unit with rack mount computer and slide out monitor, net-top computer (for remote monitoring), dual monitors, analysis software program (*Pamguard*), headphones for aural monitoring, various leads and adapters and a complete spare set of aforementioned system. Two additional spare hydrophone towed array cables were received on board the *Ramform Titan* on 4 December 2013.

The liner hydrophone array cable contained four hydrophones and a depth gauged plotted into a 20 meter section. All four elements were broadband, two with a frequency response of 2 to 200 kilohertz and two have frequency responses of 0.2 hertz to 200 kilohertz. Preamplifiers were also embedded into the cable forward of each element. The four-element linear hydrophone array design permitted a broad range for sampling marine mammal vocalizations, from the low frequency moans of baleen whales to the ultra-high frequency clicks of beaked whales.

The distance between the hydrophone array cable and the data processing unit was greater than the remaining hydrophone cable after deployment. To join the hydrophone tow cable to the DPU, a 100 meter deck cable was supplied as an extension and routed from the Lead-in Repair shop to the back deck.

The data processing unit processed the raw data from the hydrophones through two external sound cards, a *National Instruments DAQ* card and an *ASIO Fireface* card (contained within a *RME Fireface 800* unit). The *National Instruments DAQ* sound card sampled raw audio at 500 kilohertz and can be used to detect beaked whale, *Kogia* species, porpoise, and delphinid (echolocation) clicks up to up to 250 kilohertz. The *ASIO Fireface* sound card sampled audio at 48 kilohertz and can be used to detect mysticete, delphinid, and non-delphinid odontocetes (including sperm whale) vocalizations up to 48 kilohertz. The data processing unit also contains a *Measurements and Computing* data logger for the depth gauge, digital signal amplifiers, an *UltraLink Pro* audio mixer, and an *UltraCurve Pro* graphic equalizer.

The two sound cards supplied low and high frequency digital audio feed to a computer that contained a suite of software for monitoring cetacean acoustics. *Pamguard* (*Beta version 1.12.05*) was the primary software utilized on this survey. The International Federation on Animal Welfare (IFAW) software including *Logger 2000*, *Rainbow Click*, *Whistle*, and *Rainbow Click Porpoise* was the secondary software and was only to be used as back-up software if the *Pamguard* software failed.

The computer received both the raw audio from the *National Instruments DAQ* sound card as well as the raw audio from the *ASIO Fireface* sound card. *Pamguard* modules included both high and low frequency click detectors, a whistle and moan detector, spectrogram, a map with a direct GPGGA GPS feed from the *Ramform Titan's* navigation system, and high and low frequency sound recorders. Raw audio from the *ASIO Fireface* sound card was monitored aurally with *Sennheiser* headphones.

The conventional hydrophone towed array was deployed off lead-in 12 on the port side of the *Ramform Titan*. When deployed there was approximately 181 meters of hydrophone cable was towed astern (Figure 3). Spectra line was paired with the hydrophone array cable, minus the hydrophone section (the final 23 meters), to relieve tension on the cable during deployment, retrieval and severe weather. Forward of the free floating cable the spectra line was attached via a Chinese finger and taped at one to two meter intervals (Figure 4 & 5D). A buoy was fixed to the Spectra line, via a small shackle, 126 meters astern to discern position and help create drag during deployment (Figure 5A). Positioned 50 meters astern the spectra line was affixed to a sliding collar (Figure 5C) on lead-in 12, shackles attached the remaining 50 meters to lead-in 12 to prevent the Spectra line and hydrophone cable from dragging in water (Figure 6).

Prior to deployment, six kilograms of chain weight was added to the Spectra line approximately 11 meters ahead of the first hydrophone element (Figure 5B). The additional weight was used to assist the cable in descending to an appropriate towing depth. Once deployed the cable was approximately 324 meters from the center of source and towed at a depth of approximately six meters +/-1.5 meters. The conventional towed hydrophone array was retrieved and deployed 13 times each during the survey (Table 1).

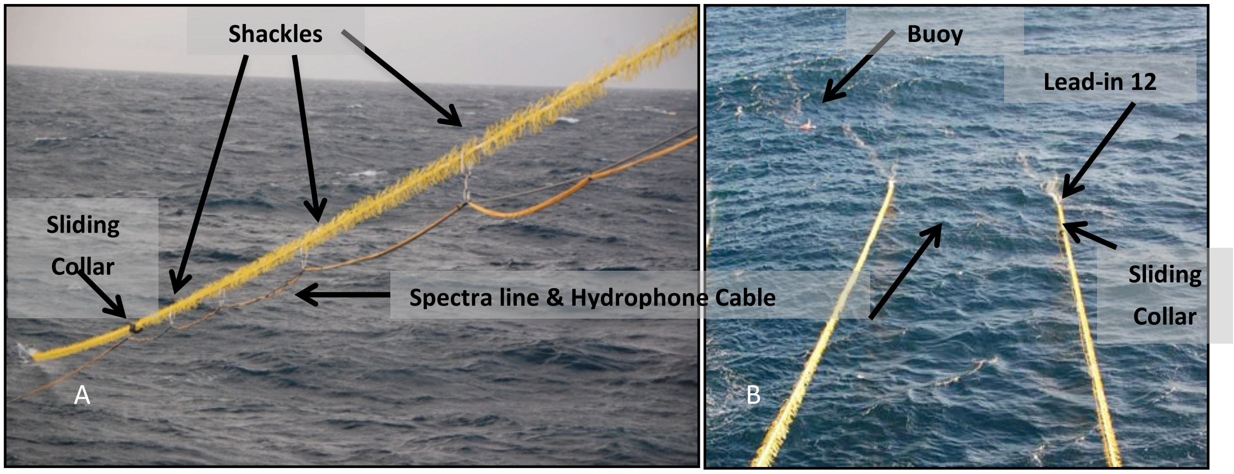


Figure 3: Deployment off port stern of Ramform Titan. A) Sliding collars and shackles B) Buoy and lead-ins.

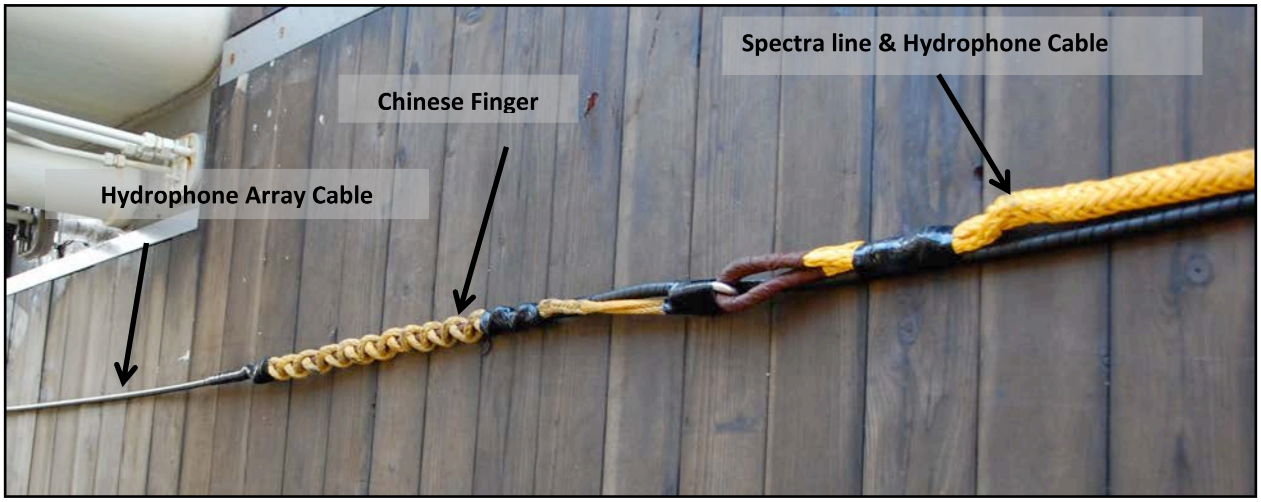


Figure 4: Free floating hydrophone array cable attached to Spectra line via Chinese finger.

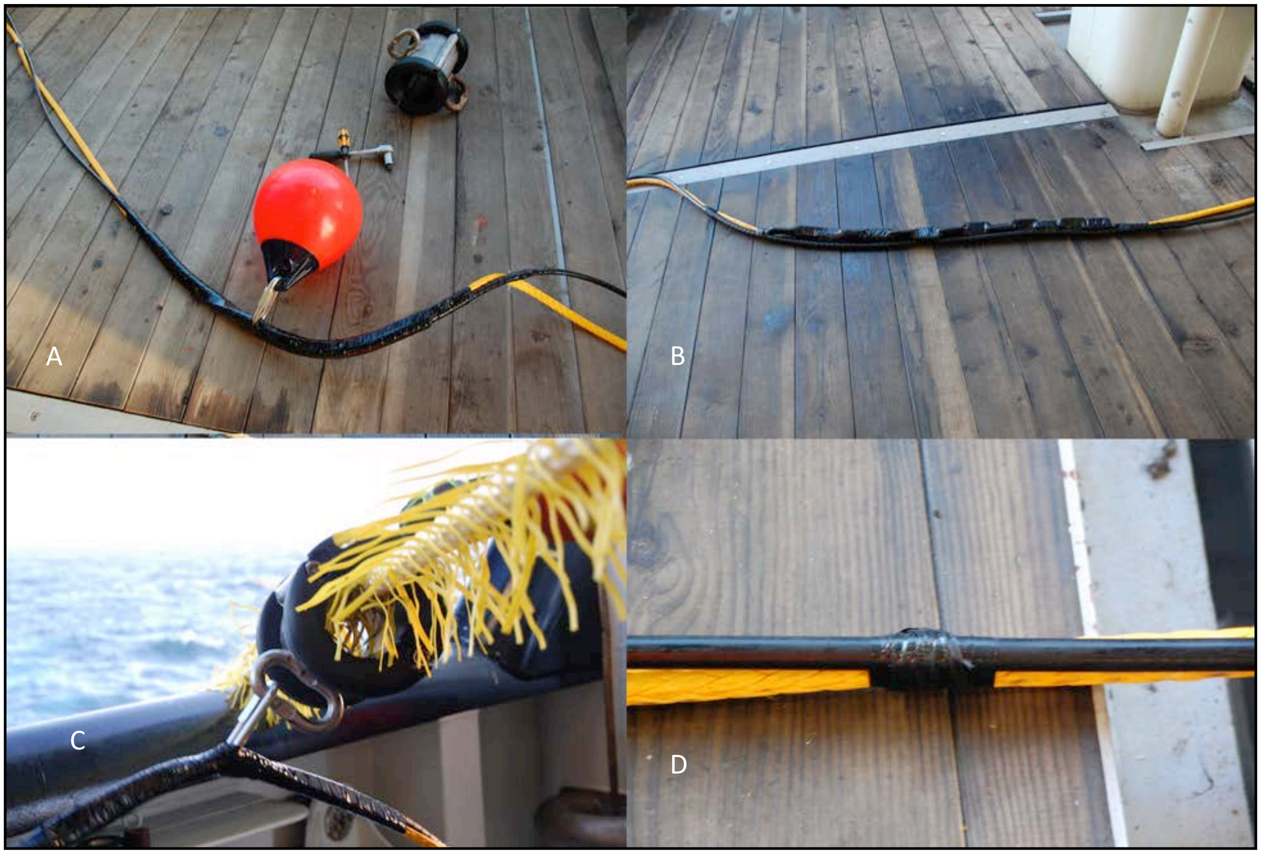


Figure 5: Attachment points, all attachment points are connected directly to Spectra line. A. Buoy B. Weights C. Sliding collar D. Hydrophone towed array cable.

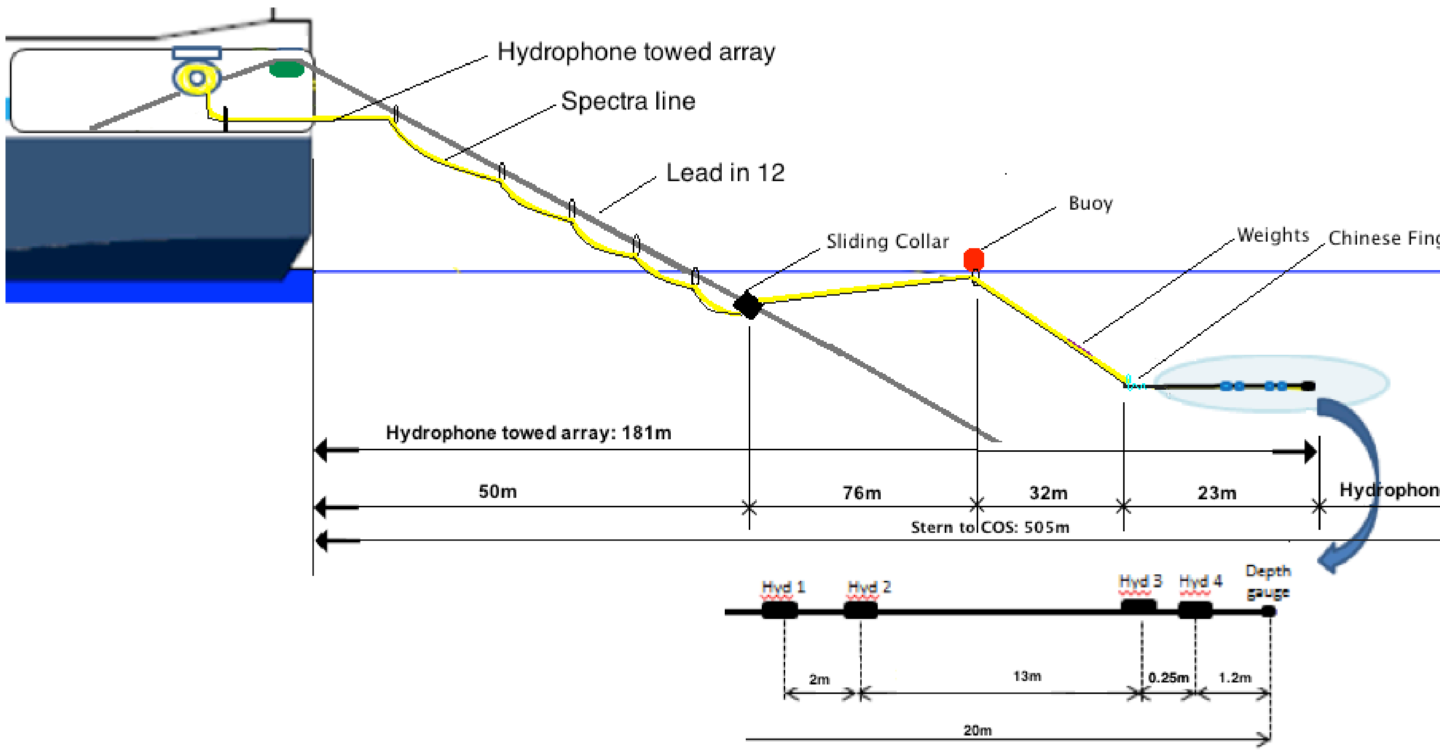


Figure 6: Sketch of the hydrophone deployment on the *Ramform Titan*.

