Marine Mammal Impact Assessment Great South Basin, Carina 2D Seismic Survey, New Zealand

Shell New Zealand Limited

December 2013

Final

0209914_Rev 1

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Shell New Zealand Limited GSB II Carina 2D Seismic Survey

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ABBREVIATIONS

2D	2 Dimensional
3D	3 Dimensional
AOI	Area of Influence
BOD	Biological Oxygen Demand
BPA	Benthic Protection Area
CIA	Cultural Impact Assessment
cm	centimetres
the Code	2012 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals.
COLREGS	International Regulations for the Prevention of Collisions at Sea
dB	Decibels
DOC	Department of Conservation
EEZ	Exclusive Economic Zone
e.g.	For example
EP	Exploration and Production
FMA	Fisheries Management Area
GSB	Great South Basin
HSE	Health, Safety and Environmental
HSSE & SP	Health, Safety, Security, Environment and Social Performance
Hz	Hertz
IA	Impact Assessment
ID	Identification
IMO	International Maritime Organisation
IUCN	International Union for Conservation of Nature
IWC	International Whaling Commission
JV	Joint Venture
kHz	kilohertz
km	Kilometres
km^2	Kilometres squared
L	Litres
m	meters
mm	millimetres
MARPOL	International Convention for the Prevention of Pollution from Ships
$mg\ m^{-3}$	Milligrams per cubic metre
MMIA	Marine Mammal Impact Assessment
MMO	Marine Mammal Observer
MMMP	Marine Mammal Management Plan
MMS	Marine Mammal Sanctuary
MPA	Marine Protected Areas

MPI	Ministry for Primary Industries
ms^{-1}	Metres per second
MSS	Marine seismic survey
MNZ	Maritime New Zealand
NABIS	National Aquatic Biodiversity Information System
n.d.	No date
NIWA	National Institute of Water and Atmospheric Research
nm	Nautical mile
NZ	New Zealand
PAM	Passive Acoustic Monitoring
PEP	Petroleum Exploration Permit
PEPANZ	Petroleum Exploration and Production Association of New Zealand
pers comms	Personal Communication
ppm	Parts per million
psi	Pounds per square inch
rms	root mean squared
SAF	Subantarctic Front
SOPEP	Shipboard Oil Pollution Emergency Plan
SP	Social Performance
STF	Subtropical Front
TRAWL	Ministry of Fisheries Research Trawl Database
μPa	Micropascal
μPa/m	Micropascals at one metre
WWF	Worldwide Fund for Nature

EXECUTIVE SUMMARY

This Marine Mammal Impact Assessment has been prepared to inform the applicant, decision makers, and affected parties about potential environmental, social and cultural issues relating to the Great South Basin Seismic Survey (the Project). The applicant is a combination of two Joint Ventures operating across two Petroleum Exploration Permits (PEPs). Throughout this Impact Assessment process, the applicant will be referred to as Shell, as they are the operating party of both JV's. Detail of the applicant can be found below in *Section 1.3*. Shell intends to undertake seismic activities within PEPs 54863 and 50119 of the Great South Basin (GSB). The programme is currently planned to comprise a marine seismic survey, across a ~70 day period, from January 2014.

The impact assessment process included consultee engagement and ensures environmental protection by consideration of potential impacts and management strategies. The objective of the impact assessment process is to ensure that all potential impacts, direct and indirect, are fully examined and addressed through a rigorous impact assessment process.

This Marine Mammal Impact Assessment was conducted over a series of phases, with each phase providing increased layers of rigour, and included:

- Project Screening
- Project Scoping
- Project and Baseline Definition
- Impact Assessment

The screening stage of the Project conducted using Shell's corporate framework categorised the Project as 'Category B' as its "impacts under normal and abnormal operations are site specific, and few if any are irreversible. Potential adverse impacts are less adverse than those of 'Category A' projects or the project is proposed to take place in a context that is less sensitive to the intended operation or activity." These categories are broadly aligned to the World Banks guidelines for Impact Assessment. As a category B Project, Shell's internal standards required the completion of an Environmental, Social and Health Baseline Report, Impact Assessment Report and Management Plan, each of which are contained within this report. Therefore, while titled a Marine Mammal Impact Assessment, this report is considered to be an Environmental, Social and Health Impact Assessment, as it goes beyond the scope required for a MMIA.

The scoping stage of the Project identified a series of potential interactions between the Project and the environment that may result in impacts of significance. The baseline environment was investigated through an extensive desktop study that included marine mammal observation data collected from the area during four previous seismic surveys. Through this research the area was found to be generally typical of its locale and water depth. Located around 100 km east of the south east corner of the South Island, the region is of generally low levels of productivity, indicated through low chlorophyll a levels and little or no fisheries interest.

The presence of transient marine mammals and migratory seabirds were considered to be the only sensitive receptors of significance, largely due to their low abundances and protected status at a national and global level.

The impact assessment assessed all impacts that would occur as a result of planned activities as well as any potential impacts from unplanned events. Planned impacts were assessed by considering the impact magnitude against receptor sensitivity, while unplanned potential impacts were assessed by considering the severity of the potential impact against the likelihood of it eventuating. Each component was assessed using criteria provided within this report. Mitigation and control measures were assigned to each impact and a residual impact was determined for each. *Table E.1* provides a summary of the impacts, receptors and a significance ranking of the impacts.

Table E.1: Impacts from the Project's Planned and Unplanned Activities, Impact Receptors and Significance

Impact Source	**Resource/ Receptor and/or Residual Impact Significance**
Impacts from Planned Project Components	
Physical presence of the seismic and support vessels	• Marine mammals - *Minor*
On board vessel lighting	• Seabirds - *Minor*
Towing of the airgun and streamers	• Commercial fishing - *Negligible* • Marine vessels - *Negligible*
Firing of airgun arrays	• Marine mammals - *Minor* • Fish and Invertebrates - *Negligible* • Commercial fishing - *Negligible*
Deck drainage and bilge water discharge	• Water quality - *Negligible* • Fish - *Negligible*
Sewage, Grey Water and Food Discharges	• Water quality - *Negligible* • Fish - *Negligible*
Atmospheric emissions	• Air quality - *Negligible*

Impact Source	Resource/ Receptor and/or Residual Impact Significance
Impacts from Unplanned Events	
Minor spills of fuels, oils and chemicals	• *Negligible*
Collisions	• *Negligible*
Loss of streamers and associated equipment	• *Negligible*
Introduction of invasive marine species	• *Negligible*

1 INTRODUCTION

1.1 PURPOSE OF THIS REPORT

This Marine Mammal Impact Assessment (MMIA) has been prepared to inform the applicant, decision makers and affected parties about potential environmental, social and health issues relating to the Great South Basin Seismic Survey (the Project).

The MMIA process included consultee engagement and ensures environmental protection by consideration of potential impacts and management strategies. The objective of the MMIA process is to ensure that all potential impacts, direct and indirect, particularly environmental, social and economic impacts, are fully examined and addressed through a rigorous impact assessment process.

1.2 OVERVIEW OF THE PROJECT

The applicant is a combination of two Joint Ventures operating across two Petroleum Exploration Permits (PEPs). Throughout this MMIA, the applicant will be referred to as Shell, as they are the operating party of both JV's. Detail of the applicant can be found below in *Section 1.3*.

Shell intends to undertake seismic activities within PEPs 54863 and 50119 of the Great South Basin (GSB). The programme is currently planned to comprise a MSS, across a ~70 day period, commencing January 2014.

1.2.1 The Great South Basin

The GSB lies offshore from the coast of Southland and south Otago, to the south and east of the South Island of New Zealand. At over 500,000 km^2, the GSB is one of New Zealand's largest petroleum basins, covering an area 1.5 times New Zealand's land mass. The GSB is a sedimentary basin with a mixture of strata having the potential for hydrocarbon deposits. The area has previously been explored for hydrocarbons with eight wells being drilled in the GSB between the late 1970's and the early 1980's and four seismic surveys completed between 2006 and 2011.

1.2.2 PEP 50119 Exploration History

PEP 50119 was granted on 11 July 2007 following the 2006/2007 Offshore Great South Basin Block Offer to a JV led by OMV New Zealand Limited (36%) and including PTTEP Offshore Investment Company Limited (36%) and Mitsui E&P Australia Pty Limited (28%). The original exploration permit covered an area of 23,860 km^2, including the area now described as PEP 50119, and was issued for a period of five years, with various requirements imposed on the permit holder by the Ministry of Economic Development to re-process existing seismic data, acquire new seismic data and undertake geology and geophysical studies. On 11 November 2011, following various programmes of work lead by OMV as the operator of the permit, Shell New Zealand Limited acquired a controlling stake in the PEP (50%) and became the operator. The duration of PEP 50119 was extended on 4 September 2012 for a further period of five years from the 11 July 2012 application date. This extension was granted in conjunction with the relinquishment of 50% of PEP 50119.

1.2.3 *PEP 54863 Exploration History*

PEP 54863 was granted on 11 December 2012. The PEP covers an area of 8507.85 km^2, and was issued for a period of five years. This PEP occurs under a joint venture agreement between Shell New Zealand (59%), Mitsui E&P Australia Pty Ltd (26%) and OMV New Zealand Ltd (15%).

1.3 *PROJECT APPLICANT*

1.3.1 *Shell New Zealand*

The Royal Dutch Shell Group was formed in 1907 with the merger of Shell Transport and Trading Company and the Royal Dutch Petroleum Company. Today, Shell operates in over 80 countries, with over 90,000 employees producing 3.2 million barrels of gas and oil per day.

In New Zealand, Shell is an industry leader in oil and gas exploration and production. Assisting New Zealand meet its energy demands now and in the future in economically, environmentally and socially responsible ways, Shell-owned ventures account for around half of New Zealand's total natural gas production and a significant proportion of the country's condensate (light oil) production. Overall, New Zealand's oil and gas industry contributes $2.5 billion to the nation's GDP.

To date, Shell's exploration and production has centred on three major assets in the Taranaki region. As the majority equity holder (83.75%) of the Māui gas and condensate field, a 50% share in Kapuni (New Zealand's oldest gas and condensate field) as well as the largest JV partner (48%) and the operator of the technologically advanced Pohokura field. Pohokura now meets around 40% of New Zealand's natural gas requirements. Overall, Shell's operating ventures produce around 80% of New Zealand's total natural gas production.

Today, Shell is looking to continue their assistance in meeting New Zealand's growing energy demands by expanding their exploration portfolio. This includes interests in the Great South Basin to which this Project will contribute, with one exploratory well potentially being drilled in the next 24 months.

1.3.2 *Shell's Health, Safety, and Environmental Commitment*

Shell has a comprehensive set of policies, standards and procedures for environmental matters. Shell's HSSE and SP Commitment and Policy was adopted in the Shell General Business Principles in 1997. It includes a commitment to pursue the goal of no harm to people and to protect the environment and requires the use of risk-based management systems, which are audited regularly. All Shell companies, contractors and Shell operated JVs are required to manage HSE in line with Shell's Policy and Commitment as discussed below in *Section 2.3, Shell HSE Policy And Commitment.*

Shell's approach to develop responsible energy can be found at:

http://www.shell.com

Shell's HSE commitment and policy are available at:

http://www.shell.com/global/environment-society/s-development/our-commitments-and-standards/hse-com-policy.html

1.4 *PROJECT RATIONALE AND ALTERNATIVES*

1.4.1 *Project Rationale*

Developing energy resources remains a cornerstone of the Government's plan for economic growth. It places a high value on the oil and gas estate and, through its Energy Strategy 2011-2021, is committed to developing its potential (MED, 2011). The immediate focus is on increasing exploration activity and on improving the knowledge of New Zealand's petroleum basins.

Previously acquired seismic data for the area has been investigated and it was concluded that further seismic work is required to determine the hydrocarbons potential for the Great South Basin.

1.4.2 *Alternative Locations*

The potential resource which the Project is investigating is located within PEP 50119 and PEP 54863. The location of the resource as well as the extent of the PEP's are definitive thus alternative locations are not possible.

1.4.3 *Alternative Methods*

Alternative methods that are being considered are largely technology related, such as the type of seismic vessel and associated seismic equipment such as the size of the acoustic source. Alongside suitability for the Project objectives, all alternatives are being considered based on environmental and safety risk primarily, with cost being a secondary but necessary consideration. These are discussed below.

Seismic Vessel

A range of potential seismic vessels were investigated for suitability for this survey. The vessel, the *MV Aquilla Explorer*, was selected due to her ability to achieve the data acquisition objectives for the survey, while doing so in a safe and reliable manner. The use of smaller vessels would increase the duration of the survey, and therefore the period of disturbance to marine fauna, as well as presenting increased safety risks. More information on the vessel can be found in *Section* 2.4.3 of this MMIA.

Acoustic Source

Selecting the acoustic source required consideration of the potential disturbance to the environment while still ensuring the survey achieves the data acquisition objectives. Currently there is little or no seismic survey data available in the AOI. Consequently the survey will target the deep basement as well as shallower drilling targets. Mapping of the basin structural framework using seismic imaging will facilitate basin models that will describe the migration path of hydrocarbons from source rocks to reservoir. Shell has determined through experience that sources of 3000 – 4000 cubic inches will suffice for intermediate target depths. However, for deep exploration targets a source size greater than 4000 cubic inches is desired. Source arrays are designed by specialists to optimize the source wavelet to improve the reflected image. The design is necessarily restricted by the equipment available from any vendor and the vessel in question. In this case a tuned array of 4230 cubic inches was designed and has the characteristics suitable, yet not overpowered, for the deep imaging objectives. More information on the acoustic source can be found in *Section* 2.4.5 of this MMIA.

Type of Survey

The selection of the Marine Seismic Surveys (MSS) type for the current survey is based on the data acquisition requirements for the Project. Seismic surveys are typically either 2-Dimensional (2D) or 3-Dimensional (3D). 2D and 3D surveys are used primarily for prospecting, exploration and characterisation of undeveloped resources. Typically, 2D surveys are conducted over wide areas with survey lines spaced at 2 km-10 km intervals and with data collected by hydrophones in a single towed streamer. These surveys provide a broad overview of submarine geology. 3D surveys are conducted across smaller spatial extents with survey lines paced at 300 - 500 m apart and with data collected by multiple seismic streamers. These surveys provide sufficient data to construct a 3D model of the submarine strata. This project will involve the collection of 2D data due to the need for a general geological overview across a larger spatial extent. More information on the survey can be found in *Section* 2.4 of this MMIA.

1.4.4 *Do Nothing Option*

As part of the work programme for each of the PEPs, Shell are required to commit to exploration activities, thereby furthering investigations into the resource potential of the PEPs as well as the wider GSB. If Shell were to not to undertake the seismic survey they would need either to surrender the PEPs back to the Crown or to undertake exploration drilling activities without adequate data to select the drilling target, potentially resulting in environmental disturbance for an extended duration with little chance of project success. The 'do nothing' option is therefore not considered to be a viable alternative.

1.5 *CONSULTEE ENGAGEMENT PROCESS*

Consultee engagement for all of Shell's GSB exploration started in late 2011 led by OMV as the then operator for the JV. In the lead-up to the change in operatorship, the applicant worked alongside OMV to continue this engagement and develop an on-going consultee engagement programme for the Otago and Southland regions.

This initial phase of engagement has involved meetings with runanga, business groups, local government, regulators and special interest groups to understand their views and lay the foundations for relationships over the longer term.

Details relating to the engagement process are provided in *Section 6.4 Socio-Economic and Cultural Environment.*

2 *PROJECT DESCRIPTION*

2.1 *OVERVIEW*

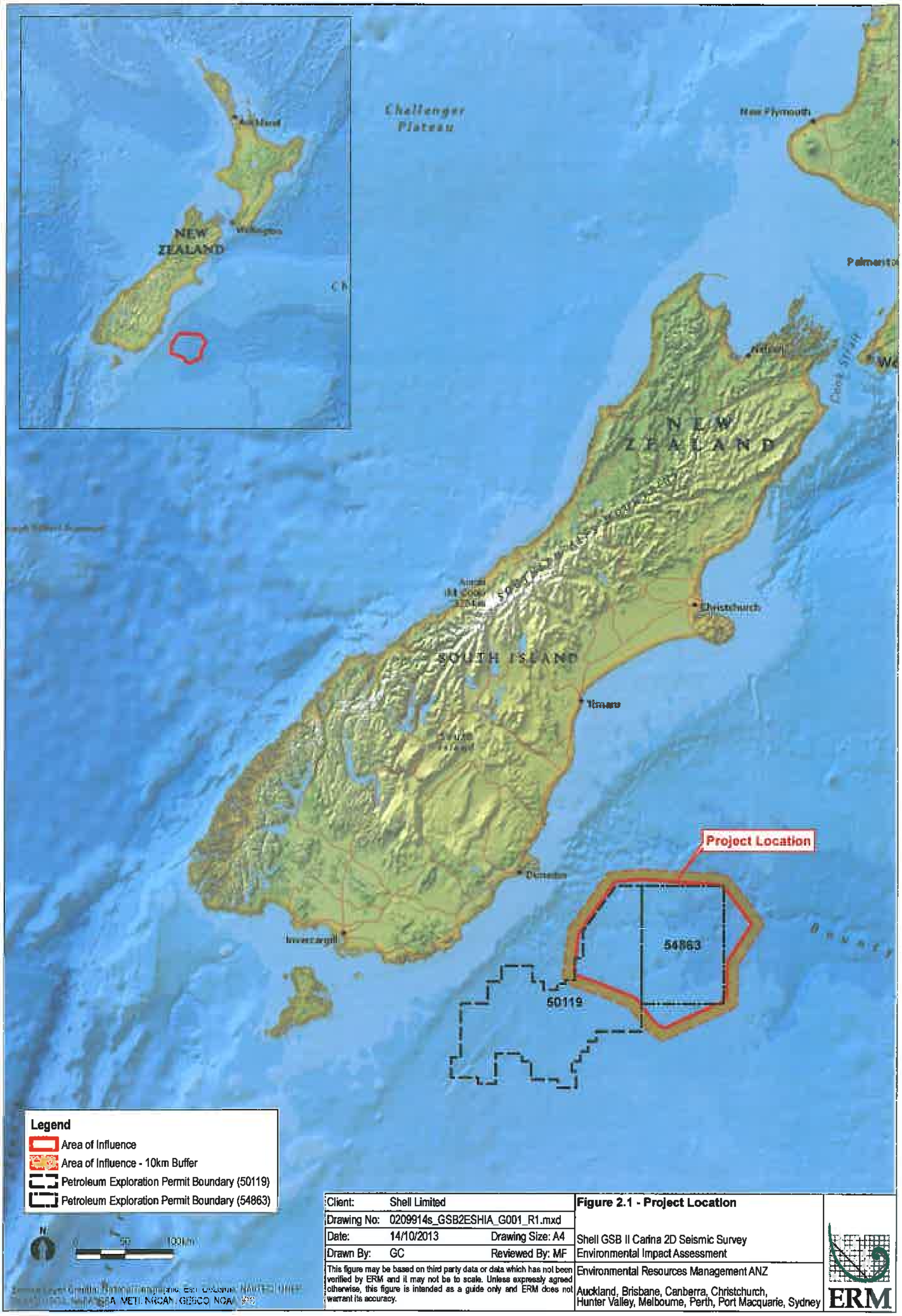
Shell proposes to conduct a 2-dimensional (2D) marine seismic survey within PEP 50119 and PEP 54863 (the PEPs) of the Great South Basin (GSB), off the south-east coast of New Zealand's South Island. The below sections outline the proposed Project.

2.2 *PROJECT LOCATION*

The Project is located within the GSB offshore from the coast of Southland and south Otago, to the south and east of the South Island of New Zealand (*Figure 2.1*). The current area of awarded exploration permits in the GSB covers approximately 7% of the basin (33,500 km^2), which is mainly in water around 1,000 m deep. A 3-dimensional (3D) seismic survey was previously conducted within a targeted zone inside PEP 50119 to assess the potential for commercial discoveries of hydrocarbons within the GSB. This next stage in exploration requires additional seismic data acquisition in an effort to establish whether or not hydrocarbon deposits are also present within the broader area. The area across which the Project will cover is approximately 16,000 km^2.

2.3 *PROJECT TIMING*

The Project is currently planned for the first quarter (Q1) of 2014 and is anticipated to take approximately 70 days to complete. This time estimate includes a 25% contingency for downtime due to weather and/or the presence of cetaceans, as well as crew changes.



Client:	Shell Limited		**Figure 2.1 - Project Location**
Drawing No:	0209914s_GSB2ESHIA_G001_R1.mxd		Shell GSB II Carina 2D Seismic Survey Environmental Impact Assessment
Date:	14/10/2013	Drawing Size: A4	
Drawn By:	GC	Reviewed By: MF	

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2.4 *MARINE SEISMIC SURVEY*

Marine seismic surveys (MSS) are routinely conducted in NZ and global offshore exploration and production operations. The objective of MSS is to define subsurface geological structures. MSS methods are currently the most feasible available to accurately prospect and explore for offshore hydrocarbons. MSS are carried out by task-specific seismic survey vessels. These vessels collect subsurface geological data while transiting along a pre-determined array of transects.

2.4.1 *Seismic Survey Operations*

MSS use air guns as sound energy sources to create seismic waves in the Earth's crust beneath the sea. Low frequency sounds, usually in the form of short-duration pulses, are created at the surface and travel through the water column to the seafloor, penetrating the geological strata beneath the seafloor and being reflected back up through the water column by the upper extent of various geological strata. These reflected pulses are received by hydrophones towed along in an array behind the vessel (*Figure 2.2*). The time elapsed between production and reception of sound is interpreted to determine the depth and spatial extent of sub-surface geology and, ultimately, the presence/absence of hydrocarbon deposits.

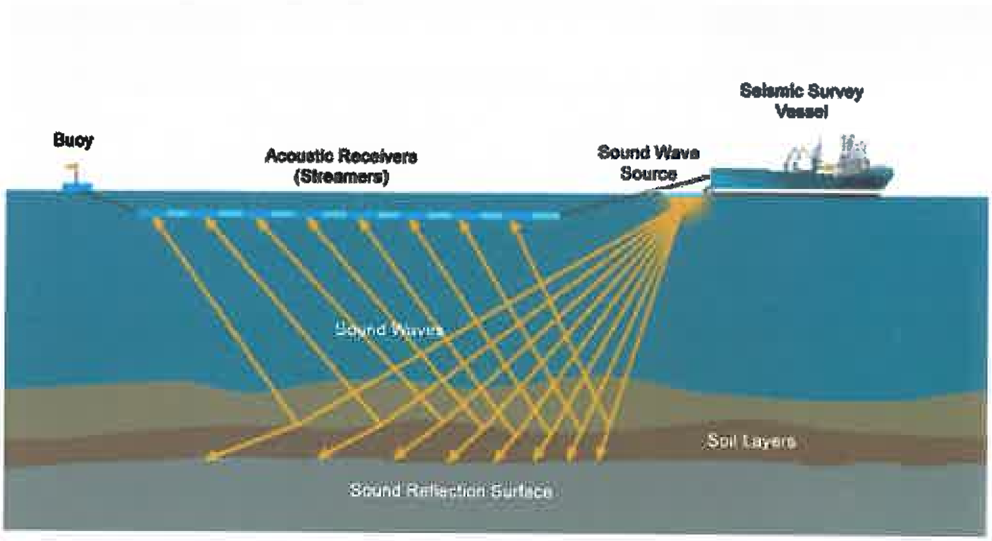

Figure 2.2 ***Graphical representation of a marine seismic survey***
Source: http://fishsafe.eu/media/7477/seismic_surveys_02.gif

2.4.2 *Crewing and Logistics*

It is anticipated that a crew of around 43 personnel will be required for the Project, rotating approximately every 5 weeks. The seismic vessel may return to Port Chalmers, Dunedin, taking around 24 hours to conduct the crew change as well as refuel and resupply the vessel. Refuelling of Marine Diesel Oil, Light Fuel Oil and Heavy Fuel Oil can occur within this port. The Project will not require helicopter support due to the plans to resupply and change crew at port, and the vessel will be equipped with a full hospital and an on-board paramedic as required for extended offshore voyages.

Emergency Plans for Refuelling

There are three tiers to oil spill response in New Zealand. A Tier 1 spill is a small spill handled either by resources on the vessel in accordance with their Shipboard Oil Prevention Emergency Plan (SOPEP) or, in the case of refuelling, the refuelling facility will manage and clean up the spill. A Tier 2 spill is a spill beyond the capacity of the facility or the vessel to manage with their people and equipment. In this case the Otago Regional Council gets involved and uses their stockpile of equipment. A Tier 3 spill is a spill beyond the capacity of the regional council (or outside the regional council marine boundaries). In this case Maritime New Zealand gets involved, and resources are brought from other regions. There will be a contingency plan in place for refuelling at sea, however this will not be the preferred option.

2.4.3 Seismic Vessel

The seismic vessel to be used in the project is the *MV Aquilla Explorer (Figure 2.3)*. It has been selected based upon suitability for the technical objectives of the Project coupled with suitability for the weather conditions within the Project area. The vessel is 71 m in length and use a diesel-electric propulsion system.

Figure 2.3 ***MV Aquilla Explorer***
Source: http://www.safety4sea.com/images/media/vessel.jpeg

Planned Operational Discharges from Seismic Vessel

The key planned operational discharges from the seismic vessel will be:

- Sewage wastes;
- Garbage wastes; and
- Deck drainage

Sewage generation rates will be in the region of 200 litres (L) per person per day. Based on an anticipated crew of 43 persons, volumes generated and discharged to sea will consequently be approximately 8,600 L/day over the duration of the proposed seismic survey.

Garbage wastes can similarly be estimated to be generated at a rate of approximately 86 kg per day (assuming a 2 kg per person per day average). *Table 2.1* summarizes garbage disposal restrictions under MARPOL that will be adhered to by the seismic vessel.

Table 2.1 ***Waste streams and MARPOL***

Garbage Type	Appropriate Disposal Route
Plastic - including synthetic ropes, fishing nets, packaging materials and plastic bags	Should be compacted and stored onboard for transfer to shore for disposal at an appropriate disposal facility.
Paper, rags, glass, metal, crockery and similar refuse	Flammable items should be separated and burned if incinerator available. All others items should be stored onboard until disposal in a controlled facility onshore is possible.
Maintenance and operational waste: rags, oil soaks, used oil, batteries	Flammable items should be separated and burned if incinerator available. All others items should be stored onboard until disposal in a controlled facility onshore is possible.
Food waste	If biodegradable, then can be discharged offshore. Processing as required under Marine Protection Rules Part 170.
Sewage	Should be treated by the ship's sewage treatment facility in accordance with national and international standards.

Deck drainage consists of effluents that accumulate from rain, deck washings and runoff from gutters and drains. Rainwater that falls on the uncontaminated areas of the seismic vessels will flow overboard without treatment. Rainwater that falls in places with exposed equipment or fuel storage will be collected and treated in an oil-water separator to meet MARPOL requirements (oil content <15 ppm). The aqueous phase will be discharged after treatment.

2.4.4 *Support Vessel*

A support vessel will be used to support the seismic survey by scouting for navigation hazards such as fishing gear or other debris and will assist in liaison with other vessels in the area as required. The support vessel will be in constant communication with the primary survey vessel. The support vessel to be used for the Project is not yet confirmed, however it will be selected based upon suitability for the technical objectives of the Project (e.g. the ability to safely lift equipment from the water) and will have the capability to tow the seismic vessel if needed. The below *Figure 2.4* is an example of a support vessel.

Figure 2.4 An example of a support vessel

2.4.5 *Seismic Survey Equipment*

A single seismic vessel will be used for the Project. The vessel will tow a single source array at a depth of approximately 7 m and a distance of 100-200 m behind the vessel. The array will be equipped with a number of air guns, which are the seismic source. These air-guns are steel cylinders charged with compressed air of approximately 2000 psi. The air guns do not use explosives nor do they fire any type of projectile, but function by rapidly discharging high-pressure air into the water. This produces an air-filled cavity (a bubble) that expands rapidly, then contracts, and re-expands. The air guns are of varying size with a combined volume of 4000 - 4500 in^3 and will be positioned and fired in a precise sequence, expected to be every 9.2 seconds if travelling at 4.6 knots, to produce a specifically designed sound wave. Different sound waves can be designed in an effort to image the sub surface in the desired manner as well as to minimise the pressure wave and frequencies emitted into the surrounding marine environment.

Further behind the air guns, extending to a distance of approximately 6 km, the seismic vessel will tow a streamer equipped with numerous hydrophones. Streamers consist of tubular sections that contain the hydrophones and electrical conductors to carry the received signals. The streamer will typically be towed at 8 - 10 m below the surface. The streamer will be foam filled (solid) a small amount of fluid where the hydrophones are located amounting to approximately 6 L in each 150 m section. The sections are connected by electronic modules in which the signals from the hydrophones are digitised and sent by telemetry to the recording system on board the vessel. In each of the three stretches, located at the head and tail of the streamer, there will be approximately 250 L of the chemical Isopar M. At the end of each streamer cable is a tail buoy with radar reflectors to act as a warning beacon to nearby marine vessels.

A summary of the seismic survey vessel and equipment specifications are provided in *Table 2.2*.

The initial deployment of a single streamer can take up to 24 hours with the potential for extra time being required for troubleshooting. The chase vessel may support this process if required. The seismic vessel will use prevailing wind and currents to assist in the deployment of the towed equipment.

2.4.6 *Data Acquisition*

While surveying, the vessel will typically travel at around 4-5 knots and record continuously. During data acquisition, the seismic vessel will follow predetermined survey lines that may be subject to change depending on prevailing current and wind conditions.

2.4.7 *Mobilisation of the Vessels to the MSS Area*

Shell currently plans to undertake mobilisation from Port Chalmers, Dunedin, New Zealand. The vessels will be fully provisioned and bunkered before mobilisation.

Table 2.2 Summary table of seismic survey vessel and equipment specifications

Vessel Size	71 m overall	
Duration of Survey	Approximately 70 days	
Survey Area	16,000 km^2	
Seismic Source Size	Up to 4500 in^3	
Operational Range at 7m depth	0-Peak - dB re 1uPa-m(z-p)	257.9
	Peak-Peak - dB re 1uPa-m(p-p)	264.3
	RMS Pressure (dB)	255.3
Number of Streamers	One	
Length of Streamers	Approximately 8,000m	
Towing Depths of the Source and Streamers	Source – 7-8 m; Streamers – 8-10	
Towing Speed	Approximately 4.5 knots	

2.5 *MARINE MAMMAL OBSERVATION*

Shell is a signatory to the *DOC Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations* (the Code). Further, as per the *Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013*, seismic surveys are a permitted activity if they comply with the Code. As such, the MSS will be planned and executed in accordance with the Code.

2.5.1 *Code of Conduct MMO Requirements*

Under the Code, the MSS will be a Level 1 Survey, thus subject to the minimum marine mammal observation requirements:

- At all times there will be at least two qualified marine mammal observers (MMOs) on board; and
- At all times there will be at least two qualified passive acoustic monitoring (PAM) operators on board.
- As per the requirements of the Code, the qualified MMOs and PAM operators will be dedicated to the detection and data collection of marine mammal sightings and the instruction of crew on their requirements when a marine mammal is detected within the relevant mitigation zone. At all times while the gun array is in the water, at least one qualified MMO (during daylight hours) and at least one qualified PAM operator will maintain watch for marine mammals.

More detail on the Code of Conduct and its requirements can be found in *Section 3 – Administrative Framework.*

3 ADMINISTRATIVE FRAMEWORK

3.1 INTRODUCTION

The administrative framework, under which the Project will be regulated, includes international conventions and regulations as well as NZ national legislation and guidelines. The following sections provide an overview of this framework.

3.1.1 International Conventions, Treaties, Agreements, and Programs

The following international agreements and conventions may affect petroleum activities in marine waters off NZ.

Convention Concerning the Protection of the World Cultural and Natural Heritage (Paris, 1972)

The Convention Concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention) was adopted by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) General Conference on the 16th of November 1972. The World Heritage Convention aims to promote cooperation among nations to protect heritage around the world that is of such outstanding universal value that its conservation is important for current and future generations. NZ ratified the convention in 1984.

International Convention for the Prevention of Pollution from Ships, 1973 as Modified by the Protocol of 1978

The International Convention for the Prevention of Pollution from Ships (MARPOL) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978 respectively, and regularly amended since that time. New Zealand is party to four of the annexes of MARPOL, specifically Annex 1 - Oil, Annex 2 - Noxious Liquid Substances Carried in Bulk, Annex 3 - Harmful Substances Carried in Packaged Form and Annex V - Garbage. The provisions of the MARPOL convention are given effect within the *Resource Management Act 1991*, the *Maritime Transport Act 1994* and the Marine Protection Rules. Additionally, the seismic vessel and any support vessels are bound by all MARPOL Annexes to which their flag state is Party.

International Regulations for the Prevention of Collisions at Sea, 1972

The International Regulations for the Prevention of Collisions at Sea (COLREGS) specify the conduct of vessels on the high seas, and provides a standard set of operational expectations and navigation procedures for maritime vessels. NZ ratified the COLREGS in 1972. The COLREGS are implemented in NZ under the *Maritime Transport Act 1994.*

United Nations Convention on the Law of the Sea (UNCLOS), 1982

The objective of UNCLOS is to set up a comprehensive legal regime for the sea and oceans; including rules concerning environmental standards as well as enforcement provisions dealing with pollution of the marine environment. NZ ratified UNCLOS in 1996, and it is in force in NZ via a number of statutes including the *Crown Minerals Act 1991* (through which petroleum exploration permits are awarded) and the *Maritime Transport Act 1994* and Rules made under the *Maritime Transport Act 1994.*

Convention on Biological Diversity, 1992

The objective of the Convention on Biological Diversity is the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. NZ ratified the convention in 1993.

The 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972

The objective of Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (the London Convention) is to promote the effective control of all sources of marine pollution and to take all practicable steps to prevent pollution of the sea by dumping of wastes and other matter. In 1996, the London Protocol was agreed to further modernize the Convention and, eventually, replace it. In New Zealand, dumping standards within and outside the 12 nm limit are derived from the 1996 Protocol. Under the Protocol all dumping is prohibited, except for possibly acceptable wastes on the so-called "reverse list".

3.1.2 *National Legislation*

Shell notified the Department of Conservation of their plan to conduct a Seismic Survey late 2013/early 2014, during a face to face meeting held in Wellington on 21 August, 2013.

The Exclusive Economic Zone and Continental Shelf (Environment Effects) Act 2012 (the EEZ Act)

The proposed seismic survey activities will be undertaken outside the 12 nautical mile limit of New Zealand's territorial waters, but within New Zealand's Exclusive Economic Zone (EEZ). The primary piece of national legislation that seeks to manage the environmental impacts of activities such as oil and gas exploration in this area is the *Exclusive Economic Zone and Continental Shelf (Environment Effects) Act 2012* (the EEZ Act). The EEZ Act was developed to fill the jurisdictional and functional gaps present in the management of offshore activities within New Zealand's EEZ and continental shelf that existed prior to its enactment. The EEZ Act seeks to manage the environmental effects of activities in NZ's oceans and to protect them from the potential environmental risks of activities such as petroleum exploration; seabed mining; marine energy generation; and carbon capture developments.

The EEZ Act came into force on 28 June 2013 when the *Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013* (the Regulations) were promulgated. These regulations prescribe the activities that are to be permitted activities for the purposes of s.20 of the EEZ Act and the conditions for undertaking these permitted activities. Under s.7 of the Regulations, seismic surveys are prescribed as permitted activities, subject to compliance with the Department of Conservations' *2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations* (see below).

The Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations

The *Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations* (the Code) was developed by the Department of Conservation (DOC) and came into effect on August 1st, 2012. It has since been updated and a revised 2013 version of the Code is in force. The objective of The Code is minimise acoustic disturbance to marine mammals from seismic survey operations. The guidelines outlined aim to minimise potential impacts without unduly affecting normal operations. These guidelines have been endorsed by the Petroleum Exploration and Production Association of New Zealand (PEPANZ).

Under the Code, the proposed seismic survey would be classified as a Level 1 survey with a total combined operational capacity of the acoustic source exceeding 427 cubic inches. Of each of the survey classifications within the Code, Level 1 surveys are subject to the most stringent requirements for marine mammal protection (DOC, 2013). The key requirements of a Level 1 survey are:

- Pre-survey planning including notification of DOC and the submission of a marine mammal impact assessment (MMIA);
- Requirements for two qualified Marine Mammal Observers (MMOs) and two qualified Passive Acoustic Monitoring (PAM) operators on board the survey vessel;

- Specific operational requirements around pre-start observations, delayed starts and shutdowns.

Areas of Ecological Importance

Areas of Ecological Importance (AEI) are marine areas under the protection of the New Zealand government for their importance to marine mammals and other important marine species.

The AOI overlaps with a 4,575 km2 area of the AEI (see *Figure 3.1*). According to DOC, under normal circumstances marine seismic surveys are not to be planned in any sensitive, ecologically important areas or during key biological periods where Species of Concern are likely to be breeding, calving, resting, feeding or migrating, or where risks are particularly evident such as in confined waters (for example, embayments or channels). However, where conducting surveys in such areas and seasons is demonstrated to the satisfaction of the Director-General to be necessary and unavoidable, further measures may be required to minimise potential impacts. In these instances, proponents are required to seek advice from the Director-General to develop and agree on mitigation strategies for implementation. This should lead to the development of an appropriate marine mammal mitigation plan for use by observers and crew to guide operations. Further, the Code specifies that a core component of the planning process is for the exploration permit holder to determine the lowest practicable power levels for the acoustic source array that will achieve the geophysical objectives of the survey—and to limit operations to this maximum level.

In this instance, Shell has identified the optimal balance of achieving the data acquisition objectives of the survey while minimising the disturbance to the marine environment (see *Section 1.4.3*). Shell is able to proceed providing sound transmission loss modelling is incorporated into this MMIA; specifically the Code requires for sound levels of 171 dB re 1 µPa2-s at and 186 dB re 1 µPa2-s at 200 m to be modelled (DOC, 2012g). As per these requirements, sound loss transmission modelling was conducted as part of this MMIA and is discussed below in *Section 7.5.3*. Further, the outputs of the model will be ground-truthed during the seismic survey. Drifting hydrophones will be used for ground truthing. These will be deployed from the support vessel at the direction of Shell's independent environmental advisors. In addition, at the suggestion of Curtin University experts, it is proposed to test a method of acquiring the data required for ground truthing using data acquired from the towed hydrophone production streamer using high sample rate data acquisition. If this method is successful it will prove easier and safer to ground truth future models. The support vessel in this case is used primarily as a safety contingency for the survey vessel and is required to remain on-site in the deep water as much as possible. However, if operational circumstances allow, drifting hydrophone data in shallow water can also be acquired.

Other National Legislation

- While the Project is also subject to the following pieces of national legislation they are of lesser influence to the Project than those outlined above:

- *Maritime Transport Act 1994*, and the associated Marine Protection Rules and Advisory Circulars under the *Maritime Transport Act 1994*, plus Maritime Rules (currently under review);

- *Biosecurity Act 1993*, as amended, including the NZ Import Health Standard for Ballast Water from all Countries;

- *Marine Mammals Protection Act 1978*, and the associated *Marine Mammals Protect Regulations 1992;*

- *Continental Shelf Act 1964;*

- *Territorial Sea, Contiguous Zone, and Exclusive Economic Zone Act 1977*; and

- *Wildlife Act 1953.*

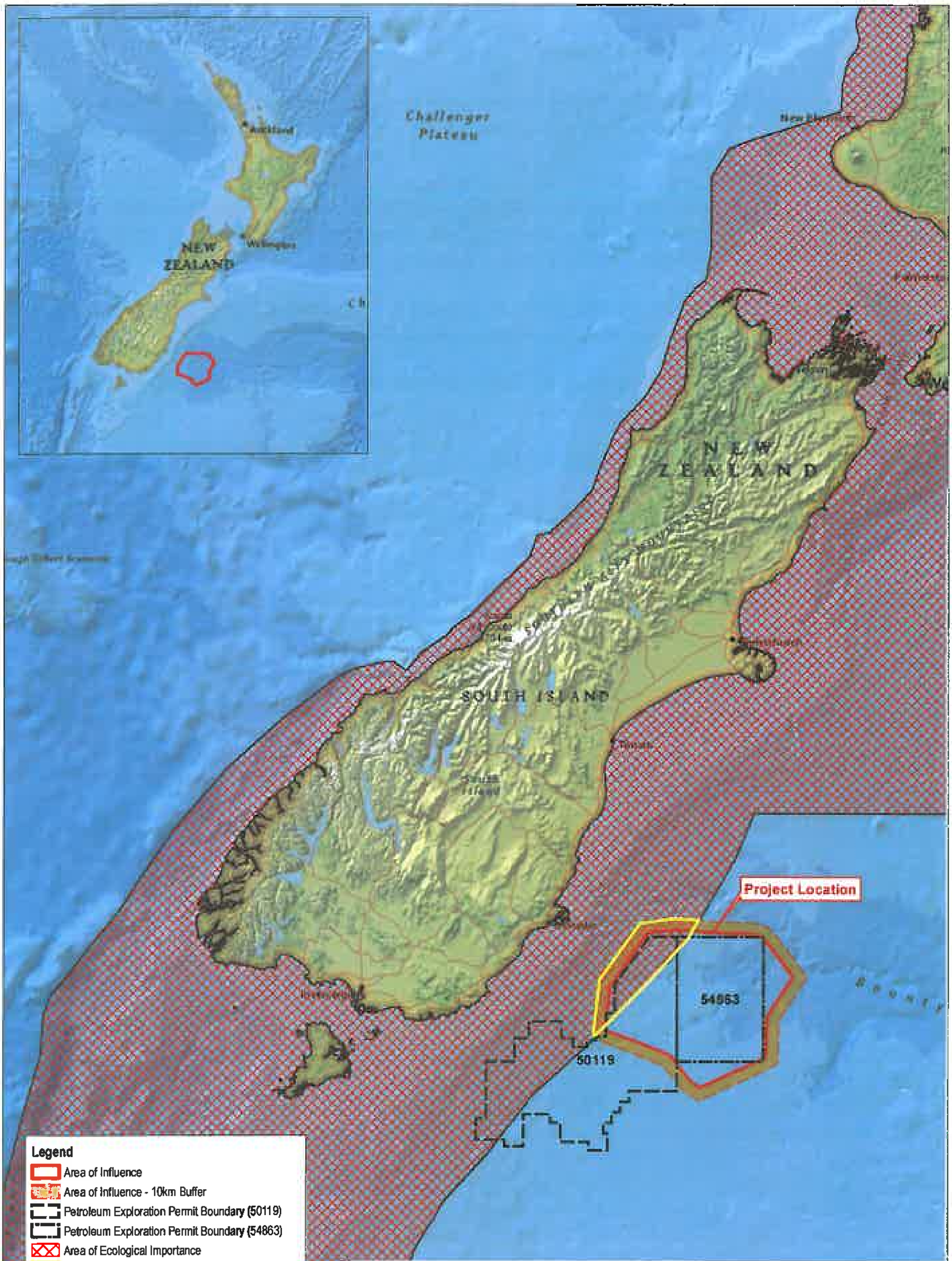

Figure 3.1 - Project Location and Area of Ecological Importance

Shell GSB II Carina 2D Seismic Survey
Environmental Impact Assessment

Client:	Shell Limited		
Drawing No:	0209914s_GSB2ESHIA_G009_R1.mxd		
Date:	05/11/2013	Drawing Size:	A4
Drawn By:	DR	Reviewed By:	MF

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3.1.3 *Shell Corporate Requirements*

Globally, Shell has requirements for the management of all offshore Projects. Shell's Health, Safety, Security, the Environment (HSSE) & Social Performance (SP) Control Framework depicts the requirements for each Project based on a series of criteria. These requirements must be fulfilled in addition to any regulatory requirements within the jurisdiction of any project in question. The criteria include such aspects as whether or not a Project uses novel technology, is located in deepwater, as well as the sensitivity of receptors and magnitude of impacts. Once categorised the Control Framework details the requirements for the impact assessment.

4 IMPACT ASSESSMENT METHODOLOGY

4.1 INTRODUCTION

This MMIA was conducted over a series of stages, with each stage providing increased layers of rigour, and included:

- Project Screening;
- Project Scoping;
- Project and Baseline Definition; and
- Impact Assessment.

4.2 MMIA SCREENING

As discussed in *Section 3.1.3, Shell Corporate Requirements*, screening was conducted by Shell using the HSSE & SP Control Framework to identify any impact assessment requirements for the Project. The process assessed all legislative and internal corporate regulations and standards to determine if the proposed development requires an Impact Assessment. It also included a high level review of the potential environmental, social and health aspects of the Project to determine any known sensitive resources and/or receptors within the potential area of influence. As a result of the initial screening it was determined that, under the Code, a MMIA was required.

4.3 MMIA SCOPING

The scoping process was conducted across three phases. The first phase considered high-level baseline environmental data within the region of the Project, thereby determining if adequate information was available. The second phase established the Area of Influence (AOI) for the Project to define the geographical boundaries of the Project's potential impacts, and to identify for potentially affected resources and receptors. The third phase of this scoping study documented the resources and receptors within the AOI, and assessed which of these the Project activities may interact with and potentially effect.

4.3.1 *Phase One – Assessing Baseline Data*

This phase consisted of an assessment of the following sets of data:

- Desktop data;
- Consultation data;
- Cultural impact data; and
- Field data (MMO reports).

Each data set was assessed for completeness, sufficiency and applicability for use in the MMIA.

4.3.2 *Phase Two - Establishing the Preliminary Area of Influence*

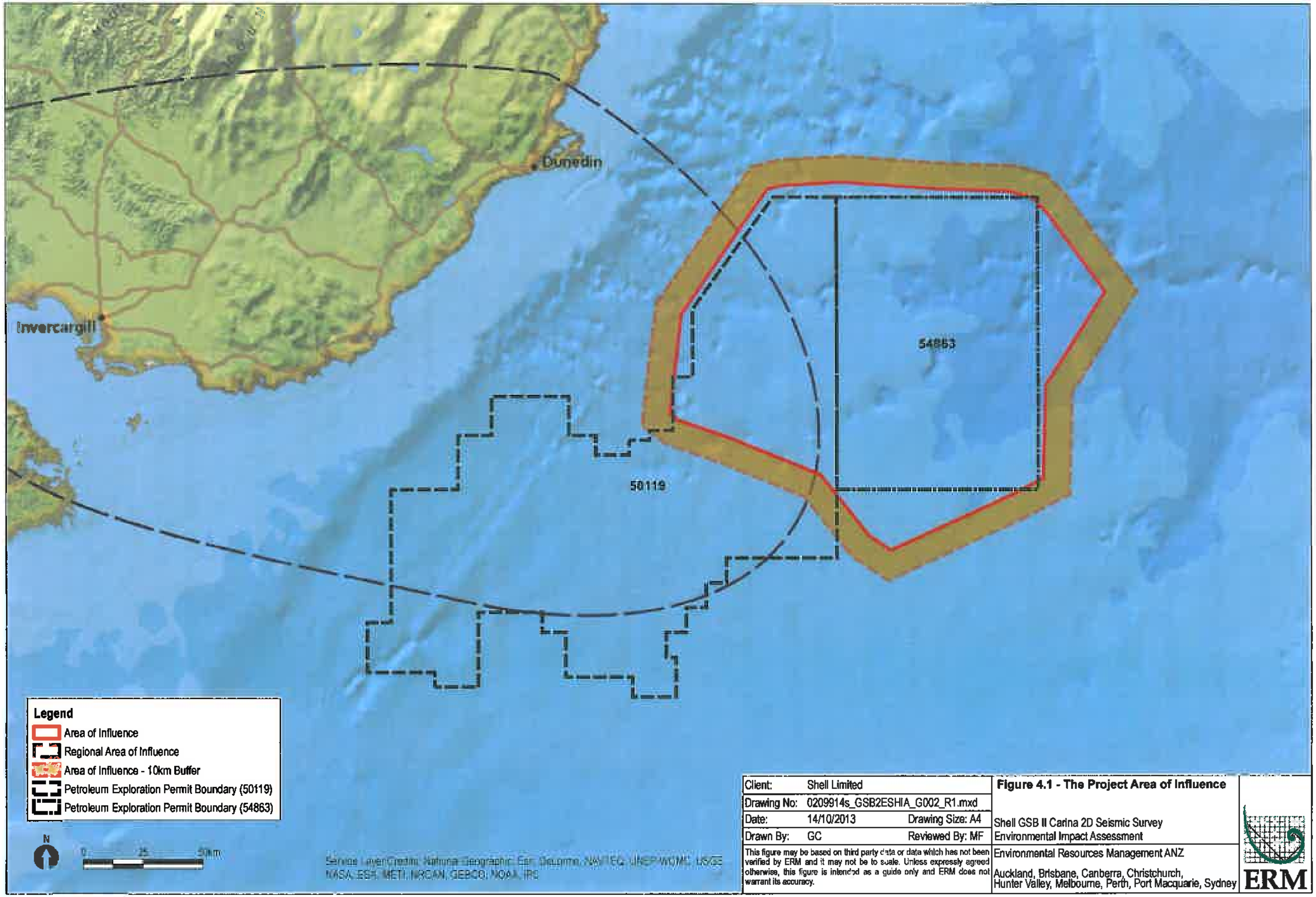
To initiate the scoping process, the Area of Influence (AOI) for the Project was defined based on the following components:

- Primary Project site: the site of the Project (in this case, the seismic vessel). The surrounding areas in which aspects of the environment could experience significant impacts due to the Project are also included.
- Associated facilities: facilities that are essential to, but are not developed as part of, the Project (e.g. support vessel). Again, the areas in which aspects of the environment could experience significant impacts due to activities at these facilities are also included.
- Potentially affected areas of cumulative impacts: resulting from other developments known at the time of the MMIA, further planned phases of the Project or any other existing circumstances.
- Potential areas affected by impacts from unplanned events resulting from the Project (i.e. minor or major spill), occurring at a later stage or at a different location.

The extent of the AOI has been defined to include all that area within which it is likely that significant impacts could result. This takes into account:

- The physical extent of the proposed Project activities (i.e. the project footprint); and
- The nature of the affected resource or receptor, the source of impact and the manner in which the resultant effect is likely to be propagated beyond the Project footprint.

- The preliminary AOI identified during the scoping stage of the Project is shown in *Figure 4.1*.



Client:	Shell Limited
Drawing No:	0209914s_GSB2ESHIA_G002_R1.mxd
Date:	14/10/2013 Drawing Size: A4
Drawn By:	GC Reviewed By: MF

This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

Figure 4.1 - The Project Area of Influence

Shell GSB II Carina 2D Seismic Survey
Environmental Impact Assessment

Environmental Resources Management ANZ

Auckland, Brisbane, Canberra, Christchurch, Hunter Valley, Melbourne, Perth, Port Macquarie, Sydney

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4.3.3 *Phase Three – Assessing Project: Resource/Receptor Interactions*

The nature and availability of baseline environmental and Project information, as well as stakeholder input, is such that the identification of the potential interactions between the Project and resources/receptors within the AOI could be undertaken to a high level of confidence. However, in recognition of the information principles considerations detailed within Section 61 of the EEZ Act, it should be noted that in some circumstances the environmental data available were collected for use in other studies (i.e. not specifically intended for this phase of the Project). As such, professional judgement was used to assess whether potential interactions are likely to result in impacts that could lead to significant effects. In addition the current regulatory requirements and industry best practices, as well as the views of stakeholders consulted to date, were considered.

Once potential interactions were identified, they were charted using a colour-coded matrix (see *Table 4.1* below as an example). The different colours within the matrix indicate the level of potential impact based on the following criteria:

- An interaction is not reasonably expected (white);
- An interaction is reasonably possible but none of the resulting impacts are likely to lead to significant effects (grey); or
- The interaction is reasonably possible and at least one of the resulting impacts is likely to lead to an effect that is significant (black).

All potential interactions were considered regardless of the probability of occurrence.

Table 4.1: Example of a Scoping Matrix

	Receptor # 1	Receptor # 2	Receptor # 3	Receptor # 4	Receptor # 5	Receptor # 6
Project Activity						

4.4 PROJECT AND BASELINE DEFINITION

To assess and define the Project components and the environmental baseline, two steps were undertaken:

- Collection of relevant Project (and Project alternative) information; and
- Collection of baseline data representative of the study area.

4.4.1 *Project Definition*

This stage of the MMIA entailed gathering information from the engineering, geotechnical and environmental teams to define the Project design as far as possible given the early stages of the Project timeline. This Project design was then broken down into a series of discrete activities which could more readily be assessed for impact against the receiving environment.

4.4.2 *Establishing the Area of Influence*

- As with the scoping phase of the MMIA, the determination of the AOI considered of four (4) key aspects, as described in *Section 4.3.2, Phase Two - Establishing the Preliminary Area of Influence* above.

Throughout the impact assessment process the extent of the AOI takes into account the specific aspect and the types of effects considered and may therefore vary between aspects, but in each case it is defined to include all that area within which it is likely that significant impacts could result.

This takes into account:

- The physical extent of the proposed Project activities (ie the Project footprint); and
- The nature of the affected resource/receptor, the source of impact and the manner in which the resultant effect is likely to be propagated beyond the Project footprint.
- For the baseline definition, the AOI is defined as the extent of the two hydrocarbon deposits of interest. This is a conservative approach as the area not only accounts for all potential drill sites, but also includes an extensive area surrounding the drill sites.

4.4.3 *Environmental, Social and Health Baseline Definition*

Desktop Study

A range of desktop information was available for use in the MMIA including:

- Desktop data from previous impact assessments including the OMV and Origin Seismic Survey MMO reports and a project-specific Cultural Impact Assessment;
- The National Aquatic Biodiversity Information System (NABIS);
- A comprehensive project-specific oil spill fate and transport model;
- A comprehensive project-specific cuttings dispersal model;
- Internet websites; and
- Primary literature.

When used, these sources have been cited in the text throughout the MMIA and a detailed reference list, using APA 6th format, has been provided at the end of this MMIA in *Section 8, List of References.* From the above studies sufficient information was obtained in all instances in alignment with the information principles detailed within Section 61 of the EEZ Act. However it was determined that further rigour could be obtained through the completion of baseline field surveys.

Field Surveys

Several data sets collated as a result of field work were obtained and considered as part of this study including:

- A multi-beam mapping study conducted by National Institute of Water and Atmospheric Research (NIWA) in 2012 as part of a wider survey through the Canterbury and Great-South Basins.
- A 3D seismic survey conducted by Shell in 2011;
- Marine mammal surveys conducted as part previous seismic surveys in the area;
- A wave and current survey conducted within the GSB by MetOcean in 2009; and
- A project-specific baseline field survey conducted by ERM in March 2013.

4.5 *IMPACT ASSESSMENT*

This section describes the impact assessment (IA) methodology adopted for identifying and assessing impacts on the physical, biological and human environment. The methodology has been developed to ensure alignment with the IA requirements detailed within Section 39 of the EEZ Act as well as the EPA considerations and information principles detailed within Sections 59, 60 and 61 of the EEZ Act. There were four phases to the impact assessment process, which are outlined in the sections below.

4.5.1 *Phase One – Identification of Impacts*

Environmental impacts arise as a result of Project activities interacting with the environment. These interactions can result in impacts on one or more aspects of the environment either directly or indirectly as well as cause secondary impacts or contribute to a wider cumulative impact. Impacts may be described and quantified in a number of ways. The types of impacts that may arise from Project activities and the terms used in this assessment are shown below in *Table* 4.2.

Table 4.2: Types of Impacts as Categorised within this Study

Type of Impact	Definition
Nature of Impact	
Negative	An impact that is considered to represent an adverse change from the baseline, or to introduce a new undesirable factor.
Positive	An impact that is considered to represent an improvement to the baseline or to introduce a new desirable factor.
Type of Impact	
Direct (or Primary)	Impacts that result from a direct interaction between a planned Project activity and the receiving environment.
Secondary	Impacts that follow on from the primary interactions between the Project and its environment as a result of subsequent interactions within the environment (eg where the loss of part of a habitat affects the viability of a species population over a wider area).
Indirect	Impacts that result from other activities that are encouraged to happen as a consequence of the Project (eg in-migration for employment placing a demand on natural resources).
Cumulative	Impacts that act together with other impacts (including those from concurrent or planned future third party activities) to affect the same resources and/or receptors as the Project.
Duration of Impact	
Temporary	Impacts are predicted to be of short duration and intermittent/occasional in nature.
Short-term	Impacts that are predicted to last only for a limited period (eg during a seismic survey) but will cease on completion of the activity, or as a result of mitigation/reinstatement measures and natural recovery.
Long-term	Impacts that will continue over an extended period, but cease when the Project stops operating. These will include impacts that may be intermittent or repeated rather than continuous if they occur over an extended time period (eg repeated seasonal disturbance of species as a result of maintenance or inspection activities).
Permanent	Impacts that occur during the development of the Project and cause a permanent change in the affected receptor or resource that endures substantially beyond the Project lifetime.
Scale of Impact	
Local	Impacts that affect locally important environmental resources or are restricted to a single habitat or biotope, a single (local) administrative area, a single community.
Regional	Impacts that affect regionally important environmental resources or are experienced at a regional scale as determined by administrative boundaries, habitat type or ecosystem.
National	Impacts that affect nationally important environmental resources, affect an area that is nationally important, protected or have macro-economic consequences.
International	Impacts that affect internationally important resources such as areas protected by International Conventions.
Trans-boundary	Impacts that are experienced in one country as a result of activities in another.

Impacts that may result from both planned activities and unplanned events relating to the project were assessed and impacts from external influences on the Project (such as the presence of icebergs) were also considered, in alignment with Section 39, clause (1)(c) of the EEZ Act. Where unplanned events were assessed, associated risk was considered by taking into account both the consequence of the event as well as the likelihood of its occurrence.

During this phase of the impact assessment, the identification of impacts was carried out prior to detailed assessment of the relative importance of each issue.

Where the magnitude of an impact was such that the sensitivity of the environment did not need to be assessed to determine significance, impacts were judged to be insignificant. These issues were not considered further in the assessment process. All issues with the potential to have a significant impact were carried forward to the next stage of the impact assessment process.

4.5.2 *Phase Two – Developing Mitigation Measures*

A key component of the MMIA process, and a requirement of the EEZ Act under Section 39, clause (1)(g), included exploring practical ways of avoiding or reducing potentially significant impacts of the proposed drilling activities. These mitigation measures are aimed at preventing, minimising or managing significant negative impacts to 'As Low As Reasonably Practicable' (ALARP) as well as optimising and maximising any potential benefits of the Project.

The approach taken to identifying and incorporating mitigation measures into the Project was based on a typical hierarchy of decisions and measures, as described in *Figure 4.2*. Generally speaking, this hierarchal approach is aimed at ensuring that, wherever possible, potential impacts are mitigated at source, rather than mitigated through restoration after the impact has occurred. Thus, the majority of mitigation measures fell within the upper two tiers of the mitigation hierarchy and were effectively incorporated into the Project.

Avoid at Source; Reduce at Source

Avoiding or reducing at source is essentially 'designing' the Project so that a feature causing an impact is designed out (e.g. a waste stream is eliminated) or altered (e.g. a reduced acoustic source size is selected) – often called minimisation

Abate on Site

This involves adding something to the basic design or procedures to abate the impact – often called 'end-of-pipe'. Pollution control (e.g. on board waste water treatment) falls within this category.

Abate Offsite/at Receptor

If an impact cannot be abated on-site then measures can be implemented off-site. Measures may also be taken to protect a receptor – an example of this is the implementation of the Code of Conduct whereby the survey is stopped when marine mammals are present.

Repair or Remedy

Some impacts involve unavoidable damage to a resource e.g. pollution from a spill. Repair essentially involves restoration and reinstatement type measures, such as the clean-up of a coast line where an oil spill has beached.

Compensate in Kind

Where other mitigation approaches are not possible or fully effective, then compensation, in some measure, for loss, damage and general intrusion might be appropriate. An example of this could be the payment of necropsies of any marine mammals that have beached during the Seismic Survey.

Figure 4.2: The Mitigation Hierarchy for Planned Project Activities

4.5.3 Phase Three – Evaluating Residual Impacts

Following the identification of potential environmental impacts (Phase One), impact significance was assessed. This process required taking into account those proposed mitigation measures already incorporated into the design of the Project, as well as any further mitigation measures that were considered feasible and justified (Phase Two). In some instances the mitigation measures applied to the Project reduced impacts ALARP ie the impacts were not eliminated entirely. These remaining impacts are termed residual impacts and the significance of these residual impacts was further defined.

For the purposes of this MMIA, the following definition of significance has been adopted:

> An impact is significant if, in isolation or in combination with other impacts, it should, in the judgment of the MMIA team, be taken into account in the decision-making process, including the identification of mitigation measures and consenting conditions.

Assessment of the level of significance requires consideration of the likelihood and magnitude of the environmental effect, taking account of the geographical scale and duration of the impact in relation to the sensitivity of the key receptors and resources. Criteria for assessing the significance of impacts stem from the following key elements.

- The magnitude (including nature, scale and duration, as defined in *Table 4.3*) of the change to the natural environment (for example, loss or damage to habitats or an increase in noise), which is expressed in quantitative terms wherever practicable.

- The nature of the impact receptor, which may be physical, biological, or human. Where the receptor is physical (eg a water body) its quality, sensitivity to change and importance are considered. Where the receptor is biological its importance (for example its local, regional, national or international importance) and its sensitivity to the impact are considered. For a human receptor the sensitivity of the community or wider societal group is considered along with its ability to adapt to and manage the effects of the impact.

- The likelihood (probability) that the identified impact will occur is estimated based upon experience and/or evidence that such an outcome has previously occurred.

Each level of significance and magnitude was defined using a prescribed set of criteria. These criteria were defined for each component of the marine environment (Seabed, Seawater Quality and Ecology) and social environment and are provided in *Table 4.3* and *Table 4.4*.

Table 4.3: The Criteria for Assessing the Magnitude of Impacts for Seabed Disturbance, Seawater Quality and Ecology

	Seabed Disturbance	Seawater and Air Quality	Ecology	Social and Health
Negligible	Immeasurable, undetectable or within the range of normal natural variation	Immeasurable, undetectable or within the range of normal natural variation.	Immeasurable, undetectable or within the range of normal natural variation.	Change remains within the range commonly experienced within the household or community.
Small	Minimal seabed disturbance	Slight change in quality expected over a limited area with quality returning to background levels within a few metres; and / or Discharges are well within benchmark discharge limits	Affects a specific group of localised individuals within a population over a short time period (one generation or less), but does not affect other trophic levels or the population itself.	Perceptible difference from baseline conditions. Tendency is that impact is local, rare and affects a small proportion of receptors and is of a short duration.
Medium	Localised and/or short term disturbance of seabed	Temporary or localised change in quality with quality returning to background levels thereafter; and / or Occasional exceedance of benchmark discharge limits.	Affects a portion of a population and may bring about a change in abundance and/ or distribution over one or more generations, but does not threaten the integrity of that population or any population dependent on it.	Clearly evident difference from baseline conditions. Tendency is that impact affects a substantial area or number of people and/or is of medium duration. Frequency may be occasional and impact may potentially be regional in scale.
Large	Widespread and/or long term disturbance or permanent change to the seabed	Change in quality over a large area that lasts over the course of several months with quality likely to cause secondary impacts on ecological or human receptors; and / or Routine exceedance of benchmark discharge limits.	Affects an entire population or species in sufficient magnitude to cause a decline in abundance and/ or change in distribution beyond which natural recruitment (reproduction, immigration from unaffected areas) would not return that population or species, or any population or species dependent upon it, to its former level within several generations.	Change dominates over baseline conditions. Affects the majority of the area or population in the area of influence and/or persists over many years. The impact may be experienced over a regional or national area.
Positive	In the case of positive impacts, it is generally recommended that no magnitude be assigned, unless there is ample data to support a more robust characterization. It is usually sufficient to indicate that the Project will result in a positive impact, without characterizing the exact degree of positive change likely to occur.			

Table 4.4: The Criteria for Assessing the Sensitivity of Seabed, Seawater Quality and Ecology

	Seabed Disturbance	Seawater and Air Quality	Ecology	Social and Health
Low	Existing seabed quality is good and the ecological resources that it supports are not sensitive to disturbance.	Existing quality is good and the ecological resources and human receptors that it supports are not sensitive to a change in quality.	Ecological receptors are abundant, common or widely distributed and are generally adaptable to changing environments Species are not endangered or protected.	Minimal areas of vulnerabilities; consequently with a high ability to adapt to changes brought by the Project. Any positive impacts will result in benefits, but only at a minor level.
Medium	Existing seabed quality shows some signs of stress and/ or supports ecological resources that could be sensitive to change in quality or physical disturbance (secondary ecological impacts are possible).	Existing quality already shows some signs of stress and/ or supports ecological resources and human receptors that could be sensitive to change in quality.	Some ecological receptors have low abundance, restricted ranges, are currently under pressure or are slow to adapt to changing environments. Species are valued locally / regionally and may be endemic, endangered or protected.	Some, but few areas of vulnerabilities; but still retaining an ability to at least in part adapt to change brought by the Project. Any positive impacts will result in benefits at a moderate level.
High	Seabed quality is already under stress and/ or the ecological resources it supports are very sensitive to change (secondary ecological impacts are likely).	Existing quality is already under stress and/ or the ecological resources and human receptors it supports are very sensitive to change (secondary ecological or health impacts are likely).	Some ecological receptors in the area are rare or endemic, under significant pressure and / or highly sensitive to changing environments. Species are valued nationally / globally and are listed as endangered or protected.	Profound, or multiple levels of vulnerabilities that undermine the ability to adapt to changes brought by the Project. Any positive impacts will result in major benefits.

The significance of impacts is then defined, based on the sensitivity of the receptor and the magnitude of impact. A convenient way of representing the overall significance is through a matrix of magnitude vs. sensitivity/value as shown in *Table 4.5*. Likelihood has been considered for the assessment of all unplanned events (eg spill), but only after the impact of the event is determined using the impact assessment matrix shown in *Table 4.5*.

Table 4.5: Impact Assessment Matrix used for the Project

		Sensitivity of Receptor		
		Low	**Medium**	**High**
Magnitude of Impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**
	Small	**Negligible**	**Minor**	**Moderate**
	Medium	**Minor**	**Moderate**	**Major**
	Large	**Moderate**	**Major**	**Major**
	Positive	**Minor**	**Moderate**	**Major**

For this assessment, four impact significance categories have been applied:

- Negligible;
- Minor significance;
- Moderate significance; and
- Major significance.

These categories of significance for environmental receptors are defined in *Table 4.6*. Major impacts were deemed intolerable and changes to the Project design, mitigation and control measures must be applied to reduce these impacts to not more than minor or as low as reasonably practicable (ALARP) before the Project proceeds.

Table 4.6: Categories of Impact Significance

Impact Significance	Definition
Negligible	A resource/receptor (including people) will essentially not be affected in any way by a particular activity or the predicted effect is deemed to be 'imperceptible' or is indistinguishable from natural background variations
Minor	A resource/receptor will experience a noticeable effect, but the impact magnitude is sufficiently small (with or without mitigation) and/or the resource/receptor is of low sensitivity/ vulnerability/ importance. In either case, the magnitude should be well within applicable standards.

Impact Significance	Definition
Moderate	Within applicable standards, but falls somewhere in the range from a threshold below which the impact is minor, up to a level that might be just short of breaching a legal limit. The emphasis for moderate impacts is on demonstrating that the impact has been reduced to a level that is as low as reasonably practicable (ALARP). This does not necessarily mean that impacts of moderate significance have to be reduced to minor, but that moderate impacts are being managed effectively and efficiently.
Major	An accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resource/receptors. An aim of this IA is to get to a position where the Project does not have any major residual impacts, certainly not ones that would endure into the long□term or extend over a large area. However, for some aspects there may be major residual impacts after all practicable mitigation options have been exhausted (ie ALARP has been applied). In such circumstances it is the function of regulators and stakeholders to weigh such negative factors against the positive ones, such as employment, in coming to a decision on the Project.

4.5.4 *Phase Four – Re-evaluating Significant Residual Impacts*

During the fourth phase of the IA process, if residual impacts were assessed to be of moderate or greater significance additional mitigation measures have been proposed to further reduce their significance. This process was iterative and was repeated until residual impacts were found to be insignificant, or "As Low As Reasonably Practicable" (ALARP).

Any MMIA is a process that interprets activities which are yet to unfold thus there is an inevitably uncertainty that arises between the predictions made and what will actually happen during the course of the Project. However, Seismic Surveys are widely practiced and the sources of impacts are well-understood. The Project is comparable to many previous surveys conducted around the globe so where uncertainty exists, inferences can be made through prior experience. Impact predictions have been made using available data, but where significant uncertainty remains, this is acknowledged and an indication of its scale was provided. Where the sensitivity of a resource to any particular activity is unknown and the magnitude of impacts cannot be predicted, the MMIA team has used its professional experience to judge whether a significant impact is likely to occur or not.

5 SCREENING AND SCOPING

5.1 OUTCOME OF SCREENING

The screening report, completed on June 13, 2013 in accordance with Shell's HSSE & SP Control Framework, categorised the Project as 'Category B' as its "impacts under normal and abnormal operations are site specific, and few if any are irreversible. Potential adverse impacts are less adverse than those of Category A projects or the project is proposed to take place in a context that is less sensitive to the intended operation or activity."