Table 1: PAM hydrophone cable deployment and retrieval during the East Falkland Basin survey.

Deployment or Retrieval	Date	Time (UTC)	Reason	Comments
Deployment	02 Nov.	08:30	Seismic equipment deployed. Setting up gear for survey.	Deployment off sliding collar on lead in 10, port side. Deployment took one hour due to attaching Chinese fingers to hydrophone cable
Retrieval and Deployment	03 Nov.	07:30	Changing deployment set up. Hydrophone depth only four meters.	Retrieval and deployment took one hour due to moving of Chinese fingers.
Retrieval and Deployment	09 Nov.	00:00	~30m of towed hydrophone array cable broke off	Damage cable stored and spare cable briefly deployed.
Retrieval	09 Nov.	08:30	Secured on deck for daylight hours	Briefly deployed cable.
Deployment	09 Nov.	22:30	Cable deployed temporarily for PAM monitoring.	
Retrieval	10 Nov.	08:30	Secured on deck for daylight hours	Briefly deployed cable.
Deployment	10 Nov.	15:30	PAM monitoring for fog during daylight hours	
Retrieval	10 Nov.	17:00	Set up for new deployment	
Deployment	10 Nov.	22:00	New deployment set up.	Deployed 131m off port stern on lead in 12, 50m to sliding collar another 26m to buoy and 55m free

				floating. Deployment took ~2 hours.
Retrieval	15 Nov.	22:30	Secure on deck due to up coming weather	
Deployment	17 Nov.	00:30	Deployed to resume acoustic monitoring.	Deployment changed to lengthen distance between sliding collar and buoy, making for easier deployment.
Retrieval	20 Nov.	16:00	Secured on port winch due to up-coming weather	
Deployment	22 Nov.	01:00	Deployed to resume acoustic monitoring	
Retrieval	22 Nov.	16:00	Secured on port winch	Streamer maintenance on port side.
Deployment	23 Nov.	11:30	Deployed to resume acoustic monitoring	Daytime soft start due to fog.
Retrieval	25 Nov.	21:00	All of spread coming on board for repair	
Deployment	10 Dec.	20:00	Seismic gear deployed, start of production	PAM hydrophone cable replaced before deployment (old cable being used as spare)
Retrieval	06 Jan.	10:00	Picking up seismic gear for crew change	Cable damaged
Deployment	12 Jan.	18:00	Deploying gear after crew change	Damaged hydrophone cable SM.3806 was replaced with SM.3439.
Retrieval	05 Feb.	22:00	Brought onboard for inspection and poor weather	Cable appeared in good condition.
Deployment	07 Feb.	08:30	Deployed to resume acoustic monitoring	
Retrieval	10 Feb.	13:00	Picking up seismic gear for crew change	
Deployment	15 Feb.	20:00	Deployed to resume acoustic monitoring	
Retrieval	18 Feb.	20:00	End of project.	

2.3 Passive Acoustic Monitoring (PAM) Survey Methodology

This project utilized passive acoustic monitoring (PAM) to acoustically monitor during the night and during times of reduced daytime visibility, in order to clear the exclusion zone prior to soft start when applicable. In addition to inclement weather and fog (including all reduced daytime visibility prior to soft start), the PAM system was monitored on a nightly basis with a start of watch time ranging from 22:30 to 00:25 UTC and an end of watch time from 06:45 to 08:35 UTC. PAM monitoring began on the night of 05 November 2013 and continued through the duration of source operations ending on 18 February 2014.

Passive acoustic monitoring surveys were conducted by the PAM operator in two to four hour shifts separated by one to two hour breaks. Acoustic monitoring for marine mammals was completed aurally with *Sennheiser* headphones and visually with *Pamguard 1.12.05 Beta*. Delphinid whistles, clicks, and burst pulses and sperm whale clicks can be viewed on a spectrogram display within *Pamguard*. In addition, sperm whale, beaked whale, *Kogia* species, and delphinid echolocation clicks can also be viewed on *Pamguard's* low and high frequency click detector displays.

Distances for acoustic detections were primarily based upon a noise or detection score system developed by Gannier *et al* (2002). Gannier *et al* monitored sperm whales (*Physeter macrocephalus*) in the Mediterranean both visually and acoustically. A subjective scale was developed based upon the strength or intensity of the sperm whale clicks at various distances that were measured visually when the sperm whale surfaced. Although the scale is subjective, and sounds produced in marine environments will vary according to local conditions, the scale provided a measure for approximating distances when using a single, linear hydrophone array.

In addition, *Pamguard 1.12.05 Beta* contained a function for calculating an approximate range based upon the least squares fit test. The mathematical function estimated the range to vocalizing animals by calculating the most likely crossing of a series of bearing lines generated from tracked clicks. The clicks were tracked in the click detector module and the bearing lines associated with each click were then plotted on the map display. After several clicks were tracked an estimated range with an associated error was displayed on the map. Several click trains, over a few minutes in duration, were required to obtain a reasonable estimate of range.

During a detection of a vocalizing animal, information regarding position, distance, water depth, and range of animal, if applicable, was recorded, along with any recordings of vocalizations. A detection report was completed, utilizing information gathered from the navigation department, as well as, from the *Pamguard* modules. All information gathered was input into the Detection Report forms and the Daily Passive Acoustic Forms (Appendix B; Appendix C). Details of these detections were submitted in Daily and Weekly Reports in combination with visual MMO data.

2.4 Survey Data

2.4.1 Source Operations Survey Summary

The *Ramform Titan* arrived in Falkland Islands on 29 October 2013. After crew change and vessel fueling, deployment of the seismic gear commenced on 1 November 2013. The seismic source was first fired for testing at 11:56 UTC on 05 November 2013 and production on East Falkland Basin continued until the last shot of the survey at 19:19 on 18 February 2014. Two weeks, 24 November through 10 December, the source was not active due to retrieval of gear, weather and crew change. Once more, from 10 to 15 February the source was silent during seismic gear retrieval for the final crew change.

During the survey, the seismic source was active for a total of 1168 hours and 34 minutes. The majority, 92%, consisted of full volume source operations (1075 hours and 16 minutes); 1039 hours and 22 minutes while in production and 35 hours and 54 minutes during non-production full volume firing. The remaining 8% consisted of soft start, testing operations and a period of auto-firing; 48 hours and 30 minutes in testing, 44 hours and 36 minutes in soft start and 12 minutes of recorded auto-firing (Figure 7). Over the duration of the survey, from the first test shot until the last production shot, there was 1,406 hours and 49 minutes of acoustic silence, resulting in 54.63% silence during the survey.

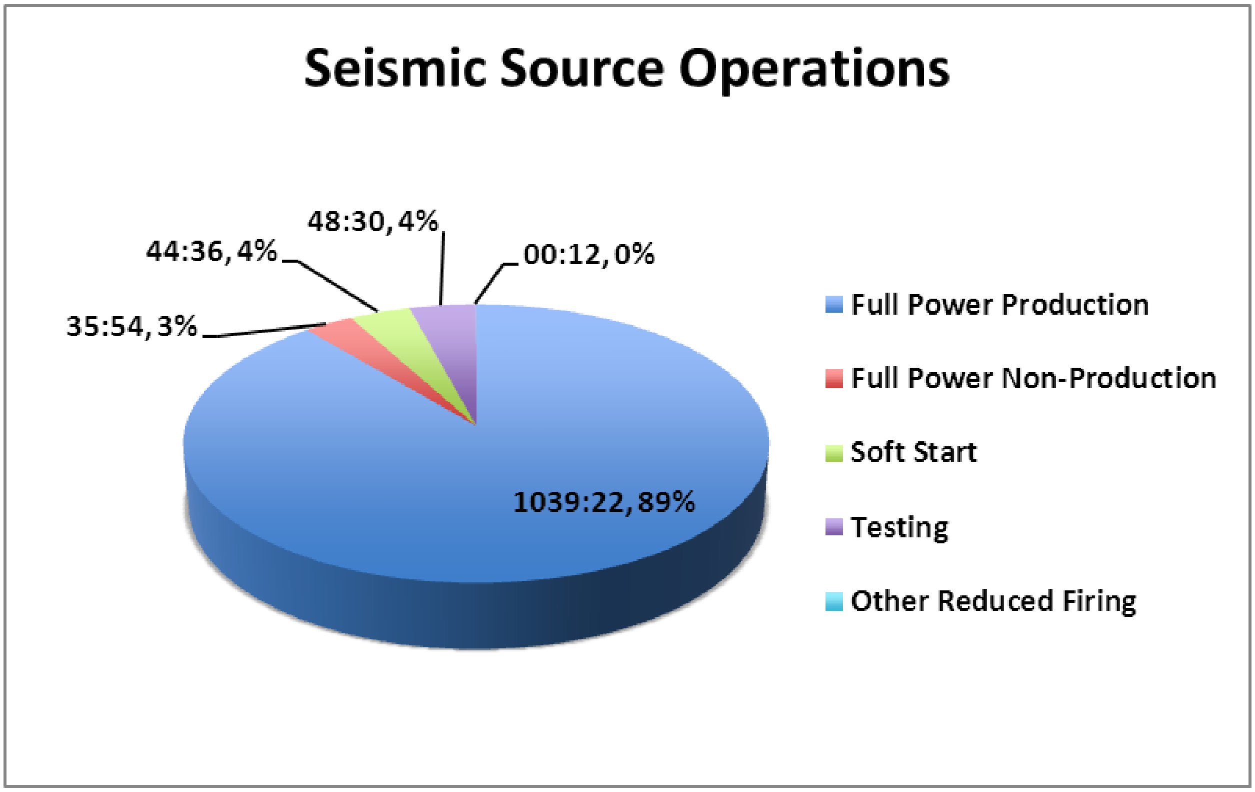


Figure 7: Breakdown of seismic source operations.

There were 130 soft starts performed over the course of the survey, 122 in order to commence full power survey operations and eight prior to acoustic source testing. In addition there was one episode of auto-fire from silence and 45 acoustic source tests that did not reach full volume (and therefore, a soft start was not necessary). Though soft starts were conducted using an automated acoustic source controller program which adds airguns sequentially to achieve full source, there were three episodes of 19 minute soft starts. Prior to soft starts and airgun testing the area was monitored for 60 minutes either visually, during daytime, acoustically, during night-time or periods of limited visibility, or a combination of the two. The only exception was during a time of auto-fire which continuous monitoring was briefly interrupted due to fog. The exclusion zone was cleared of marine mammals and sea turtles prior to the seismic source activity a total of 166 times. The exclusion zone was cleared 82 times through visual monitoring, 70 times through acoustic monitoring and 14 times through a necessary joint effort between visual and acoustic monitoring (Table 2; Figure 8). Of the 82 visual clearances, four were clearances after source silences of less than ten minutes in duration. Furthermore, two acoustic clearances of the total 70 were granted clearance of the seismic source during silences of less than ten minutes during night-time operations. Of the 130 soft starts, 52 occurred during night-time operations.

Table 2: Total acoustic source operations during the East Falkland Basin project.

Acoustic Source Operations	Number	Duration (hh:mm)
Airgun Tests		48:30
Soft start	130	44:36
Day-time pre-firing cleared by visual observation	82	
Day-time pre-firing cleared by PAM	20 (4 joint)	
Night time pre-firing cleared by PAM	54	
Pre-firing cleared with a combination of PAM and visual	14	
Full power survey acquisition		1039:22
Full power non-production		35:54
Total time acoustic source was active		1168:34

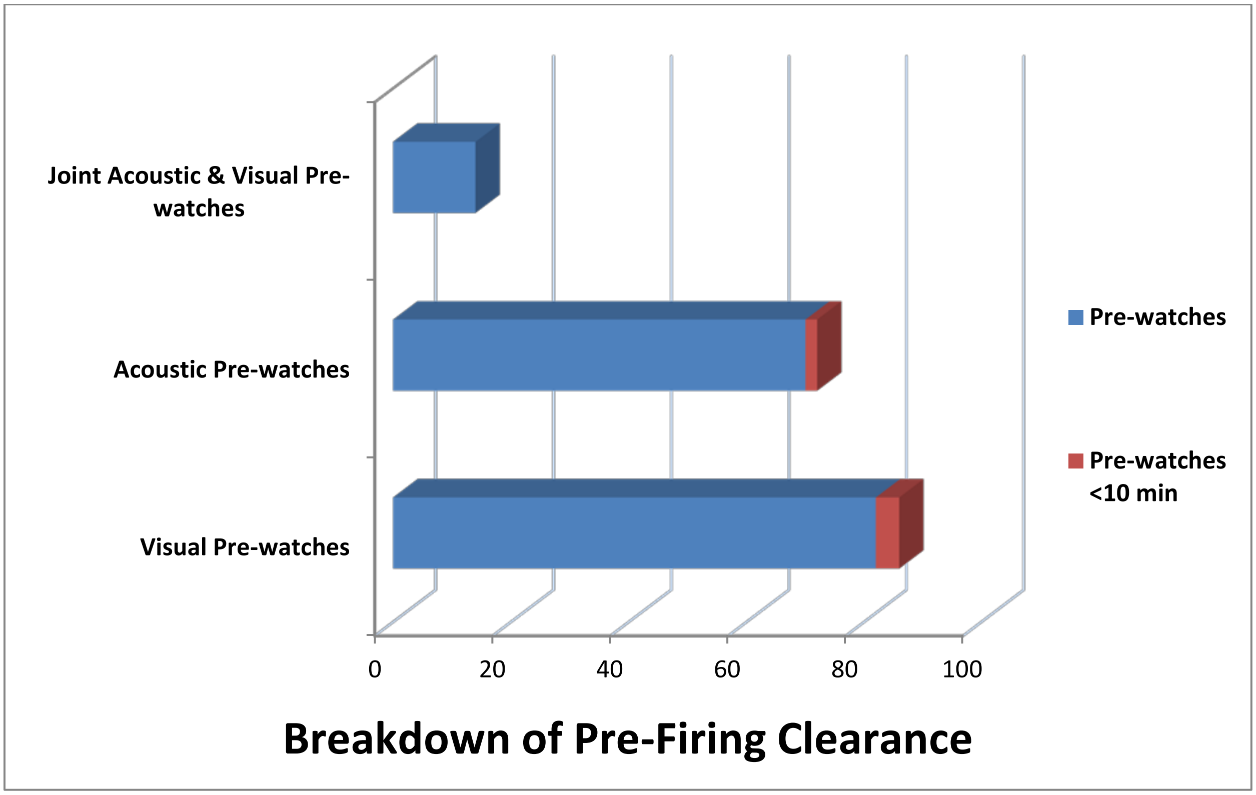


Figure 8: Breakdown of Pre-firing clearance.