As a Category B Project, the following needed to be completed:

- Screening note.
- Aspect and impact register.
- Stakeholder engagement plan.
- Scoping report.
- Environmental, Social and Health Baseline Report.
- Impact Assessment Report (this MMIA).
- Environmental, Social and Health Management Plan.

5.2 SCOPING

Potential impacts from the Project have been identified through a systematic process whereby the features and activities (both planned and unplanned) associated with each stage of the Project have been considered with respect to their potential to interact with resources/receptors. Potential impacts have each been classified in one of three categories:

- **No interaction**: where the Project is unlikely to interact with the resource/receptor (e.g. offshore projects are unlikely to interact with onshore receptors);
- **Interaction possible, but not likely to be significant**: where there is likely to be an interaction, but the resultant impact is unlikely to change baseline conditions in an appreciable or detectable way; and
- **Significant interaction**: where there is likely to be an interaction, and the resultant impact has a reasonable potential to cause a significant effect on the resource/receptor.

Each cell on the Potential Interactions Matrix presented in *Table 5.1* represents a potential interaction between a Project feature/activity and a resource/ receptor. Those cells that are coloured white were scoped out of further consideration in the IA Process. Those interactions that are grey are also scoped out, but the IA report includes a discussion that presents the evidence base used to justify this decision. Those interactions that are shaded black were further considered in the IA Process.

Table 5.1 ***Potential Interactions Matrix completed as part of the Scoping stage of the Project***

Project Phases and Activities	Resources and Receptors								
	Biological				Physical		Social		
	Marine Mammals	Seabirds	Fish and/or Invertebrates	Ecosystem	Water Column	Air Quality	Commercial Fishing	Marine Vessels	Cultural Receptors
Planned Activities									
Operation of the seismic and support vessels and towing of									
Underwater noise from the firing of the airgun arrays									
Waste discharges from the survey and support vessels									
Unplanned Activities									
Minor spills of fuels, oils and chemicals									
Collisions									
Accidental loss of streamers or other equipment									
Introduction of invasive marine species									

Those resources/receptors with interactions that have been identified as possible, but which are not likely to lead to impacts of significance are presented in *Table 5.2*.

Table 5.2 ***Interactions identified as possible, but that are not likely to lead to significant impacts*** ***(Note: All unplanned activities have been assessed within Section 7.7***

Interaction (between Project activity and resource/receptor)	Justification for expectation of non-significant impacts
Operation of the seismic and support vessels and towing of equipment	
Tourism and recreation	Given the distance of the AOI from shore, there are unlikely to be tourism or recreational interests present. Thus, while an interaction is possible in theory, given the short duration of the Project and the distance from shore of the Project area, it is highly unlikely that this will lead to impacts of significance.
Marine reptiles	While there are several species of marine reptiles that occasionally occur within New Zealand waters, including loggerhead turtle, green turtle, hawksbill turtle, Olive Ridley turtle, they are typically limited to the temperate to sub-tropical waters of the Northern Exclusive Economic Zone (Gill, 1997). There have been some sightings of marine reptiles in the southern waters around New Zealand (WWF, 2012). While it is possible that these species could occur within the AOI during the survey, it is considered unlikely. As such, they are considered unlikely to be subject to any impacts of significance.
Underwater noise from the firing of the airgun arrays	
Marine reptiles	It is considered unlikely that marine reptiles will occur within the AOI during the seismic survey. As such, they are unlikely to be subject to any impacts of significance from the firing of the airgun arrays.
Waste discharges from the survey and support vessels	
Marine mammals, marine reptiles and seabirds	Discharges of liquid waste may interact with marine mammals, marine reptiles and seabirds if they are present within the mixing zone at the time of discharge. However, given the unlikely nature of such an occurrence eventuating, coupled with the short duration of exposure should it occur, it is unlikely that any impacts will be significant.

6 BASELINE CONDITIONS

6.1 OVERVIEW

This chapter provides a detailed baseline description of the environment in which the Project is proposed to operate. There are three (3) sections to the chapter as follows:

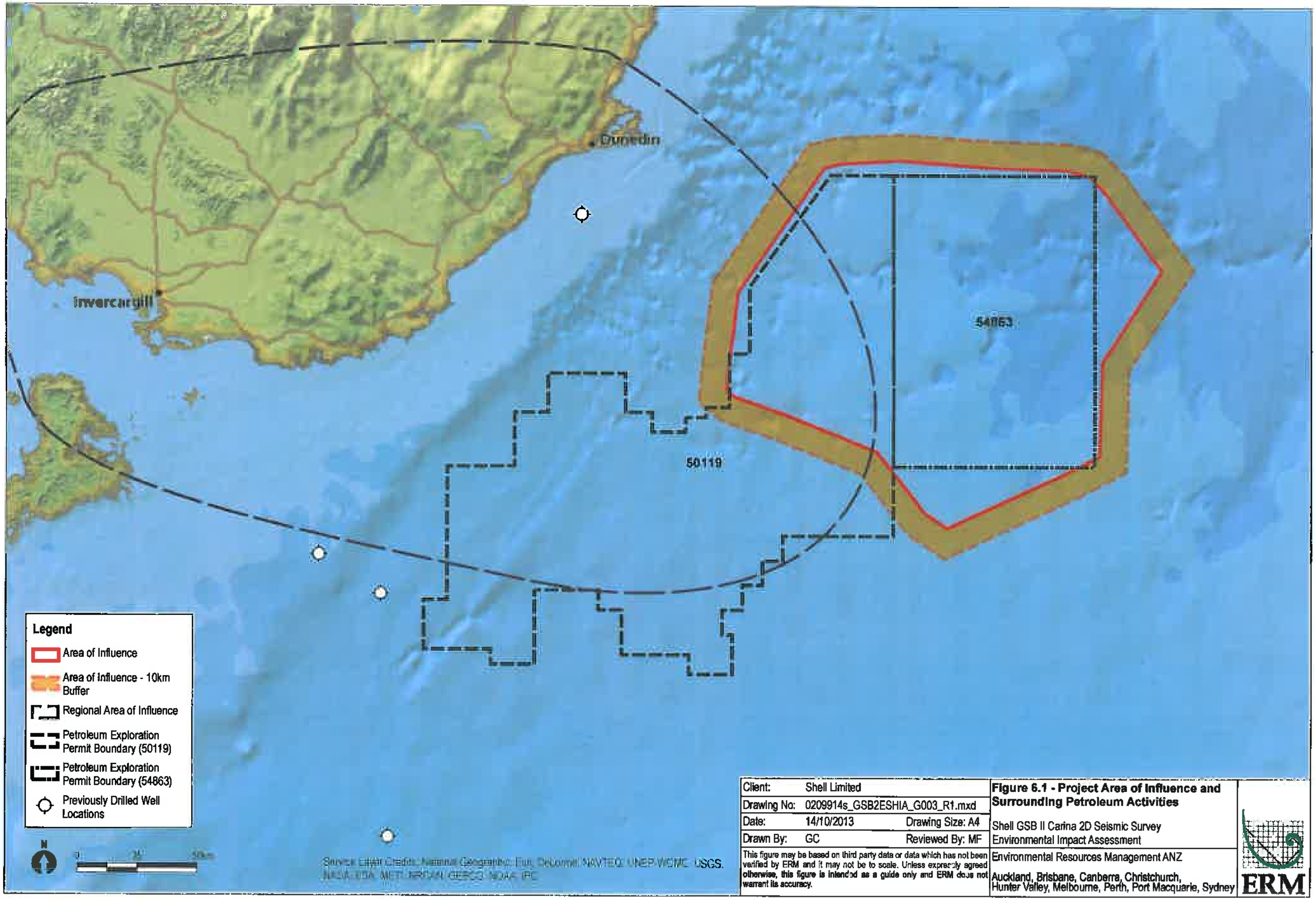
- Section 6.2 *Physical Environment*
- *Section 6.3 Biological Environment*
- *Section 6.4 Socio-Economic and Cultural Environment*

The information contained in each of the following sections was obtained through either desktop or field surveys, or a combination of the two.

6.1.1 *Extent of Existing Disturbance*

This region of the EEZ has been subject to petroleum exploration activities (seismic and exploratory drilling, not production) aside from those associated with this Project. However these activities were not located within the AOI (*Figure 6.1*). Outside of petroleum activities other potential disturbance includes commercial fisheries and trawl research. Details on species recorded by commercial fisheries and the TRAWL database are outlined in *Section 6.3.3* below.

Through consultation with the commercial fisheries sector and the Ministry for Primary Industries (MPI), it is understood that neither fisheries nor trawl research have occurred within the AOI (more detail provided below in *Section 6.3.3 Fish*).



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Drawing No:	0209914s_GSB2ESHIA_G003_R1.mxd	
Date:	14/10/2013	Drawing Size: A4
Drawn By:	GC	Reviewed By: MF

This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

Figure 6.1 - Project Area of Influence and Surrounding Petroleum Activities

Shell GSB II Carina 2D Seismic Survey
Environmental Impact Assessment

Environmental Resources Management ANZ

Auckland, Brisbane, Canberra, Christchurch, Hunter Valley, Melbourne, Perth, Port Macquarie, Sydney

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6.2 PHYSICAL ENVIRONMENT

A metocean study was conducted by MetOcean Solutions for GSB1 in early 2013. This survey collected information within the vicinity of the project, predominantly at two areas within the PEP 50119 (Sirius, in the eastern area of the PEP, and Rigel, in the southern area). As Sirius is located within the AOI, data from this area has been used in the following section to define the physical environment of the project area.

6.2.1 Climate and Atmosphere

Wind Speed

A summary of the wind speed statistics for the 10-minute mean at 10 m elevation recorded within the AOI is provided in *Table 2.1*. The annual mean wind speed is 8.47 ms^{-1}, while the windiest month is June (mean 9.09 ms^{-1}) and the least windy month is December (mean 7.80 ms^{-1}). The monthly and annual wind speed exceedence probabilities indicate the wind speeds exceeding 22 ms^{-1} can occur at Sirius throughout the year, with February and March having the highest occurrence of strong wind events.

Table 6.1 Annual and monthly wind speed statistics within the AOI

Month	Mean ($m\ s^{-1}$)	Median ($m\ s^{-1}$)	P95[1] ($m\ s^{-1}$)	P99[2] ($m\ s^{-1}$)	Max ($m\ s^{-1}$)
January	7.95	7.60	14.99	17.89	26.95
February	7.88	7.62	14.51	17.14	28.41
March	8.35	8.12	15.21	18.45	29.86
April	8.54	8.28	15.43	18.16	23.51
May	9.05	8.77	16.38	19.30	25.37
June	9.09	8.85	16.14	19.25	24.66
July	8.56	8.28	15.35	18.08	24.46
August	8.67	8.50	15.18	18.15	22.93
September	8.90	8.69	15.69	18.45	24.39
October	8.47	8.26	15.06	17.83	25.26
November	8.34	8.09	15.00	17.86	26.44
December	7.80	7.61	14.20	17.26	24.82
Annual	8.47	8.22	15.31	18.22	29.86

Source: MetOcean (2013)

1. P95 specifies the maximum wind speed during 95% of the time which data were recorded
2. P99 specifies the maximum wind speed during 99% of the time which data were recorded

Wind Direction

The recorded wind direction recorded in the AOI is west-south-westerly through northerly greater than 75% of the time with the prevailing direction being westerly and little seasonal variation (~15% of the time; *Figure 6.2*).

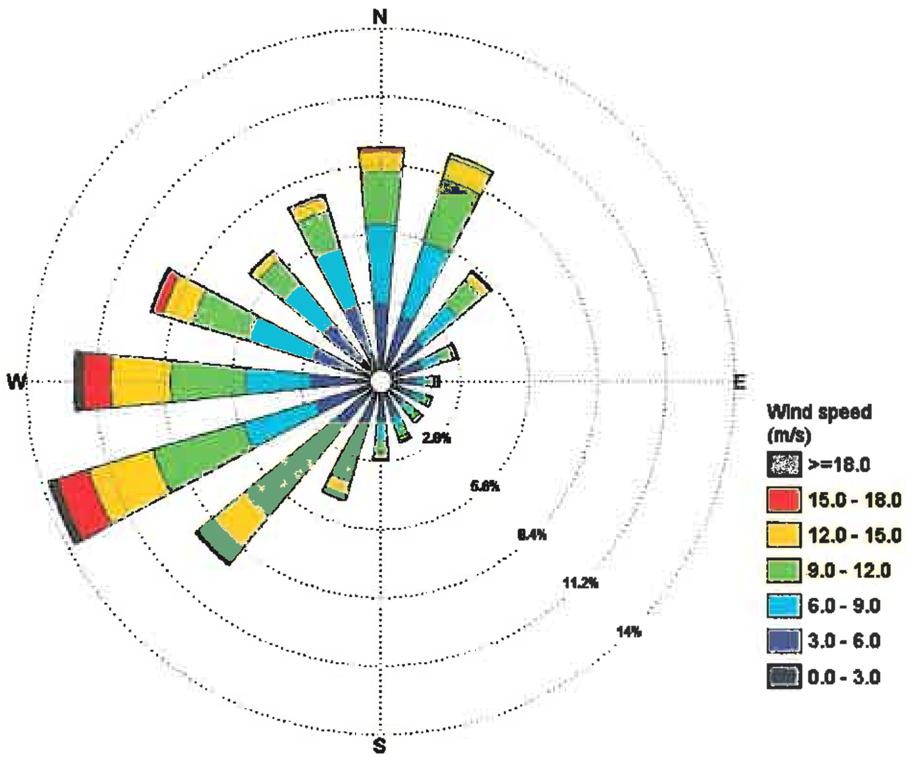


Figure 6.2: ***Annual wind rose for within the AOI.***
Source: MetOcean (2013)

Temperature, Humidity and Precipitation

Detailed climatological data, such as mean temperature and precipitation, are unavailable for the AOI, and so data from the onshore Otago region have been used due to its proximity (~120 km) to the AOI.

The Otago region is situated in a zone subject to strong moist westerly winds and experiences successional depressions (lows) and subtropical anticyclones (highs) bringing alternating periods of rainy and sunny weather. Generally the coastal regions are characterised by little variability in temperatures that are influenced mainly through fluctuations of winds and weather from the sea.

The mean monthly air temperatures in a Dunedin summer typically peak at 15.3°C in January with the lowest mean minimum of 6.6°C in July. Mean monthly humidity is at its lowest in December, reaching a maximum in July.

Mean monthly rainfall, humidity, and temperature and mean total annual rainfall for Dunedin are presented below in *Table 6.2*.

Table 6.2: *Mean temperature, humidity and precipitation for the Dunedin region*

Parameter	Jan	Feb	Mar	Apr	May	Jun	
Rainfall (mm)	72.9	67.8	64.0	50.9	64.7	57.9	
Humidity (%)	74.2	77.6	77.1	76.9	79.5	79.7	
Temperature (°C)	15.3	15.0	13.7	11.7	9.3	7.3	
Parameter	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Rainfall (mm)	57.1	55.7	48.3	61.7	56.4	80.2	726.6
Humidity (%)	80.2	77.6	72.1	71.6	70.6	73.2	75.9
Temperature (°C)	6.6	7.7	9.5	10.9	12.4	13.9	11.1

Source: NIWA (2010)

6.2.2 *Oceanographic Conditions*

Tides and Currents

The currents of New Zealand's EEZ are interlinked with those at an international scale. As part of the South Pacific Ocean, the anti-clockwise south-pacific gyre is instrumental in New Zealand's currents (*Figure 6.3*). Driven by the southern ocean's circumpolar current, the ocean is driven northward up the coast of South America toward the tropical waters of the equator. Here, the water warms and, with the influence of the trade winds, is driven southward down the east coast of New Zealand where it re-joins the Southern Ocean the ocean around the New Zealand coastline. While relatively consistent, the South Pacific Gyre is not constant due to the influence of El Nino and La Nina periods.

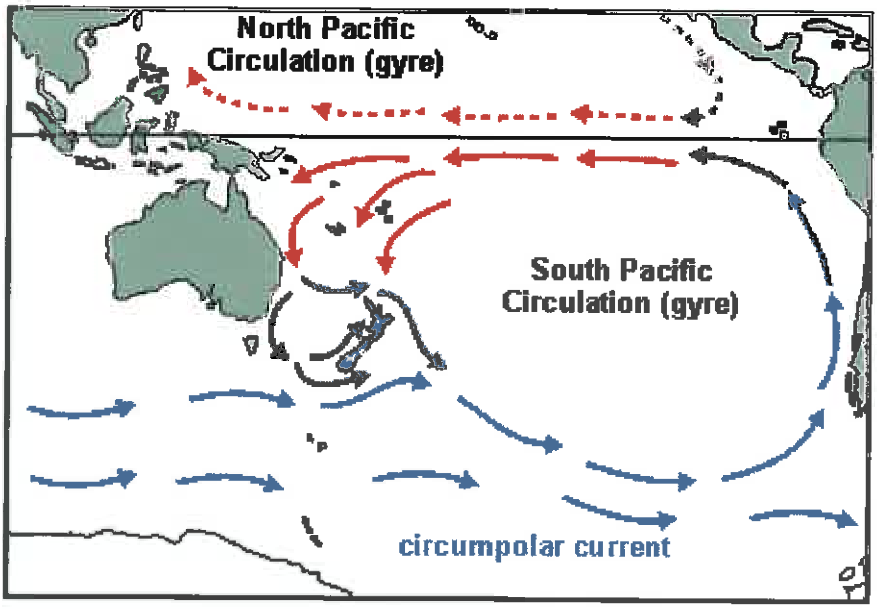


Figure 6.3: *The South-Pacific gyre circulating water toward and away from New Zealand*

Source: http://www.seafriends.org.nz/oceano/special.htm

Of more local influence to the AOI are a series of currents traversing New Zealand. There are three such currents, as seen in *Figure 6.4*, each of which influence New Zealand's oceanic features differently. These are the Tasman Front, the subtropical front and the subantarctic front. It is the subtropical front (STF) and the subantarctic front (SAF) that influence the AOI, providing both cool water from the south as well as some warmer water from the east.

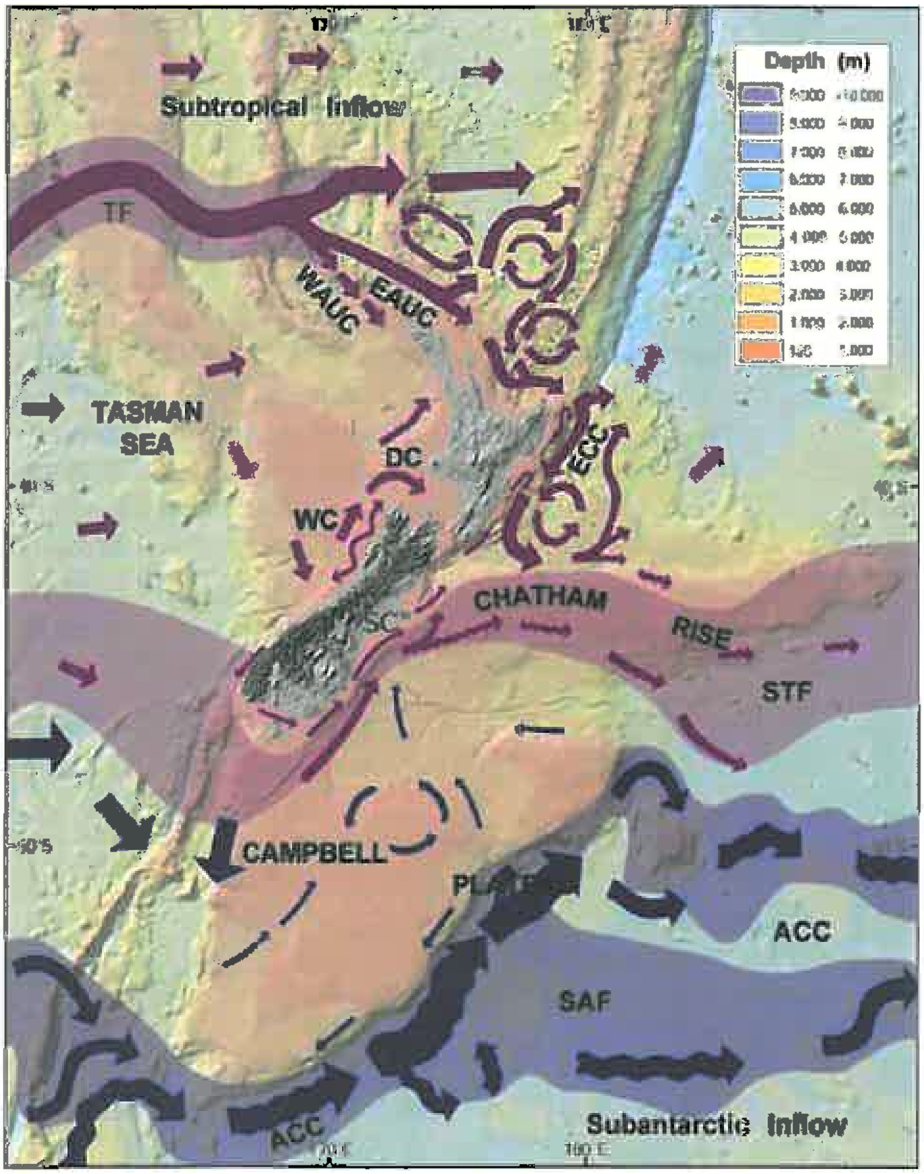


Figure 6.4: ***The three major water masses crossing through New Zealand water masses.***
Source: http://www.teara.govt.nz/en/ocean-currents-and-tides/1/1

At a local scale the Southland Current flows in a general northerly direction up the east coast of the South Island. Studies of the Southland Current have identified waters from the STF as well as a significant amount of subantarctic water, possibly from the SAF influence (NIWA, 2009; Chiswell, 1996). Within the AOI, the SAF is of greatest influence, while in the coastal environments the STF dominates. Current speeds and direction within the AOI is displayed in *Figure 6.5*.

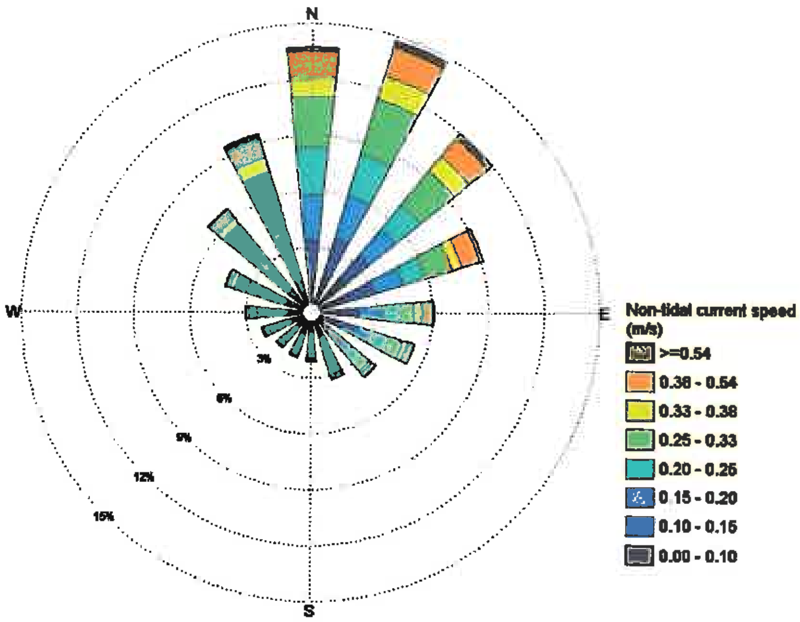


Figure 6.5: ***Annual non-tidal current rose plot at 10 m below surface within the AOI.***
Source: MetOcean, 2013

The AOI is influenced by tidal flows that shift from south-west to north-east (*Figure 6.6*). In this offshore environment changes in the tidal flow occur without the water speed dropping to zero, unlike coastal environments where a drop to zero is typical.

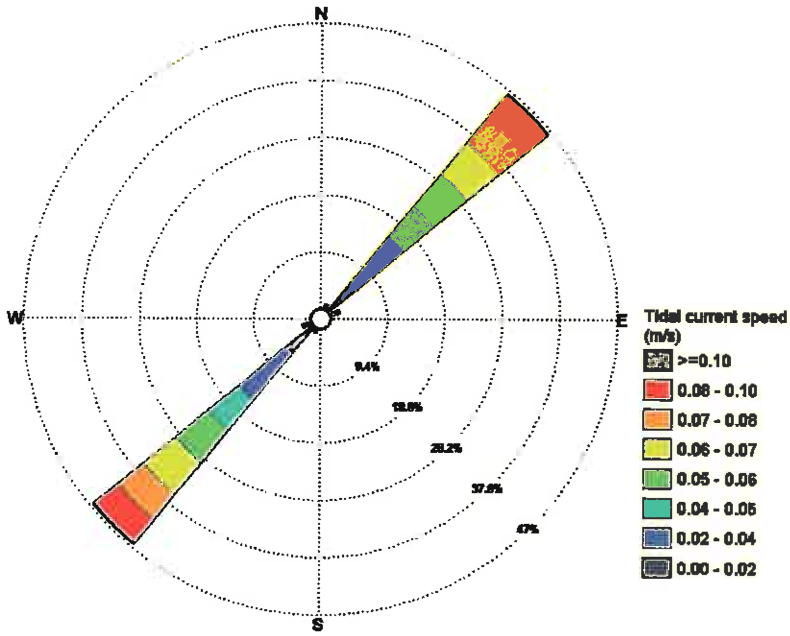


Figure 6.6: ***Depth-averaged tidal current rose plot within the AOI.***
Source: MetOcean, 2013

Waves

A summary of the total significant wave height statistics within the AOI is provided in *Table 6.3*. The largest significant wave height over the hindcast period (1979-2012) was 11.30 m, while the mean annual significant wave height was 3.32 m. The annual 99th percentile non-exceedence level (P99) is 7.18 m (i.e. on an annual basis, for 99% of the time the total significant wave height is less than 7.18 m; *Table 6.4*).

Table 6.3 Annual and monthly total significant wave heights statistics within the AOI

Month	Mean (m)	Median (m)	P95 (m)	P99 (m)	Max (m)
January	2.88	2.68	4.88	6.26	10.92
February	3.00	2.83	4.76	6.19	11.30
March	3.29	3.05	5.59	7.00	9.84
April	3.43	3.17	5.78	7.27	9.78
May	3.69	3.45	6.45	7.92	9.66
June	3.65	3.39	6.21	8.03	10.70
July	3.47	3.27	5.72	7.22	10.92
August	3.52	3.33	5.76	7.24	9.43
September	3.54	3.30	5.87	7.42	9.40
October	3.38	3.18	5.57	6.89	8.91
November	3.17	2.94	5.15	6.60	8.39
December	2.81	2.62	4.57	5.90	8.82
Annual	3.32	3.09	5.61	7.18	11.30

Source: MetOcean, 2013

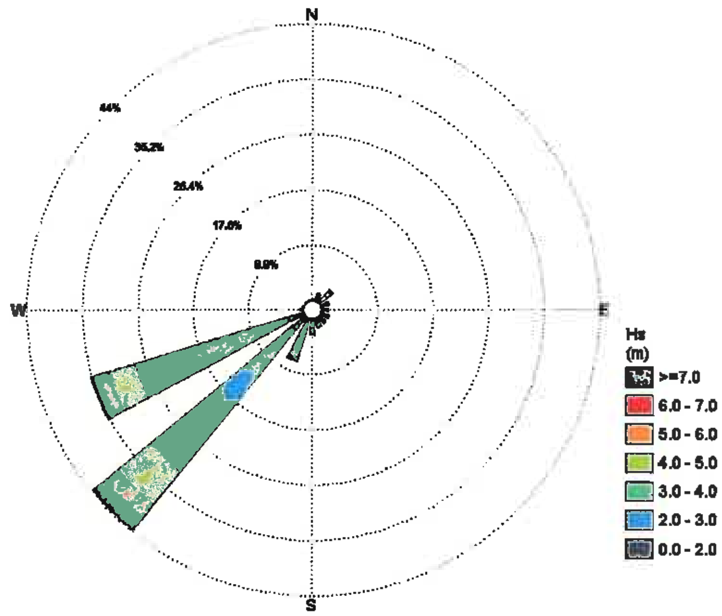


Figure 6.7: Annual wave rose plot for the total significant wave height within the AOI.
Source: MetOcean, 2013

Temperature

Sea surface temperatures (SST) around New Zealand are well documented and are dominated by an annual cycle, with the temperatures peaking in February and at their minimum in August (NIWA, 2009). Within the AOI the SST has been recorded to range from ~7 °C to ~14 °C throughout the year (NIWA, 2009). The sea temperature at the sea floor is far lower, which is typical, especially for deepwater. Within the AOI average bottom temperatures have been recorded as around 3 °C.

6.2.3 *Natural Hazards*

Storms

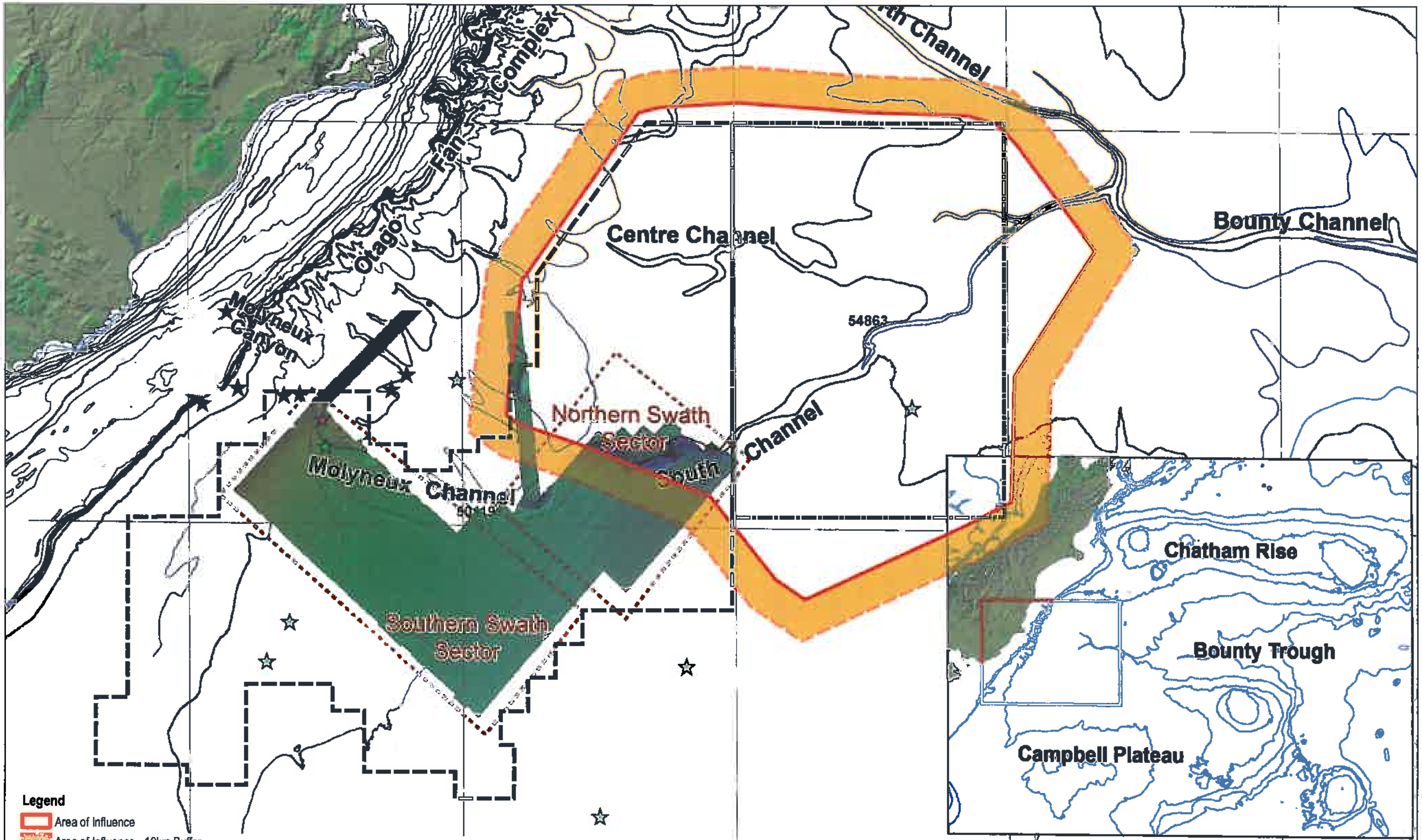
As outlined above in *Section 6.2.1 Climate and Atmostphere* storm or violent storm winds exceeding 25 ms^{-1} have been recorded on regular occasions in the AOI. The highest winds within the AOI have been recorded during the month of February reaching hurricane level on the Beaufort scale (40 ms^{-1}). In addition, nine of the twelve months of data collection had a maximum wave height over 9 m with four months recording a maximum wave height over 10 m. In combination, such winds and wave heights can be classified as storm events. Given the frequency of these events, there is a chance that during the ~70 day seismic programme the area will experience a storm.

Icebergs

Icebergs have been seen within the broader GSB region, with some approaching the subantarctic islands (NIWA, 2012b). The closest iceberg observation to the coast of New Zealand and the AOI was in November of 2006. This sighting was of an armada of small icebergs that had broken up east of Stewart Island. The general direction of the original iceberg and the subsequent armada was north from the subantarctic islands, up the east coast of the South Island to Banks Peninsula, before heading east toward the Chatham Islands (NIWA, 2012b). In this instance the largest iceberg of the armada was estimated at over 500 m long and 300 m wide, with an estimated thickness of 350 m, about 300 m of which was below the water line (NIWA, 2012b).

6.2.4 *Bathymetry and Seabed Features*

The AOI is located at the western most extent of the Bounty Channel. The Bounty Channel is a narrow and steep-sided channel that cuts into the axis of Bounty Trough (LINZ, 2012). It includes numerous tributaries rising on the outer continental shelf off of Otago (LINZ, 2012). Of these tributaries, the AOI encompasses the western reaches of the south channel (*Figure 6.8*). With the exception of this channel, the AOI consists predominantly of flat sea bed with a shallow gradient sloping in an easterly direction (*Figure 6.8*). Depths range from ~1000 m in the Southwest to ~1600 m the Northeast of the AOI.



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© (NIWA, 2012).

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Figure 6.8 - Bathymetry Features within the Great South Basin

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6.2.5 *Noise Conditions*

Noise in the marine environment comes from a variety of natural (e.g. wind, waves) and anthropogenic (e.g. shipping) sources and varies in terms of amplitude and frequency depending on the source. Earthquakes for example, produce very low frequency sounds in the range of 240 dB re 1 µPa/m at 10-100 Hz (Coates, 2002; *Figure 6.9*). Echo-sounders (See 'ES' in *Figure 6.9*) commonly emit quieter but higher frequency sounds (150 dB re 1 µPa/m at >10,000 Hz), whilst the engines of large container ships and super tankers create low frequency sounds below 100 Hz and at volumes up to 200 dB re 1 µPa/m (Coates, 2002; *Figure 6.9*).

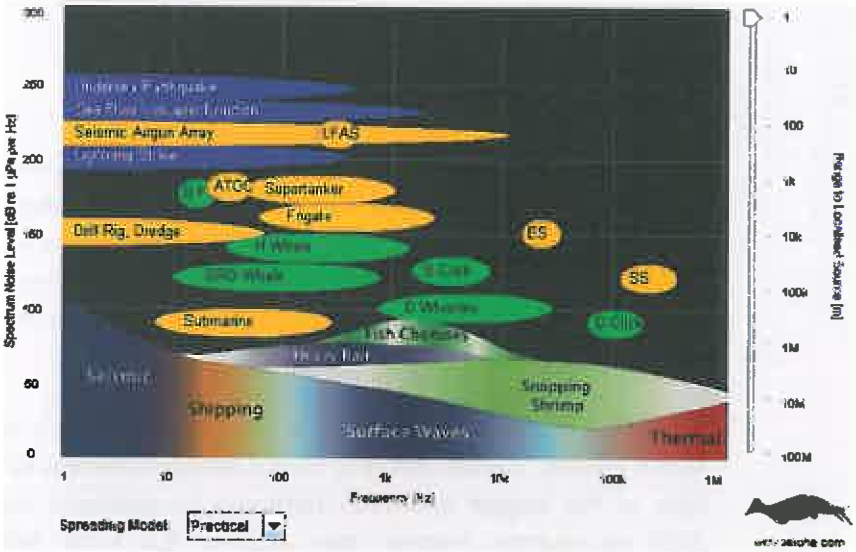


Figure 6.9: ***Ambient and localised noise level from various sources in the ocean, at a range of 1 m***
Source: www.seiche.com; © Seiche Ltd. 2006

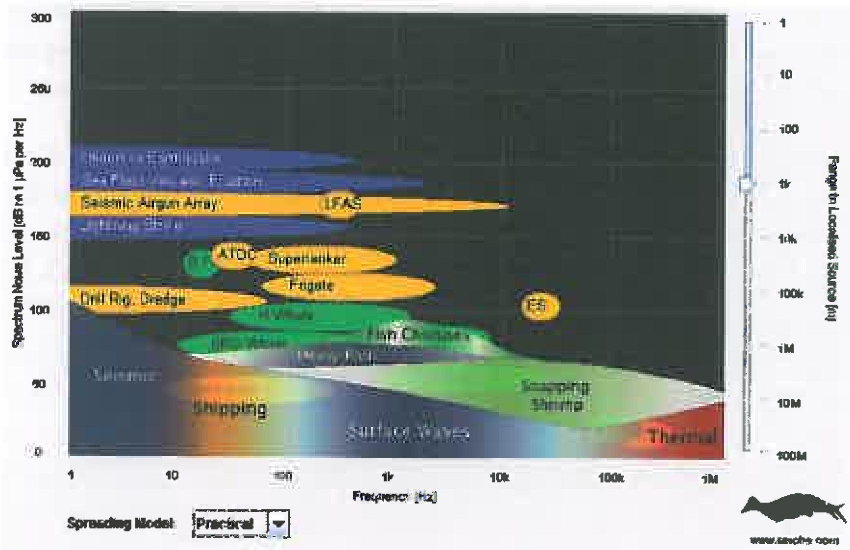


Figure 6.10: ***Ambient and localised noise level from various sources in the ocean, at a range of 1 km***
Source: www.seiche.com; © Seiche Ltd. 2006

Ambient noise conditions within the AOI will vary across time and space depending on oceanographic conditions, and the presence of both biological (e.g. whales) and anthropogenic (e.g. shipping) contributions in the area. Underwater noise levels drop off rapidly within a few hundred metres from the source and by a distance of 1000 m the detectable sound is significantly different (Coates, 2002; see *Figure 6.10* in comparison to *Figure 6.9*).

6.2.6 *Islands, Reefs and Shoals*

There are no islands, reefs or shoals located within the AOI. The South Island is the closest island at around 100 km to the west. The Snares Islands are located around 300 km to the south-west and Bounty Island is located around 600 km to the east.

6.2.7 *Existing and Proposed Marine Protected Areas*

New Zealand has a commitment through the Convention on Biological Diversity to protect at least 10% of its coastal and marine territory via Marine Protected Areas (MPA). Currently, there are 34 marine reserves throughout the country, of which 20 are in the South Island. However only four of these are located on the east coast, and none of them are located within the AOI (*Figure 6.11*).

The MPA most closely located to the Project location is the Te Wharawhara (Ulva Island) Marine Reserve found around 200 km to the west of the AOI. One of the largest sheltered harbours in southern New Zealand this is a 1075 ha marine reserve that adjoins the Ulva Island open sanctuary (*Figure 6.11*). This reserve was established in 2004.

The Catlins Coast Marine Mammal Sanctuary (MMS) is the closest MMS to the AOI, and is around 130 km to the west of the AOI (*Figure 6.11*). Mataitai and Taiapure customary local fisheries grounds also exist within the region with the East Otago and Akaroa Harbour Taiapures, and the Rapaki, Koukourarata, and Wairewa/Lake Forsyth Mataitais.

In November 2007, the government established 17 Benthic Protection Areas (BPAs) that close areas within NZ's EEZ to bottom trawling and dredging. These BPAs protect the biodiversity within about 1.1 million km^2 of seabed – approximately 30 % of the EEZ. There are two BPA's located on the mid and east Chatham Rise, over 600 km to the north-east of the AOI. There are no BPAs located inside the AOI (*Figure 6.11*).

6.3 *BIOLOGICAL ENVIRONMENT*

6.3.1 *Introduction*

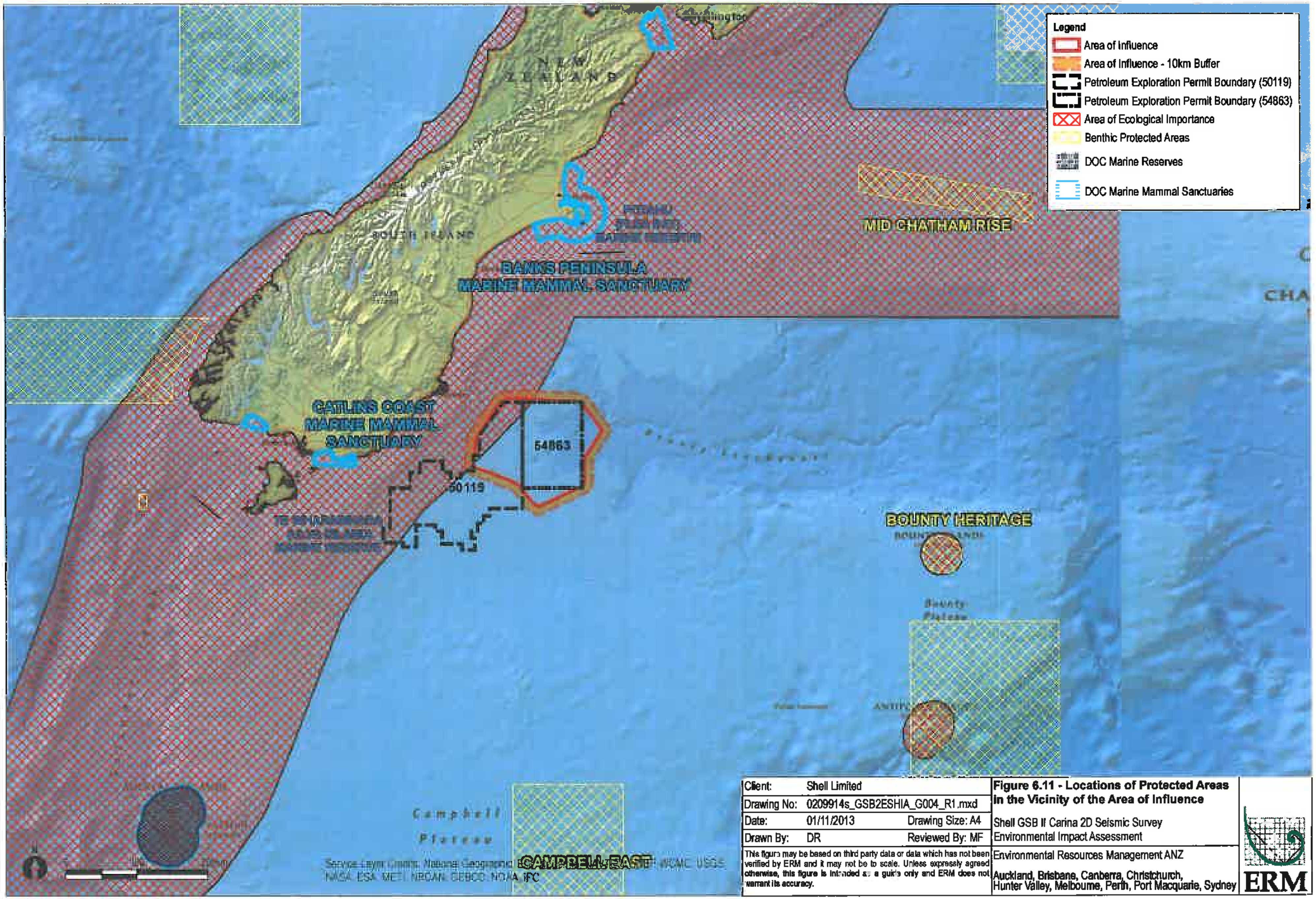
Generally considered to include the sea and seabed below ~200m deep, the deep sea environment includes a series of unique physical features that influence the habitat in which the ecosystems and communities exist (Castro & Huber, 2005). Levels of light, pressure, temperature and oxygen are all significantly different within deeper waters compared to shallower environments. As a result of this unique habitat, many of the species that are found at these depths have evolved specific adaptions to enable their survival. The following sections outline the ecosystems, communities and habitats that exist within the deep sea environment of the AOI.

6.3.2 *Plankton*

Plankton can be broadly categorised as any organisms within the water column that cannot swim against the flow of water (Castro & Huber, 2005). Such species include animals (zooplankton), bacteria (bacterioplankton) and algae (phytoplankton), all of which contribute significantly to the food chain of oceanic ecosystems. The abundance of phytoplankton provides an indication of the overall levels of productivity within a study area. This is because phytoplankton are at the bottom of the food-chain linking to the broader marine ecosystem via the trophic linkages. Accordingly only phytoplankton has been considered within this study.

Phytoplankton distribution and abundance is influenced by a range of factors including light availability for photosynthesis as well as the presence of nutrients in the water column, which are transported through oceanic currents. The measurement of phytoplankton abundance can be most effectively achieved by satellite remote sensing. Multispectral sensors can estimate chlorophyll-*a* concentration at the surface which can be used as a proxy for phytoplankton abundance. While *in situ* sampling of phytoplankton is another method, such single cast sampling provides only a snapshot in time of a population that varies significantly through time.

Using the NASA Giovanni system (SeaWIFS), the chlorophyll-*a* concentration within the region of the AOI was estimated across a five year period. The outputs indicated low concentrations of between 0.2 – 0.3 mg m^{-3} which is considered to have an accuracy of ±35% (*Figure 6.12*). These results are consistent with previous studies where concentrations of chlorophyll-*a* within the region have been ~0.2 mg m^{-3} (Howard-Williams *et al.*, 1995; Boyd *et al.*, 1999; Murphy *et al.*, 2001). In NZ there are seasonal fluctuations in chlorophyll-*a* levels (peaking in spring and autumn and lowest in winter) with annual variation typically ±0.01 mg m^{-3}. Within the AOI fluctuations have been reported to a maximum in late summer or early autumn and a minimum in late winter, and concentrations within the region rarely exceed 0.4 mg m^{-3} (Murphy *et al.*, 2001).



Client:	Shell Limited		Figure 6.11 - Locations of Protected Areas in the Vicinity of the Area of Influence
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Date:	01/11/2013	Drawing Size: A4	Shell GSB II Carina 2D Seismic Survey Environmental Impact Assessment
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6.3.3 *Fish*

The diversity of the marine environment is often defined using the metric of species richness, defined as the number of different species found within a given area. Because the occurrence of a species is influenced by a number of factors (such as prey and habitat availability) species richness can be predicted by assessing such factors. Leathwick *et al.*, (2006) analysed this relationship with fish species, using an extensive set of data from around New Zealand oceans. The study concluded that depth was the single most important factor influencing species richness in New Zealand waters and that the highest species richness was found between 900 m and 1100 m deep, shallower than most of the AOI (see *Figure 6.8* above). The study also concluded that areas of high primary productivity (i.e., high chlrophyll-*a*) also resulted in high species richness. Given the relatively low level of productivity within the AOI (see *Section 6.3.2 Plankton*) is anticipated that diversity of fish species is also low. The below sections discuss the likely presence of fish within the AOI, using various data sources.

Trawl Database

The Ministry of Fisheries research trawl database (TRAWL) contains both inshore and deepwater research trawl survey data (including stratum, station, catch, and biological data) from both research and chartered vessels, dating back to pre-1979 (MPI, 2012a). The effort contributing to the database is extensive. Since-1979 numerous species including invertebrates and vertebrates have been surveyed and over 600 stations per year are sampled.

Within the eight statistical areas surrounding the AOI, the fish species recorded with the highest catch as part of the TRAWL surveys include hoki, ghost sharks, red cod, barracouta and blue cod. These species are discussed below.

Listed Fish Species

The Department of Conservation (DOC) classifies threatened species according to their risk of extinction using criteria developed specifically for NZ conditions. The New Zealand Threat Classification System Listing (DOC Listing) is updated every three years, with the last complete listing cycle from 2008 to 2011. However, marine fish species were not included in this cycle thus the 2005 listing, published in 2007, still applies (DOC, 2007). In this listing, DOC lists 45 species of marine fish (not including sharks that are addressed in *Section 6.3.7*) as being in gradual decline, sparse, or range restricted. It is possible that some of these species may be found in the AOI however, possibly due to the rarity of these species, exact distributions are unknown. Thus, it has been assumed that some individuals of these species may occur within the AOI.

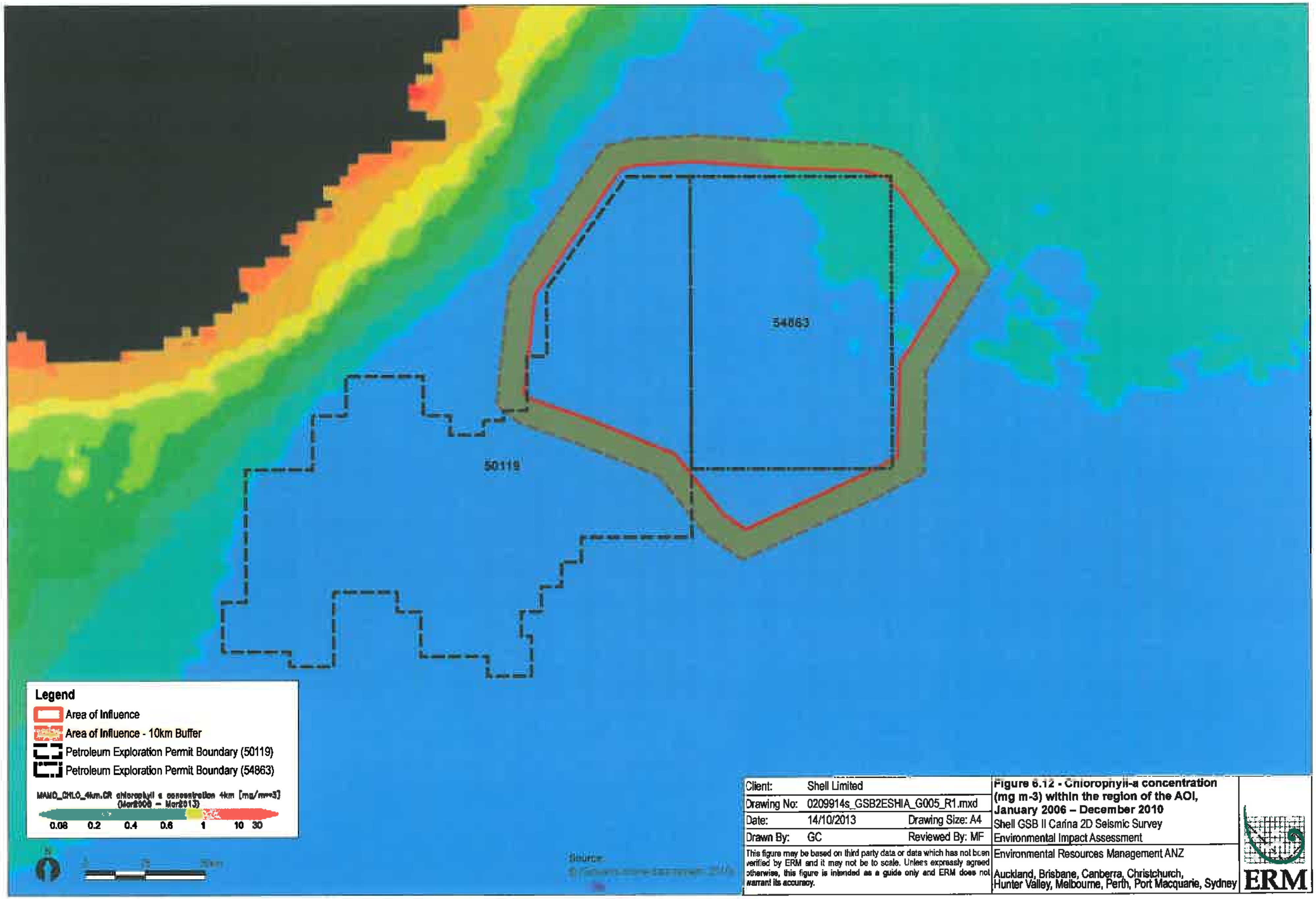

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Figure 6.12 - Chlorophyll-a concentration (mg m-3) within the region of the AOI, January 2006 – December 2010

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Commercial Fisheries

While there are over 1000 species of fish known to occur in NZ waters, only ~130 of these species are commercially exploited from within the NZ EEZ (Te Ara, 2013a; MPI, 2013b). The Project is located within the Fisheries Management Area (FMA) 3 (Southeast Coast Fisheries Region; MPI, 2013c). This FMA is rated of high significance for recreational and customary fisheries, as well as of high environmental importance. There are three main fisheries areas within FMA 3 being Kaikoura, Canterbury and Otago. The region is also home to the countries second and third largest fishing ports being Lyttelton and Timaru which are port to some deep-sea trawlers.

The total tonnage of catch from the eight statistical areas surrounding the AOI between 2007 and 2012 is detailed in *Table 6.4* below displayed in *Figure 6.13*.

Table 6.4 ***Reported commercial catch for all fisheries in the eight stat areas surrounding the AOI (2007/2008 - 2011/2012 - fishing years).***

Statistic Area	Total Catch (t)
024	17688.56
026	23022.22
027	40829.79
301	No data[1]
302	746.92
303	137.93
605	311.88
606	8707.39

1. No fisheries data was recorded within Statistic Area 301.

Within these areas, the most commonly caught species (constituting > 58% of all catch) are hoki, arrow squid, barracouta, silver warehou and black oreo (see *Table 6.5*).

Table 6.5 ***Top 5 species reported as commercial catch for deepwater fisheries in the AOI (2007/2008 - 2011/2012 - fishing years)***

Common name	Total catch (t)
Hoki	16555.012
Arrow squid	14448.188
Barracouta	10653.897
Silver warehou	6762.599
Black oreo	4876.453

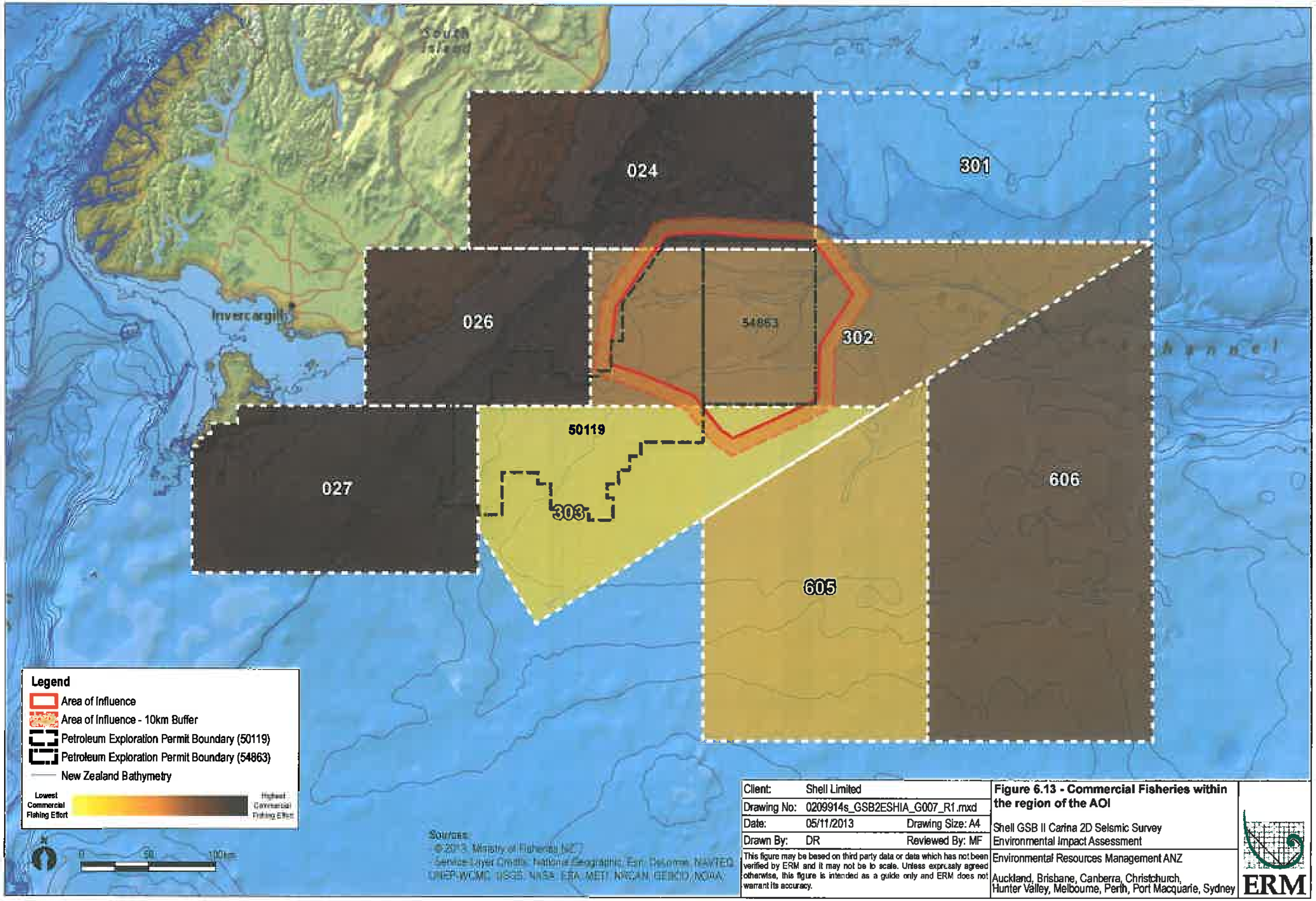

Figure 6.13 - Commercial Fisheries within the region of the AOI

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Hoki

Hoki (*Macruronus novaezelandiae)* reach adult maturity between 5 and 20 years (*Figure 6.14*). Caught by trawling, hoki are most common in the Cook Strait and off the west coast of the South Island during the winter spawning season. During the remaining seasons they can be found on the Chatham Rise and the Campbell Plateau. Typically inhabiting depths ranging 200 to 600 m, they can be found in depths ranging 10 to 900 m (MPI, 2010d).

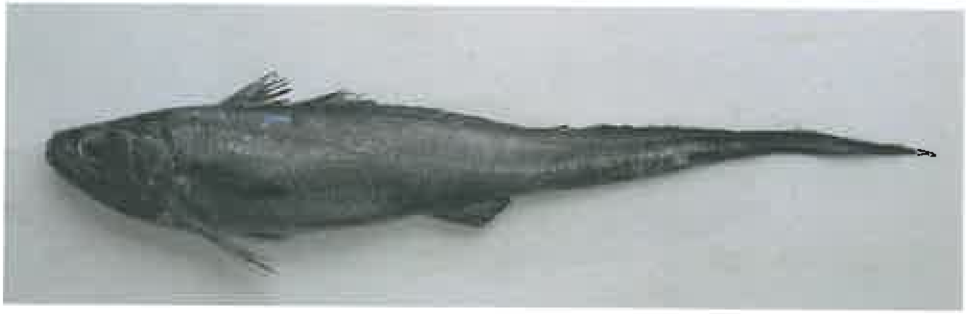

Figure 6.14: Hoki
Source: www.deepwater.co.nz

Arrow Squid

The NZ squid fishery consists of two species of squid; *Nototodarus gouldii* and *Nototodarus sloanii (Figure 6.15*). Both species are found across the continental shelf in waters up to 500 m in depth, though they are most commonly found in waters less than 300 m in depth. The main spawning season is in winter. In general, *N. sloanii* hatches in July and August, with spawning occurring in June and July. *N. gouldi* may generally spawn one-two months before this. However, it is not known where these two species of arrow squid spawn (MPI, 2012e).

Figure 6.15 Arrow Squid.
Source: www.nabis.govt.nz; Photo taken by NIWA

Barracouta

Barracouta (*Thyrsites atum)* is a common species around New Zealand's South Island waters between 30 and 300 m (*Figure 6.16*; MPI, 2002). Over 99% of the recorded catch is taken by trawlers. Major target fisheries have been developed on spring spawning aggregations (Chatham Islands, Stewart Island, west coast South Island and northern and central east coast South Island) as well as on summer feeding aggregations, particularly around The Snares and on the east coast of the South Island (MPI, 2010).

Figure 6.16 **Barracouta**
Source: http://www2.nabis.govt.nz)

Silver Warehou

Silver warehou (Seriolella punctate) are a common species found around the South Island and on the Chatham Rise in depths of 200–800 m (*Figure* 6.17; MPI, 2010b). The majority of the commercial catch is taken from the Chatham Rise, Canterbury Bight, southeast of Stewart Island and the west coast of the South Island (MPI, 2010b). This species is a school species, migrating to feed along the continental slope off the east and southeast coast of the South Island during spring and summer (MPI, 2008).

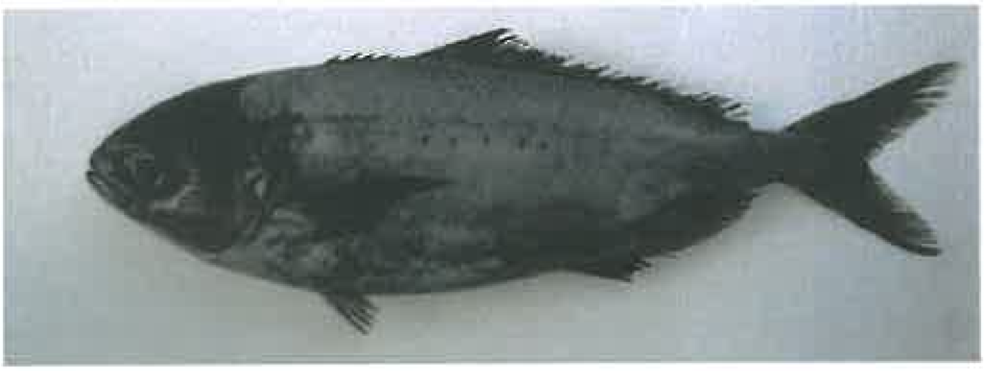

Figure 6.17 ***Silver Warehou***
Source: http://www.deepwater.co.nz

Black Oreo

Fished throughout the southern waters of the NZ EEZ, between 600 and 1300 m deep the black oreo (*Allocyttus niger*) spawn on the South Chatham Rise in late October to at least December (*Figure 6.18*). Otilith sampling has indicated this species is extremely long lived, with the maximum estimated age at 153 years, yet maturity, for females, has been reported at 27 years. They appear to have a pelagic juvenile phase, but little is known about this phase because juveniles are rarely caught. (MPI, 2012i).

Figure 6.18: **Black Oreo**
Source: ***www.deepwater.co.nz***

Red Cod

Red cod (*Pseudophycis bachus*) (*Figure 6.19)* are a fast growing, short lived species found throughout New Zealand. This species is most commonly found at in shallow coastal waters to depths of over 700 m. They are most common around the South Island at depths of 100 to 300 m (Forest & Bird, 2012) and are targeted primarily by domestic trawlers at depths of between 30 to 200 m (MPI, 2012n).

Figure 6.19 **Red Cod**
Source ***www.unitedfisheries.co.nz***

Blue Cod

The Blue cod (*Parapercis colias*) is an endemic bottom dwelling species that is relatively common throughout New Zealand, but is most abundant south of the Cook Strait and around the Chatham Islands (MPI, n.d). Predominantly found in sandy areas at depths of up to 200 m, this species (*Figure 6.20*) feeds primarily on shellfish, crustaceans, salps and small fish (MPI, n.d). The main fisheries for this species occur off Southland and the Chatham Islands with smaller but significant fisheries off Otago, Marlborough Sounds and Wanganui (Forest & Bird, 2012).

Figure 6.20 **Blue Cod**
Source: *www.fish.govt.nz*

Ghost Shark

Two species (dark and pale ghost sharks) make up effectively all the commercial ghost shark landings. Dark ghost sharks *(Hydrolagus novaezealandiae)* (*Figure 6.21*) occur through much of the New Zealand EEZ in depths from 30 to 850 m, however, they are sparse north of 40° S (MPI, 2009b). These sharks are most abundant at depths between 150-500 m on the west coast of the South Island and the Chatham Rise, and at depths between 150-700 m on the Stewart-Snares shelf and Southland/subantarctics (MPI, 2009b).

Figure 6.21 ***Dark Ghost Shark***
Source: *www.oceaniaseafoods.co.nz*

Pale ghost sharks *(Hydrolagus bemisi)* occur throughout most of the New Zealand EEZ in depths ranging from 270-1200 m. This species is most abundant at depths of 400-1000 m on the Chatham Rise and Southland/subantactics, and is uncommon north of 40° S (MPI, 2009c).

Both species are taken almost exclusively as a bycatch of other target trawl fisheries (MPI, 2009c).

6.3.4 *Macrobenthic Communities*

Benthic Infauna

In 2012, the Ministry for Primary Industries released a report that reviewed existing published and unpublished sources of information on soft-sediment marine assemblages around New Zealand (Rowden *et al.*, 2012). The report identified a basic pattern of composition of soft-sediment macroinvertebrate assemblages coupled with some of the environmental factors that influenced their distribution, and referred to thousands of benthic samples that had been collected throughout New Zealand's continental shelf. A large portion of these samples were either collected or collated as part of a large study conducted by the New Zealand Oceanographic Institute in 1961 and 1962 and published in McKnight (1969). The report concluded that assemblages correlated strongly to benthic sediments, with four key communities being identified across four broad sediment types. In New Zealand, soft sediments (unconsolidated substrata such as mud, sand and gravels) are the most regularly found sediment type across the continental shelf, slope and deep-sea (Mitchell et al., 1989).

In a study of benthic communities on the Chatham Rise and associated slopes, macrobenthic infauna biomass (dominated by polychaetes) was linked to surface water primary productivity and the resulting organic flux to the seabed (Probert & McKnight, 1993). Further work identified two deepwater epifaunal communities, comprising mainly echinoderms (McKnight & Probert, 1997). Both deepwater groups were associated with muddy sediment; 462–1693 m included *Ypsilothuria bitentaculata* and *Pentadactyla longidentis* (Holothuroidea), *Brissopsis oldhami* (Echinoidea), and *Amphiophiura ornata* (Ophiuroidea); and 799–2039 m included *Ophiomusium lymani* (Ophiuroidea), *Porcellanaster ceruleus* (Asteroidea), *Gracilechinus multidentatus* (Echinoidea), and *Aenator recens* (Gastropoda).

Given the similarity in depth and sediment type between the habitat sampled on the Chatham Rise and that found within the AOI, it is likely that the macrobenthic communities will be similar. However the biomass and homogeneity of the macrobenthic communities is likely to be influenced by surface productivity and the associated organic flux of the AOI. Given the region has low chlorophyll-*a* levels (ie low primary productivity; see *Section 6.3.2 Plankton* above), the biomass of macrobenthic communities of the AOI is also expected to be low.

Cold-Water Corals

There are three main groups of corals that make up cold-water coral communities being hard (stony) corals of the order Scleractinia, which form hard, ahermatypic reefs; black and horny corals of the order Antipatharia; and soft corals of the order Alcyonacea, which includes the gorgonians (sea fans). Different from warm-water corals, which require the symbiotic relationship with the photosynthesising zooxanthelae for energy, cold-water corals rely on the capture and consumption of organic detritus and plankton that are transported by strong, often deep, sea currents (Friedman et al., 2004). As they lack this reliance on photosynthesis, cold-water corals can be found below the photic zone of approximately 200m and into the deeper reaches of the ocean (Friedman et al., 2004). See *Table 6.6* for a summary of some differences between warm- and cold-water coral reefs.

Table 6.6: Similarities and Differences Between Cold-Water and Warm-Water Coral Reefs

Source: Friedman et al., 2004

	Cold-water Corals	Warm-water Corals
Distribution	Global – potentially all latitudes and all seas	Global – in subtropical and tropical seas between 30°N and 30°S.
Coverage	Unknown – but studies thus far indicate global coverage could equal, or exceed that of warm-water corals	284 300km²
Largest Reef Complex	Unknown – Røst Reef (100 km2) discovered in 2002 in northern Norway is so far regarded as the largest	Great Barrier Reef (more than 30 000 km2), Australia
Temperature Range	4 °C – 13 °C	20 °C – 29 °C
Depth Range	39 – 1000+m	0 – 100m
Number of reef building species	Estimated six (6) primary species	Around 800
Reef composition	Typically one or just a few species	Mainly comprised of numerous species
Symbiotic Algae	No	Yes
Nutrition	Uncertain but likely suspended organic matter and zooplankton	Suspended organic matter and photosynthesis

Cold-water corals can be found at a range of sizes from individuals to that of the largest known cold-water coral reef, the Røst Reef in Norway which is around 40 km long and 3 km wide (CoRIS, 2013). Such reef systems create niche habitat for an array of other marine species including sponges, polychaete worms, crustaceans, echinoderms, bryozoans and fish (Friedman et al., 2004). However, only a few cold-water coral species form such reef systems, the most important of which are *Lophelia pertusa, Madrepora oculata,* *Enallopsammia profunda, Goniocorella dumosa, Solenosmilia variabilis and Oculina varicose* (Friedman et al., 2004). *G. dumosa* and *S. variabilis* are the most prominent reef builders in New Zealand waters (Friedman et al., 2004). All "black corals" and "red corals" are protected under the Wildlife Act 1953.