2.4.2 Acoustic Monitoring Survey Summary

The RPS PAM operator monitored the hydrophones aurally and visually monitored the *Pamguard* detection software from sunset until sunrise and as needed during reduced visibility (fog or inclement weather). Acoustic monitoring began on 05 November 2013 at 23:00 UTC during a series of airgun tests and continued throughout the East Falklands Basin project. Acoustic monitoring for the project ended at 14:16 UTC on 18 February 2014 when the final survey line was cleared through PAM during a time of limited visibility due to fog. After the completion of the final survey line, the hydrophone cable was retrieved prior to the retrieval of seismic equipment. The four hydrophone array cables were packed up for demobilization in the next port of call. All other PAM equipment was set to remain onboard.

Over the course of this project, the PAM operators conducted 452 hours and 39 minutes of acoustic monitoring; the seismic source was active during 312 hours 26 minutes (70%) during acoustic monitoring and silent during 140 hours 13 minutes (30%) of acoustic monitoring (Figure 8). Daytime PAM was used to clear the exclusion zone 16 times during this project and overlapped with daytime pre-watches with visual monitoring an additional four times resulting in 20 total periods of passive acoustic monitoring during daytime limited visibility.

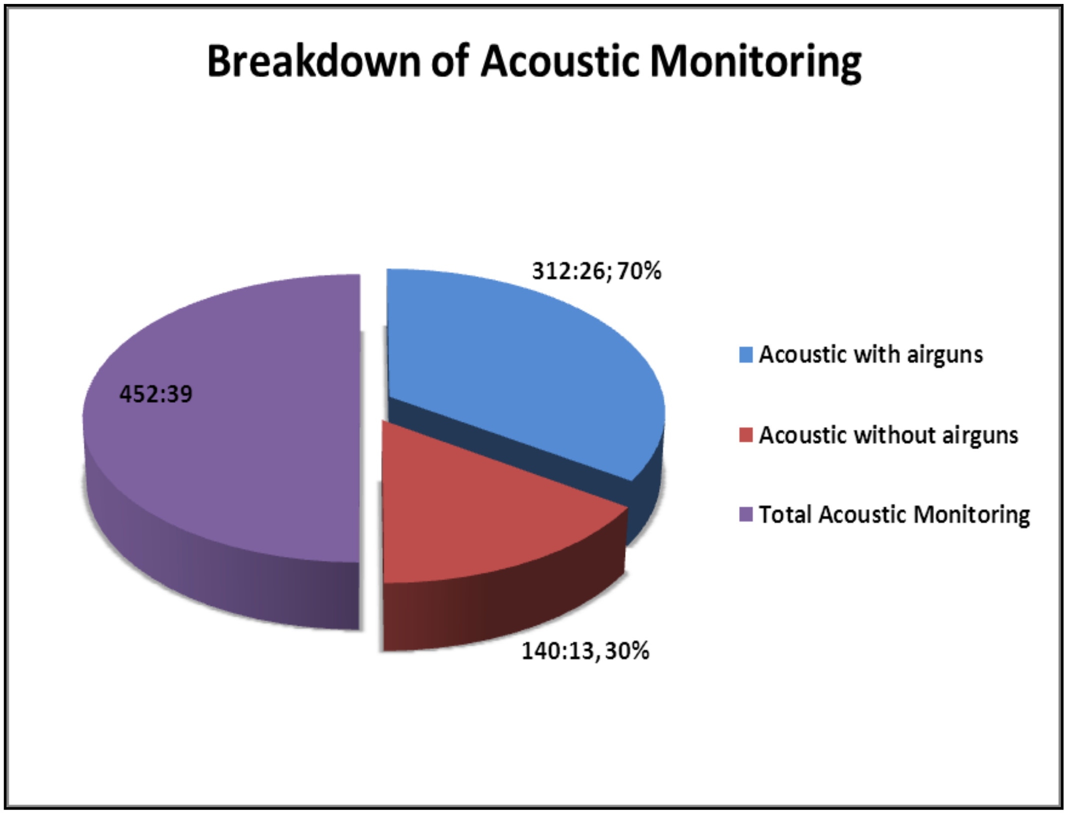


Figure 9: Breakdown of acoustic monitoring

2.5 Mitigation Actions

No mitigation actions were taken as a result of acoustic monitoring during this project.

3 Wildlife Summary

3.1 Acoustic Detections

Acoustic monitoring on the *Ramform Titan* from 05 November 2013 to 18 February 2014 produced eight acoustic detections; three were recorded as unidentified baleen whales, suborder Mysticeti, four from the family Delphinidae and one as a sperm whale (*Physeter macrocephalus)*.

Distribution of six of the eight acoustically made detections occurred near the northern section of the prospect, one in the southern end and one mid-prospect (Figure 10). The baleen whales were observed in water depths from 1322 to 1545 meters, the sperm whale 1541 meters and the Delphinidae in 1380 to 1509 meters.

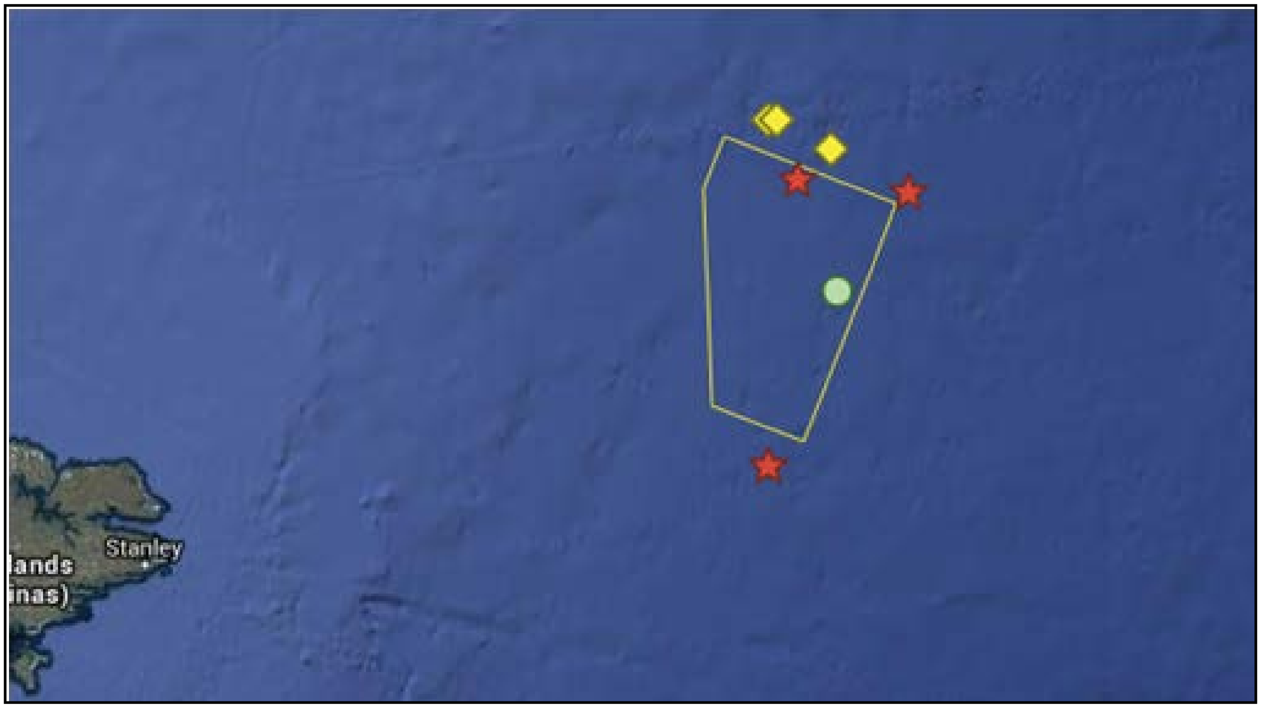


Figure 10: Distribution of acoustic detections mapped on Google Earth: yellow represents the suborder mysticeti, red the family Delphinidae and green sperm whale.

On 11 December 2013 at 06:38 UTC extremely faint double calls were detected by the PAM operator aurally through the headphones and then visually on the *Pamguard LF spectrogram* (acoustic detection 501). Due to the faintness of the calls and that the moans did not register on the *Pamguard Whistle and Moan detector,* distance was determined by the PAM operator as being outside the exclusion zone. The majority of the detection consisted of pairs of 'whoops' with peak energy at 205 hertz (between 165 and 225 hertz). They occurred at regular intervals of about 5.5 seconds between pairs, and 0.6 seconds between calls. The calls themselves about were approximately 0.25 seconds long, tonal and pulse-like (Figure 11).

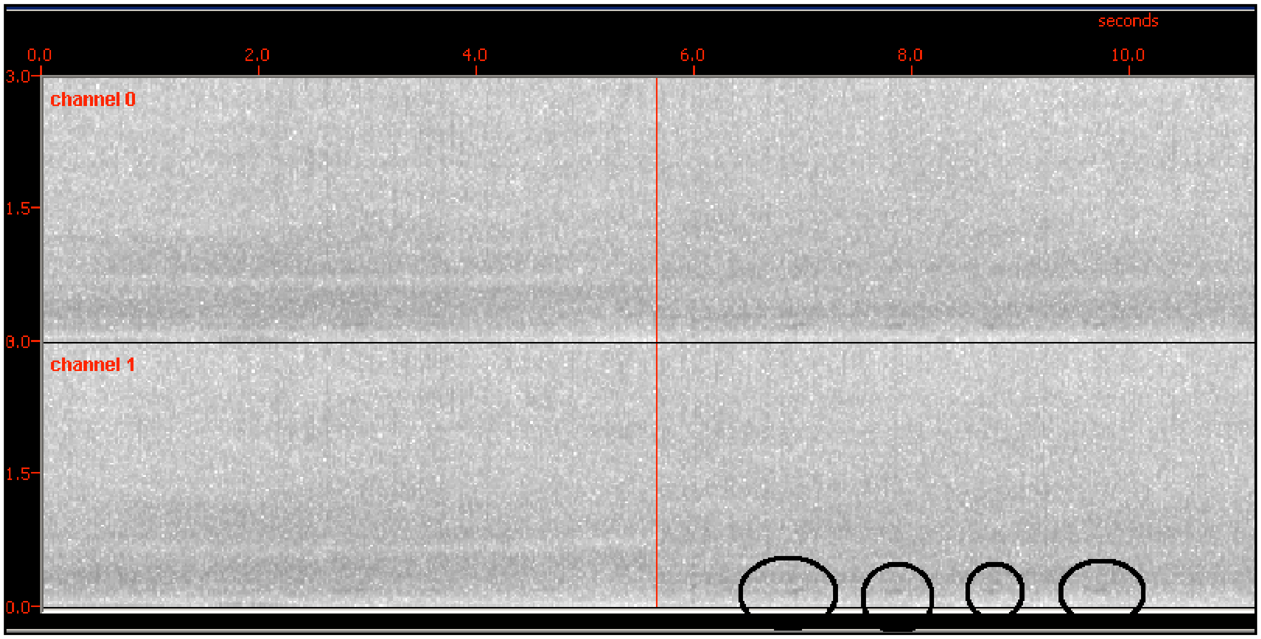


Figure 11: Screen capture of baleen whale detection through *Pamguard* on 11 December 2013 (Acoustic detection 501).

Acoustic detection 501 lasted nine minutes. After a silent period of 17 minutes, at 07:04 UTC the calls were again detected (acoustic detection 502). Double 'whoops' with the same frequency and timing were produced. These call trains of 4 to 6 “whoop’s” lost intensity as the train extended, starting at 120 decibels per 1µPa. It is possible that detection 501 and 502 were duplicate detections.

Double calls were once again detected on 23 December 2013 at 7:04 UTC (acoustic detection 503). These calls were detected aurally and on *Pamguard LF spectrogram* (Figure 12) and produced the same signature as previously described detections on 11 December 2013. Moans of 0.5 seconds in length were also detected during this vocalization, upsweeping and tonal. The detection occurred while visual MMO’s were on watch and lasted until 07:47 UTC but a visual correlation was not made.

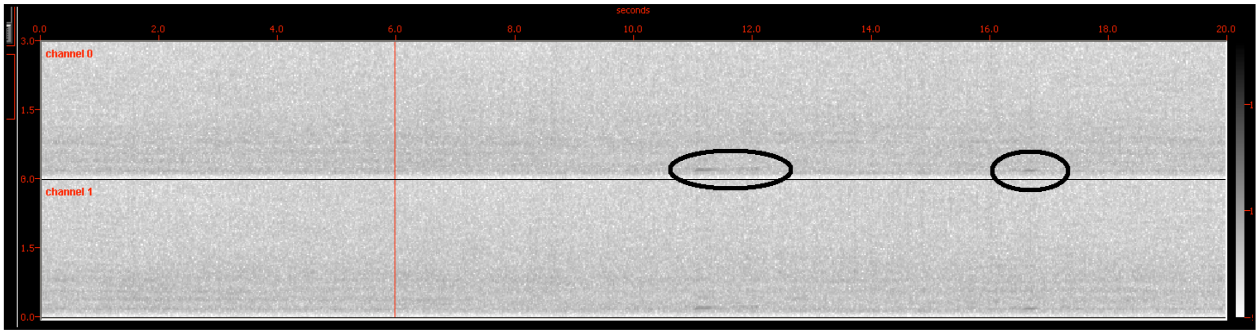


Figure 12: Screen capture of unidentified baleen whale detection through *Pamguard* on 23 December 2013 (acoustic detection 503).

Low frequency (LF) whistles were first detected aurally via headphones then visually on the *Pamguard spectrogram* on 02 January 2014 at 07:18 UTC (acoustic detection 504; Figure 13). Up-sweeping, down-sweeping and tonal single whistles were detected ranging in frequency from 1.6 to 23 kilohertz, in combination with harmonizing whistles ranging in frequency from 4.4 to 24 kilohertz. Echolocation clicks were also noted during this detection. Via the *Pamguard LF click detector* and the *map module* triangulation of location was determined to be approximately 300 meters from the acoustic source (Figure 14). Intensity of clicks trains and whistles were between 120 to 143 decibels per 1μPa.

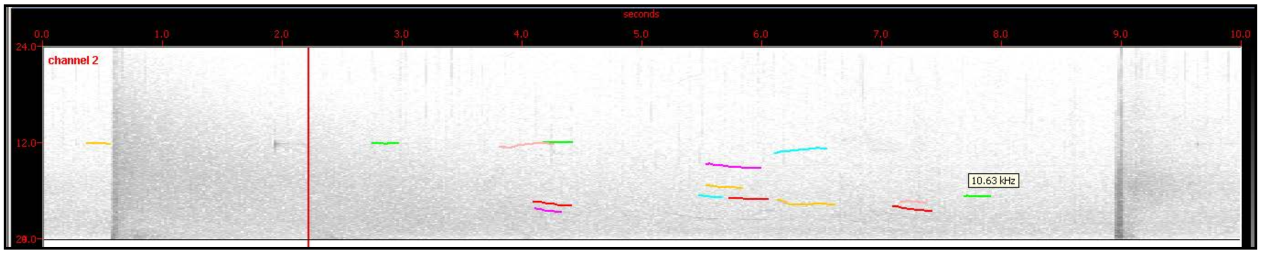


Figure 13: Screen capture of unidentified delphinid whistles detected through *Pamguard* on 02 January 2013 (acoustic detection 504).