It has been proposed that three key environmental requirements need to exist for the presence of cold-water corals (Cairns and Stanley, 1981) being:

- Hard substrata;
- Association with vigorous current activity and nutrient supply; and
- Cool water temperature

In terms of hard substrata, there is limited availability in the deep ocean, with soft sediment being the largest of the ecosystems on earth (Snelgrove et al., 1997; Consalvey et al., 2006). As such, seamounts are the main providers of the habitat required for the recruitment of sessile invertebrates (Gage and Tyler, 1991). Seamounts, as well as other topographical highs, also alter oceanic water flow and currents in turn increasing the availability of prey for suspension feeding animals (Genin et al., 1986; Rogers, 1994). These factors, coupled with depth where cooler waters exist, result in deep-sea seamounts being a key habitat for coral assemblages. While there are no seamounts known to exist within the AOI, they do exist within the surrounding region.

Baseline Survey

In early 2013, an environmental baseline survey (the survey) was conducted by Shell. The benthic environment within the area surveyed is adjacent to the AOI thus at similar depths and with similar benthic characteristics. The survey included benthic video assessment of the seabed at 13 different sites selected as representative of the main sediment types found in the area. Short video tows or transects using the NIWA - DTIS allowed for the recording of low resolution video footage of the seabed that was assessed post survey by qualified NIWA scientists utilising Ocean Floor Observation Protocol software. Identification of individual organisms (>ca. 50 mm) was documented down to the lowest taxonomic level possible with high levels of confidence.

Species identified within the survey included deepwater anemones (*Figure 6.22*) gorgonian corals (*Figure 6.23*) sponges (*Figure 6.24*) and brittle stars (*Figure 6.25*).

Figure 6.22: Representative Image of an Anemone from the Phylum Cnidaria
Image acquired during the Environmental Baseline Survey

Figure 6.23: Representative Image of Gorgonian Coral from the Phylum Cnidaria
Image acquired during the Environmental Baseline Survey

Figure 6.24: Representative Image from the Phylum Porifera
Image acquired during the Environmental Baseline Survey

Figure 6.25: Representative Image of Ophiomusium lymani from the Phylum Echinodermata
Image acquired during the Environmental Baseline Survey

6.3.5 *Marine Mammals*

Species of Concern

The marine waters off NZ support a diverse community of marine mammals. Forty-one species of cetaceans (whales, dolphins, and porpoises) and nine species of pinnipeds (seals and sea lions) are known to exist in NZ waters (Suisted & Neale, 2004). The below *Table 6.7* outlines the species listed as of concern in the Code that have been included or excluded in this MMIA, and the justification for doing so. Further below are separate discussions for each of the species that are known to occur within the AOI.

Table 6.7 Marine mammal Species of Concern included or excluded from this MMIA

Marine Mammal	Included in the MMIA (Y/N)	Justification if species excluded from this of MMIA
Bryde's whale	N	Brydes whales (*Balaenoptera edeni*) are baleen whales of which three subspecies are recognised. Within New Zealand waters, Brydes whales are only found in northern New Zealand, primarily around the Bay of Plenty (see *Figure 6.31* below) and would therefore be unlikely to be within the vicinity of the project.
Melon-headed whale	N	The Melon-headed whale (*Peponocephala electra*) has a pantropical distribution (Perryman, 2002) within tropical/subtropical oceanic waters between about 40°N and 35°S (Jefferson & Barros, 1997). The range of this species is limited to at least 500km north of the North Island (IUCN, 2008b) and is therefore not expected to occur within the AOI.
Pygmy/peruvian beaked whale	N	The distribution of the pygmy beaked whale (*Mesoplodon peruvianus*) is generally unknown. One record in New Zealand exists of a stranding on the south island (Baker & Van Helden, 1999). This species is not expected to within the AOI as there is no documentation of this species within New Zealand waters.
Pygmy killer whale	N	The pygmy killer whale (*Feresa attenuate*) is a tropical/subtopical species, inhabiting oceanic waters generally between 40°N and 35°S (IUCN, 2008a). This species is not expected to occur within the vicinity of the project.
True's beaked whale	N	This species (*Mesoplodon mirus*) occurs in the southern Indian Ocean, from South Africa, Madagascar, southern Australia and the Atlantic coast of Brazil (MacLeod *et al.*, 2006). This species is not expected to occur within New Zealand waters, and therefore is not expected within the AOI.
Blainville's beaked whale	N	Blainville's beaked whales (*Mesoplodon densirostris*) occur in temperate and tropical waters of all oceans (Mead, 1989). Within New Zealand they have been recorded around both the Chatham islands and North Island (Taylor *et al.*, 2008h). Their distribution is not known to extend to the South Island and they are therefore not expected to occur within the AOI.

Marine Mammal	Included in the MMIA (Y/N)	Justification if species excluded from this of MMIA
Ginkgo-toothed whale	N	Ginkgo-toothed whales (*Mesoplodon ginkgodens*) are generally found in tropical and warm temperate waters of the Indo Pacific (Taylor *et al.*, 2008j). Its distribution is not known to extend to the South Island and therefore is not expected to occur within the AOI.
Maui's dolphin	N	The Maui's dolphin (*Cephalorhynchus hectori maui*) is endemic to New Zealand and known exclusively from the west coast of North Island, New Zealand (Ferreria & Roberts, 2003). This species is not expected to occur within the AOI.
Dwarf sperm whale	N	The dwarf sperm whale (*Kogia sima*) is a tropical species and occurs rarely in New Zealand. This species has been recorded within waters off the North Island, but are not found around the South Island (IUCN, 2012) and therefore no expected to be encountered within the AOI.
Humpback whale	Y	Not applicable
Sei whale	Y	Not applicable
Antarctic minke whale	Y	Not applicable
Dwarf minke whale	Y	Not applicable
Blue whale	Y	Not applicable
Fin whale	Y	Not applicable
Pygmy blue whale	Y	Not applicable
Southern right whale	Y	Not applicable
Pygmy right whale	Y	Not applicable
Southern right-whale dolphin	Y	Not applicable
Long-finned pilot whale	Y	Not applicable
Short-finned pilot whale	Y	Not applicable
Sperm whale	Y	Not applicable
Pygmy sperm whale	Y	Not applicable
Gray's beaked whale	Y	Not applicable
Arnoux's beaked whale	Y	Not applicable
Cuvier's beaked whale	Y	Not applicable
Strap-toothed whale	Y	Not applicable
Southern bottlenose whale	Y	Not applicable
Andrew's beaked whale	Y	Not applicable
Hector's beaked whale	Y	Not applicable

Marine Mammal	Included in the MMIA (Y/N)	Justification if species excluded from this of MMIA
Shepherd's beaked whale	Y	Not applicable
Killer whale	Y	Not applicable
False killer whale	Y	Not applicable
Hector's dolphin	Y	Not applicable
New Zealand sea lion	Y	Not applicable
Bottlenose dolphin	Y	Not applicable

Seasonal Distribution of Marine Mammal Species and Marine Mammal Observations from Seismic Surveys

Since 2007, four seismic surveys have been conducted within the region of the AOI. As part of these surveys, marine mammal observations were recorded and reported on. These data have been provided by DOC for the development of this assessment (Crown Minerals, 2006; Origin Energy, 2007; Exxon Mobil, 2008; OMV, 2012). This provided information relating to the presence of marine mammals within the region. It is important to note that while these studies did record the presence of certain species, one cannot conclude other mammals do not exist within the area based on these records.

Across the four studies, there were a total of 612 recorded sightings across ~340 days of survey effort, using either visual or acoustic methods, or both. In all cases the majority of the sightings were of NZ fur seals however there were also six species of whales and six species of dolphin identified, as well as unidentified marine mammals across both voyages.

Table 6.8 also outlines all species sighted during the four previous seismic surveys as well as the seasonal distribution of all marine mammals identified as having the potential to occur within the AOI. The sections following the table provide information on each of these species.

Table 6.8: Total number of sightings and the species of marine mammals identified visually and/or acoustically across the two seismic surveys, as well as other marine mammal species identified as potentially occurring within the AOI, with timing of potential occurrence within the AOI. NOTE: *When timing is unknown, assumption of year-round occurrence has been made.*

Year of Survey	2006[1]	2007[2]	2008[3]	2011[4]	Timing of Potential Occurrence in AOI	Discussion of Timing of Potential Occurrence in AOI
Days Effort/ Sightings	43/57	68/28	136/46	101/66		
Pinnepeds						
NZ fur seal	✓	✓	✓	✓	Year round but less likely during breeding season of mid-November to mid-January.	The New Zealand fur seal (*Arctocephalus forsteri*) is a non-migratory species found typically below 40°S (Baird, 2011). Breeding colonies are found throughout NZ with the largest colonies found on the west and southern coasts of the South Island, and smaller colonies in the north (Goldsworthy & Gales, 2008). These seals can also be found on all of NZ's subantarctic islands and return to the same breeding colony each year to give birth to pups between mid-November and January (DOC, 2012f; NABIS, 2013).
Whales						
Blue whale	✗	✗	✗	✓	Year Round*	A foraging population of pygmy and possibly Antarctic blue whales (*Balaenoptera musculus*) is thought to exist off the Taranaki coast (pers comms, Mike Patrick, 2012). Sightings have been recorded in North Western NZ waters during summer months. (Branch TA *et al.*, 2007). While considered a migratory species, the migratory patterns of this species are not well understood (Reilly *et al.*, 2008b).
Antactic Minke whale	✗	✗	✓	Possible	Year Round*	In the southern hemisphere minke whales (*Balaenoptera bonaerensis*) have been found as far south as 76 °S in the Ross Sea in the summer and as far north as 7 °S during the winter (Shirihai *et al.*, 2006) and a high abundance of minke whales were recorded between 10°-30°S in the central South Pacific and in much of the eastern and southern Indian Ocean down to 50°S in the month of November (Miyashita *et al.*, 1995). The migratory patterns of minke whales, however, are poorly known (Reilly *et al.*, 2008c).

Year of Survey	2006[1]	2007[2]	2008[3]	2011[4]	Timing of Potential Occurrence in AOI	Discussion of Timing of Potential Occurrence in AOI
Days Effort/ Sightings	43/57	68/28	136/461	101/66		
Fin whale	✗	✗	✗	Possible	Year Round*	New Zealand is one of the aggregation areas for fin whales (*Balaenoptera physalus*) in the southern hemisphere (Gambell, 1985). The location and season in which pairing and calving occurs is largely unknown because, unlike other large cetaceans, calving does not appear to take place in distinct inshore areas (Mackintosh, 1965; Reeves *et al.*, 2002; Jefferson *et al.*, 2008). Occurrence in the AOI is not well understood thus assumed to be year round.
Sei whale	✗	✓	✓	Possible	Year Round*	Around February and March sei whales (*Balaenoptera borealis*) migrate south to Antarctic feeding grounds and return to warmer waters to calve, passing through the Pacific Ocean to the east of New Zealand between the mainland and the Chatham Islands (Hutching, 2012a). However, occurrence in the AOI is not well understood thus assumed to be year round.
Sperm whale	✓	✓	✗	✓	Year Round	Resident male population of sperm whales (*Physeter macrocephalus*) occur in the waters surrounding Kaikoura, approximately 500km north of the AOI (Childerhouse, *et al.*, 1995.) The migration of the sperm whale is not as well understood. In some locations, there appears to be a seasonal migration pattern while in others, such as in tropical and temperate areas, there appears to be no obvious seasonal migration (NOAA, 2012i). It is possible for this species to occur in the AOI year round.
Southern right whale	✗	✗	✗	✓	Year Round*	Southern right whales (*Eubalaena australis*) generally inhabit waters at 20-60° latitude (Townsend, 1935) and are known to mate and calve during winter in sheltered harbours of the subantarctic Auckland Islands and Campbell Island (Baker *et al.*) The summer feeding grounds of the Southern right whales are not well known, however their distribution is likely to be linked to the distribution of their main prey species (NOAA, 2012h). It is assumed this species occurs in the AOI year round.

Year of Survey	2006[1]	2007[2]	2008[3]	2011[4]	Timing of Potential Occurrence in AOI	Discussion of Timing of Potential Occurrence in AOI
Days Effort/ Sightings	43/57	68/28	136/461	101/66		
Dolphin						
Orca	✗	✓	✓	✗	Year Round*	Orcas (*Orcinus orca*) can be seen in virtually any marine region around the world however the distribution of this species increases significantly toward the higher latitudes and cooler waters of the north and south (Forney & Wade, 2006). The NZ orca population is thought to be made up of at least three subpopulations based on geographic distribution (North Island-only, South Island-only and North + South-Island subpopulations) (Visser, 2000). It is possible for this species to occur in the AOI year round.
Pilot whale	✓	✓	✗	✓	Year Round*	There is some overlap between the distributions of the two species of pilot whale, with both species occurring in NZ waters. However, generally speaking, the short finned species (*Globicephala macrorhynchus*) prefers the warmer waters of the north (thus not likely in the AOI), while the long finned species (*Globicephala melas*) prefers the cooler waters of the south (NOAA, 2012g). It is possible for this species to occur in the AOI year round.
Dusky dolphin	✗	✓	✓	✓	Year Round*	Dusky dolphins (*Lagenorhynchus obscurus*) are generally seen around most of the South Island this species has also been sighted occasionally at the Chatham Islands, and at the Auckland Islands and Campbell Island, about 600 kilometres south of the South Island. It is possible for this species to occur in the AOI year round.
Common dolphin	✓	✓	✗	✓	Year Round*	In New Zealand the distribution of the common dolphin (*Delphinus delphis*) encompasses most of the North Island, South Island, Stewart Island and Chatham Island coastlines, with dominance in the northern half of the North Island, East Cape, Cook Strait, Marlborough Sounds and northwest coast of the South Island (NABIS, 2013). It is possible for this species to occur in the AOI year round.

Year of Survey Days Effort/ Sightings	2006[1] 43/57	2007[2] 68/28	2008[3] 136/461	2011[4] 101/66	Timing of Potential Occurrence in AOI	Discussion of Timing of Potential Occurrence in AOI
Bottlenose dolphin	✗	✗	✗	✓	Year Round*	The coastal bottlenose dolphins (*Tursiops truncates*) are found in three regions: the eastern North Island from Doubtless Bay to Tauranga; the north of the South Island from Cloudy Bay to Westport; and Fiordland, where the biggest group is found in Doubtful Sound. For this reason the sighting of this species within the AOI is likely to have been a pelagic population transiting the area as opposed to a resident population frequenting it. Accordingly it is assumed this species may occur within the AOI year round.
Hector's dolphin	✗	✓	✗	✗	Year Round*	The Hector's dolphin (*Cephalorhynchus hectori*) is endemic to New Zealand and has one of the most restricted distributions of any cetacean (Dawson & Slooten, 1988; Dawson, 2002). This species is most commonly recorded off the South Island with a population estimated to include 7,270 individuals (Dawson *et al.*, 2004; Gormley *et al.*, 2005). Hector's dolphins are found in shallow coastal waters, less than 100m deep and generally within 15 km of the shore (NABIS, 2013).
Unidentified Marine Mammal						
Unidentified marine mammal	✗	✓	✓	✗	Not Applicable	
Marine Mammals not identified during Seismic Surveys, but potentially occurring within the AOI						
Southern elephant seal	Not Applicable				Winter Months	Southern elephant seals (*Mirounga leonine*) range throughout the Southern Ocean around the Antarctic continent and on most subantarctic islands (DOC, 2012i). In winter, they frequently visit the Auckland, Antipodes and Snares Islands, less often the Chatham Islands and occasionally various mainland locations, from Stewart Island to the Bay of Islands (DOC, 2012i).

Year of Survey Days Effort/ Sightings	2006[1] 43/57	2007[2] 68/28	2008[3] 136/461	2011[4] 101/66	Timing of Potential Occurrence in AOI	Discussion of Timing of Potential Occurrence in AOI
New Zealand sea lion	Not Applicable				Year Round*	New Zealand sea lions (*Phocarctos hookeri*) have an annual distribution ranging from the southern coast of the South Island down and throughout the waters surrounding both the Auckland Islands and Campbell Island. NABIS shows the waters surrounding these islands and the coasts off the Caitlans and Dunedin as a hotspot for these species, with breeding colonies known along these coasts. It is assumed this species may occur within the AOI year round.
Humpback whale	Not Applicable				May to August while migrating north[3]	The annual migration typically sees humpback whales (*Megaptera novaenglia*) heading north along the east coast between May and August and south along the west coast between September and December (Gibbs & Childerhouse, 2000). Humpback whales are therefore most likely to occur within the AOI between May and August.
Dwarf minke whale	Not Applicable				Year Round*	Dwarf minke whales (*Balaenoptera acutorostrata*) are often mistaken for Antarctic minke whales, with most occurrences surrounding New Zealand based on strandings. Compared with Antactic minke whales, dwarf minke whales are much less common and occur more predominantly at higher latitudes (Reilly, 2008e). Dwarf minke whales prefer the more temperate waters and are seen off the New Zealand coast in and north of the Bay of Plenty (WWF, 2013b). This species is found in both coastal and offshore waters, with breeding known to occur in New Zealand (WWF 2013b). Although this species is known to prefer more temperate waters, there is the potential for dwarf minke whales to occur within the project area.

Year of Survey	2006[1]	2007[2]	2008[3]	2011[4]	Timing of Potential Occurrence in AOI	Discussion of Timing of Potential Occurrence in AOI
Days Effort/ Sightings	43/57	68/28	136/461	101/66		
False killer whale	Not Applicable				Year Round*	False killer whales (*Pseudorca crassidens*) are known to occur worldwide in deep, offshore tropical and warm temperate waters (Odell & McClune, 1999) but are occasionally sighted in cold temperate waters (Stacey and Baird, 1991). There is little known about the occurrence or distribution of this species in New Zealand waters, with only a few at-sea documented records (e.g., Visser *et al.*, 2010). However, it is known to occur around the South Island and Chatham Islands (Taylor *et al.*, 2008a). It is assumed this species may occur within the AOI year round.
Pygmy right whale	Not Applicable				Year Round*	The pygmy right whale (*Caperea marginata*) has a circumpolar distribution in temperate waters between 30°S and 55°S (Hoffmann & Best, 2005). This species is one of the least known baleen whales and there is little known about its abundance or distribution in New Zealand waters with only a few confirmed records of live whales at sea. Stranding's have been recorded on both the North and South Islands (Kemper, 2002a,b; Rice, 1998). It is assumed this species may occur within the AOI year round.
Pygmy sperm whale	Not Applicable				Year Round*	The pygmy sperm whale (*Kogia breviceps*) is found in deep tropical and warm temperate waters across all oceans (McAlpine, 2002). The specific range of this species is poorly known through a lack of records of live animals, most likely due to the species inconspicuous behaviour (Taylor *et al.*, 2012a). Within New Zealand, East Coast/Hawke Bay is a key area for this species, where stranding events are quite common (DOC, 2004). It is assumed this species may occur within the AOI year round.
Pygmy blue whale	Not Applicable				Year Round*	Pygmy blue whales (*Balaenoptera musculus brevicauda*) are listed as migrants within New Zealand waters (WWF, 2013b), occurring predominantly in the subantarctic zone of the Indian ocean between 0°E and 80°E (Cetacean Specialist Group 1996). The winter range for this species is virtually unknown, with scattered records from South Africa and Australia (Rice 1998). A beached Pygmy Blue whale was found at Motutapu Island, off the North Island, in 1994. Therefore, there is the possibility that this species may occur within the AOI.

Year of Survey Days Effort/ Sightings	2006[1] 43/57	2007[2] 68/28	2008[3] 136/461	2011[4] 101/66	Timing of Potential Occurrence in AOI	Discussion of Timing of Potential Occurrence in AOI
Southern right-whale dolphin	Not Applicable				Year Round*	The southern right-whale dolphin (*Lissodelphis peronii*) is a poorly known species, with an assumed distribution across the cool subantarctic waters of the Southern Hemisphere, between 30°S and 65°S (Hammond *et al.*, 2012b). Within New Zealand waters, southern right-whale dolphins are seen year-round around Chatham Island (approximately 850km from the AOI) (Stanley & Podzikowski, 2013). Southern right-whale dolphins are most often observed in cool, deep, offshore waters with temperatures of 1-20°C (Hammond *et al.*, 2012b), with only occasional sightings in near shore environments (Jefferson *et al.*, 1994; Rose & Payne 1991). It is assumed this species may occur within the AOI year round.
Arnoux's beaked whale	Not Applicable				Year Round*	Arnoux's beaked whales (*Berardius arnuxii*) are found in a circumpolar pattern in the southern Hemisphere from the Antarctic continent and ice edges (ca. 78°S) north to about 34°S in the South Pacific (Kasuya, 2002). Nowhere within this range are they very well known or considered common. This species generally occurs in deep, cold temperate and subpolar waters, especially in areas with steep-bottomed slopes beyond the continental shelf edge (Kasuya, 2002). They have been recorded within New Zealand waters around 37°S (Culik, 2010). There is potential that this species could occur within the AOI. It is assumed this species may occur within the AOI year round.
Shepherd's beaked whale	Not Applicable				Year Round*	This offshore species (*Tasmacetus shepherdi*) is associated with cooler waters from 33°S to 53°50'S (Van Waerebeek *et al.*, 2004). A number of strandings have occurred on New Zealand Shores (Mead, 1989a) and this species has a listed distribution covering the entire New Zealand coast (IUCN, 2008c). This species therefore could potentially occur within the AOI. It is assumed this species may occur within the AOI year round.
Southern bottlenose whale	Not Applicable				Year Round*	Southern bottlenose whales (*Hyperoodon planifrons*) have a circumpolar distribution in the southern Hemisphere, south of about 30°S (Mead, 1989b; Jefferson *et al.*, 1993). This species is most common beyond the continental shelf and over submarine canyons, in waters deeper than 1000 m (Taylor *et al.*, 2008d) This species could potentially occur within the AOI. It is assumed this species may occur within the AOI year round.

Year of Survey	2006[1]	2007[2]	2008[3]	2011[4]	Timing of Potential Occurrence in AOI	Discussion of Timing of Potential Occurrence in AOI
Days Effort/ Sightings	43/57	68/28	136/461	101/66		
Andrews' beaked whale	Not Applicable				Year Round*	To date, Andrews' beaked whale (*Mesoplodon bowdoini*) is known only from a few dozen stranding records between 32°S and 55°S; and most of these have come from the South Pacific and Indian oceans (well over half are from New Zealand – Mead, 1989c; Baker, 2001). Based on the concentration of stranding records in this area (Baker, 2001), the waters around New Zealand may represent an area of concentration for the species (Taylor *et al.*, 2008e). This species has the potential to occur within the AOI. It is assumed this species may occur within the AOI year round.
Gray's beaked whale	Not Applicable				Year Round*	Gray's beaked whales (*Mesoplodon grayi*) are a primarily southern hemishphere cool temperate species (Mead 1989c, MacLeod *et al.*, 2006) with most records south of 30°S. Strandings of this species have been recorded on New Zealand shores (Taylor *et al.*, 2008f) and the Chatham Islands have been suggested to be a "hot spot" for sightings of this species (Dalebout *et al.*, 2004). This species could potentially occur within the AOI. It is assumed this species may occur within the AOI year round.
Hector's beaked whale	Not Applicable				Year Round*	Hector's beaked whales (*Mesoplodon hectori*) are considered a Southern Hemisphere cool temperate species (Mead, 1989c) and may be relatively common around New Zealand, with a number of strandings recorded along the coasts. There has, however, been only one confirmed sighting of a live individual so their actual distribution is highly unknown. This species could potentially occur within the survey area as they are expected to occur in deep waters beyond the edge of the continental shelf (Taylor *et al.*, 2008g). It is assumed this species may occur within the AOI year round.
Strap-toothed whale	Not Applicable				Year Round*	Strap-toothed whales (*Mesoplodon layardii*) have a continuous distribution in cold temperate waters of the Southern Hemisphere, mostly between 35° and 60°S, with stranding records on New Zealand shores (MacLeod *et al.*, 2006). The seasonality of strandings suggests that this species may migrate (Taylor *et al.*, 2008h). This species appears to prefer deep oceanic waters of temperate (10–20 °C) to subantarctic (1–8 °C) regions (Pittman, 2002; Ross, 2006). This species, therefore, could potentially occur within the AOI. It is assumed this species may occur within the AOI year round.
Cuvier's beaked (goosebeak) whale	Not Applicable				Year Round*	Cuvier's beaked whales (*Ziphius cavirostris*) may have the most extensive range of any beaked whale species (Heyning, 1989, 2002). They are widely distributed in offshore waters of all oceans, from the tropics to the polar regions in both hemispheres. This species, therefore, could potentially occur within the AOI. It is assumed this species may occur within the AOI year round.

Year of Survey	2006[1]	2007[2]	2008[3]	2011[4]	Timing of Potential Occurrence in AOI	Discussion of Timing of Potential Occurrence in AOI
Days Effort/ Sightings	43/57	68/28	136/461	101/66		

1. Crown Minerals, 2006
2. Origin Energy, 2007
3. Exxon Mobil, April 2008
4. OMV, 2012
5. Gibbs and Childerhouse, 2000

Key:

✓ = Identified ✗ = Not Identified Possible = Identification not certain

* Timing is unknown and an assumption of year-round occurrence has been made.

New Zealand Fur Seal

The New Zealand fur seal (*Arctocephalus forsteri*) or Kekeno (Maori name) is one of the nine species of pinnipeds in the Otariidae family (eared seals) of which only two breed in NZ waters (*Figure 6.26*; Baird, 2011). The New Zealand fur seal are a non-migratory species and can be found in New Zealand, and south and Western Australia, typically below 40°S (Baird, 2011). Breeding colonies are found throughout New Zealand with the largest colonies found on the west and southern coasts of the South Island, and smaller colonies in the north (Mattlin, 1987). These seals can also be found on all of New Zealand's subantarctic islands and return to the same breeding colony each year to give birth to pups between mid-November and January (DOC, 2012f; NABIS, 2013). This species has been sighted within the region of the Project during each of the seismic surveys for which data was available (Origin Energy, 2007; OMV, 2011).

Figure 6.26: ***The New Zealand fur seal***
Source: www.scuba-equipment-usa.com

Sexually maturity of this species is reached around 4-6 years for females and 5-9 years for males, with a maximum age being recorded of a female at 22 years old and 15 years for a male (Mattlin, 1978; Mattlin, 1987, Dickie & Dawson, 2003). This species forages on a diverse range of sea animals including squid, octopus and several small fish species (Boren, 2010).

Once fully protected, due to a significant drop in population from sealing activities in the 1800's and further culling in the 1900's (Smith, 1989; Goldsworthy *et al.*, 2003), the International Union for Conservation of Nature (IUCN) now classifies the New Zealand fur seal as of least concern and the DOC Listing classifies them as not threatened. This is due to their increasing population which is now estimated at greater than 100 000 in New Zealand (Wilson, 1981; Suisted & Neale, 2004; pers. comms DoC). Threats to the species still exist such as entanglement in fishing gear and debris, drowning due to by-catch in trawl or set nets and the potential for indirect impacts from prey depletion due to intensive commercial harvesting of fish and squid (Chilvers, 2012).

Southern Elephant Seal

The southern elephant seal (*Mirounga leonine*), also known as ihupuku or ihu koropuka (Maori name), is a member of the Phocidae family. Southern elephant seals range throughout the Southern Ocean around the Antarctic continent and on most subantarctic islands (DOC, 2012i). In winter, they frequently visit the Auckland, Antipodes and Snares Islands, less often the Chatham Islands and occasionally various mainland locations, from Stewart Island to the Bay of Islands (DOC, 2012i).

Globally, the southern elephant seal has four distinct population stocks and breeding colonies; the Peninsula Valdes stock in Argentina, the South Georgia stock in the South Atlantic Ocean, the Kerguelen stock in the south Indian Ocean and the Macquarie stock in the southern Pacific Ocean (McMahon *et al.*, 2003).

Figure 6.27 ***Southern elephant seal***
Source : http://www.teara.govt.nz

Elephant seals are wide-ranging, pelagic, deep-diving (average of 400–600 m) predators that typically travel to open waters and continental shelf edges thousands of kilometres from their land breeding colonies (Campanga *et al.*, 2007). This species was not sighted within the region of the Project during the seismic surveys for which data was available, however as their occurrence is possible, they have been included in this MMIA.

Sexually maturity of males is reached around 3-6 years, but few breed before they are 10 years old, as only the largest two or three males breed in a given year. Females are sexually mature at 2-4 years old and may then give birth annually for 12 years. Many males will never breed with 90% dying before reaching sexual maturity.

The southern elephant seal is listed as Nationally Critical under DOC (DOC, 2005), and of least concern under the IUCN (IUCN, 2013) red list.

New Zealand Sea Lion

New Zealand sea lions (*Phocarctos hookeri*), also known as Whakahao (male) or Kaki (female) (Maori name) are an endemic species, with an annual distribution ranging from the southern coast of the South Island down and throughout the waters surrounding both the Auckland Islands and Campbell Islands. NABIS shows the waters surrounding these islands and the coasts off the Catlins and Dunedin as a hotspot for these species, with breeding populations occurring along the Otago coast and on Auckland and Campbell Islands (DOC, 2012j).

Figure 6.28 **_New Zealand sea lion_**

Source : ***www.biopix.com***

Female New Zealand sea lions can travel up to 175kms from the coast to feed, diving to depth of up to 700m although most dives are only up to 200m in depth (DOC, 2012j). This species was not sighted within the region of the Project during each of the seismic surveys for which data was available, however as their occurrence is possible, they have been included in this MMIA.

Females reach maturity from 3 years of age, with a life expectancy of up to 21 years (DOC, 2012j). The New Zealand sea lion is listed as Range Restricted under DOC (DOC, 2005) and as Vulnerable under the IUCN (IUCN, 2013) Red List.

Humpback Whales

The humpback whale (*Megaptera novaeangliae;*) is a species of baleen whale – a member of the Mysticeti suborder and the Cetcea order (*Figure 6.29*). Baleen whales are named due to the plates of baleen suspended from the roof of their mouths which determine their feeding method of filtering small fish and krill from the water column.

Figure 6.29: The humpback whale
Source: Red Orbit (2012)

Internationally, the population can be divided into distinct populations split across the northern and southern hemisphere and, due to the seasonal timing of their migrations, the northern and southern populations rarely mix (Searle, 2012; *Figure 6.30*). The southern hemisphere humpback whales breed in subtropical or tropical waters to the north during the winter and feed in Antarctic waters during the summer (Gibbs & Childerhouse, 2000). Antarctic waters host six distinct populations, of which those found in New Zealand waters are thought to belong to Group V (Gibbs & Childerhouse, 2000; Constantine, 2007). The migration north of Group V is not well understood, although tagging, whale fluke ID as well as genetic and song analysis data, provide evidence of these animals migrating to Tonga, Norfolk Island, East Australia, Fiji and New Caledonia (Chittleborough, 1959; Dawbin, 1964; Donoghue, 1994; Constantine *et al.*, 2007).

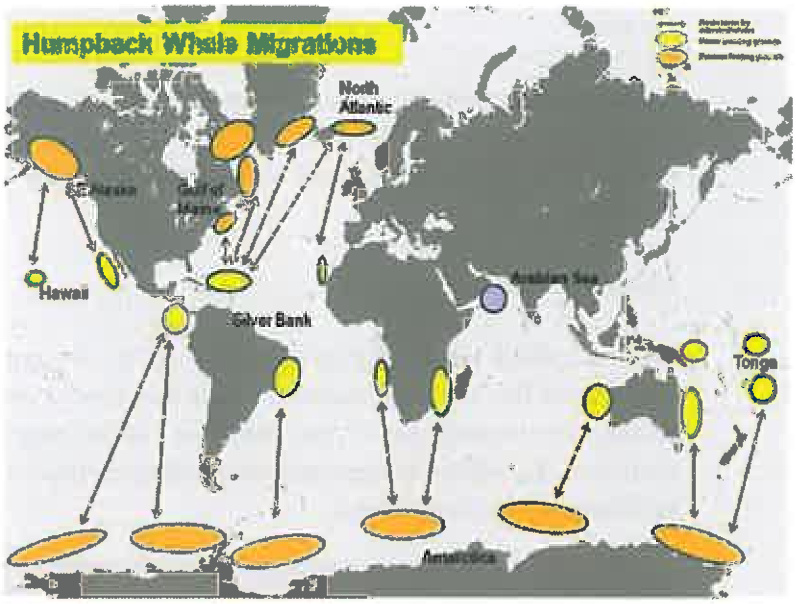

Figure 6.30: ***Annual migration of humpback whales***
Source: www.hwrf-uk.org/About-humpback-whales.html.

The annual migration typically sees humpback whales heading north between May and August and south between September and December (Gibbs & Childerhouse, 2000). While sightings have been recorded along both the east and west coasts of New Zealand, humpbacks are thought to migrate south along the west coast and north along the east coast, thus are most likely to occur within the AOI between May and August (Gibbs & Childerhouse, 2000) (*Figure 6.31*). Both the northern and southern migrations follow the same pattern of a gradual increase in the numbers of whales passing through NZ waters, with a peak near the middle of the season. During the migration lactating females and yearlings are seen early in the season, followed by immature whales, then mature males and females, and late in the spring pregnant females (Gibbs & Childerhouse, 2000). This species was not sighted within the region of the Project during each of the seismic surveys for which data was available, however as their occurrence is expected during their migration season, they have been included in this MMIA.

Humpback whales were almost hunted to extinction through intensive whaling activities throughout the 20th Century. It is thought that population V in Antarctic waters was reduced from a population of 10 000 to as little as 250-500 by the 1960's (Chittleborough, 1965). However, since being provided total protection by the International Whaling Commission (IWC) in 1966 the humpback whale population has recovered from an IUCN status of endangered to least concern today (Reilly *et al.*, 2008a).

Source:
© 2013. www.teara.govt.nz/en/whales/1/1

Client:	Shell Limited		
Drawing No:	0209914s_GSB2ESHIA_G006_R1.mxd		
Date:	14/10/2013	Drawing Size:	A4
Drawn By:	DR	Reviewed By:	MF

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Figure 6.31 - Humpback Whale Migration Through New Zealand Waters and Approximate Locations of Sperm, Bryde's and Southern Right Whales

Shell GSB II Carina 2D Seismic Survey
Environmental Impact Assessment

Environmental Resources Management ANZ

Auckland, Brisbane, Canberra, Christchurch, Hunter Valley, Melbourne, Perth, Port Macquarie, Sydney

ERM

Blue Whales

The blue whale (*Balaenoptera musculus*), is likely to be the largest animal to ever inhabit planet earth (Croll *et al.*, 2005; *Figure 6.32*). Like the humpback, the blue whale is part of the baleen suborder, and has four recognised subspecies being the northern blue whale (B. m. *musculus*), Antarctic or southern blue whale (B. m. *intermedia*), Indian Ocean blue whale (B. m. indica) and the pygmy blue whale (B. m. *brevicauda*) (Reilly et al., 2008b). Pygmy blue whales (B. m. *brevicauda*) are listed as migrants within New Zealand waters (WWF, 2013b), occurring predominantly in the subantarctic zone of the Indian ocean between 0°E and 80°E (Cetacean Specialist Group 1996). The winter range for this species is virtually unknown, with scattered records from South Africa and Australia (Rice 1998). They are a small number of records of these whales within Cook Strait (Museum of NZ, 1998). A beached Pygmy Blue whale was found at Motutapu Island, off the North Island, in 1994. Therefore, there is the possibility that this species may occur within the AOI.

Figure 6.32: ***The blue whale feeding***
Source: www.bbc.co.uk/nature/life/Blue_Whale

The IUCN Red List notes blue whales as endangered, verging on critically endangered (Reilly *et al.*, 2008b). Although the global population is uncertain, the IUCN estimate that it is likely in the range of 10 000 to 25 000 globally, thought to be between 3 % - 11 % of the estimated 1911 population (Reilly *et al.*, 2008b). The endangered status of this species is a direct result of commercial harvesting of this species throughout the 20th century. It is thought that throughout this period more than 360 000 individuals were killed by whaling fleets in the Antarctic alone, and that thousands more were killed by Soviet fleets after being protected, during the 1960s and 1970s (WWF, 2012).

The blue whale is distributed throughout all oceans with the exception of the Arctic and some regional areas such as the Mediterranean, Okhotsk and Bering Seas (Reilly *et al.*, 2008b). While considered a migratory species, the migratory patterns of this species are not well understood (Reilly *et al.*, 2008b). However they are considered to be diverse with some remaining resident year round where high oceanic productivity provides regular food source, while other populations migrate to high-latitude feeding grounds. While known from New Zealand waters, little is known about their movement. However, a foraging population of pygmy and possibly Antarctic blue whales is thought to exist off the Taranaki coast, possibly a result of an aggregation of zooplankton in the area (pers comms, Mike Patrick, 2012). This species has been sighted within the region of the Project during the more recent of the seismic surveys for which data was available (OMV, 2011).

Minke Whales

Globally, there are now two recognised species of minke whale being the common minke whale (*Balaenoptera acutorostrata*) and the Antarctic minke whale (*Balaenoptera bonaerensis; Figure 6.33*). Both of these species are baleen whales and are found in New Zealand waters. Occurring in both coastal and offshore waters, the minke whale opportunistically feeds on a variety of prey including krill, plankton, and small schooling fish such as anchovies (NOAA, 2012a).

Figure 6.33: ***The minke whale***
Source: http://blog.diversiondivetravel.com.au. Photographer: Rod Klein

Favouring temperate to boreal waters, the minke whale is most commonly found throughout the higher latitude oceans of the northern and southern hemispheres. The minke is a migratory species, yet the migrations vary with age, reproductive status and sex. Mature males and females will migrate to polar waters for the summer feeding season, yet the females will typically remain within coastal waters, while the males are typically found around the ice edge (NOAA, 2012a). The migratory patterns of minke whales, however, are poorly known (Reilly, 2008c). In the southern hemisphere minkes have been found as far south as 76 °S in the Ross Sea in the summer and as far north as 7 °S during the winter (Shirihai *et al.*, 2006) and a high abundance of minke whales was recorded in November between 10 °S - 30 °S in the central South Pacific and in much of the eastern and southern Indian Ocean down to 50 °S (Miyashita *et al.*, 1995). Due to this broad distribution, while not identified within the region of the Project during the seismic surveys for which data was available, there is still a possibility minke whales may occur within the area.

There is currently no estimate of total global population size, but regional estimates indicate that the species is well above the threatened species threshold (Reilly *et al.*, 2008c). As such it is currently classified as "least concern" by the IUCN Red List. Using IWC Revised Management Procedure, safe catch limits are set for this species in Norway and Greenland for subsistence communities. Additionally, Japan harvest up to 850 minke whales each year in Antarctic waters under their scientific whaling permit.

Dwarf minke whales

Dwarf minke whales (*Balaenoptera acutorostrata*) are often mistaken for Antarctic minke whales, with most recordings surrounding New Zealand based on strandings. Compared with Antarctic minke whales (see above), dwarf minke whales are much less common and occur more predominantly at higher latitudes (Reilly, 2008e). Dwarf minke whales prefer the more temperate waters and are seen off the New Zealand coast in and north of the Bay of Plenty (WWF, 2013b). This species is found in both coastal and offshore waters, with breeding known to occur in New Zealand (WWF, 2013b). Although this species is known to prefer more temperate waters, there is the potential for dwarf minke whales to occur within the AOI. This species was not sighted within the region of the Project during each of the seismic surveys for which data was available. However, the species is known to occur around the North Island and Antarctic waters (WWF, 2013b; Reilly, 2008e) and therefore their occurrence is possible, they have been included in this MMIA.

Figure 6.34 ***Dwarf minke whale***
Source: forum.uw3some.com-

Fin Whales

Fin whales (*Balaenoptera physalus*) are baleen whales of which two subspecies recognised. In the northern hemisphere exists the subspecies *B. p. physalus* while in the southern hemisphere exists the subspecies *B. p. quoyi* (Rice, 1998). Living up to 100 years, fin whales filter feed, consuming planktonic crustacean, some fish and cephalopods. In Antarctic waters, fin whales feed primarily on krill (*Euphausia superba*) (Nemoto, 1970).

Figure 6.35: ***The fin whale***
Source: http://www.oceanlight.com, Photographer Philip Colla

Fin whales can be found worldwide, staying in offshore waters. They show well defined migratory movements between polar, temperate and tropical waters (Mackintosh, 1965). In the southern hemisphere, fin whales enter Antarctic waters however, the bulk of the fin whale summer distribution is in middle latitudes, mainly 40°S-60°S in the southern Indian and South Atlantic oceans, and 50°-65°S in the South Pacific (Miyashita *et al.*, 1996, IWC, 2006). New Zealand is one of the aggregation areas for fin whales in the southern hemisphere (Gambell, 1985). The location and season in which pairing and calving occurs remain largely unknown (Mackintosh, 1965) because, unlike other large cetaceans, calving does not appear to take place in distinct inshore areas (Reeves *et al.*, 2002; Jefferson *et al.*, 2008).

Due to significant population reduction (more than 70%), the IUCN Red List lists the fin whale as endangered. Most fin whale populations were severely depleted by modern whaling from the early 1900's until their protection in 1975 (DEH, 2005).

Sei Whales

Sei whales (*Balaenoptera borealis*) are baleen whales of which two subspecies are recognised. In the northern hemisphere exists the subspecies *B. b. borealis* while in the southern hemisphere exist the subspecies *B. b. schlegellii* (Reilly *et al.*, 2008d; *Figure 6.36*). Living for between 50-70 years, sei whales filter feed, consuming copepods, krill, squid and small schooling fish (NOAA, 2012b).

Figure 6.36: ***The sei whale***
Source: www.arkive.org Photographer: Gerard Soury

Sei whales can be found worldwide staying mainly in water temperatures of 8 °C to 18 °C. In the southern hemisphere, sei whales migrate south to Antarctic feeding grounds in the summer months, they return to warmer waters to calve, migrating back up between New Zealand and the Chatham Islands (Hutching, 2009). Important areas for baleen whales include waters off Kaikoura, Cook Strait, and off the west coast of the South Island when baleen whales migrate between their feeding and breeding grounds (May-July and November-December) (Baker *et al.*, 2009). This species was positively identified within the region of the AOI during the first of the seismic surveys for which data was available, and was possibly sighted during the second (Origin Energy, 2007; OMV, 2011).

Due to a significant population reduction (up to 80%), the IUCN Red List lists the sei whale as endangered. From the late 1950s to mid-1970s sei whale stocks were seriously depleted, particularly in the southern hemisphere, where it is estimated that 200 000 sei whales were harvested during the 1905-1979 period (Reilly *et al.*, 2008d).

Sperm Whales

The sperm whale (*Physeter macrocephalus*) is a species of the toothed whale (Odontoceti) (*Figure 6.37*). This species targets larger prey than the baleen whales, occurring in deep waters due to its capability to dive to depths of over 1000 m, for up to 60 minutes at a time and preying upon large squid, sharks, skates and fishes (NOAA, 2012c, Hutchings, 2012b).

Figure 6.37: ***The sperm whale***
Source: http://www.flickr.com/photos/barathieu/7991520863/

Sperm whales are found throughout the oceans between about 60 °N and 60 °S latitudes (NOAA, 2012c). Within the region of Australasia, the sperm whale is distributed mainly off the coast of Kaikoura (Larivière, 2001), east coast South Island, north of the Project, as well as northeast off the top of the North Island (*Figure 6.31*). This distribution is a result of their predominant feeding habitat being deepwater, with the Kermadec trench in the north and the Kaikoura canyon in the south.

The migration of sperm whales is not as well understood as many other whale species. In some locations, there appears to be a seasonal migration pattern while in others, such as in tropical and temperate areas, there appears to be no obvious seasonal migration (NOAA, 2012c). Within the Kaikoura region, probably due to high productivity and therefore prey availability, sperm whales congregate year round (Childerhouse *et al.*, 1995; Jaquet *et al.*, 2000). However, there are localised seasonal shifts in distribution, from congregations in the deeper waters across the summer and to a more evenly spread out distribution across the winter (Jaquet *et al.*, 2000). Sperm whales were identified during both of the seismic surveys for which data is available (Origin Energy, 2007; OMV, 2011).

Listed by the IUCN as vulnerable, historically sperm whales were one of the most heavily exploited or commercially whaled whales. As a result of commercial harvesting, sperm whales were reduced from an estimated population of 1.1 million globally to today's population of around 100 000 (Taylor *et al.*, 2008i).

Southern Right Whales

The southern right whale (*Eubalaena australis*) is one of three baleen whale species classified as right whales (*Figure 6.38*). The female of this species is typically sexually active around eight years of age, generally calving every three years (DOC, 2012h).

Figure 6.38: ***The southern right whale***
Source: http://seawayblog.blogspot.com.au/2008/11/close-encounters-of-whale-kind.html

In the 18th and 19th centuries, the southern right whale was hunted to near extinction (Reilly *et al.*, 2013). While there is uncertainty around the number of whales that were killed yet not recovered during this time, the number of this species processed between 1770 and 1900 is conservatively estimated at 150 000 (Reilly *et al.*, 2013). It is estimated that the hemispheric population was reduced to around 300 by the 1920's as a result of this intensive commercial harvest (Reilly *et al.*, 2013). Previously classified as vulnerable, today this species is listed by IUCN as least concern due to evidence of strong population recovery (Reilly *et al.*, 2013). This recovery is particularly evident in some regions such as Australia that has shown 6.79% increase annually, while there is insufficient data on other regional populations to provide accurate conclusions (Reilly *et al.*, 2013; SEWPaC, 2012).

This species has a circumpolar distribution typically between 20°S and 55°S (DOC, 2012h). Migrating seasonally between higher latitudes and mid-latitudes the major calving grounds of the southern right whale is in near-shore waters (DOC, 2012h). The summer feeding grounds of the southern right whales are not well known, however their distribution is likely to be linked to the distribution of their main prey species (NOAA, 2012). Historical whaling records suggest summer feeding grounds off the Chatham Rise to the north of the AOI, however today most sightings occur among the subantarctic Islands, in particular the Auckland Islands (Patenaude, 2003), where southern right whales mate and calve during winter in sheltered harbours of both Auckland Islands and Campbell Island (Baker *et al.*, 2009). This species was identified within the region of the AOI during the second of the seismic surveys from which data is available (OMV, 2011).

Orca

The orca (*Orcinus orca*), also known as the killer whale, is the largest of the dolphin (Delphinidae) family (*Figure 6.39*). Female orca first reproduce between the age of approximately 11 and 16, and continue to reproduce around every 5 years for the remainder of their ~25 year reproductive lifespan (DOC, 2012c). They live until around 80 to 90 years of age. Males reach maturity around 21, and live to only 50 or 60 years of age (DOC, 2012c).

Figure 6.39: The orca

Source: http://www.dominiontours.com/galeria/index.php/Animales-Oeste-de-Canada/Orca-Greeting-by-Christina-Craft

Orca can be found in virtually any marine region around the world however the distribution of this species increases significantly toward the higher latitudes and cooler waters of the north and south (Forney & Wade, 2006). This species has a diverse diet including fish species (such as seals, salmon, tuna, herring, cod) sharks, stingrays, squid, octopus, sea birds and sea turtles (DOC, 2012c).

Globally, the species is considered to have four types or forms, which consequently result in their being classified as data deficient by the IUCN Red List (Taylor *et al.*, 2013). In New Zealand, the resident population is estimated at only 117, all of which are considered Type A (common form globally). The New Zealand orca population is thought to be made up of at least three subpopulations based on geographic distribution (North Island only, South Island only and North & South-Island subpopulations) (Visser, 2000). While globally the Type A population is considered stable, nationally they are classified as nationally critical (Baker *et al.*, 2009). Type B, C and D individuals have also been recorded (all considered vagrant) in New Zealand waters (Baker *et al.*, 2009). While global populations are uncertain, there is a general consensus that it is a minimum of 50 000 globally, with the majority of this population in Antarctica (Taylor *et al.*, 2013). This species was identified within the region of the AOI during the first of the seismic surveys from which data is available (Origin Energy, 2007).

False Killer Whales

False killer whales (*Pseudorca crassidens*) are found in tropical and warm temperate zones, generally in in deep offshore waters of all major oceans (Taylor *et al*, 2008a) in latitudes below 50°S. This species was not sighted within the region of the Project during each of the seismic surveys for which data was available. However, the species is known to occur around the South Island and Chatham Islands (Taylor *et al.*, 2008a). As their occurrence is possible, they have been included in this MMIA.

Figure 6.40: The false killer whale
Source: http://www.arkive.org/false-killer-whale/pseudorca-crassidens/image-G35219.html

Although this species is known to eat primarily fish and cephalopods, they have also been recorded attacking small cetaceans, humpback whales and sperm whales (Taylor *et al.*, 2008a). False killer whales are listed as 'data deficient' under the IUCN red list (IUCN, 2013) and as 'not threatened' by DOC (DOC, 2005). This species was not sighted within the region of the Project during each of the seismic surveys for which data was available, however as their occurrence is possible, they have been included in this MMIA.

Pilot Whales

Two species of pilot whales occur in New Zealand waters being the long-finned pilot whale (*Globicephala melas; Figure 6.41*) and the short-finned pilot whale (*Globicephala macrorhynchus;*). There are physical differences between the species, yet in some areas, where their distributions overlap, such as New Zealand, they can be indistinguishable at sea (NOAA, 2012d). Pilot whales eat mostly squid, but they also eat octopus, cuttlefish, herring, and other small fish (Bernard & Riley, 1999).

Figure 6.41: ***The long-finned pilot whale***
Source: http://life-sea.blogspot.com.au/2012/05/long-finned-pilot-whale.html

There is some overlap between the distributions of the two species of pilot whale, with both species occurring in New Zealand waters. However, generally speaking, the short finned species prefers the warmer waters of the north (thus not likely in the AOI), while the long finned species prefers the cooler waters of the south (see *Figure 6.42* and *Figure 6.43*).

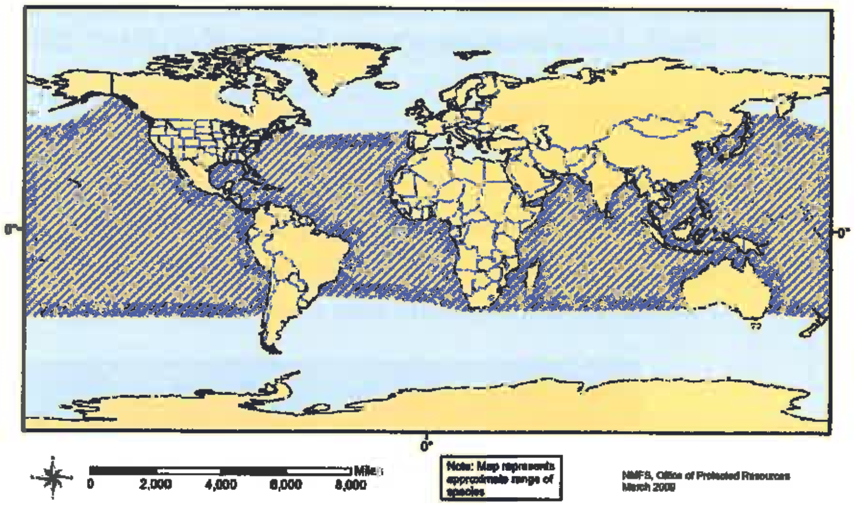

Figure 6.42: ***The global distribution of the short-finned pilot whale***
Source: http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/pilotwhale_shortfinned.htm

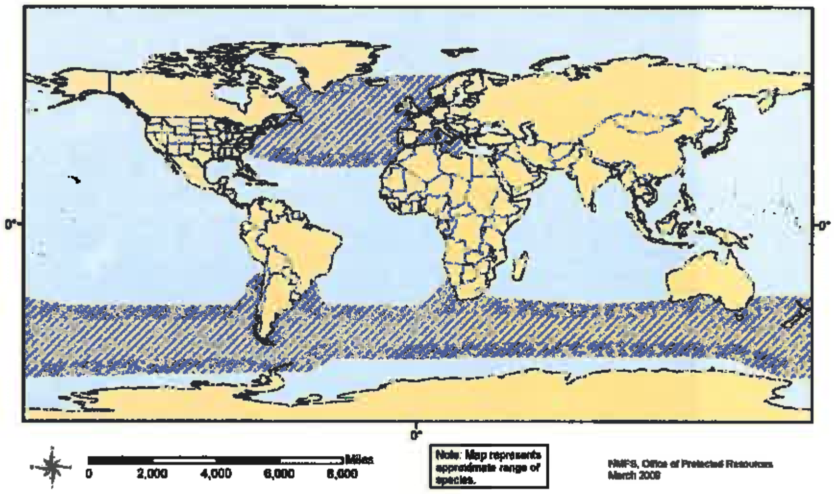

Figure 6.43: ***The global distribution of the long-finned pilot whale range***
Source: http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/pilotwhale_longfinned.htm

The IUCN Red List classifies both species of pilot whale as data deficient, however there global estimated population of around 750 000 (Taylor *et al.*, 2011). In New Zealand this species is know well for its tendency to strand, with mass stranding's occurring in some areas of New Zealand including Northland, Golden Bay, Stewart Island and the Chatham Islands (Brabyn, 1991). Pilot whales were identified during both of the seismic surveys for which data is available (Origin Energy, 2007; OMV, 2011).

Pygmy Right Whales

The pygmy right whale (*Caperea marginata*) has a circumpolar distribution in temperate waters between 30°S and 55°S (Hoffmann & Best 2005). This species is one of the least known baleen whales and is poorly understood in New Zealand waters with only a few confirmed records of live whales at sea.

Figure 6.44: ***The pygmy right whale***
Source: www.marinespecies.org

Strandings of pygmy right whales have been recorded on both the North and South Islands (Kemper, 2002a,b; Rice, 1998). The population size for this species is unknown due to the lack of records. This species was not sighted within the region of the Project during each of the seismic surveys for which data was available, however as their occurrence is possible, they have been included in this MMIA.

The analysis of the stomach contents of three pygmy right whales revealed that this species mainly feeds on cephalopods (Ivashin 1972 and Sekiguchi *et al.*, 1992). This species is listed as data deficient under both DOC (DOC, 2005) and the IUCN Red List (IUCN, 2013).

Pygmy Sperm Whale

The pygmy sperm whale (*Kogia breviceps*) is found in deep tropical and warm temperate waters across all oceans (McAlpine, 2002). The specific range of this species is poorly known through a lack of records of live animals (Taylor *et al.*, 2012a). Within New Zealand, East Coast/Hawke Bay is a key area for this species, where stranding events are quite common (DOC, 2004). This species was not sighted within the region of the Project during the seismic surveys for which data was available, however as their occurrence is possible they have been included in this MMIA.

Figure 6.45: The pygmy sperm whale
Source: www.tumblr.com

Pygmy sperm whales are the most common species stranded on New Zealand coastlines with 242 individuals stranded between 1978 and 2004 (Hutching, 2012a). Pygmy sperm whales feed in deep water on cephalopods, deep-sea fishes and shrimps (Santos & Haimovici, 2001; McAlpine *et al.*, 1997).

This species is listed as 'data deficient'; under both the IUCN Red List and by DOC (DOC, 2005).

Beaked Whales

There are twenty six species of beaked whale, with at least twelve of these known to occur in New Zealand waters (WWF, 2013a) and eight listed as species of concern. These include;

- Arnoux's beaked whale;
- Shepherd's beaked whale;
- Southern bottlenose whale;
- Andrews' beaked whale;
- Gray's beaked whale;
- Hector's beaked whale;
- Strap-toothed whale; and
- Cuvier's beaked (goosebeak) whale.

Many of these species occur within the Great South Basin, and therefore could possibly occur within the AOI. Beaked whales, in general, are ellusive and poorly known, making their distributions, migrations and behaviours difficult to learn and track. The presence of beaked whales is generally determined by stranding records within the area, with the majority of New Zealand strandings occurring within the Bay of Plenty, Chatham Islands and some subantarctic islands (WWF, 2013a). *Figure 6.46* shows an example of a beaked whale – the Curvier's Beaked Whale.

Figure 6.46 ***The Curvier's beaked whale***
Source: www.cascadiaresearch.org

Dusky Dolphin

The dusky dolphin (*Lagenorhynchus obscurus*) has three subspecies, the South American dusky dolphin (*L. obscurus fitzroyi*), Indian Ocean dusky dolphin (*L. obscurus obscurus*) and an unnamed New Zealand dusky dolphin (Hammond *et al.*, 2012a; *Figure 6.47*). Calving between November to around mid-January, the dusky dolphin has a lifespan of around 30 years (DOC, 2012k).

Figure 6.47: ***The dusky dolphin***
Source: http://www.mota.ru/en/wallpapers/source/id/23116

DOC has classified the dusky dolphin to be non-threatened in New Zealand, with an estimated national population of between 12 000 and 20 000 throughout NZ waters (DOC, 2012k). However, the IUCN Red List classifies this species as data deficient (Hammond *et al.*, 2008a). With a widespread distribution in the southern hemisphere, the main New Zealand populations occur in Kaikoura and the Marlborough Sounds (DOC, 2012k). While the National Aquatic Biodiversity Information System (NABIS) does not include the AOI as part of the dusky dolphin's distribution, they were sighted on both of the seismic surveys in the area for which data is available (Origin Energy, 2007; OMV, 2011).

Common Dolphin

Globally, the common dolphin is split into two species, the long-beaked (*Delphinus delphis*) and short beaked (*Delphinus capensis*) (*Figure 6.48*). Short-beaked common dolphins are found in waters throughout New Zealand and Australia. Living until around 35 years of age, the common dolphin is sexually mature between 3 and 12 and calves every 1 to 3 years (NOAA, 2012e). Typically calving occurs every year among the wider population with the 10 -11 month gestation typically beginning around June to September (NOAA, 2012e).

Figure 6.48: ***The common dolphin***
Source: http://life-sea.blogspot.com.au/2011_08_01_archive.html

The common dolphin is a highly abundant species with nearly 3 million in the Pacific region alone (Hammond *et al.*, 2008b). As such, this species is listed as 'least concern' by the IUCN Red List and in New Zealand they are not considered to have any conservation or management issues (Hammond *et al.*, 2008b; Suisted & Neale, 2004). Their distribution is broad, reaching the majority of global waters between temperatures of 10°C and 28°C. In New Zealand their distribution encompasses most of the North Island, South Island, Stewart Island and Chatham Island coastlines, with dominance in the northern half of the North Island, East Cape, Cook Strait, Marlborough Sounds and northwest coast of the South Island (NABIS, 2012). While NABIS does not include the AOI within the distribution of this species, they were sighted on both of the seismic surveys in the area for which data is available (Origin Energy, 2007; OMV, 2011).

Bottlenose Dolphin

The bottlenose dolphin (*Tursiops truncates*), one of the most widely recognised species of dolphin, has two subspecies within New Zealand, being the indo-pacific bottlenose dolphin (*Tursiops aduncus*) and the common bottlenose dolphin (*Tursiops truncatus*) (Hammond *et al.*, 2012c; NOAA, 2012f; *Figure 6.49*). The bottlenose dolphin may be split into more species in the future, with morphological, ecological and genetic variation within the North Atlantic region alone (Mead & Potter, 1995; Le Duc & Curry, 1997; Hoelzel *et al.*, 1998; Reeves *et al.*, 2003). This species lives for 40 to 50 years, reaching sexual maturity ranging from 5 to 14 years of age (NOAA, 2012f). Calving occurs around every 3 to 6 years in this species, peaking in New Zealand between spring and summer/autumn months (DOC, 2012b).

Figure 6.49: ***The bottlenose dolphin***
Source: http://www.coral.org/_403

Globally, the bottlenose dolphin is distributed throughout most tropical and temperate inshore, coastal, shelf and oceanic waters (*Figure 6.50;* Leatherwood and Reeves 1990, Wells & Scott 1999, Reynolds *et al.*, 2000). In New Zealand this species is found among three main populations. Populations are known off the east coast of the North Island (ranging from Doubtless Bay in the north to Tauranga in the south), in the Doubtless Sound in Fiordland, and another group ranges from Marlborough Sounds to Westport. However the range of this species may extend beyond these population centres and into the AOI. This is evident by the identification of bottlenose dolphin during one of the seismic surveys for which data is available, however based on the above information from DOC, this is likely to be a relatively rare occurrence (OMV, 2011).

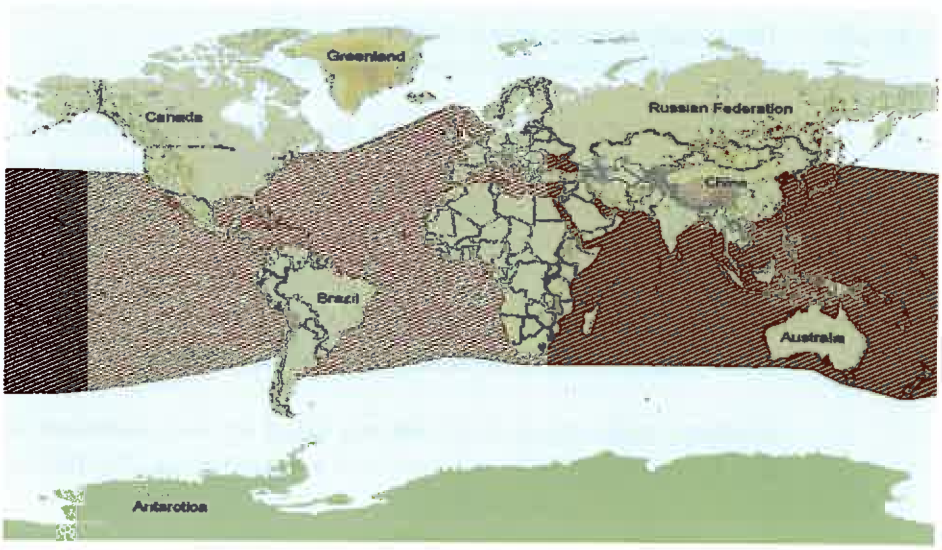

Figure 6.50: ***Global distribution of bottlenose dolphins***
Source: IUCN Red List

The IUCN Red List classifies this species as least concern due to their global estimated minimum population of 600 000 (Hammond *et al.*, 2012c). In New Zealand the species is considered not threatened, albeit subject to increasing pressure from tourism (Suisted & Neale, 2004).

Southern Right-Whale Dolphin

The southern right-whale dolphin (*Lissodelphis peronii)* is a poorly known species, with an assumed distribution across the cool subantarctic waters of the Southern Hemisphere, between 30°S and 65°S (Taylor *et al.*, 2012b). Within New Zealand waters, southern right-whale dolphins are seen year-round around Chatham Island (approximately 850 km from the AOI) (Stanley & Podzikowski 2013).

Figure 6.51: The southern right-whale dolphin
Source: http://www.flickriver.com/photos/tags/lissodelphis/

Southern right-whale dolphins are most often observed in cool, deep, offshore waters with temperatures of 1 to 20°C (Taylor *et al.*, 2012b), with only occasional sightings in near shore environments (Jefferson *et al.*, 1994; Rose & Payne, 1991). This species feeds primarily on squid and fish (Jefferson *et al.*, 1994). This species was not sighted within the region of the Project during the seismic surveys for which data was available, however as their occurrence is possible, they have been included in this MMIA.

Southern right-whale dolphins are listed as 'data deficient' under the IUCN Red List (IUCN, 2013) and as 'not threatened' under by DOC (DOC, 2005).

Hector's Dolphin

The Hector's dolphin (*Cephalorhynchus hectori*) is endemic to New Zealand and has one of the most restricted distributions of any cetacean (Dawson & Slooten, 1988; Dawson, 2002). This species is most commonly recorded off the South Island and the west coast of the North Island. DNA studies on this species identified that the South Island Hector's dolphin is genetically distinct from the North Island sub-species, known as Maui's dolphin. According to Dawson *et al.* (2001), differences over such a small geographic scale have not been observed in any other marine mammal. The population in the South Island is estimated at around 7270 individuals (Dawson *et al.*, 2004; Gormley *et al.*, 2005).

Figure 6.52: The ***Hector's dolphin***
Source: http://cetaceans.tumblr.com/post/2312279606/whale-of-the-day

Hector's dolphins are found in shallow coastal waters, less than 100 m deep and generally within 15 km of the shore. This species feeds on small fish and squid (Dawson, 2002).

Hector's dolphins are listed as 'endangered' under the IUCN Red List (IUCN, 2013) and as 'nationally endangered' by DOC (DOC, 2005).

6.3.6 Sharks

According to the NABIS database nine different species of shark have with distributions that include the AOI. All of these species aside from the great white shark (*Carcharodon carcharias*) are classified as not threatened in the DOC Listing. However, the IUCN Red List categorises two of these as least concern, two as near threatened with the remainder being classified as vulnerable. Below, *Table 6.9* displays the nine shark species and associated listings with DOC and IUCN.

Table 6.9: ***Nine shark species with distributions including the AOI as listed in NABIS***

Common Name	Scientific Name	New Zealand Threat Classification System Listing	IUCN Red List Listing
Blue shark	*Prionace glauca*	Not Listed	Near threatened
Mako shark	*Isurus oxyrinchus*	Not threatened	Vulnerable
Pale ghost shark	*Hydrolagus bemisi*	Not threatened	Least concern
Porebeagle shark	*Lamna nasus*	Not threatened	Vulnerable
School shark	*Galeorhinus galeus*	Not threatened	Vulnerable
Seal shark	*Dalatias licha*	Not threatened	Near threatened
Thresher shark	*Alopias vulpinus*	Not threatened	Vulnerable
Great white	*Carcharodon carcharias*	Gradual decline	Vulnerable
Shovelnose dogfish	*Deania calcea*	Not threatened	Least concern

Great White Shark

The great white shark (*Carcharodon carcharias*) is listed as under threat in the DOC Listing and is fully protected under the Wildlife Act 1953 (*Figure 6.53*). Internationally this species is listed in Appendix I and II of the Convention on Migratory Species (CMS) and Appendix II of the International Convention on Trade in Endangered Species (CITES).

Figure 6.53: ***The great white shark***
Source: http://www.elasmodiver.com

Great white sharks in New Zealand have a wide distribution and are found from the northern limit of the EEZ down to Campbell Island located to the south of the AOI. This species is highly migratory with individuals having been tracked through tagging programmes as migrating from Stewart Island to New Caledonia in both 2009 and 2011 (NIWA, 2012c). In 2011 and 2012, 45 great white sharks were tagged with either acoustic or pop up tags off the northeast coast of Stewart Island. Many of these were found to migrate away from the area toward the end of June on long journeys of thousands of kilometres before returning to the same location between December and May (NIWA, 2012c). With long migratory patterns and a regular population in the southern area of the EEZ, it is possible that this species is found within the AOI at some stage throughout the year.

6.3.7 *Seabirds*

Introduction

With a total of 84 seabird species (96 different taxa) in New Zealand, of which 35 are endemic, New Zealand is home to the most diverse range of endemic seabirds in the world. Of the 96 taxa, a total of 47 are considered threatened under the new IUCN criteria (critical, endangered, or vulnerable) and four taxa are listed as 'data deficient' (DOC, 2001). New Zealand is also the breeding ground for the largest populations of albatross and petrels in the world, many of which forage a long way offshore (Robertson el at., 2003). Multiple species of seabirds have distributions that include the AOI (NABIS, 2013) and are discussed in greater detail below.

Petrels

The petrels comprise the seabird order Procellariiformes and include prions, shearwaters, storm petrels, diving petrels, albatrosses and several other groups (Wilson, 2012). New Zealand has a rich diversity of petrels. With the exception of albatrosses, which are addressed below, 41 species of the world's 97 petrels breed in the New Zealand region, and 14 of these only breed in New Zealand (Wilson, 2012).

Figure 6.54: Buller's shearwater
Source: http://nathistoc.bio.uci.edu/birds

According to the NABIS database, nine petrel species have distributions that include the AOI. While not exhaustive of all species potentially present within the AOI at any one time, *Table 6.10* outlines these nine species alongside their conservation status in New Zealand and globally.

Table 6.10: The petrel species (not including albatrosses) whose distribution include the AOI with key information

Petrel Species	2008 New Zealand Threat Classification System Listing[1]	IUCN Red List Listing	Estimated Global Population[2]
Bullers shearwater (*Puffinus bulleri*)	Naturally Uncommon	Vulnerable	2 500 000
Flesh-footed shearwater (*Puffinus carneipes*)	Declining	Least Concern	650 000
Sooty shearwater (*Puffinus griseus*)	Declining	Near Threatened	20 000 000
Northern giant petrel (*Macronectes halli*)	Naturally Uncommon	Least Concern	11 000 - 14 000
Westland petrel (*Procellaria westlandica*)	Naturally Uncommon	Vulnerable	16 000
White chinned petrel (*Procellaria aequinoctialis*)	Declining	Vulnerable	3 000 000
Kermadec white-faced storm-petrel (*Pelagodroma marina albiclunis*)	Threatened	***Not Yet Assessed***	
Grey petrel (*Procellaria cinerea*)	Declining	Near Threatened	160 000
Codfish island south georgian diving petrel (*Pelecanoides georgicus*)	Nationally Critical	Least Concern	15 000 000

1. Miskelly *et al.*, 2008
2. IUCN Red List, 2012

Albatross

Globally there are as many as 24 different species of albatross of which 14 are found in New Zealand (DOC, 2012a; *Figure 6.55*). NABIS includes a total of nine albatross species as having an annual distribution that includes the AOI. Albatross, sometimes referred to as mollymawks, are from the Diomedeidae family and the Procellariiformes order. Albatross spend a large portion of their life at sea, foraging on fish, squid, krill, and barnacles (IUCN, 2012). Current threats to albatross species include disease, marine debris, and habitat degradation due to severe storm events. Often with exposed and specific breeding locations, such storm events can significantly threaten their reproductive capability at least in the short term (DOC, 2001).