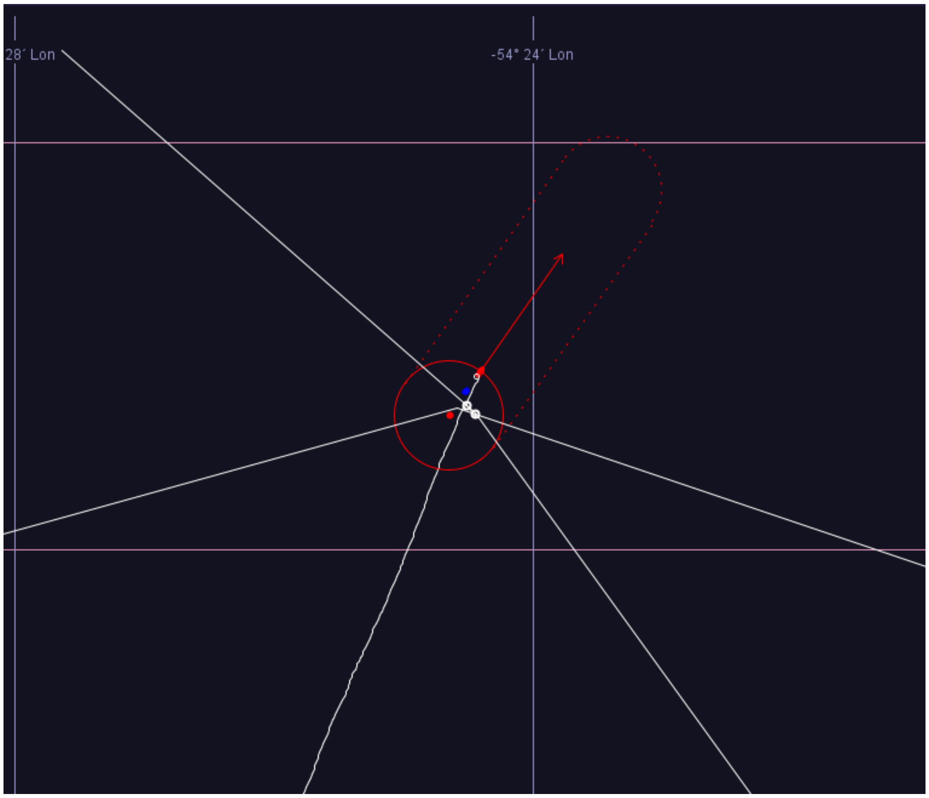


Figure 14: The *Pamguard* map display orientation of echolocation clicks on 02 January 2014 (acoustic detection 504).

On 21 January, acoustic detection 505 occurred on the low frequency system (Figure 15). The sperm whales (two individual click trains side-by-side were observed during the detection) were observed from 06:38 to 07:48 UTC ahead of the vessel. The PAM operator observed the whales ahead, parallel and then behind the vessel during the detection. Echolocation clicks ranged from 2 to 23 kilohertz with peak energy near 2.5 and 11 on various clicks. Click interval was approximately one click per half a second. The distance was estimated to be approximately 830 meters by the majority of cross lines on the map, as well as, clarity of echolocation clicks aurally observed by the operator. The hydrophone was towing at seven meters during the detection with vessel speed of 4.3 knots. Airguns were firing at full source. Therefore, there was no mitigation action required.

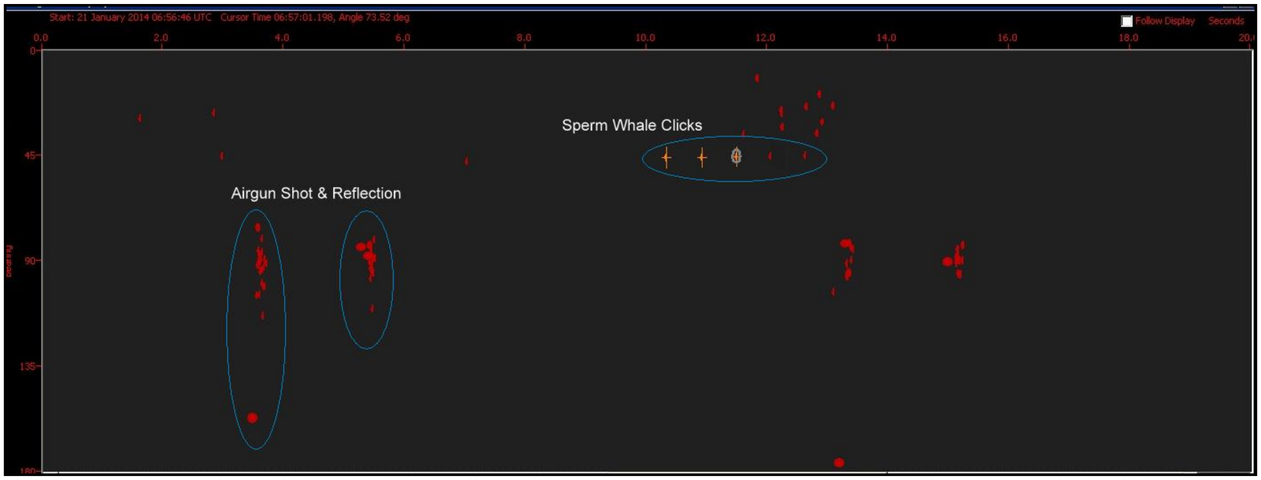


Figure 15: Click trains during acoustic detection 505 and acoustic source activity.

On 26 January, The acoustic detections 506 and 507 of Delphinidae occurred on the low frequency system. Acoustic detection 506 showed low frequency echolocation clicks that appeared split and narrowband, with frequencies between approximately 2.8 to 4 and 7 to 9 kilohertz with peak energy at 3 kilohertz (01:33-01:45 UTC). The inter-click interval appeared to be approximately 0.15 seconds (Figure 16). Bearing was approximately 201 or 335 degrees due to left right ambiguity. It was possible that detection 506 and 507 were the same detection comprised of one or more species since it correlates with acoustic detection 507's bearing off the portside stern as observed when localized. Acoustic detection 507, from 01:46 though 02:27 UTC, exhibited low frequency echolocation clicks from approximately 3 to 22 kilohertz with peak energy between 12 to 14 kilohertz. The inter-click interval appeared to be 0.25 seconds. No whistles or high frequency vocalizations were detected during either detection. Airguns were silent during pre-survey and localization was made outside of the exclusion zone as early as 02:14 UTC approximately 1130 meters off the portside stern. Therefore, there was no mitigation action required when soft start was requested at 02:38 UTC. This soft start was aborted at 02:46 when the vessel went down for weather and all airguns were silenced. The hydrophone was towing at 6.7 meters and the vessel speed was 3.4 knots.

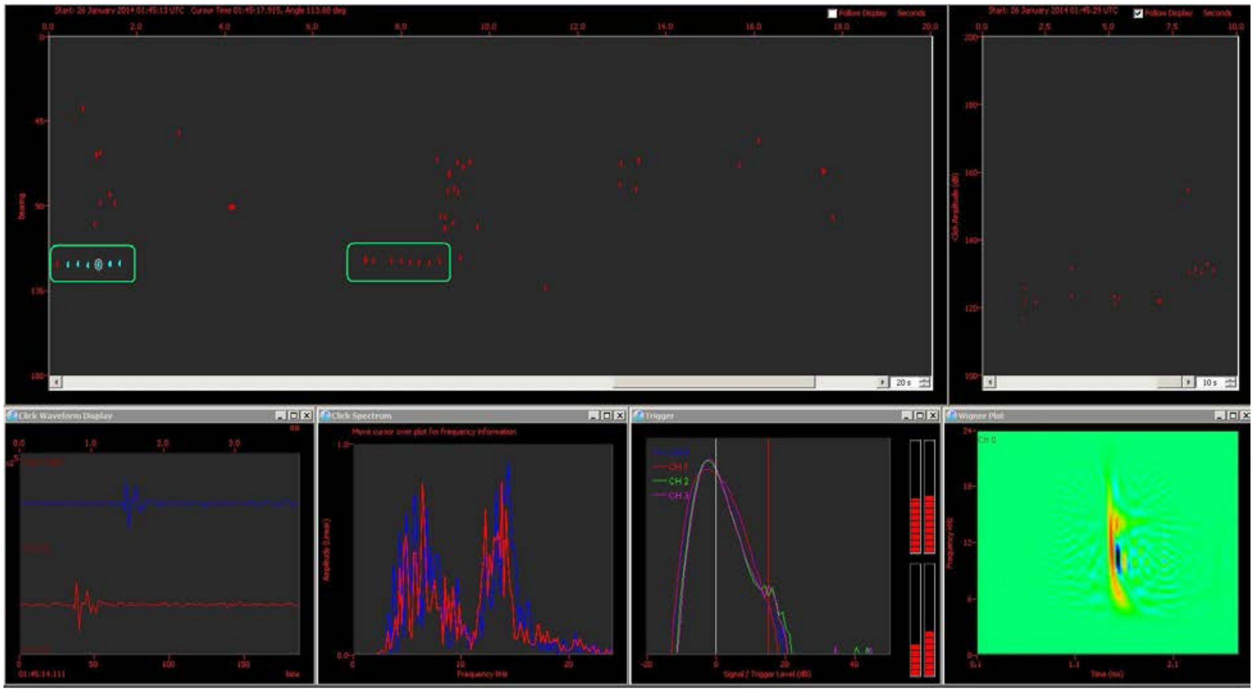


Figure 16: Acoustic detection 506 exhibiting low frequency click trains.

On 18 February, There was one acoustic detection today of unidentified delphinid (AD 508). At 13:12 UTC, the two sinusoidal marks were visually observed but not aurally detected during the pre-watch (Figure 17). Though not determined to be within the exclusion zone, there were no acoustic detections within the final 20 minutes of the pre-watch. Therefore, no mitigation action was required and soft start was cleared at 13:36 UTC. The hydrophone was towing at 6.5 meters and the vessel was traveling at 3.1 knots during the detection.

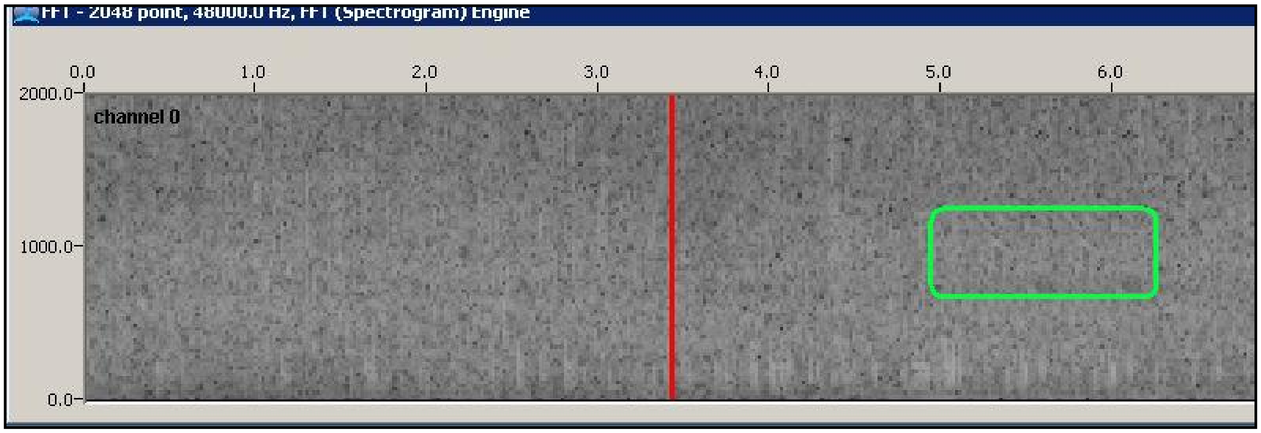


Figure 17: Acoustic detection 508 on 18 February 2014.

3.2 Wildlife Summary Tables

3.2.1 Protected Species

Table 3: Protected species observed during acoustic monitoring.

Detection No.	Date	Common Name	Species	Time (UTC)	Name of Recording	Source Activity at Initial Detection	Closest Approach to Source (m)	Mitigation Action
501	12/11/13	Baleen whale spp.	Undetermined	06:38–06:47	20131211 Noble PGS Ramform Titan Falklands 063958, 064326	Silent	>500	None
502	12/11/13	Baleen whale spp.	Undetermined	07:04–07:07	20131211 Noble PGS Ramform Titan Falklands 070416	Reduced volume	>500	None
503	12/23/13	Baleen whale spp.	Undetermined	07:04-07:47	20131223 PGS Noble Ramform Titan Falklands 070459, 070900, 071405, 072650 and 073058	Silent	>500	None
504	01/02/14	Delphinid spp.	Undetermined	07:18-07:28	20140102 PGS Noble Ramform Titan Falklands 071826, 072002, 072542	Full Volume	300	None
505	01/21/14	Sperm whale	*Physeter macrocephalus*	06:38-07:48	20140121 PGS Noble Ramform Titan Falklands: 063807, 065202, 065433, 065745, 070345, 070651, 071238, 072432, 072743, 074340, 074535 & 074825	Full Volume	830	None
506	01/26/14	Delphinid spp.	Undetermined	01:33-01:45	20140126 PGS Noble Ramform Titan Falklands: 013343; 013425; 014550	Silent	>500	None
507	01/26/14	Delphinid spp.	Undetermined	01:46-02:27	20140126 PGS Noble Ramform Titan Falklands: 014644; 014707; 015558; 020252; 020352; 020743; 020850; 020907; 021001; 021100 & 021314	Silent	1130	None
508	02/18/14	Delphinid spp.	Undetermined	13:12-13:13	20140218 PGS Noble Ramform Titan Falklands_131208	Silent	Undetermined	None