Below, *Table 6.11* provides a list of the nine albatross species with distributions including the AOI, as well as the associated DOC and IUCN listings and some key life history information for each.

Figure 6.55: The Gibson's albatross
Source: Lane, A. 2013

Table 6.11: The Albatross species whose distribution listed in NABIS includes the AOI with key information

Albatross Species with a Distribution that Includes the AOI[1]	DOC Listing[2]	IUCN Red List Listing[3]	Average Maturity Age[4]	Adult Survival Average[4]	Estimated NZ Population[4]	Reproductive Frequency (per year)[4]
• Antipodean albatross (*Diomedea antipodensis*).	Naturally uncommon	Vulnerable	9	95.4	5186	0.5
• Gibson's albatross (*Diomedea antipodensis gibsoni*)	Nationally vulnerable	n/a	9	97	7417	0.5
• Campbell albatross (*Thalassarche impavida*)	Naturally uncommon	Vulnerable	10	94.5	21000	1
• Chatham albatross (*Thalassarche eremita*)	Naturally uncommon	Vulnerable	7.5	94	4575	1
• Grey headed albatross (*Thalassarche chrysostoma*)	Nationally critical	Vulnerable	10	95	7803	0.5
• Light-mantled sooty albatross (*Phoebetria palpebrata*)	Declining	Near threatened	7	97.3	6818	1
• Northern royal albatross (*Diomedea sanfordi*)	Naturally uncommon	Endangered	9	94.6	6293	0.5
• Salvins albatross (*Thalassarche salvini*)	Migrant	Vulnerable	7.5	94	31962	1
• Southern royal albatross (*Diomedia epomophora epomophora*)	Naturally uncommon	Vulnerable	9	97	8484	0.5

1. MPI, 2012
2. Miskelly *et al.*, 2008
3. IUCN Red List, 2012
4. DOC, 2005

Yellow-eyed penguin

The yellow-eyed penguin (*Megadyptes antipodes)*, known to Maori as Hoiho, is endemic to New Zealand, and is one of the rarest of the New Zealand penguins. They live and breed around the south-east coast of the South Island, on Stewart Island and in the subantarctic Auckland and Campbell islands. The most distinguishing feature of this species is its distinctive yellow eye and bright yellow stripe that runs from the eyes around the back of the head (*Figure 6.56*).

Figure 6.56: Yellow-eyed penguin
Source: http://mesh.biology.washington.edu

Yellow-eyed penguins usually nest in a secluded site backed up to a bank, tree or log (MPI, 2013a). Nest sites are selected in August and normally two eggs are laid in September (MPI, 2013a). After the chicks are six weeks of age, both parents go to sea to supply food to their rapidly growing offspring until the chicks fledge around mid-February when they reach the full 5 and 6 kg (MPI, 2013a).

The population of yellow-eyed penguins is estimated to be 1780 to 2090 breeding pairs with over 1000 on the subantarctic Auckland and Campbell Islands, around 300 on the South Island and around another 500 on Stewart Island (McKinlay, 2001; *Figure 6.57*). A study into the foraging distance of this species found a mean travelling distance of 13 km from the breeding area, with a maximum of 57 km for the breeding area. The majority of the birds studied were found to be mid-shelf forages, typically located between 5 km and 16 km from the coast (Moore, 1999). With the population being centred on coastal areas it is unlikely that this species will be found within the AOI.

Figure 6.57: ***Distribution of the yellow-eyed penguin***
Source: yellow-eyed penguin.org.nz

Yellow-eyed penguins are listed on the DOC Listing as threatened and the on the IUCN Red List as endangered. Disease, predation and human interference from ecotourism and fishing activity (set or gill nets) are all considered threats to this species, particularly given the location of their breeding sites (McKinleay, 2001). Recently, yellow-eyed penguin adults were found dead on Otago Peninsula beaches and in breeding areas. By 15 February 2013, a total of 56 were found. The cause is still unknown.

Little Blue Penguin

The little blue penguin (*Eudyptula minor*) is also known as the blue penguin, fairy penguin, little penguin or Korora (Maori name) (DOC, 2012e; *Figure 6.58*). These penguins spend much of their time at sea hunting small fish, crustaceans and squid up to 25 km offshore and 70 km from their respective colonies (DOC, 2012e). Little blue penguins only come ashore at night and live underground in burrows, natural holes, or even under human structures (DOC, 2012e).

Figure 6.58: **Little blue penguins**
Source: www.indykids.net

Little blue penguins come ashore between May and June to breed, with usually two eggs being laid between August and November (DOC, 2012e). Left alone from around three weeks while their parents source food, chicks become completely independent after around eight weeks (DOC, 2012e). Within New Zealand, they are distributed around the entire coastline including the Chatham Islands. Globally, their distribution includes Australia with breeding populations found from near Perth, across the southern coast line and as far north on the east coast as the southern Solitary Islands (MarineBio, 2013). As this species is thought to venture a maximum of 75 km offshore, it is unlikely to be found within the AOI.

Considered to be of least concern by the IUCN due to their large range and population of around 1.2 million birds with 500 000 breeding pairs, they are listed as a nationally vulnerable bird on the DOC Listing. The greatest threat to little blue penguin populations has been predation (including nest predation) from cats, foxes, large reptiles, ferrets and stoats (DOC, 2012e).

6.3.8 *Marine Reptiles*

Seven species of marine reptiles are known to occur off New Zealand's coast. These include the loggerhead turtle (*Caretta caretta)*, the green turtle (*Chelonia mydas)*, the hawksbill turtle (*Eretmochelys imbricate)*, the olive-ridley turtle (*Lepidochelys olivacea)*, the leatherback turtle (*Dermochelys coriacea*) the yellow-bellied sea snake (*Pelamis platurus)*, and the banded sea snake (*Laticauda colubrine)*. With the exception of the leatherback turtle, marine reptiles are characteristically found in warm temperate seas, so most of New Zealand's marine reptiles are concentrated in the warm waters off the northeast coast of the North Island (WWF, 2010). However, marine reptiles are occasionally found on New Zealand shores with sightings of leatherback and green turtles recorded on Banks Peninsula (WWF, 2012b). It is considered unlikely that any marine reptiles would be encountered in the AOI.

6.3.9 *Species of Local Cultural Importance*

Introduction

While some of the above species are considered of local cultural importance, such as marine mammals, there are additional species that are of enough significance that they are also worthy of discussion. The following sub sections encompass those species.

Oyster

In the early 20th century the oyster trade in New Zealand was dominated by the Māori (MPI, 2005). Māori people were undertaking aquaculture activities in farming oysters prior to European settlement, in which they placed rocks into the intertidal zone of oyster larvae (Jeffs, 2003). Many species of shellfish, including oysters are regarded as treasures of the sea (tangaroa) by Maori people (ICM, 2013) with a number of areas considered significantly important to the Māori people for oyster harvesting. Oystering in the Bluff community and the Foveaux Strait is vital to their wellbeing, where oysters were harvested for trading or for food (Tipa & Associates Ltd, 2013). Increased pressure on harvests and the burning of oysters for lime were two key reasons that led to the localised depletion of oysters in most harbours of the North Island (MPI, 2005).

Figure 6.59 ***Bluff Oysters.***
Source: www.gourmetseafood.co.nz

Abalone (Pāua)

Pāua (*Haliotis iris*) are collected by Māori people, with regulations confining collections to 10 per person per day, with the use of traditional methods only. This shellfish species is utilized in a number of ways, including its flesh as food, its shell for jewellery or carvings and also the thick lip of the shell is used for fishing lures (Whaanga, 2012). Māori people were also thought to have transplanted abalone between areas in an effort to enhance localized production of coastal seafood which was of major dietary significance for the pre-European Māori population (Best, 1986). A number of areas are significantly important to the Māori people for paua harvesting including the Foveaux Strait, Tītī Islands, and Tokatā (Tipa & Associates Ltd, 2013). An endemic species of paua (whitefoot or virgin paua) are found only around the subantarctic islands of New Zealand (Tipa & Associates Ltd, 2013).

Figure 6.60 **_Harvested Pāua._**
Source: www.stuff.co.nz

Sooty Shearwater (Tītī)

Sooty shearwaters (*Puffinus griseus*) are a member of the petrel family of seabirds. Chicks of this species are harvested from the islands surrounding Rakiura (Stewart Island) and are of great economic, social and cultural importance to Ngāi Tahu (the Māori people of the southern islands of New Zealand). Rakiura Māori have the right to collect these birds on 36 islands, between April 1st and May 31st each year (Lyver *et al.*, 2012).

These birds are also collected as a trade item and for their feathers and down (Lyver *et al.*, 2012). This traditional harvest is of tītī is the most important cultural event of the year for the Rakiura Māori (Tipa & Associates Ltd, 2013).

Figure 6.61 **_Tītī chick_**
Source: nzbirdsonline.org.nz

6.3.10 *Introduced Marine Species*

As this region is subject to little or no human impacts it is unlikely that any introduced marine species will currently be present within the AOI, however there are extensive recordings of marine invasive species around the New Zealand coastline. *Table 6.12* provides a summary of the presence/absence of the key invasive marine species found within the harbours and ports located most closely to the Project.

Table 6.12: ***Recorded sightings of marine invasive species in the Biosecurity New Zealand database***

Region	*Didemnum sp.*	*Undaria sp.*	*Styela clava*	Mediterranean Fanworm
Dunedin	✘	✓	✓	✘
Timaru	✘	✓	✘	✘
Lyttleton	✓	✓	✓	✓
Bluff	✘	✓	✘	✘
Stewart Island	✘	✓	✘	✘

6.4 *SOCIO-ECONOMIC AND CULTURAL ENVIRONMENT*

This section provides an overview of the socio-economic and cultural environment relevant to the Project. Whilst the AOI is located a significant distance from the shoreline, it is recognised that the nature of the proposed activity and the potential extent of unplanned events in particular require discussion of key socio-economic and cultural aspects within the broader regional AOI, including onshore communities, regional industries and cultural contexts. Data for this section has been compiled from a broad range of sources, including Census data from Statistics New Zealand, outputs from local community consultation and engagement activities, and reviews of local media, regional council information and other community information forums.

6.4.1 *Consultation*

Consultation is an integral part of Shell's project development process. It informs business decisions and identifies issues that require action. Shell has internal policies and processes which outline the requirements of consultation. These are underpinned by Shell's General Business Principles, which govern how the Shell companies that make up the Shell Group conduct their affairs (see *Section 2.3, Shell HSSE and SP Policy and Commitment*).

Shell's approach to consultation is a systematic process, starting with developing an understanding of the issues, identifying interested parties developing an engagement plan (EP) and then creating and maintaining interested party relationships and partnerships using a variety of engagement methods. Consultation is a two-way process, designed to ensure interested parties are able to understand, absorb, respond and interact within appropriate timeframes.

An EP was developed in May 2012 to assist Shell in effectively communicating with interested parties regarding the Project and soliciting feedback, which is captured in an internal issues register. The EP is modified to evolve with the project as well as when new information and variables arise requiring a change in plan. Effectively it is a living document capable of adapting to the changing needs of the project and interested parties.

Interested Parties were identified through various means, including Shell identification, self-identification through the implementation of the EP and discussions with DOC. All interested parties were mapped to determine the level of engagement required and/or desired in order to tailor communications and interactions to their specific needs. A wide range of interested parties have been identified for the Project, compromising individuals and organisation from groups including local government, government agencies, local runanga, business, tourism, fishing and interests, environmental groups and tertiary education institutions.

Engagement was broken down into phases to focus more time and effort on stakeholders likely to be impacted by the Project. As part of the consultation process, a series of community workshops were held where feedback and concerns were sought from attendees. The main concerns and issues raised by interested parties during our consultation meetings were:

- Potential environmental impacts;
- Economic opportunities and benefits to local communities; and
- Continued community engagement.

Table 6.13 Seismic survey specific consultation

Consultee	Form of Consultation	Outcomes
Kai Tahu Ki Otago; Chris Rosenbrock on behalf of Te Rūnanga o Ōtākou and Kāti Huirapa Rūnaka ki Puketeraki	Phone conversation, email and letter	Shell outlined their obligations under the Code of Conduct to Chris Rosenbrock, Manager of Kai Tahu ki Otago and he was comfortable with the approach. Chris has requested: 1. Regular updates from the MMOs whilst the seismic operations are underway. These will be weekly updates during the survey 2. A presentation by the MMO to the runanga once the relevant data is available 3. The possibility of a tour of the seismic vessel when in port 4. The possibility of having an iwi advisor on the vessel/supply boat.

Consultee	Form of Consultation	Outcomes
		Shell agreed to points 1 and 2 with 3 and 4 being discussed with the iwi. In addition, a hui has been organised for early December 2013
Te Rūnanga o Awarua; Maria Pera on behalf of the runanga	Phone conversation, email and letter	In addition, a hui has been organised for early December 2013
The Deepwater Group	Face to face meeting in October 2013.	During the meeting the Project was discussed including the area of the Project as well as the potential timing. No issues or concerns were expressed; however DWG did request the coordinates of the Project Area to provide to their shareholders, which were subsequently provided.
Helen McConnell, Massey University	Face to face meeting	Consultation focussed around potential impacts from MSS on marine mammals. Agreement was reached to incorporate research on fur seals into the Project.
Dave Lundquist, Department of Conservation	Several face to face and phone discussions	Open lines of communication were established at the Project's implementation. This communication continued throughout the process of producing this MMIA, including the provision of draft baseline and impact assessment sections for his review pre-submission.
Jim Fyfe, Department of Conservation	A phone conversation was had between Shell and Jim Fyfe, Marine Ranger in Otago.	With regards to the MMIA, Jim requested that we consider the following: 1. Supplying a copy of the MMIA to him; 2. Supply the results of the sound modelling being undertaken by Curtin University; and 3. Agree to undertake necropsy (by Massey Uni) for any unexplained marine mammal fatality during the Project. Shell agreed to all of the above requests. Points one and two have been fulfilled through the submission of this MMIA to DoC. In relation to point three, Shell agree that if a marine mammal fatality occurs during the survey and for 2 weeks after it ends, which cannot be attributed to natural causes (i.e. shark attack) they will fund the necropsy. The spatial extent of the area this commitment applies is from Stewart Island and Bluff in the south, to Timaru in the north.

Regular consultation with the project's identified interested parties will continue throughout the lifespan of Shell's GSB interest, ensuring that queries and concerns raised are addressed and, where feasible, appropriate responses are built and into the design and/or management plans.

6.4.2 *Physical Context*

Otago covers approximately 32 000 km^2 making it the country's third largest region. The landscape is made up of ranges and basins and consists mainly of high alpine mountains, dry lands, and rough hill country. Major centres include:

- Dunedin (population of 118 683 representing ~57% of the region);
- Oamaru;
- Balclutha;
- Alexandra;
- Queenstown (major tourist town); and
- Wanaka (major tourist town).

Otago Harbour is the natural harbour of Dunedin consisting of a stretch of water separating the Otago Peninsula from the mainland. The harbour is tidal and shallow. It is home to the deep water port of Port Chalmers at the harbour entrance that, in combination with the shallower facilities in Dunedin, form the two wharf system of Port Otago Limited.

Southland is New Zealand's southernmost region and covers 32 612 km^2. It consists mainly of the south-western portion of the South Island and Stewart Island/Rakiura. Southland comprises three main zones:

- The rugged forested Fiordland;
- The plains of Southland proper; and
- The Upland Regions that extends up to Central Otago.

Major centres include:

- Invercargill (population of 50 328 representing ~53% of the region);
- Bluff; and
- Gore.

The Port of Bluff is located near Invercargill and is the home of South Port New Zealand Ltd (South Port), which is the southern-most commercial deep water port in New Zealand (South Port, 2013) and majority-owned by the Environment Southland (the Southland regional council).

Both Otago and Southland are more rural than other regions of New Zealand. Outside of Dunedin and Invercargill, the regions' other cities and towns can be described as small provincial towns rather than urban centres due to the surrounding agricultural industry that they support. According to Census 2006, of all regions in the country, Southland has the highest proportion of households resident in separate (detached) houses, while Otago had a proportion above national average.

6.4.3 *Indigenous Cultural Context*

As with many indigenous cultures, Māori have a close affinity with the natural environment in which they live, and have developed a complex spiritual, psychological and physical world view that focuses strongly on the management and custodianship of this environment. These interactions, and concepts of guardianship and authority such as kaitiaki and mana whenua, extend strongly into the coastal and marine environment as a result of the traditional history of Māori as seafaring island peoples.

The importance of the coastal and marine environments to Māori in the southern regions of New Zealand both in the spiritual and physical contexts is highlighted in iwi-developed management plans such as the Ngai Tahu ki Murihiku Natural Resource and Environmental Iwi Management Plan 2008, *Te Tangi a Tauira - The Cry of the People* (Ngāi Tahu ki Murihiku, 2008) and the Kāi Tahu ki Otago Natural Resource Management Plan 2005 (Kāi Tahu ki Otago, 2005).

Māori Population Demographic[1]

The Māori population for Otago and Southland is represented in *Figure 6.62*. As a percentage of the regional populations Māori represent 6.3% of the total population in Otago and 11.5% of the total population in Southland. Nationally Māori represent 7.9% of the total population, so there is slightly less represented in Otago by percentage of the total population and almost 50% more in Southland.

[1] Statistics used for the Māori population has been randomly rounded by Statistics New Zealand to protect confidentiality. Individual figures may not add up to totals, and values for the same data may vary in different text, tables and graphs.

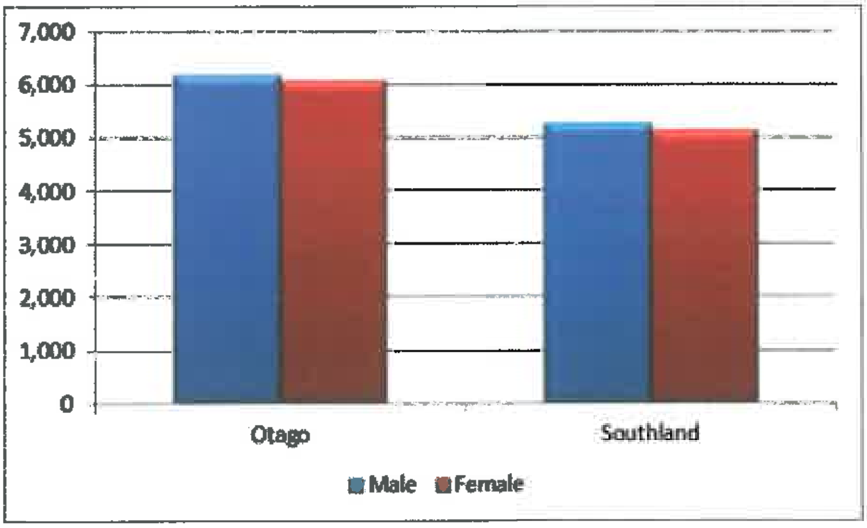

Figure 6.62: ***Māori Population in Otago and Southland, 2006 (Census[2])***
Source: Statistics New Zealand

The population pyramids in *Figure 6.63* and *Figure 6.64* for the Māori population show a significant proportion of the population is below the age of 30, with 63.2% in Otago and 60.7% in Southland. In Otago there are noticeable variations between the number of males and females for the 0-4 cohort (117 more males) and 20-24 cohort (60 more females). In Southland there are more males from 0-19 across all cohorts and more females from 20-44 across all cohorts.

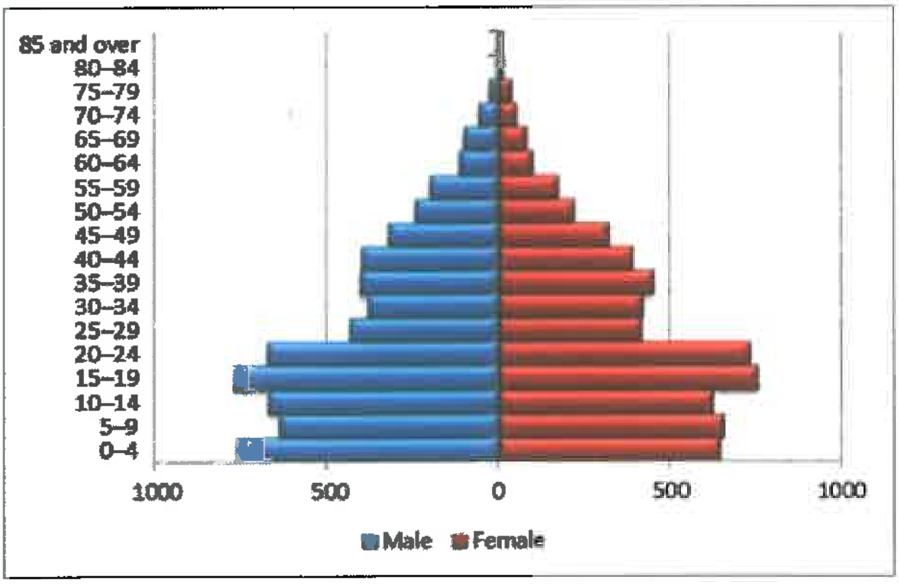

Figure 6.63: ***Māori Population Pyramid for Otago, 2006 (Census)***
Source: Statistics New Zealand

[2] The Māori ethnic population is the count for people of the Māori ethnic group. It includes those people who stated Māori as being either their sole ethnic group or one of several ethnic groups. Source: Statistics New Zealand.

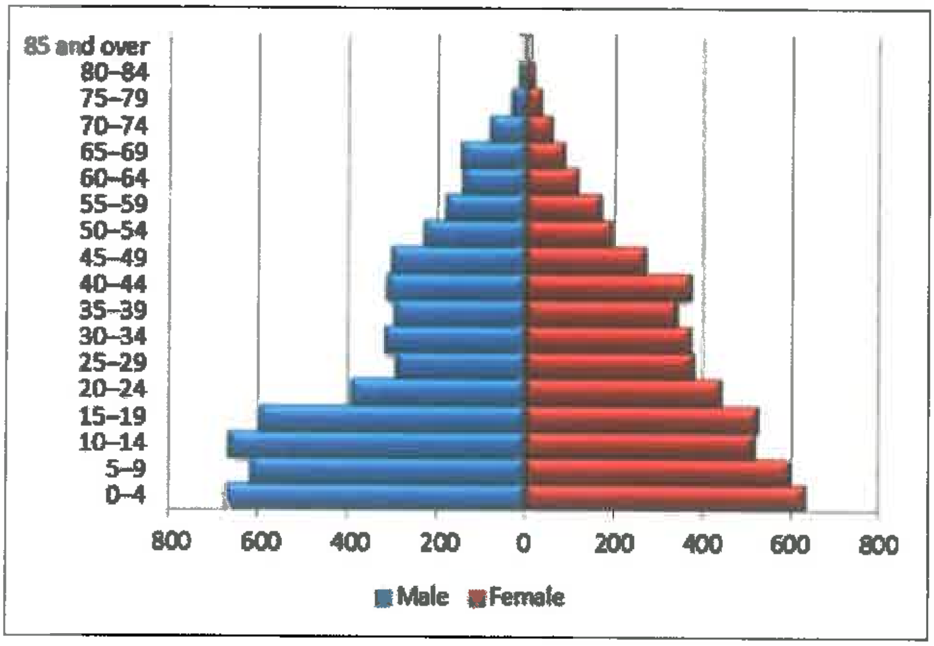

Figure 6.64: ***Māori Population Pyramid for Southland, 2006 (Census)***
Source: Statistics New Zealand

Māori income distributions in the regions are compared to all Māori in New Zealand in *Figure 6.65*. As is common in more rural areas, the majority of the population in the regions are represented in the lower income brackets, though the Māori population has a higher representation in the lower brackets then the rest of the population, particularly in Otago.

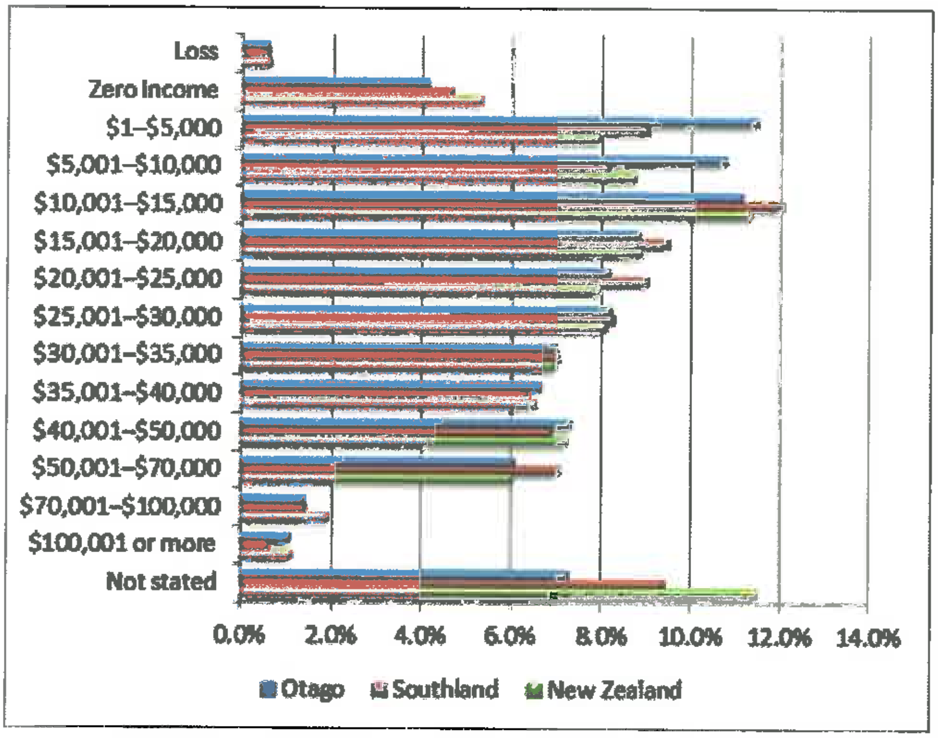

Figure 6.65: ***Māori Population Income for Otago, Southland and New Zealand, 2006 (Census)***
Source: Statistics New Zealand

Unemployment among the Māori population is higher in Otago, though it has dropped each Census year from 13.9% in 1996 to 8.4% in 2006. In Southland it has also dropped but only from 2001 (12.3%) to 2006 (8.0%) as there was no change between 1996 (12.2%) and 2001. Māori unemployment levels are almost 50% higher than the regional average in Otago and more than 50% higher in Southland in 2006.

Cultural Impact Assessment

In recognition of the cultural importance placed on the coastal and marine environments by local iwi, and to ensure appropriate identification and management of the potential impacts of the Project activities two separate Cultural Impact Assessments (CIA) have been commissioned by Shell. One on behalf of Te Rūnanga o Awarua and the other on behalf of Te Rūnanga o Ōtākou and Kāti Huirapa Rūnaka ki Puketeraki. The CIA process is ongoing at the time of issue of this MMIA, however key considerations raised through the CIA process have been integrated within this MMIA (for example see *Section 6.3.5, Species of Local Cultural Importance*).

7 IMPACT ASSESSMENT

7.1 INTRODUCTION

This chapter describes the assessment of the potential environmental impacts from planned and unplanned activities relating to the Project. The assessment considers how the various components of the Project (*Section 2, Project Description*) could affect aspects of the physical, biological, and human environment within the AOI (*Section 6, Baseline Conditions*).

7.2 IMPACT ASSESSMENT SCOPE

This impact assessment considers impacts of the Project's activities on relevant environmental and socioeconomic resources and receptors. It addresses all impacts that will occur and may occur during the seismic survey programme, both within the AOI and in the broader region where secondary impacts may occur.

As outlined in *Section 5, Screening and Scoping*, this MMIA has scoped the focus of the impact assessment down to those Project aspects that are considered to be of likely significance. It is these impacts which are addressed in this section. The remainder of impacts, which are not considered to be of significance, are outlined in *Table 5.2*.

The Project components that may result in significant impacts include:

- The presence of the seismic survey vessel and its planned operations;
- The presence of the support vessel and its planned operations; and
- Any unplanned activities resulting from operation of the seismic and support vessels.

The majority of the impacts resulting from Project activities are anticipated to occur in the marine environment near the proposed transect locations. The main impact sources and receptors relating to the proposed seismic survey programme are presented in *Table 7.1*.

Table 7.1: Potential significant impacts and relevant receptors

Impact Source	Resource/ Receptor	Section
Impacts from Planned Project Components		
Physical presence of the seismic and support vessels	• Commercial fishing • Marine vessels • Seabirds • Marine mammals	7.4.3
On board vessel lighting	• Commercial fishing • Fish • Marine mammals	7.4.4
Towing of the airgun and streamers	• Commercial fishing • Marine vessels	7.4.5
Firing of airgun arrays	• Commercial fishing • Fish • Marine mammals	7.5
Deck drainage and bilge water discharge	• Water quality • Fish	7.6.3
Sewage, Grey Water and Food Discharges	• Water quality • Fish	7.6.4
Impacts from Unplanned Events		
Minor spills of fuels, oils and chemicals	• Commercial fishing • Fish • Marine mammals • Seabirds • Water quality	7.8.2
Collisions	• Commercial fishing • Fish • Marine mammals • Seabirds • Water quality	7.8.3
Loss of streamers and associated equipment	• Water quality	7.8.4
Introduction of invasive marine species	• Ecosystem wide	7.8.5

7.3 *ASSESSMENT METHODOLOGY*

As discussed in *Section 4.5, Impact Assessment*, planned impacts have been quantified by assessing the sensitivity of the resources and receptors being impacted, coupled with the magnitude of the impacts, to determine the overall impact significance. Unplanned impacts (see *Section 7.9, Potential Impacts from Unplanned Events*) have been assessed by considering the severity of potential impacts against the likelihood of the impacts occurring to assess the overall impact significance. In all instances, mitigation and control measures are considered after the initial impact assessment, and residual impact significance is then provided.

A Marine Mammal Management Plan (MMMP) will be produced for the Project, prior to any seismic activities commencing. The MMMP will incorporate all of the mitigation measures outlined in this MMIA, as well as any additional measures identified as necessary, through consultation with DOC and the contracted MMO's, after completion of this MMIA. The MMMP will be an operational document for use during the survey and a copy will be provided to DOC.

7.4 PHYSICAL PRESENCE OF THE SEISMIC AND SUPPORT VESSELS AND IN-WATER EQUIPMENT

7.4.1 *Sources of Impact*

The key sources of disturbance from the Project infrastructure's physical presence include:

- The presence of the seismic survey vessel;
- The presence of the support vessel;
- Vessel lighting; and
- The towed airgun and streamers.

7.4.2 *Sensitivity of Receptors*

The key receptors potentially subject to physical impacts are:

- Commercial fishing;
- Marine vessels;
- Seabirds; and
- Marine mammals.

Commercial Fisheries Sensitivity

There is potential that the physical presence of the seismic vessel and support vessel may exclude fisheries from the area for the duration of the Project, or cause disruption to fish stocks. However, as the Project will be completed within approximately 70 days and across a small proportion of the total fisheries management area (FMA) available for fishing operations, the physical presence of the vessels is not expected to cause any significant disruption to fishing or displacement of fish stocks. While a number of commercial fisheries operate within the region surrounding the AOI, the AOI itself is contained almost entirely within an area of low commercial fishing activity (see *Figure 6.13*). Any impact is therefore expected to be temporary and localised. Further, direct discussions with representatives of the fishing industry did not identify any specific concerns. Accordingly, the sensitivity of commercial fisheries to physical disturbance is considered ***low***.

Commercial Fisheries Sensitivity	Low	Medium	High
Applicable Criteria	Minimal areas of vulnerabilities; consequently with a high ability to adapt to changes brought by the Project.		

Marine Vessel Sensitivity

As discussed in *Section 6.3.3*, the Project is located within the FMA 3 (Southeast Coast Fisheries Region), which is rated of high significance for recreational and customary fisheries (MPI, 2013a). During the Project, marine traffic will be able to move through the region despite the navigation safety area around the survey vessel. Marine traffic in the area will therefore be required to navigate around the survey vessel and in-water equipment. The COLREGS and the *Maritime Rules Part 22: Collision Prevention* outline the compulsory use of warning signs including those announcing restricted manoeuvrability or the presence of underwater structures including fishing equipment or streamers. Following these guidelines reduces the risk of any collisions between vessels and therefore the sensitivity of marine vessels to physical disturbance is considered ***low***.

Marine Vessel Sensitivity	Low	Medium	High
Applicable Criteria	Minimal areas of vulnerabilities; consequently with a high ability to adapt to changes brought by the Project.		

Seabird Sensitivity

The interaction of seabirds with vessels has been well studied among commercial fishery operations (DOC, 2008; Thompson, 2009). Such studies have shown that vessels alone don't attract seabirds and that other attractors are required, such as food availability (Pierre *et al.*, 2010). During the Project, artificial light sources that may attract seabirds include deck lighting on the seismic survey vessel and the support vessel. If seabirds are within the visual range of the vessels at night they may be attracted to lighting and there is some risk that birds may collide with the vessels' structures (Black, 2005). The low population numbers of some of the bird species known to occur within the region means that any mortality of endangered bird species may impact on the population (NIWA, 2012a). Accordingly, the sensitivity of seabirds to the physical presence of the Project infrastructure is considered to be ***medium***.

Seabird Sensitivity	Low	Medium	High
Applicable Criteria	Seabirds in the area are rare or endemic, under pressure and / or slow to adapt to changing environments. Species are valued nationally / globally and are listed as endangered or protected.		

Marine Mammal Sensitivity

A total of thirty (30) marine mammal species have been identified within the project during previous seismic surveys (see *Section 6.3.5*). However, given the remote location of the AOI as well as the general low level of productivity, it is unlikely any marine mammals are resident within, or reliant upon any specific or unique characteristics of, the AOI. Nonetheless, the populations of these species are under pressure both within New Zealand and globally, thus they are afforded regulatory protection. Accordingly, marine mammal sensitivity to physical disturbance resulting from the physical presence of the vessels and in-water equipment is considered ***medium.***

Marine Mammal Sensitivity	Low	Medium	High
Applicable Criteria	Marine mammals generally have low abundance and are under pressure. Species are valued nationally/globally and are listed as endangered or protected.		