4 Data forms

4.1 Basic Data Form

BASIC DATA FORM				
Project Number		UMS04150		
Seismic Contractor		PGS		
Client		Noble Energy Falklands Ltd.		
Geographical coordinates of the survey area:		**Latitude**		**Longitude**
	Northeast Corner	50°30'20.33"S		53°53'36.48"W
	Southeast Corner	51°17'59.04"S		54°23'09.53"W
	Southwest Corner	51°10'41.46"S		54°52'13.93'W
	West mid-point	50°27'44.02"S		54°54'45.44"W
	Northwest Corner	50°16'38.27'S		54°47'44.71"W
Survey Type		3D dual source		
Vessel and/or Rig Name		*Ramform Titan*		
Permit Number		PON3		
Location / Distance of Airgun Deployment		Astern 505m		
Water Depth	**Min**	1000m		
	Max	1650m		
Dates of project		05 November 2013	THROUGH	18 February 2014
Dates included in reporting period		05 November 2013 through 18 February 2014		
Total time airguns operating – all power levels:		1168:34		
Amount of time airguns operating at full power:		1075:16		
Time airguns operating at full power on a survey line:		1039:22		
Time airguns operating at full power approaching survey line:		35:54		
Amount of time compliance gun/reduced power operations:		00:12 recorded auto-fire		
Amount of time in soft start:		44:36		
Number daytime soft starts		78		
Number of night time soft starts		52		
Number of soft starts from mitigation source:		0		
Number of clearances from PAM system:		70		
Number of clearances from PAM and visual:		14		
Amount of time conducted in airgun testing:		48:30		
Duration of acoustic monitoring:		452:39		
Duration of acoustic monitoring while airguns firing:		312:26		
Duration of acoustic monitoring during airgun silence:		140:13		
Visual Observers:		Kevin Robinson (05 November 2013 – 08 January 2014), Panagiota Giogli (08 January 2014 – 18 February 2014)		
		Alan Addison (05 November 2013 – 08 January 2014), Rachel Monkhouse (08 January 2014 – 18 February 2014)		
Acoustic Observers:		Breanna Evans (05 November 2013 – 08 January 2014), Lynn Henneberger (08 January 2014 – 18 February 2014)		
Number of Marine Mammals Acoustically Detected:		8		
Number of acoustic detections confirmed by visual sighting:		0		
Number of visual sighting confirmed by acoustic detection:		0		
List Mitigation Actions (eg. shutdowns, soft start delays)		None through PAM		
Duration of operational downtime due to mitigation:		00:00		
Flagged Data Forms (list sheet & date)		22 Jan., 16 Feb. & 18 Feb. 19 minute soft start		

5 Cover Data Sheet

RPS

PROTECTED SPECIES RECORDING FORM

COVER PAGE

Regulatory Reference Number (e.g. DECC no., BOEM permit no., OCS lease no., etc.) PON3	**Country** Falkland Islands	**Project Number** UMS04150
Client Noble Energy Falklands LTD	**Seismic Contractor** PGS	**Vessel Name** *Ramform Titan*
Start Date 2013-11-05	**End Date** 2014-02-18	**Survey Type** 3D
Source Vessel(s) *Ramform Titan*	**Type of Source (e.g. airguns)** Airguns	**Number of Airguns (if used)** 32
Source Depth (metres) 7	**Source Volume (cu. in.)** 4130	**Shot Point Interval (metres)** 25
Frequency (Hz) 0 - 214	**Intensity (dB re. 1µPa or bar meters)** 140.9	**Method of Soft Start** increase number of guns

Visual monitoring equipment used (e.g. binoculars, big eyes, etc.) Binoculars	**Magnification of optical equipment (e.g. binoculars)** 12	**Height of eye off water surface (metres)** 19	**How was distance of animals estimated?** [x] by eye [ ] with laser rangefinder [ ] with rangefinder stick / calipers [x] with reticle binoculars [ ] by relating to object at known distance [ ] other

Marine Mammal Observers Kevin Robinson, Alan Addison, Panagiota Giogli, Rachel Monkhouse	**Training of MMOs** [x] JNCC approved MMO induction course for UK waters [ ] PSO training course for the Gulf of Mexico [ ] MMO training course for Irish waters [ ] other [ ] none

Was PAM used? yes	**PAM Operator(s)** Breanna Evans, Lynn Henneberger

Description of PAM equipment

A 250 meter towed array, deployed off port stern, connected to data processing unit via a 100 meter deck cable. Signals were converted digitally and monitored on *Pamguard* version 1.12.05 BETA.

Range of PAM hydrophones from airguns (metres) 324	**Bearing of PAM hydrophones from airguns relative to direction of travel** (degrees) 135	**Depth of PAM hydrophones** (metres) 7

6 References

Gannier A, Violaine D, Goold JC. 2002. *Distribution and relative abundance of sperm whales in the Mediterranean Sea*. Marine Ecology Progress Series 243:281-291.

Carwardine, Mark. *Whales, Dolphins and Porpoises.* Smithsonian Handbooks. Ed. Evans, P., and Weinrich, M., Illustrated by Camm, M., Dorling Kindersley Publishing, Inc. (1995).

Joint Nature Conservation Committee, (2010). JNCC Guidelines for minimizing the risk of disturbance and injury to marine mammals from seismic surveys. JNCC Aberdeen, United Kingdom.

Petroleum Operations Notice 3 Notification of Geophysical Surveys Form. Dept. of Mineral Resources, Stanley, Falkland Islands.

Project Plan PGS Geophysical Ramform Titan Project No 2013063 and Noble EnergyFalklands Limited East Falkland Basin version 1.2. PGS Geophysical, Norway.

APPENDIX A: JNCC GUIDELINES FOR MINIMIZING THE RISK OF INJURY AND DISTURBANCE TO MARINE MAMMALS FROM SEISMIC SURVEYS

Joint Nature Conservation Committee

JNCC guidelines for minimizing the risk of injury and disturbance to marine mammals from seismic surveys

August 2010

To find out more about seismic surveys visit http://www.jncc.gov.uk/page-1534
To learn more about JNCC visit http://www.jncc.gov.uk/page=1729

JNCC, Marine Advice,
Inverdee House, Baxter Street
Aberdeen, AB11 9QA,
United Kingdom
Tel: +44(0)1224 266550
Email: seismic@jncc.gov.uk

JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys

August 2010

Introduction

The guidelines have been written for activities on the United Kingdom Continental Shelf (UKCS) and are aimed at reducing the risk of injury to negligible levels and can also potentially reduce the risk of disturbance from seismic surveys to marine mammals including seals, whales, dolphins and porpoises. Whilst there are no objections to these guidelines being used elsewhere JNCC would encourage all operators to determine if any special or local circumstances pertain, as we would not wish these guidelines to be used where a local management tool has already been adopted (for instance in the Gulf of Mexico OCS Region). In this context, JNCC notes that other protected fauna, for example turtles, will occur in waters where these guidelines may be used, and would suggest that, whilst the appropriate mitigation may require further investigation, the soft-start procedures for marine mammals would also be appropriate for marine turtles and basking sharks[i].

The guidelines require the use of trained Marine Mammal Observers (MMOs) whose role is to advise on the use of the guidelines and to conduct pre-shooting searches for marine mammals before commencement of any seismic activity. A further duty is to ensure that the JNCC reporting forms are completed for inclusion in the MMO report. In addition to the visual mitigation provided by MMOs, if seismic surveys are planned to start during hours of darkness or low visibility it is considered best practice to deploy Passive Acoustic Monitoring (PAM).

The 2010 version of the JNCC seismic guidelines reflects amendments (2007 and 2009 amendments) to the Conservation (Natural Habitats &c.) Regulations 1994 (Habitat Regulations, HR) for England and Wales[ii] and the Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (Offshore Marine Regulations, OMR**,** as amended in 2009 and 2010). Both regulations have revised the definition of deliberate disturbance of 'European Protected Species' (EPS), which now excludes

[i] Basking sharks are protected from intentional capture or disturbance in British waters (up to 12 miles offshore) under a 1998 listing on the Wildlife and Countryside Act (1981), Schedule 5.
[ii] In 2010 a consolidated version of the regulations came into force: The Conservation of Habitats and Species Regulations 2010.

trivial disturbance from the offence. Both regulations now also include the offence of deliberate injury. European Protected Species include cetaceans and turtles.

It has been recognised that sound generated from seismic sources has the potential to cause injury and possibly also disturbance to marine mammals. Seismic surveys have therefore the potential to cause a deliberate injury offence as defined under regulations 41(1)(a) and 39(1)(a) and a deliberate disturbance offence as in 41(1)(b) and 39(1)(b) of the HR and OMR, respectively. The JNCC seismic guidelines reflect best practice for operators to follow during the planning, operational and reporting stages. **It is considered that compliance with the recommendations in these guidelines will reduce the risk of injury to EPS to negligible levels**.

Please note that the mitigation measures recommended in the existing guidelines are more relevant to the prevention of injury rather than disturbance as defined in regulations 41(2) and 39(1A), of the HR and OMR, respectively. The onus should be on the entity responsible for the activity to assess whether a disturbance offence is likely to occur. Guidance on how to carry out such risk assessment is provided in the JNCC, NE and CCW document 'The protection of marine European Protected Species from injury and disturbance'.

In relation to oil and gas seismic surveys in the UKCS, it is a requirement of the consent issued under regulation 4 of the Petroleum Activities (Conservation of Habitats) Regulations 2001 (& 2007 Amendments) by the Department for Energy Climate Change (DECC), that the JNCC Seismic Guidelines must be followed, and the elements of the guidelines that are relevant to a particular survey are incorporated into the legally-binding condition of consent. It should be noted that it is the responsibility of the company issued consent by DECC[iii], referred to in these guidelines as the 'applicant', to ensure that these guidelines are followed, and it is recommended that a copy of the JNCC guidelines are available onboard all vessels undertaking seismic activities in UK waters. Where relevant, when the survey is completed a MMO report must be submitted to the JNCC.

[iii] Department of Energy and Climate Change was formerly known as Department for Business and Regulatory Reform (BERR)

Index

Terminology

Marine European Protected Species: These are marine species in Annex IV(a) of the Habitats Directive that occur naturally in the waters of the United Kingdom. These consist of several species of cetaceans (whales, dolphins and porpoises), turtles, and the Atlantic Sturgeon.

Marine Mammal Observer (MMO): Individual responsible for conducting visual watches for marine mammals. For some seismic surveys it may be requested that observers are trained, dedicated and / or experienced. The MMO may also be a PAM operative if trained.

- **Trained MMO**: Has been on a JNCC recognised course
- **Dedicated MMO**: Trained observer whose role on board is to conduct visual watches for marine mammals (although it could double up as a PAM operative)
- **Experienced MMO**: Trained observer with 3 years of field experience observing for marine mammals, and practical experience of implementing the JNCC guidelines
- **PAM Operative**: Person experienced in the use of PAM software and hardware and marine mammal acoustics

Mitigation Zone: The area where a Marine Mammal Observer keeps watch for marine mammals (and delays the start of activity should any marine mammals be detected).

Passive Acoustic Monitoring (PAM): Software system that utilises hydrophones to detect the vocalisations of marine mammals.

Seismic Survey: Any survey that uses airguns, including 2D/3D/4D and OBC (On-Bottom Cabling) surveys and any similar techniques that use airguns. Surveys using multibeam systems and sub-bottom profiling equipment such as boomers, pingers etc are not considered in these guidelines. However, the guidelines can be adapted and applied to the operation of such systems if considered appropriate.

Shot Point Interval (SPI): Interval between firing of the airgun or airguns.

Site Survey: Seismic survey of a limited area proposed for drilling, infrastructure emplacement etc (typically with source size of 180 cubic inches or less).

Soft-Start: Turning on the airguns at low power and gradually and systematically increasing the output until full power is achieved (usually over a period of 20 minutes). The appropriate soft-start method is dependant upon the type of seismic survey and is discussed in section 3.

United Kingdom Waters: Parts of the sea in or adjacent to the United Kingdom from the low water mark up to the limits of the United Kingdom Continental Shelf.

Vertical Seismic Profiling (VSP) or Borehole Seismic: Seismic survey undertaken 'down hole' in connection with well operations (typically with a source size of 500 cubic inches).

Section 1 – Assessing and minimising the risk of injury

1.1 The Planning Stage

When a seismic survey is being planned, the applicant should consider the following recommendations and best practice advice:

- Determine what marine mammal species are likely to be present in the survey area and assess if there are any seasonal considerations that need to be taken into account, for example periods of migration, breeding, calving or pupping. For UKCS activities the 'Atlas of cetacean distribution in north-west European waters' (Reid *et al*. 2003) is a useful starting point.
- Consult the latest relevant regulatory guidance notes; in the UK, DECC issues guidance notes for oil and gas seismic activities.
- As part of the environmental impact assessment, assess the likelihood of injuring or disturbing a European Protected Species. In the UK, it will be necessary to assess the likelihood of committing an offence as defined in the HR and in the OMR.
- Consult the JNCC, NE and CCW guidance on 'The protection of marine European Protected Species from injury and disturbance' to assist in the environmental impact assessment. To obtain a copy of the latest draft version of the guidance please contact JNCC.

The operator should whenever possible implement the following best practice measures:

- If marine mammals are likely to be in the area, only commence seismic activities during the hours of daylight when visual mitigation using Marine Mammal Observers (MMOs) is possible.
- Only commence seismic activities during the hours of darkness, or low visibility, or during periods when the sea state is not conducive to visual mitigation, if a Passive Acoustic Monitoring (PAM) system is in use to detect marine mammals likely to be in the area, noting the limitations of available PAM technology (seismic surveys that commence during periods of darkness, or low visibility, or during periods when the observation conditions are not conducive to visual mitigation, could pose a risk of committing an injury offence).
- Plan surveys so that the timing will reduce the likelihood of encounters with marine mammals. For example, this might be an important consideration in certain areas/times, e.g. during seal pupping periods near Special Areas of Conservation for common seals or grey seals.
- Provide trained MMOs to implement the JNCC guidelines.
- Use the lowest practicable power levels to achieve the geophysical objectives of the survey.
- Seek methods to reduce and/or baffle unnecessary high frequency noise produced by the airguns (this would also be relevant for other acoustic energy sources).

Section 2 - Marine Mammal Observers

2.1. Role of an MMO

The primary role of an MMO is to act as an observer for marine mammals and to recommend a delay in the commencement of seismic activity should any marine mammals be detected. In addition, a MMO should be able to advise the crew on the procedures set out in the JNCC guidelines and to provide advice to ensure that the survey programme is undertaken in accordance with the guidelines. Before the survey commences it is important to attend any pre-mobilisation meetings to discuss the working arrangements that will be in place, and to request a copy of the survey consent issued by DECC (if applicable). An MMO may also work closely with Passive Acoustic Monitoring operatives. As the MMO role in relation to the vessel and survey operations is purely advisory, it is important to be aware of the command hierarchy and communication channels that will be in place, and determine who the main MMO / PAM operative contacts should be.

In a typical vessel based seismic survey, the MMO / PAM operative may pass advice to the party chief and client's representative through the navigators or seismic observers, and it is important to establish what the working arrangements are, as this may vary from one survey to the other. The MMOs should consider themselves as part of the crew and respect the chain of command that is in place.

MMOs should make certain that their efforts are concentrated on the pre-shooting search before the soft-start. These guidelines cannot be interpreted to imply that MMOs should keep a watch during all daylight hours, but JNCC would encourage all MMOs to manage their time to ensure that they are available to carry out a watch to the best of their ability during the crucial time - the 30 minutes before commencement of the firing of the seismic source (or 60 minutes if surveying where deep diving marine mammals are likely to be present). Whilst JNCC appreciates the efforts of MMOs to collect data at other times, this should be managed to ensure that those observations are not detrimental to the ability to undertake a watch prior to a soft-start. Where two MMOs are onboard a seismic vessel, JNCC would encourage collaboration to ensure that cetacean monitoring is always undertaken during all daylight hours.

2.2. Training requirements for MMOs

A prerequisite for an MMO to be classified as a 'trained MMO' is that they must have received formal training on a JNCC recognised course. (Further information on MMO course providers is available at: http://www.jncc.gov.uk/page-4703)

2.3. MMO equipment and reporting forms

MMOs should be equipped with binoculars, a copy of the JNCC guidelines and the 'Marine Mammal Recording Form' which is an Excel spreadsheet and has embedded worksheets named: 'Cover Page', 'Operations', 'Effort' and 'Sightings'. A Word document named 'Deckforms' is also available, and MMOs may prefer to use this when observing before transferring the details to the Excel spreadsheets.

The ability to determine range is a key skill for MMOs to have, and a useful tool to perform this function is a range finding stick.

All MMO forms, including a guide to completing the forms, and instructions on how to make and use a range finding stick are available on the JNCC website.

2.4. Reporting requirements – the MMO report

A report, the 'MMO report', should be sent to the JNCC after the survey has been completed. It is the responsibility of the consent holder to ensure that the MMO report is sent to JNCC. Ideally the MMO report should be sent via e-mail to seismic@jncc.gov.uk, or it can be posted to the address on the front page of these guidelines. Reports should include completed JNCC marine mammal recording forms and contain details of the following:

- The seismic survey reference number provided to the applicant by DECC.
- Date and location of survey.
- Total number and volume of the airguns used.
- Nature of airgun array discharge frequency (in Hz), intensity (in dB re. 1µPa or bar metres) and firing interval (seconds), and / or details of any other acoustic energy used.
- Number and types of vessels involved in the survey.
- A record of all occasions when the airguns were used.
- A record of the watches made for marine mammals, including details of any sightings and the seismic activity during the watches.
- Details of any problems encountered during the seismic survey including instances of non-compliance with the JNCC guidelines.

If there are instances of non-compliance with the JNCC guidelines that constitute a breach of the survey consent conditions, JNCC will copy the report, and their comments on the potential breach to DECC. It is therefore essential that MMO reports are completed as soon as possible after the survey has been completed.

Section 3 – Guidance before and during seismic activity

All observations should be undertaken from the source vessel (where the airguns are being deployed from), unless alternative arrangements have been agreed with DECC. The MMO should be positioned on a high platform with a clear unobstructed view of the horizon, and communication channels between the MMO and the crew should be in place before commencement of the pre-shooting search (this may require portable VHF radios). The MMO should be aware of the timings of the proposed operations, so that there is adequate time to conduct the pre-shooting search. Figure 1 illustrates a typical seismic survey with decision making pathways in the event a marine mammal is detected.

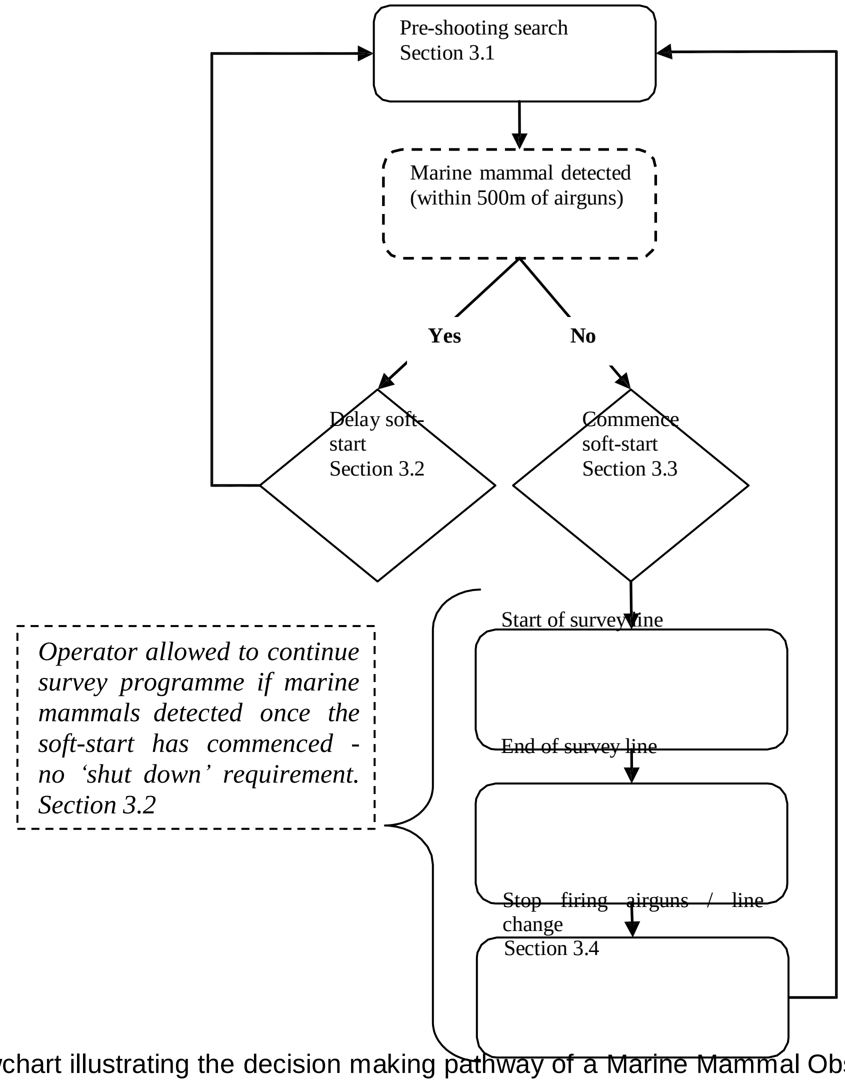


Figure 1. Flowchart illustrating the decision making pathway of a Marine Mammal Observer during a seismic survey.

3.1 Pre-shooting search

The pre-shooting search should normally be conducted over a period of 30 minutes before commencement of any use of the airguns. The MMO should make a visual assessment to determine if any marine mammals are within 500 metres of the centre of the airgun array.

In deep waters (>200m) the pre-shooting search should extend to 60 minutes as deep diving species (e.g. sperm whale and beaked whale) are known to dive for longer than 30 minutes. A longer search time in such areas is likely to lead to a greater detection and tracking of deep diving marine mammals.

To facilitate more effective timing of proposed operations when surveying in deeper waters, the searches for marine mammals can commence before the end of the survey line (whilst the airguns are still firing); this condition may be necessary for surveys which have relatively fast line turn times. If any marine mammals are

detected whilst the airguns are still firing, then no action is required other than for the MMO to monitor and track any marine mammals. The commencement of the soft-start for any subsequent survey lines should be delayed for at least 20 minutes if marine mammals are detected when the airguns have ceased firing.
If PAM is used in conjunction with visual monitoring the PAM operatives should ensure the system is deployed and being monitored for vocalisations during each designated pre-shooting period.

3.2 Delay if marine mammals are detected within the mitigation zone (500 metres)

If marine mammals are detected within 500 metres of the centre of the airgun array during the pre-shooting search, the soft-start of the seismic sources should be delayed until their passage, or the transit of the vessel, results in the marine mammals being more than 500 metres away from the source. In both cases, there should be a 20 minute delay from the time of the last sighting within 500 metres of the source to the commencement of the soft-start, in order to determine whether the animals have left the area. If PAM is used it is the responsibility of the PAM operatives to assess any acoustic detections and determine if there are likely to be marine mammals within 500 metres of the source. If the PAM operatives consider marine mammals are present within that range then the start of the operation should be delayed as outlined above.

If marine mammals are detected within 500 metres of the centre of the airgun array whilst the airguns are firing, either during the soft-start procedure or whilst at full power, there is no requirement to stop firing the airguns.

In situations where seal(s) are congregating around a drilling or production platform that is within the survey area, it is recommended that the soft-start should commence at a location at least 500 metres from the platform.

3.3 The soft-start

The soft-start is defined as the time that airguns commence shooting till the time that full operational power is obtained. Power should be built up slowly from a low energy start-up (e.g. starting with the smallest airgun in the array and gradually adding in others) over at least 20 minutes to give adequate time for marine mammals to leave the area. This build up of power should occur in uniform stages to provide a constant increase in output. There should be a soft-start every time the airguns are used, the only exceptions being for certain types of airgun testing (section 3.3.2), and the use of a 'mini-airgun' (single gun volume less than 10 cubic inches), these are used on site-surveys (section 3.3.1). The duration of the pre-shooting search (at least 30 minutes) and the soft-start procedure (at least 20 minutes) should be factored into the survey design.

General advice to follow for soft-starts:

- To minimise additional noise in the marine environment, a soft-start (from commencement of soft-start to commencement of the line) should not be significantly longer than 20 minutes (for example, soft-starts greater than 40 minutes are considered to be excessive, and an explanation should be provided within the MMO report).

- Where possible, soft-starts should be planned so that they commence within daylight hours.
- Once the soft-start has been performed and the airguns are at full power the survey line should start immediately. Operators should avoid unnecessary firing at full power before commencement of the line.
- If, for any reason, firing of the airguns has stopped and not restarted for at least 10 minutes, then a pre-shooting search and 20 minute soft-start should be carried out (the requirement for a pre-shooting search only applies if there was no MMO on duty and observing at this time, and if the break in firing occurred during the hours of daylight). After any unplanned break in firing for less than 10 minutes the MMO should make a visual assessment for marine mammals (not a pre-shooting search) within 500 metres of the centre of the airgun array. If a marine mammal is detected whilst the airguns are not firing the MMO should advise to delay commencement, as per the pre-shooting search, delay and soft start instructions above. If no marine mammals are present then they can advise to commence firing the airguns.
- When time-sharing, where two or more vessels are operating in adjacent areas and take turns to shoot to avoid causing seismic interference with each other, the soft-start and delay procedures for each vessel should be communicated to, and applied on, all the vessels involved in the surveying.

3.3.1 Soft-start requirements for site survey or Vertical Seismic Profiling (VSP)

Surveys should be planned so that, whenever possible, the soft-start procedures for site surveys and Vertical Seismic Profiles (VSP's) commence during daylight hours. Whilst it is appreciated that high resolution site surveys / VSP operations may produce lower acoustic output than 2D or 3D surveys it is still considered desirable to undertake a soft-start to allow for marine mammals to move away from the seismic source.

For ultra high resolution site surveys that only use a 'mini-airgun' (single airgun with a volume of less than 10 cubic inches) there is no requirement to perform a soft-start, however, a pre-shooting search should still be conducted before its use.

For site surveys and VSPs, a number of options are available to effect a soft-start.

- The standard method, where power is built up slowly from a low energy start-up (e.g. starting with the smallest airgun in the array and gradually adding in others) over at least 20 minutes to give adequate time for marine mammals to leave the vicinity.
- As the relationship between acoustic output and pressure of the air contained in the airgun is close to linear and most site surveys / VSP operations use only a small number of airguns and a soft-start can be achieved by slowly increasing the air pressure in 500 psi steps. From our understanding, the minimum air pressure which the airgun array can be set to will vary, as this is dependent on the make and model of the airgun being used. The time from initial airgun start up to full power should be at least 20 minutes.

- Over a minimum time period of 20 minutes the airguns should be fired at an increasing frequency (by decreasing the Shot Point Interval (SPI)) until the desired firing frequency is reached.

3.3.2 Soft-starts and airgun testing

Airgun tests may be required before a survey commences, or to test damaged or misfiring guns following repair, or to trial new arrays. Individual airguns, or the whole array may need testing, and the airguns may be tested at varying power levels. The following guidance is provided to clarify when a soft-start is required:

- If the intention is to test all airguns at full power then a 20 minute soft-start is required.
- If the intention is to test a single airgun on low power then a soft-start is not required.
- If the intention is to test a single airgun, or a number of guns on high power, the airgun or airguns should be fired at lower power first, and the power then increased to the level of the required test; this should be carried out over a time period proportional to the number of guns being tested and ideally not exceed 20 minutes in duration.

MMOs should maintain a watch as outlined in the pre-shooting search guidance (section 3.1) before any instances of gun testing.

3.4 Line Change

Seismic data is usually collected along predetermined survey lines. Line change is the term used to describe the activity of turning the vessel at the end of one line prior to commencement of the next line. Depending upon the type of seismic survey being undertaken, the time for a line change can vary. Line changes are not necessary for all types of seismic surveys, for example, in certain regional surveys where there is a significant distance between the lines, and for VSP operations.

The guidance relating to line change depends upon the airgun volume.

3.4.1 Seismic surveys with an airgun volume of 500 cubic inches or more

- If the line change time is expected to be greater than 20 minutes, airgun firing should be terminated at the end of the line and a full 20 minute soft-start undertaken before the next line. A pre-shooting search should also be undertaken during the scheduled line change, and the soft-start delayed if marine mammals are seen within 500 metres of the centre of the airgun array.

3.4.2 Seismic surveys with an airgun volume of 180 cubic inches or less (site surveys)

- If the line change time is expected to be greater than 40 minutes, airgun firing should be terminated at the end of the line and a full 20 minute soft-start undertaken before the next line. The pre-shooting search should also be undertaken during the scheduled line change, and the soft-start delayed if marine mammals are seen within 500 metres of the centre of the airgun array.

- If the line change time is expected to be less than 40 minutes, airgun firing can continue during the turn, but the Shot Point Interval (SPI) should be increased (longer duration between shots). Ideally, the SPI should not exceed 5 minutes during the turn.

Depending upon the duration of the line turns and the nature of seismic survey it may be necessary to vary the soft-start procedures. If an applicant determines that an effective line change can not be achieved using the above methods please contact JNCC at the earliest possible opportunity to discuss the proposed alternative, and include the details of the agreed procedure and the consultation with the JNCC in the application for survey consent.

3.5 Undershoot operations

During an undershoot operation, one vessel is employed to tow the seismic source and a second vessel used to tow the hydrophone array, although the main vessel will still tow the hydrophone array. This procedure is used to facilitate shooting under platforms or other obstructions. The MMO may be too far away from the airguns to effectively monitor the mitigation zone, and it is therefore recommended to place the MMO on the source vessel. If this is not possible, for example for logistical reasons, or the health and safety implications of transferring personnel from one vessel to another, the application should explain that the recommended procedure cannot be followed in the application for the survey consent, or the application for a variation of that consent. Irrespective of the MMO location agreed with DECC, the pre-shooting search and soft-start procedures should still be followed prior to undertaking an undershoot operation.

Section 4 - Acoustic Monitoring

Visual observation is an ineffective mitigation tool during periods of darkness or poor visibility (such as fog), or during periods when the sea state is not conducive to visual mitigation, as it will not be possible to detect marine mammals in the vicinity of airgun sources. Under such conditions, PAM is considered to be the only currently available mitigation technique that can be used to detect marine mammals. Current PAM systems can be particularly helpful in detecting harbour porpoises within the 500 metre mitigation zone, although the systems have their limitations and can only be used to detect vocalising species of marine mammals.

PAM systems consist of hydrophones that are deployed into the water column, and the detected sounds are processed using specialised software. PAM operatives are needed to set up and deploy the equipment and to interpret the detected sounds.

4.1 Use of PAM as a mitigation tool

PAM can provide a useful supplement to visual observations undertaken by MMOs and JNCC may recommend that it is used as a mitigation tool when commenting on applications for survey consents. However, in many cases it is not as accurate as visual observation for determining range, and this will mean that the mitigation zone will reflect the range accuracy of the system. For example, if the range accuracy of a system is estimated at +/-300 metres, animals detected and calculated to be within 500 metres from the source could, in reality, be 500 + 300 = 800 metres, but their detection would still lead to a delay in the soft-start. Although, at present it is not possible to express the range accuracy of most PAM systems in numerical terms, this example serves to illustrate that it is in the operator's best interests to use the most accurate system available, and for the PAM operative to factor in a realistic estimate of the range accuracy.

Some PAM systems do not have a reliable range determination facility or can only calculate the range for some species. In such cases, the detection of a confirmed cetacean vocalisation should still be used to initiate postponement of the soft-start if the PAM operator is able to make a judgement about the range of the animals from the airgun source, because of their experience gained in differentiating between distant and close vocalisations. In the absence of PAM systems capable of range determination, this expert judgement will constitute the basis for deciding whether an area is free from cetaceans prior to the soft-start.

In all cases where PAM is employed, a brief description of the system and an explanation of how the applicant intends to deploy PAM to greatest effect should be included in the application for survey consent.

In the last few years, software that processes and analyses cetacean sounds has been developed. An example of this is PAMGuard, an open source software that has been developed as part of the International Association of Oil and Gas Producers Joint Industry Project (JIP). JNCC recognises that PAMGuard is currently in a transition period between use as a research tool and widespread adoption as a monitoring technique. Moreover, JNCC recognises the need to balance proactive implementation of PAM with the need to further develop its capability, for example to include species recognition and baleen whale detection, and therefore encourages users of these systems to actively contribute to their development and refinement.

Section 5 – Requirements for MMOs and PAM

Any survey application or consultation received by JNCC will be considered on a case-by-case basis, and the mitigation measures advised to DECC will reflect the particulars of the survey and the importance of the survey area for marine mammals. The following paragraphs are provided as a guide to the advice applicants are likely to receive following submission of an application with JNCC.

For areas that are currently considered particularly important for marine mammals, for example in the UK this includes areas West of Scotland, the Moray Firth and Cardigan Bay, JNCC may recommend that:

- The MMOs should be experienced MMOs, and that PAM should be used.
- The PAM system should be used to supplement visual observations, or as the main mitigation tool if the seismic survey activity commences during periods of

darkness or poor visibility, or during periods when the sea state is not conducive to visual mitigation.

JNCC will advise that two marine mammal observers should be used when daylight hours exceed approximately 12 hours per day (between 1st April and 1st October north of 57^{O} latitude), or the survey is in an area considered particularly important for marine mammals.

When a non-dedicated MMO is recommended by JNCC (e.g. for VSPs and certain site-surveys), and the recommendation is incorporated into the conditions of the survey consent, a member of the rig's or vessels crew can perform the duties providing the crew member is a trained MMO.

When a dedicated MMO is recommended and this is a condition of the survey consent, the MMO should be employed solely for the purpose of monitoring the implementation of the guidelines and undertaking visual observations to detect marine mammals during periods of seismic activity.

When two dedicated MMOs are requested and this is a condition of the survey consent, both should be employed solely for the purposes of monitoring the implementation of the guidelines and undertaking visual observations, and the use of a crew member with other responsibilities as the second observer is not considered to be an adequate substitute for a dedicated MMO, or to be in compliance with the conditions of the survey consent.

Section 6 - Background Information

These guidelines were originally prepared by a Working Group convened by the Department of the Environment, and were developed from a draft prepared by the Sea Mammal Research Unit (SMRU). The guidelines have subsequently been reviewed three times by the Joint Nature Conservation Committee, following consultation with interested parties.

6.1. Existing protection to cetaceans

Section 9 of the Wildlife and Countryside Act 1981 (CRoW amended) prohibits the intentional or reckless killing, injuring or disturbance of any cetacean. The UK is also a signatory to the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) and has applied its provisions in all UK waters. Amongst other actions required to conserve and manage populations of small cetaceans, ASCOBANS requires range states to "work towards...the prevention of ...disturbance, especially of an acoustic nature".

Reflecting the requirements of the Convention on the Conservation of European Wildlife and Habitats (the Bern Convention) and Article 12 of the EC Habitats and Species Directive (92/43/EEC), the UK has the following legislation in place:

- The Conservation of Habitats and Species Regulations 2010
- The Conservation (Natural Habitats, &c.) Regulations 1995 (Northern Ireland) (and 2009 amendments)

- The Conservation (Natural Habitats, &c.) Amendment (No. 2) Regulations 2008 (Scotland) (and 2009 amendments)
- The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (and 2007 amendments),
- The Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (and 2009 and 2010 amendments) (beyond 12 nautical miles UKCS)

Section 7 – References and contacts

Further information on DECC's survey consent procedure can be found at: http://www.og.decc.gov.uk/.

A copy of these guidelines, the standard forms (electronic and hard copy) and further background information is available from the above address, or can be found on the JNCC website at: http://www.jncc.gov.uk/page-1534

Reid, J.B., Evans, P.G.H., & Northridge, S.P. (2003). 'Atlas of cetacean distribution in north-west European waters' (Online). http://www.jncc.gov.uk/page-2713

If you have any comments or questions relating to these guidelines, or suggestions on how they may be improved, please email seismic@jncc.gov.uk

APPENDIX B: MARINE MAMMAL RECORDING FORMS - ACOUSTIC DETECTIONS

PROTECTED SPECIES RECORDING FORM
DETECTION

Regulatory reference number	Ship/ platform name	Sighting number (start at 1 for first sighting of survey)	Acoustic detection number (start at 501 for first detection of survey)
PON3	*Ramform Titan*		501

Date	Time at start of encounter (UTC, 24hr clock)	Time at end of encounter (UTC, 24hr clock)
11/12/2013	6:38	6:47

Were animals detected visually and/ or acoustically?

	visual
X	acoustic
	both

How were the animals first detected?

	visually detected by observer keeping a continuous watch
	visually spotted incidentally by observer or someone else
X	acoustically detected by PAM
	both visually and acoustically before operators/ observers informed each other

Observer's/ operator's name	Position (latitude and longitude)		Water depth (metres)
Breanna Evans	*50°13.273*	*54°34.235*	1322

Species/ species group	Description (include features such as overall size; shape of head; colour and pattern; size, shape and position of dorsal fin; height, direction and shape of blow; characteristics of whistles/ clicks
Unidentified baleen whale	Double calls mainly flat with occasional down-sweeping and upsweeping moans, between 165 and 315 Hz, with peak energy at 205 Hz.

Bearing to animal (when first seen or heard) (bearing from true north)	Range to animal (when first seen or heard) (metres)
Unknown	>500

Total number	Number of adults (visual sightings only)	Number of juveniles (visual sightings only)	Number of calves (visual sightings only)	Photograph taken			
n/a	n/a	n/a	n/a		Yes	X	No

Behaviour (visual sightings only)

n/a

Direction of travel (relative to ship)

	towards ship		variable
	away from ship		milling
	parallel to ship in same direction as ship		stationary
	parallel to opposite direction to ship		other
	crossing perpendicular ahead of ship	X	unknown

Direction of travel (compass points)

	N		SW
	NE		W
	E		NW
	SE		variable
	S		stationary
		X	unknown

Airgun (or other source) activity when animals first detected

	full power
X	not firing
	soft start
	reduced power (other than soft start)

Airgun (or other source) activity when last detected

	full power
	not firing
	soft start
X	reduced power (other than soft start)

Time animals entered mitigation/ exclusion zone (UTC, 24hr clock)	Time animals left mitigation/ exclusion zone (UTC)
n/a	n/a

Closest distance of animals from airguns (or other source) (metres)	Time of closest approach (UTC)
0	0:00

If seen during soft start give:

First distance:	n/a
Closest distance:	n/a
Last distance:	n/a

during soft start (metres)

What action was taken?(according to requirements of guidelines/ regulations in country concerned)

X	none required
	delay start of firing
	shut-down of active source
	power-down of active source
	power-down then shut-down of active source

Length of power-down and/ or shut-down)	Estimated loss of production (if relevant) due to mitigating actions (km)
n/a	n/a

Other notes or comments

It was determined by PAM op that the animal was outside the exclusion zone, exact distance could not be determined. Number of animals, direction of travel, and any fields left blank could not be determined due to the type of detection.

PROTECTED SPECIES RECORDING FORM
DETECTION

Regulatory reference number	Ship/ platform name	Sighting number (start at 1 for first sighting of survey)	Acoustic detection number (start at 501 for first detection of survey)
PON3	*Ramform Titan*		502

Date	Time at start of encounter (UTC, 24hr clock)	Time at end of encounter (UTC, 24hr clock)
11/12/2013	7:04	7:07

Were animals detected visually and/ or acoustically?		How were the animals first detected?	
			visually detected by observer keeping a continuous watch
	visual		visually spotted incidentally by observer or someone else
X	acoustic	X	acoustically detected by PAM
	both		both visually and acoustically before operators/ observers informed each other

Observer's/ operator's name	Position (latitude and longitude)		Water depth (metres)
Breanna Evans	*50°13.11*	*54°31.41*	1322

Species/ species group	Description (include features such as overall size; shape of head; colour and pattern; size, shape and position of dorsal fin; height, direction and shape of blow; characteristics of whistles/ clicks
Unidentified baleen whale	Double calls mainly flat with occasional down-sweeping and upsweeping moans, between 165 and 315 Hz with peak energy at 205 Hz. Presumably the same animal in both detections.

Bearing to animal (when first seen or heard) (bearing from true north)	Range to animal (when first seen or heard) (metres)
Unknown	>500

Total number	Number of adults (visual sightings only)	Number of juveniles (visual sightings only)	Number of calves (visual sightings only)	Photograph taken			
n/a	n/a	n/a	n/a		Yes	X	No

Behaviour (visual sightings only)
n/a

Direction of travel (relative to ship)				Direction of travel (compass points)			
	towards ship		variable		N		SW
	away from ship		milling		NE		W
	parallel to ship in same direction as ship		stationary		E		NW
	parallel to opposite direction to ship		other		SE		variable
	crossing perpendicular ahead of ship	X	unknown		S		stationary
						X	unknown

Airgun (or other source) activity when animals first detected		Airgun (or other source) activity when last detected		Time animals entered mitigation/ exclusion zone (UTC)	Time animals left mitigation/ exclusion zone (UTC)
	full power		full power	n/a	n/a
	not firing		not firing		
	soft start		soft start	Closest distance of animals from airguns (or other source) (metres)	Time of closest approach (UTC)
X	reduced power (other than soft start)	X	reduced power (other than soft start)	0	0:00

If seen during soft start give:		What action was taken?(according to requirements of guidelines/ regulations in country concerned)		Length of power-down and/ or shut-down (if relevant) (length of time until subsequent soft start, in minutes)	Estimated loss of production (if relevant) due to mitigating actions (km)
First distance:	n/a				
Closest distance:	n/a	X	none required		
Last distance:	n/a		delay start of firing		
during soft start (metres)			shut-down of active source	n/a	n/a
Other notes or comments			power-down of active source		
It was determined by PAM op that the animal was outside the exclusion zone, exact distance could not be determined. Number of animals, direction of travel, and any fields left blank could not be determined due to the type of detection.			power-down then shut-down of active source		

PROTECTED SPECIES RECORDING FORM
DETECTION

Regulatory reference number	Ship/ platform name	Sighting number (start at 1 for first sighting of survey)	Acoustic detection number (start at 501 for first detection of survey)
PON3	*Ramform Titan*		503

Date	Time at start of encounter (UTC, 24hr clock)	Time at end of encounter (UTC)
23/12/2013	7:04	7:47

Were animals detected visually and/ or acoustically?		How were the animals first detected?	
			visually detected by observer keeping a continuous watch
	visual		visually spotted incidentally by observer or someone else
X	acoustic	X	acoustically detected by PAM
	both		both visually and acoustically before operators/ observers informed each other

Observer's/ operator's name	Position (latitude and longitude)		Water depth (metres)
Breanna Evans	*50°19.212*	*54°14.349*	1545

Species/ species group	Description (include features such as overall size; shape of head; colour and pattern; size, shape and position of dorsal fin; height, direction and shape of blow; characteristics of whistles/ clicks
Unidentified baleen whale	Double "whoop-whoop" calls, first up-sweeping second with less intensity and more tonal. Occasional single moans 0.5 seconds in duration. Trains of 3 to 6 also detected slowly losing intensity with each call. Frequency range of 178 to 373Hz.

Bearing to animal (when first seen or heard) (bearing from true north)	Range to animal (when first seen or heard) (metres)
Unknown	>500

Total number	Number of adults (visual sightings only)	Number of juveniles (visual sightings only)	Number of calves (visual sightings only)	Photograph taken			
n/a	n/a	n/a	n/a		Yes	X	No

Behaviour (visual sightings only)
n/a

Direction of travel (relative to ship)					Direction of travel (compass points)			
	towards ship		variable		N		SW
	away from ship		milling		NE		W
	parallel to ship in same direction as ship		stationary		E		NW
	parallel to opposite direction to ship		other		SE		variable
	crossing perpendicular ahead of ship	X	unknown		S		stationary
						X	unknown

Airgun (or other source) activity when animals first detected		Airgun (or other source) activity when last detected		Time animals entered mitigation/ exclusion zone (UTC, 24hr clock)	Time animals left mitigation/ exclusion zone (UTC)
	full power		full power	n/a	n/a
X	not firing	X	not firing		
	soft start		soft start	**Closest distance of animals from airguns (or other source) (metres)**	**Time of closest approach (UTC)**
	reduced power (other than soft start)		reduced power (other than soft start)	0	0:00

If seen during soft start give:		What action was taken?(according to requirements of guidelines/ regulations in country concerned)		Length of power-down and/ or shut-down (if relevant) (length of time until subsequent soft start, in minutes)	Estimated loss of production (if relevant) due to mitigating actions (km)
First distance:	n/a				
Closest distance:	n/a	X	none required		
Last distance:	n/a		delay start of firing		
during soft start (metres)			shut-down of active source	n/a	n/a
Other notes or comments			power-down of active source		
It was determined by PAM op that the animal was outside the exclusion zone, exact distance could not be determined. Number of animals, direction of travel, and any fields left blank could not be determined due to the type of detection.			power-down then shut-down of active source		

PROTECTED SPECIES RECORDING FORM
DETECTION

Regulatory reference number	Ship/ platform name	Sighting number (start at 1 for first sighting of survey)	Acoustic detection number (start at 501 for first detection of survey)
PON3	*Ramform Titan*		504
Date		**Time at start of encounter (UTC, 24hr clock)**	**Time at end of encounter (UTC, 24hr clock)**
02/01/2014		7:18	7:28

Were animals detected visually and/ or acoustically?		How were the animals first detected?	
			visually detected by observer keeping a continuous watch
	visual		visually spotted incidentally by observer or someone else
X	acoustic	X	acoustically detected by PAM
	both		both visually and acoustically before operators/ observers informed each other

Observer's/ operator's name	Position (latitude and longitude)		Water depth (metres)
Breanna Evans	*50°25.431*	*54°24.628*	1380

Species/ species group		Description (include features such as overall size; shape of head; colour and pattern; size, shape and position of dorsal fin; height, direction and shape of blow; characteristics of whistles/ clicks
Unidentified dolphin spp.		
Bearing to animal (when first seen or heard) (bearing from true north)	**Range to animal (when first seen or heard) (metres)**	Single LF up-sweeping, down-sweeping and tonal whistles from 1.6 to 23kHz. Harmonizing whistles between 4 - 24 kHz. Echolocation clicks bearing 36 (as pod moved further astern vessel) final 106. Intensity between 120 and 143 dB per 1µPa.
36	300	

Total number	Number of adults (visual sightings only)	Number of juveniles (visual sightings only)	Number of calves (visual sightings only)	Photograph taken			
n/a	n/a	n/a	n/a		Yes	X	No

Behaviour (visual sightings only)
n/a

Direction of travel (relative to ship)				Direction of travel (compass points)			
	towards ship		variable		N		SW
X	away from ship		milling		NE		W
	parallel to ship in same direction as ship		stationary		E		NW
	parallel to opposite direction to ship		other		SE		variable
	crossing perpendicular ahead of ship		unknown	X	S		stationary
							unknown

Airgun (or other source) activity when animals first detected		Airgun (or other source) activity when last detected		Time animals entered mitigation/ exclusion zone (UTC, 24hr clock)	Time animals left mitigation/ exclusion zone (UTC)
	full power		full power	7:18	7:28
	not firing		not firing		
	soft start		soft start	**Closest distance of animals from airguns (or other source) (metres)**	**Time of closest approach (UTC)**
	reduced power (other than soft start)		reduced power (other than soft start)	300	7:27

If seen during soft start give:		What action was taken?(according to requirements of guidelines/ regulations in country concerned)		Length of power-down and/ or shut-down (if relevant) (length of time until subsequent soft start, in minutes)	Estimated loss of production (if relevant) due to mitigating actions (km)
First distance:	n/a				
Closest distance:	n/a		none required		
Last distance:	n/a		delay start of firing		
during soft start (metres)			shut-down of active source		
Other notes or comments			power-down of active source		
It is thought that the pod was traveling away from the vessel, but the change in bearings could have also come from the movement of the vessel.			power-down then shut-down of active source	n/a	n/a

PROTECTED SPECIES RECORDING FORM
DETECTION

Regulatory reference number	Ship/ platform name	Sighting number (start at 1 for first sighting of survey)	Acoustic detection number (start at 601 for first detection of survey)
PON3	*Ramform Titan*		505
Date		**Time at start of encounter (UTC, 24hr clock)**	**Time at end of encounter (UTC, 24hr clock)**
21/01/2014		6:38	7:48

Were animals detected visually and/ or acoustically?		How were the animals first detected?	
			visually detected by observer keeping a continuous watch
	visual		visually spotted incidentally by observer or someone else
X	acoustic	X	acoustically detected by PAM
	both		both visually and acoustically before operators/ observers informed each other

Observer's/ operator's name	Position (latitude and longitude)		Water depth (metres)
Lynn Henneberger	*50°47.441*	*54°12.141*	1541

Species/ species group		Description (include features such as overall size; shape of head; colour and pattern; size, shape and position of dorsal fin; height, direction and shape of blow; characteristics of whistles/ clicks
Sperm whale		
Bearing to animal (when first seen or heard) (bearing from true north)	**Range to animal (when first seen or heard) (metres)**	multiple LF click trains (~2 to 23kHz peak energy near 2.5 and 11), click interval was ~0.5 sec
155 at 07:26	830	

Total number	Number of adults (visual sightings only)	Number of juveniles (visual sightings only)	Number of calves (visual sightings only)	Photograph taken			
2	n/a	n/a	n/a		Yes	X	No

Behaviour (visual sightings only)

Was first observed ahead, then 90 degrees, then behind the hydrophones as the detection progressed.

	Direction of travel (relative to ship)			Direction of travel (compass points)			
	towards ship		variable		N		SW
	away from ship		milling		NE		W
	parallel to ship in same direction as ship		stationary		E		NW
	parallel to opposite direction to ship		other		SE		variable
	crossing perpendicular ahead of ship	X	unknown		S		stationary
						X	unknown

Airgun (or other source) activity when animals first detected		Airgun (or other source) activity when last detected		Time animals entered mitigation/ exclusion zone (UTC, 24hr clock)	Time animals left mitigation/ exclusion zone (UTC)
	full power		full power	n/a	n/a
	not firing		not firing		
	soft start		soft start	**Closest distance of animals from airguns (or other source) (metres)**	**Time of closest approach (UTC)**
	reduced power (other than soft start)		reduced power (other than soft start)	830	7:26

If seen during soft start give:			What action was taken?(according to requirements of guidelines/ regulations in country concerned)	Length of power-down and/ or shut-down (if relevant) (length of time until subsequent soft start, in minutes)	Estimated loss of production (if relevant) due to mitigating actions (km)
First distance:	n/a				
Closest distance:	n/a		none required		
Last distance:	n/a		delay start of firing		
during soft start (metres)			shut-down of active source	n/a	n/a
Other notes or comments			power-down of active source		
outside the exclusion zone			power-down then shut-down of active source		

PROTECTED SPECIES RECORDING FORM
DETECTION

Regulatory reference number	Ship/ platform name	Sighting number (start at 1 for first sighting of survey)	Acoustic detection number (start at 701 for first detection of survey)
PON3	Ramform Titan		506

Date	Time at start of encounter (UTC, 24hr clock)	Time at end of encounter (UTC)
26/01/2014	1:33	1:45

Were animals detected visually and/ or acoustically?		How were the animals first detected?	
			visually detected by observer keeping a continuous watch
	visual		visually spotted incidentally by observer or someone else
X	acoustic	X	acoustically detected by PAM
	both		both visually and acoustically before operators/ observers informed each other

Observer's/ operator's name	Position (latitude and longitude)		Water depth (metres)
Lynn Henneberger	*51°22.453*	*54°34.021*	1509

Species/ species group		Description (include features such as overall size; shape of head; colour and pattern; size, shape and position of dorsal fin; height, direction and shape of blow; characteristics of whistles/ clicks
Delphinidae		
Bearing to animal (when first seen or heard) (bearing from true north)	Range to animal (when first seen or heard) (metres)	split, narrowband echolocation clicks from 2.8 to 4 and 7 to 9 kHz, peak energy at 3; inter-click interval 0.15s
201 or 335	>500	

Total number	Number of adults (visual sightings only)	Number of juveniles (visual sightings only)	Number of calves (visual sightings only)	Photograph taken			
1	n/a	n/a	n/a		Yes	X	No

Behaviour (visual sightings only)
n/a

	Direction of travel (relative to ship)				Direction of travel (compass points)		
	towards ship		variable		N		SW
	away from ship		milling		NE		W
	parallel to ship in same direction as ship		stationary		E		NW
	parallel to opposite direction to ship		other		SE		variable
	crossing perpendicular ahead of ship	X	unknown		S		stationary
						X	unknown

Airgun (or other source) activity when animals first detected		Airgun (or other source) activity when last detected		Time animals entered mitigation/ exclusion zone (UTC, 24hr clock)	Time animals left mitigation/ exclusion zone (UTC, 24hr clock)
	full power		full power	n/a	n/a
	not firing		not firing		
	soft start		soft start	Closest distance of animals from airguns (or other source) (metres)	Time of closest approach (UTC, 24hr clock)
	reduced power (other than soft start)		reduced power (other than soft start)	>500	0:00

If seen during soft start give:		What action was taken?(according to requirements of guidelines/ regulations in country concerned)		Length of power-down and/ or shut-down (if relevant) (length of time until subsequent soft start, in minutes)	Estimated loss of production (if relevant) due to mitigating actions (km)
First distance:	n/a				
Closest distance:	n/a	X	none required		
Last distance:	n/a		delay start of firing		
during soft start (metres)			shut-down of active source	n/a	n/a
Other notes or comments			power-down of active source		
outside the exclusion zone			power-down then shut-down of active source		

PROTECTED SPECIES RECORDING FORM
DETECTION

Regulatory reference number	Ship/ platform name	Sighting number (start at 1 for first sighting of survey)	Acoustic detection number (start at 801 for first detection of survey)
PON3	*Ramform Titan*		507
Date		**Time at start of encounter (UTC, 24hr clock)**	**Time at end of encounter (UTC, 24hr clock)**
26/01/2014		1:46	2:27

Were animals detected visually and/ or acoustically?		How were the animals first detected?	
			visually detected by observer keeping a continuous watch
	visual		visually spotted incidentally by observer or someone else
X	acoustic	X	acoustically detected by PAM
	both		both visually and acoustically before operators/ observers informed each other

Observer's/ operator's name	Position (latitude and longitude)		Water depth (metres)
Lynn Henneberger	*51°22.453*	*54°34.021*	1509

Species/ species group		Description (include features such as overall size; shape of head; colour and pattern; size, shape and position of dorsal fin; height, direction and shape of blow; characteristics of whistles/ clicks
Delphinidae		
Bearing to animal (when first seen or heard) (bearing from true north)	**Range to animal (when first seen or heard) (metres)**	clicks from 3 to 22kHz, peak from 12-14kHz; inter-click interval ~0.25s
335	1130	

Total number	Number of adults (visual sightings only)	Number of juveniles (visual sightings only)	Number of calves (visual sightings only)	Photograph taken			
2	n/a	n/a	n/a		Yes	X	No

Behaviour (visual sightings only)

n/a

Direction of travel (relative to ship)				Direction of travel (compass points)			
	towards ship		variable		N		SW
	away from ship		milling		NE		W
	parallel to ship in same direction as ship		stationary		E		NW
	parallel to opposite direction to ship		other		SE		variable
	crossing perpendicular ahead of ship	X	unknown		S		stationary
						X	unknown

Airgun (or other source) activity when animals first detected		Airgun (or other source) activity when last detected		Time animals entered mitigation/ exclusion zone (UTC, 24hr clock)	Time animals left mitigation/ exclusion zone (UTC)
	full power		full power	n/a	n/a
	not firing		not firing		
	soft start		soft start	**Closest distance of animals from airguns (or other source) (metres)**	**Time of closest approach (UTC)**
	reduced power (other than soft start)		reduced power (other than soft start)	1130	2:14

If seen during soft start give:		What action was taken?(according to requirements of guidelines/ regulations in country concerned)		Length of power-down and/ or shut-down (if relevant) (length of time until subsequent soft start, in minutes)	Estimated loss of production (if relevant) due to mitigating actions (km)
First distance:	n/a				
Closest distance:	n/a	X	none required		
Last distance:	n/a		delay start of firing		
during soft start (metres)			shut-down of active source	n/a	n/a
Other notes or comments			power-down of active source		
outside the exclusion zone			power-down then shut-down of active source		

PROTECTED SPECIES RECORDING FORM
DETECTION

Regulatory reference number	Ship/ platform name	Sighting number (start at 1 for first sighting of survey)	Acoustic detection number (start at 901 for first detection of survey)
PON3	*Ramform Titan*		508

Date	Time at start of encounter (UTC, 24hr clock)	Time at end of encounter (UTC, 24hr clock)
18/02/2014	13:12	13:13

Were animals detected visually and/ or acoustically?		How were the animals first detected?	
			visually detected by observer keeping a continuous watch
	visual		visually spotted incidentally by observer or someone else
X	acoustic	X	acoustically detected by PAM
	both		both visually and acoustically before operators/ observers informed each other

Observer's/ operator's name	Position (latitude and longitude)		Water depth (metres)
Lynn Henneberger	*50°27.77*	*53°49.852*	1213

Species/ species group		Description (include features such as overall size; shape of head; colour and pattern; size, shape and position of dorsal fin; height, direction and shape of blow; characteristics of whistles/ clicks
Delphinidae		
Bearing to animal (when first seen or heard) (bearing from true north)	**Range to animal (when first seen or heard) (metres)**	Two sinusoidal marks from 1.027 to 1.05 kilohertz. The sounds were not aurally detected or high-lighted by the program.
Unknown	Unknown	

Total number	Number of adults (visual sightings only)	Number of juveniles (visual sightings only)	Number of calves (visual sightings only)	Photograph taken			
1	n/a	n/a	n/a		Yes	X	No

Behaviour (visual sightings only)

n/a

	Direction of travel (relative to ship)			Direction of travel (compass points)			
	towards ship		variable		N		SW
	away from ship		milling		NE		W
	parallel to ship in same direction as ship		stationary		E		NW
	parallel to opposite direction to ship		other		SE		variable
	crossing perpendicular ahead of ship	X	unknown		S		stationary
						X	unknown

Airgun (or other source) activity when animals first detected		Airgun (or other source) activity when last detected		Time animals entered mitigation/ exclusion zone (UTC, 24hr clock)	Time animals left mitigation/ exclusion zone (UTC)
	full power		full power	n/a	n/a
	not firing		not firing		
	soft start		soft start	**Closest distance of animals from airguns (or other source) (metres)**	**Time of closest approach (UTC)**
	reduced power (other than soft start)		reduced power (other than soft start)	0	13:12

If seen during soft start give:		What action was taken?(according to requirements of guidelines/ regulations in country concerned)		Length of power-down and/ or shut-down (if relevant) (length of time until subsequent soft start, in minutes)	Estimated loss of production (if relevant) due to mitigating actions (km)
First distance:	n/a				
Closest distance:	n/a	X	none required		
Last distance:	n/a		delay start of firing		
during soft start (metres)			shut-down of active source	n/a	n/a
Other notes or comments			power-down of active source		
Low frequency that was not aurally detected. Not localized			power-down then shut-down of active source		