7.4.3 *Evaluation of Impacts – Physical Presence of Seismic Survey Vessel and the Support Vessel*

Impact Description

The only receptors considered likely to be affected by the movement of the seismic and support vessel are marine mammals. Vessel collision has been assessed as an unplanned event and is covered in *Section 7.8.3.*

The potential for behavioural changes of marine mammals as a result of vessel presence vary between species, locations and vessel activity, and a variety of behavioural changes of cetaceans has been recorded in studies throughout New Zealand. Behavioural changes such as the formation of tighter dolphin pods as well as shorter respiratory intervals and decreased surface intervals with sperm whales are all thought to indicate an element of stress from vessel interaction (MacGibbon, 1991; Bejder, 1997; Barr, 1997; Barr & Slooten, 1998). However, this stress is thought to be associated specifically with rapid approaches, sudden changes in speed and close approaches as part of tourism-related activities that typically use small fast-moving vessels (Gordon *et al.*, 1992). Further, these vessels intentionally locate themselves in the vicinity of the cetaceans. When vessels slowed their approaches and limited sudden changes in speed and direction around the mammals, less behavioural impacts on sperm whales were observed (Gordon *et al.*, 1992).

Given the localised nature of this impact, slow operating speeds of the seismic vessel, large area of open water in which the vessels are operating and the temporary nature of the Project (approximately 70 days) it is expected this impact will be limited to a specific group of localised individuals, travelling through the area at the time of the Project, and any impacts will be limited to the duration of the activity. Thus, the overall magnitude of this impact is considered to be ***small.***

Magnitude of Impacts – Vessel Movements	Negligible	Small	Medium	Large
Applicable Criteria	Affects a specific group of localised individuals within a population over a short time period (one generation or less), but does not affect other trophic levels or the population itself.			

Mitigation Measures

Vessels working on the Project will abide by the guidelines outlined in the *Marine Mammals Protection Regulations 1992* and will not intentionally approach marine mammals and, where safely possible, vessel operators will take evasive action such as reducing speed or changing course to avoid close interactions with whales.

Residual Impact

While the sensitivity of marine mammals to physical disturbance was found to be ***medium***, the impact magnitude from vessel movement was found to be ***small***. Accordingly, the impact significance from physical disturbance relating to the presence of the seismic and support vessels on marine mammals is considered to be ***minor***.

Category	Impact before Mitigation	Residual Impact
Magnitude of Impact	Small	Small
Sensitivity of Marine Mammals	Medium	Medium
Significance of Vessel Movement on Marine Mammals	Minor	Minor

7.4.4 *Evaluation of Impacts – On board Vessel Lighting*

Impact Description

Lighting of the seismic survey and support vessel decks can attract bird species resulting in bird strikes (Wiese *et al.*, 2001). It is not considered that there is any potential for other receptors to be impacted by vessel lighting relating to the operations. The duration of the risk is limited to the project duration of approximately 70 days. Further, the physical distance across which this lighting would be visible and could have an impact will be limited. Due to the time frame and the localised nature of the impact, coupled with the limited number of vessels (a single seismic and single support vessel), the magnitude from lighting is considered to be ***small***.

Magnitude of Impacts - Deck Illumination	Negligible	Small	Medium	Large
Applicable Criteria	Affects a specific group of localised individuals within a population over a short time period (one generation or less), but does not affect other trophic levels or the population itself.			

Mitigation Measures

The key mitigation of impacts from lighting on board the seismic survey vessel and the support vessel decks involves using only lighting required for safe navigation and operations and limiting the degree of light spill on the water surface as far as is safe and practicable.

Residual Impact

While the sensitivity of seabirds to lighting impacts was found to be ***medium***, the impact magnitude from lighting on the seismic survey vessel and the support vessel decks was found to be ***small***. Accordingly, the impact significance from deck lighting is considered to be ***minor***.

Category	Impact before Mitigation	Residual Impact
Magnitude of Lighting Impacts	Small	Small
Sensitivity of Seabirds to Lighting Impacts	Medium	Medium
Significance of Lighting Impacts on Seabirds	Minor	Minor

7.4.5 *Evaluation of Impacts – Towing of the airgun and streamers*

Impact Description

The only receptors considered likely to be affected by equipment towed by the seismic survey vessel (airgun and streamers) are commercial fishing and other marine vessel traffic. The towing of the approximately 8km streamer array poses a risk to other marine vessels, including commercial fishers, operating or transiting through the area. Not only could the array limit the area within which commercial fishing and marine vessel traffic can navigate, should the vessels not be aware of the towed array they may cross the streamers and cause damage to the vessel or fishing equipment. Further, streamers can become tangled in set nets should they be present in the area, causing damage to the nets. Although low commercial fishing activity is reported in the AOI (refer to *Figure 6.13*), there will be a perceptible difference from baseline conditions. Accordingly, the magnitude of this impact is ***small***.

Magnitude of Impacts – Towed equipment	Negligible	Small	Medium	Large
Applicable Criteria	Perceptible difference from baseline conditions. Tendency is that impact is local, rare and affects a small proportion of receptors and is of a temporary nature.			

Mitigation Measures

The mitigation of impacts from towed equipment involves communications between Shell, commercial fisheries and marine traffic, both prior to and during the Project. This communication will be conducted through a Notice to Mariners following the guidelines outlined in the *Maritime Rules Part 22: Collision Prevention*. Further, the streamer will have a tail buoy attached with radar reflectors to ensure that all vessels can visualise the tail of the streamer. Finally, on board AIS will ensure the vessel is tagged as a seismic vessel while at sea, alerting all surrounding vessels to the potential for streamers.

Residual Impact

The sensitivity of commercial fishing and marine vessels was found to be ***low*** and the impact magnitude from towed equipment was found to be ***small***. With the introduction of the above mitigation measures, the magnitude of impact is reduced to ***negligible***. The resulting impact significance from towed equipment is ***negligible***.

Category	Impact before Mitigation	Residual Impact
Magnitude of Towed Equipment Impacts	Small	Negligible
Sensitivity of Marine Vessels to Towed Equipment	Low	Low
Sensitivity of Commercial Fishing to Towed Equipment	Low	Low
Significance of Towed Equipment on Marine Vessels	Negligible	Negligible
Significance of Towed Equipment on Commercial fishing	Negligible	Negligible

7.5 *FIRING OF THE AIRGUN ARRAYS*

7.5.1 *Sources of Impact*

The firing of airgun arrays during the seismic survey is considered to be the only significant underwater noise source for the Project. Marine seismic surveys use sound energy sources to create seismic waves in the Earth's crust beneath the sea. Moderate to high energy, low frequency sounds, usually in the form of short-duration pulses, are created along the transect grids.

7.5.2 *Sensitivity of Receptors*

The key receptors potentially subject to impacts from underwater noise generated by the airgun arrays are:

- Marine mammals;
- Fish and Invertebrates; and
- Commercial fishing

Marine Mammal Sensitivity

Marine mammals, in particular cetaceans, are the receptor most prone to impacts from seismic activity. Whales and dolphins utilise their highly sensitive acoustic sense to monitor their environment, communication, socialising, breeding and (for odontocetes) foraging and feeding. Accordingly they can be sensitive to loud underwater sound.

Baleen whales have a low frequency hearing range of approximately 7 Hz to 22 kHz with greatest sensitivity around 10 Hz to 10 kHz (Southall *et al.*, 2007; DCENR, 2008). The baleen species identified as potentially occurring within the AOI include the following:

- Humpback whale;
- Blue whale;
- Pygmy blue whale;
- Antarctic minke whale;
- Dwarf minke whale
- Fin whale;
- Sei whale;
- Southern right whale;
- Pygmy right whale

Most toothed whales have auditory sensitivity ranges of 150 Hz to 160 kHz with greatest sensitivity around 20 kHz, and are classified as mid-frequency cetaceans (Southall *et al.*, 2007). Toothed whales and dolphins identified as potentially occurring within the AOI include:

- Common dolphins;
- Dusky dolphin;
- Bottlenose dolphin;
- Long-finned Pilot whales;
- Short-finned Pilot whales;
- Orca;

- False killer whale
- Sperm whale;
- Pygmy sperm whale;
- Gray's beaked whale
- Arnoux's beaked whale
- Cuvier's beaked whale
- Strap-toothed whale
- Southern bottlenose whale
- Andrew's beaked whale
- Hector's beaked whale
- Shepherd's beaked whale
- Hector's dolphin

The work of Southall *et al.*, (2007) of the Marine Mammal Criteria Group (MMCG) sets out criteria for permanent and temporary impacts on marine mammals as a result of noise. In order to cause instantaneous injury to cetaceans resulting in a permanent loss in hearing ability the sound level needs to exceed 230 decibels (dB) re 1 micropascal (µPa) (peak). Behavioural changes as a result of noise can include cessation of normal activities such as regular diving patterns and commencement of avoidance or 'startle' behaviour, particularly when the noise source is intermittent. Such behavioural effects can result in long-term impacts on individuals, particularly if a startle response causes a deep-diving animal to rush to the surface, or if avoidance of the source causes the animal to be exposed to predators. For continuous sounds, avoidance behaviour is more likely.

A review of the environmental implications of marine seismic surveys on marine species was undertaken by a team of scientists in 2000 (McCauley *et al.*, 2000a). The report outlined that the observed the localised avoidance behavioural responses of migrating humpback whales to a 3D seismic vessel was to take avoidance manoeuvres of greater than 4km then allowing the vessel to pass no closer than 3km. Resting pods with females showed an even greater avoidance response of between 7 and 12km. However, some males were seen to be attracted to a single operating air gun thought to be due to it potentially sounding similar to a whale breaching (McCauley *et al.*, 2000a).

For humpback whales, studies have shown behavioural response to the upper levels of noise from the seismic survey array of around 175-180 dB re 1µPa (McCauley *et al.*, 1998; McCauley *et al.*, 2000a), which is still below levels of the highest component of Humpback song (192 dB re 1µPa) (McCauley *et al.*, 2000a). Humpback migrations along New Zealand's west coast occur between September and December (Gibbs & Childerhouse, 2000). Other baleen whales have shown behavioural responses to received sound levels of

120-150 dB re 1 µPa (root mean squared (rms)) for continuous sound such as will be generated by the Project (Southall *et al.*, 2007). Adopting a conservative approach, the lower of this range (120 dB re 1 µPa (rms)) has been applied as the sensitivity threshold above which behavioural changes by baleen whales may occur *(Table 7.2)*.

Some toothed whales have highly advanced echolocation systems that use intermediate to very high frequencies (tens of kHz to 100+ kHz) (Richardson *et al.*, 1995; Wartzok & Ketten, 1999). Nachtigall *et al.* (2008) showed that false killer whales have very acute hearing capabilities including an active 'automatic gain control' mechanism entailing a high susceptibility to marine noise pollution. Social sounds appear to be emitted at a lower frequency band (1 kHz to tens of kHz) (Southall *et al.*, 2007). It is then expected that their functional hearing would cover a wide range of frequencies, but most sensitive at the frequency of their echolocation signals. Based on the combined available data, mid-frequency species are estimated to have lower and upper frequency "limits" of nominal hearing at approximately 150 Hz and 160 kHz, respectively (Southall *et al.*, 2007). Orca have been recorded as displaying strong reactions to noise levels of 140-150 dB re 1 µPa (rms) (Morton and Symonds, 2002 in Table 16 of Southall *et al.*, 2007). Adopting a conservative approach, the lower of this range (140 dB re 1 µPa (rms)) has been assumed to apply to toothed whales and dolphins *(Table 7.2)*.

Table 7.2: Noise Assessment Criteria for Baleen Whales, Toothed Whales and Dolphins

Faunal Group	Long-term Impact Threshold	Temporary Impact Threshold
Baleen whales (low-frequency hearing)	230 decibels (dB) re 1 µPa	120 dB re 1 µPa (rms)
Toothed whales (mid-frequency hearing)	230 decibels (dB) re 1 µPa	140 dB re 1 µPa (rms)

The presence of various marine mammals has been recorded within the AOI and their susceptibility to noise impacts is well studied. Yet, should any cetaceans be in the region at the time of the Project, they are likely to be in low numbers relative to their overall population (*see Section 6.3.5* and Origin Energy, 2007; OMV, 2012; Crown Minerals, 2006; Exxon Mobil, 2008 for sighting data) and the disturbances associated with most seismic programs are likely to be temporary, infrequent and very localised, so the effects on marine mammals are therefore expected to be minimal (McCauley, 1994). However, many of the cetaceans in the AOI are vulnerable, of low global populations, protected and of high intrinsic value. Given the above, the sensitivity of marine mammals to underwater noise impacts is considered ***high***.

Marine mammal sensitivity	Low	Medium	High
Applicable criteria	Marine mammals generally have low abundance and are under pressure. Species are valued nationally/globally and are listed as endangered or protected.		

Fish and Invertebrate Sensitivity

If present, fish may be exposed to underwater noise during the firing of the airgun arrays. Some fish use sound to communicate, locate prey, detect predators and as a cue for orientation (McCauley & Cato, 2000). The susceptibility of fish to seismic sound differs between species, with those with a swim bladder more susceptible. Fish have been shown to display a startle response to short range start up or high level air gun air gun level above 156–161 dB re 1 µPa rms; (McCauley *et al.*, 2000a) or may swim faster and form tighter groups or swim deeper and the accumulations of fish adjacent to operating facilities indicates that in the absence of any associated threats, they can be expected to habituate to this noise (Lindquist *et al.* 2005). Normal fish behaviours are expected to return some 14-30 minutes after the cessation of the sound emission (McCauley *et al.*, 2000a). Within close range however, seismic surveys have been found cause a variety of sublethal impacts on fish such as damaging orientation systems and reducing their ability to find food and even lead to mortality in both adult and larval fish (AMCC n.d.). Other studies have identified developmental impacts on invertebrate larvae as a result of sound impacts (de Soto *et al.*, 2013). Impacts on squid species (*Sepioteuthis australis*) have been investigated and the results indicated that noise levels greater than 147 dB re 1 lPa2.s induce avoidance behaviour but that a gradual increase in acoustic intensity and prior exposure to air gun noise, decreases the severity of the alarm responses (Fewtrell and McCauley, 2012). Damage can also be done to fish's inner ear system, where sensory hair cells are damaged and regeneration is generally either very slow or non-existent (McCauley, Fewtrell & Popper, 2002). These results however were recorded with caged fish, unable to flee after the immediate startle from the source sound, and potentially not relating to actual oceanic conditions.

Invertebrate species are often sessile thus unable to avoid impacts from sound. Some species of invertebrates possess mechanosensors that show some resemblance to vertebrate ears (Popper, 2003) and a number of reports show reaction by invertebrates to sound (e.g. Frings & Frings, 1966). Research on a species of crayfish (*Cherax destructor*) indicated sensitivities to water vibration frequencies between 150-300 Hz (Tautz & Sandeman, 1980) and North Sea shrimp (*Crangon crangon*) indicating maximal sensitivities to water vibration at 170 Hz (Heinisch & Wiese, 1987). Kosheleva (1992) found no discernible effects on amphipods (*Gammarus locusta*) or molluscs (*Mytilus edulis*) exposed to source levels of 220-240 dB re 1 µPa. McCauley et al., (2000b) found behavioural changes in squid (*Sepioteuthis australis*) with alarm responses at 156-161 dB re 1 µPa rms and startle responses with ink ejection and rapid avoidance at 174 dB re 1 µPa rms. No impacts have been detected in available research on soft or hard corals (Woodside, 2008) Research indicates that the majority of marine benthic invertebrates will only respond the seismic sources at extremely close ranges, where deep ocean seismic surveys generally have no effect on benthic invertebrates (McCauley et al., 1994).

Given the above information, the sensitivity of fish and invertebrates to underwater noise impacts is considered *low.*

Fish and invertebrate sensitivity	Low	Medium	High
Applicable criteria	Fish species are abundant, common or widely distributed and are generally adaptable to changing environments. Species within the AOI are not endangered or protected.		

Commercial Fisheries Sensitivity

As sound source transmissions can cause disturbance to fish species, this can impact on the catch of any commercial fisheries within the area. As stated above, the AOI is contained almost entirely within an area of low commercial fishing activity (see *Figure 6.13*). Nonetheless there is potential that the sound produced from the seismic survey may cause a temporary localised reduction in fish abundance in the area during the Project. Accordingly, while there is an impact, it is temporary and localised in nature therefore the sensitivity of commercial fisheries to physical disturbance is considered *low*.

Commercial Fisheries	Low	Medium	High
Applicable criteria	Perceptible difference from baseline conditions. Tendency is that impact is local, rare and affects a small proportion of receptors and is of a temporary nature.		

7.5.3 *Evaluation of Impacts – Firing of Airgun Arrays*

Impact Description

A seismic airgun is an impulsive underwater transducer which produces moderate to high energy level sound at low frequencies. Airguns function by venting high-pressure air into the water. This produces an air-filled cavity that expands rapidly, then contracts, and re-expands. A seismic wave is created with each oscillation. During operation, air at high pressure (nominally 2,000 psi) is supplied continuously to the airgun. The pulses from the guns are broad band, with most energy concentrated in the 10-200 Hz frequency range, with lower levels in the 200-1000 Hz range. Sound levels at the source can range from 237-262 dB re 1uPa/m, but will vary based on the makeup of the arrays i.e., the number of guns fired concurrently. Generally this sound, in particular at higher frequencies, attenuates rapidly across the initial few hundred metres, with the lower frequency sounds dropping off more slowly (Wyatt, 2008). For seismic airgun sound, usually a reduction in sound intensity of around 6 dB per doubling of distance from the source can be expected, however attenuation is dependent on the conditions and in can range dramatically (McCauley, 1994). Typically, most underwater sound from the airguns will be low frequency (0.01 to 0.3 kHz) with some weaker pulses of higher frequencies (up to 0.5-1 kHz) interspersed, depending on the Project requirements (Richardson *et al.*, 1995).

The results of the sound transmission loss modelling show that the majority of the sound energy is transmitted downward and is absorbed by the seabed. Modelling predicted that the Aquila Explorer 4230 cui array operating within the Carina 2D survey area will produce received sound exposure levels below 186 dB re 1 µPa2.s at a range of 200m, and below 171 dB re 1 µPa2.s at a range of 1km and will therefore meet the sound exposure level requirements of the Code (*Figure 7.1*). At a range of just over 100m, 95% of received sound exposure levels are predicted to be below 186 dB re 1 µPa2.s, and at a range of just over 500m, 95% of received sound exposure levels are predicted to be below 171 dB re 1 µPa2.s. The full modelling report prepared by Curtain University is provided in *Annex B* of this MMIA.

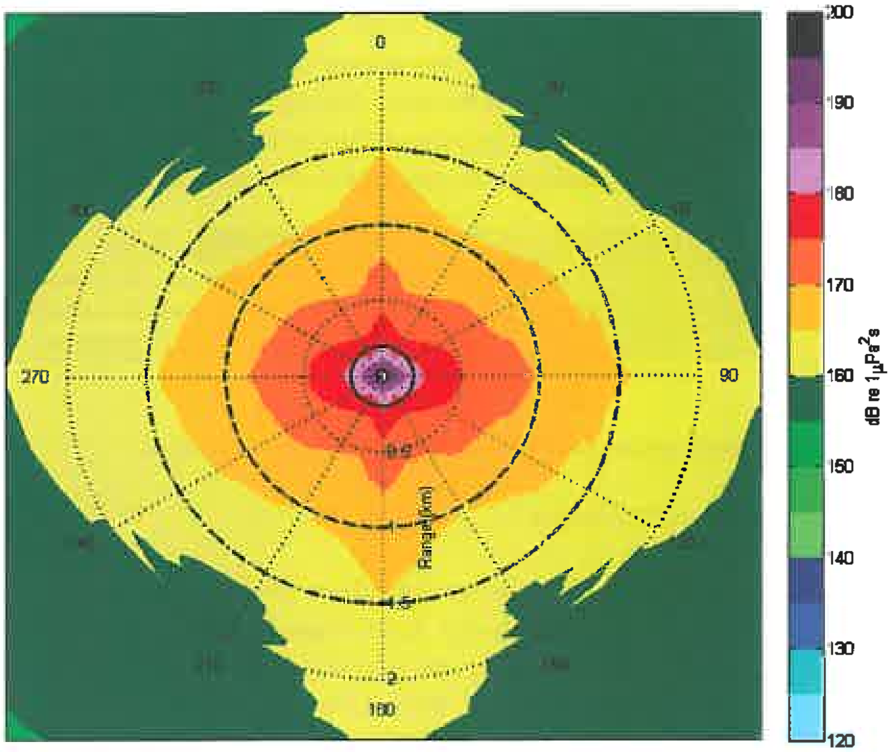

Figure 7.1 ***Predicted maximum received SEL at any depth as a function of azimuth and range from the source to a maximum range of 3km. An azimuth of 0° (up) corresponds to the in-line direction. The thick black circles correspond to mitigation ranges of 200m (solid), 1km (dash), and 1.5km (dash-dot) (Source: Curtin, 2013; Annex B)***

The duration of the impact on any single receptor will vary depending on the firing sequence required at the time, coupled with the speed of the airgun through the water and the frequency of the sound thereby determining the attenuation. The impacts from the firing of the airgun arrays will be limited to a specific group of localised individuals present at the time of the Project. These impacts will not flow through into future generations, nor will it significantly impact the overall population of any marine organisms. Accordingly, the magnitude of the impacts on any receptor from the firing of the airgun arrays is considered to be *small*.

Magnitude of impacts - Seismic Source Sound	Negligible	Small	Medium	Large
Applicable criteria	Affects a specific group of localised individuals within a population over a short time period (one generation or less), but does not affect other trophic levels or the population itself.			

Mitigation Measures

The As per the Code the following will be in place for the survey:

- Section 4.1 of the Code outlines the requirements in which the Project will comply during this activity including pre-survey planning, observers, soft starts and delayed starts and shutdowns. Section 4.1 is applicable as this will be a Level 1 survey due to the size of the acoustic source (expected to be >427 cubic inches).
- Section 4.1 of the Code of Conduct addresses Level 1 surveys which requires, but is not limited to, the following:
  - The completion of a Marine Mammal Impact Assessment to be completed and provided to the Director-General of DOC (this MMIA fulfils this requirement);
  - At least two (2) qualified Marine Mammal Observers (MMO) and passive acoustic monitoring (PAM) operators on board the source vessel;
  - Continuous pre-start observations for 30 minutes by a MMO and PAM;
  - Continuous pre-start PAM for 30 minutes at night or during poor sighting conditions;
  - No sightings of marine mammals within the respective mitigation zones for at least 30 minutes before start up;
  - No species of concern with a calf are located within 1.5 km of the source during seismic activity;
  - No species of concern are located within 1km of the source during seismic activity; and
  - No marine mammals are located within 200m of the source during seismic activity.

- If the PAM system has malfunctioned or become damaged, operations may continue for 20 minutes without PAM while the PAM operator diagnoses the issue. If the diagnosis indicates that the PAM gear must be retrieved to solve the problem, operations may continue for an additional 2 hours without PAM monitoring as long as all of the following conditions are met:

  - It is daylight hours and the sea state is less than or equal to Beaufort 4
  - No marine mammals were detected solely by PAM in the relevant mitigation zones in the previous 2 hours
  - Two MMOs maintain watch at all times during operations when PAM is not operational
  - DOC is notified via email as soon as practicable with the time and location in which operations began without an active PAM system
  - Operations with an active source, but without an active PAM system, do not exceed a cumulative total of 4 hours in any 24 hour period.

- Additional requirements for start-up in a new location in poor sighting conditions. Where there have been less than 2 hours of good sighting conditions preceding proposed operations (within 20 nautical miles of the planned start up position), the source may be activated if:

  - PAM monitoring has been conducted for 2 hours immediately preceding proposed operations, and
  - Two MMOs have conducted visual monitoring in the 2 hours immediately preceding proposed operations, and
  - No Species of Concern have been sighted during visual monitoring or detected during acoustic monitoring in the relevant mitigation zones in the 2 hours immediately preceding proposed operations, and
  - No fur seals have been sighted during visual monitoring in the relevant mitigation zone in the 10 minutes immediately preceding proposed operations, and
  - No other marine mammals have been sighted during visual monitoring or detected during acoustic monitoring in the relevant mitigation zones in the 30 minutes immediately preceding proposed operations.

- In relation to other Marine Mammals within a mitigation zone of 200m, if, during pre-start observations prior to initiation of a Level 1 acoustic source soft start, a qualified observer detects a marine mammal within 200m of the source, start up will be delayed until:
  - A qualified observer confirms the marine mammal has moved to a point that is more than 200m from the source; or
  - Despite continuous observation, 10 minutes has passed since the last detection of a New Zealand fur seal within 200 m of the source and 30 minutes has elapsed since the last detection of any other marine mammal within 200m of the source, and the mitigation zone remains clear.

Residual Impact

The sensitivity of marine mammals and fish to noise impacts without mitigation was found to be ***high*** and ***low*** respectively and the significance of noise impacts from the firing of airgun arrays on marine mammals and fish without mitigation is considered to be ***moderate and negligible*** respectively. While the significance of impacts on fish will remain unchanged after the implementation of the above mitigation measures, the sensitivity of marine mammals will be reduced to a ***medium*** level. This will happen by substantially reducing the potential of marine mammals being within close proximity to the sound source at the time of firing. As a result the overall significance for this impact on marine mammals should be ***minor***.

The sensitivity of commercial fisheries to noise impacts and resulting disturbance of fish stocks is considered to be ***low***. Consequently, the overall significance of this impact on commercial fisheries is found to be ***negligible***.

Category	**Impact before Mitigation**	**Residual Impact**
Magnitude of impact	Small	Small
Sensitivity of marine mammals	High	Medium
Sensitivity of fish and invertebrates	Low	Low
Sensitivity of commercial fisheries	Low	Low
Significance of impacts from the firing of the airgun arrays on marine mammals	Moderate	Minor
Significance of impacts from the firing of the airgun arrays on fish and invertebrates	Negligible	Negligible
Significance of impacts from the firing of the airgun arrays on commercial fisheries	Negligible	Negligible

7.6 *WASTE DISCHARGES TO SEA*

7.6.1 *Sources of Impact*

This section addresses the potential impacts from routine operational discharges to the sea from the vessels.

Wastewater and discharges to the marine environment may occur from the following operational vessel discharges:

- Deck drainage and treated oily water from machinery spaces;
- Treated sewage;
- Grey water (e.g. showers, sinks); and
- Food wastes.

7.6.2 *Sensitivity of Receptors*

Water Quality Sensitivity

The AOI has not been subject to prior anthropogenic disturbance and there are few vessel operations within the area. Accordingly, the water quality of the AOI is expected to be very high. Given the strong currents and wave action of the open ocean environment where the Project activities are taking place (see *Section 6.2.2, Oceanographic Conditions*) any discharges into the marine environment will be subject to very high levels of dispersion and the water quality is expected to rapidly return to its pre-impact state. Accordingly, the sensitivity of the water quality within the AOI is considered to be ***low***.

Water quality sensitivity	Low	Medium	High
Applicable criteria	Existing water quality is good and the ecological resources that it supports are not sensitive to a change in water quality.		

Fish Sensitivity

If present within the region of the vessels, fish may be attracted to waste discharges resulting from operation of the vessels. If this attraction occurs during the discharge of the airgun arrays the noise impacts may be compounded by the increased number of fish in close proximity to the seismic source. Further, fish may be exposed to localised and brief reductions in water quality in the immediate area of the discharge prior to dilution. However, given the wide distribution and high abundances of fish species that may be present in the area the sensitivity of fish to operational vessel discharges is considered ***low***.

Fish sensitivity	Low	Medium	High
Applicable criteria	Fish species are abundant, common or widely distributed and are generally adaptable to changing environments. Species within the AOI are not endangered or protected.		

7.6.3 *Evaluation of Impacts - Deck Drainage and Bilge Water Discharge*

Impact Description

Drainage and bilge water will be directed to a holding tank then routed through an oil/water separator and monitored for oil concentration before discharge. The content of oil contaminated water that may be discharged to the marine environment is controlled under MARPOL Annex I, with oil-in-water concentrations not to exceed 15 ppm. Based on a maximum concentration of 15 ppm oil-in-water, any impact will be highly localised to the immediate area of the discharge point, and there would be no visible sheen. Accordingly, the magnitude of this impact is considered to be ***small***.

Magnitude of impacts - deck drainage and oily water discharges	Negligible	Small	Medium	Large
Applicable criteria	Slight change in water quality expected over a limited area with water quality returning to background levels within a few metres; and / or discharges are well within benchmark effluent discharge limits			

Mitigation Measures

Mitigation measures to reduce the impacts of deck drainage and oily water discharges are inherent in the project design or required by regulation including:

- Only uncontaminated deck drainage water can be discharged overboard, all deck drainage from areas that may be contaminated will be directed to bilges for treatment prior to discharge.
- Oily water discharges will be fitted with continuous monitoring equipment and automatic valves to ensure that oil content in effluent being discharged does not exceed 15 ppm.
- Any waste oil transfers will be logged and recorded in the vessels' Oil Record Book and all transfer records held for the required period.
- Vessels will maintain a valid International Oil Pollution Prevention (IOPP) Certificate and Oil Record Book (ORB) and will have onboard IMO-type approved oily water separators and piping arrangements.

Residual Impact

The impact magnitude of these discharges was found to be ***small*** due to the localised nature of the impact and rapid dispersion at the offshore location. The sensitivity of water quality and fish to these discharges was found to be ***low***. Accordingly, the overall impact significance of vessel emissions is considered to be ***negligible***.

Category	Impact before Mitigation	Residual Impact
Magnitude of deck drainage and oily water impacts	Small	-
Sensitivity of water quality	Low	-
Sensitivity of fish	Low	-
Significance of deck drainage and bilge water discharge impacts on water quality	Negligible	Negligible
Significance of deck drainage and bilge water discharge impacts on fish	Negligible	Negligible

7.6.4 *Evaluation of Impacts – Sewage, Grey Water and Food Discharges*

Impact Description

Sewage can contain harmful microorganisms, nutrients, suspended solids, organic material with an associated chemical and biological oxygen demand (BOD), and residual chlorine from sewage treatment. On-board treatment in an IMO-compliant sewage treatment facility will treat sewage to IMO standards as set out in Annex IV of MARPOL. The treatment standard for discharge is 100 faecal coliforms per 100 ml, the total suspended solids must be less than 35 mg l^{-1} and the 5-day BOD less than 25 mg $^{-1}$. Increased BOD directly impacts water quality as it is a measure of the increased uptake of dissolved oxygen by microorganisms that decompose organic material in the sewage, which in turn temporarily reduces the dissolved oxygen content of the water in the localised area of the discharge. Treated sewage will be discharged offshore in relatively small volumes, which is expected to disperse and dilute quickly due to the ocean currents and wave action in the open ocean environment of the Project area (see *Section 6.2.2, Oceanographic Conditions*). Accordingly, the magnitude of impact from sewage discharge is considered ***small***.

Grey water discharge includes drainage from baths, showers, laundry, wash basins and dishwater. Grey water is not required to be treated before discharge under MARPOL (provided it does not contain a prescribed pollutant). Grey water will be discharged within the AOI throughout the ~70 day Project duration. This discharge is not predicted to cause any deterioration to water quality outside the immediate point of discharge with high levels of dilution. The magnitude of this discharge is considered to be ***small***.

In accordance with MARPOL Annex V food waste will be discharged without treatment where the vessel is at least 12 nm from nearest land and, when the vessel is less than 12 nm from nearest land, food waste will only be discharged after being comminuted so that the waste is not more than 2.5 mm in diameter. Accordingly, the magnitude of this discharge is considered to be ***small***.

Magnitude of impacts - sewage and grey water discharges	Negligible	Small	Medium	Large
Applicable criteria	Slight change in water quality expected over a limited area with water quality returning to background levels within a few metres; and / or discharges are well within benchmark effluent discharge limits			

Mitigation Measures

- All waste will be handled and disposed of in accordance with the Waste Management Plan (to be developed prior to project initiation) and in full compliance with MARPOL Annexes IV and V. All sewage and organic kitchen waste generated on-board Project vessels will either be treated in an approved on-board wastewater treatment facility and discharged more than 12 nautical miles from shore (in compliance with MARPOL Annex V), or contained and discharged at appropriate onshore facilities when the vessels call into port. No marine pollutants will be discharged in operational waste streams.
- Clinical waste will be stored separately and will not be placed into the sewage or grey water waste stream.
- Any discharges of controlled (non-hazardous) wastes and effluent from the washing or rinsing of containers or equipment will meet acceptable standards for marine discharge in accordance with the relevant regulations.

Residual Impact

The impact magnitude of sewage, grey water and food discharges was found to be ***small*** due to the treatment of waste pre-discharge and the rapid dispersion in the offshore environment. The sensitivity of water quality to these discharges was found to be ***low***. Accordingly, the overall impact significance of sewage, grey water and food discharges is considered to be ***negligible***.

Category	Impact before Mitigation	Residual Impact
Magnitude of sewage and grey water discharge impacts	Small	-
Sensitivity of water quality	Low	-
Sensitivity of fish	Low	-
Significance of sewage and grey water discharge impacts on water quality	Negligible	Negligible
Significance of sewage and grey water discharge impacts on fish	Negligible	Negligible

7.7 *ATMOSPHERIC EMISSIONS*

7.7.1 *Sources of Impact*

The sources of emissions to air from the Project will be fuel consumption from the seismic survey and support vessels.

7.7.2 *Sensitivity of Receptors*

As the AOI is located greater than 100 km offshore and similar distances from any islands, there are no sensitive receptors within the region with the exception of the crew on board the vessels, and the atmosphere itself. The remoteness of the project also ensures the ambient air quality in this area is very high, with the only likely air emissions being from occasional passing vessels. Emissions from the operation of the vessels will slightly impact air quality, however dispersion rates at sea particularly with the high winds recorded within the area (see *Section 6.2.1, Climate and Atmosphere*) will be significant. These high dispersion rates away from the human receptors on-board the vessels, coupled with the high ambient air quality in the region, mean the sensitivity of both the air quality and the human receptors is considered to be ***low***.

Air Quality Sensitivity	Low	Medium	High
Applicable Criteria	Existing air quality is good and the ecological resources that it supports are not sensitive to a change in quality		

7.7.3 *Evaluation of Impacts – Atmospheric Emissions*

Impact Description

To power the main engines on both of the vessels, will use Marine Gas Oil (MGO) which, when burnt, will release gaseous pollutants to the atmosphere. This may cause a short-term reduction in local air quality and a negligible contribution to greenhouse gases. Given disturbance will be minimal across time and space, coupled with the rapid recovery of the area to a pre-impact state, the impact magnitude of air emissions is considered to be ***small***.

Magnitude of Impacts – Atmospheric Emissions	Negligible	Small	Medium	Large
Applicable Criteria	Slight change in air quality expected over a limited area with air quality returning to background levels within a few metres			

Mitigation Measures

Mitigation measures to reduce atmospheric emissions inherent in the Project design include the following.

- Only light grades of fuel oil (e.g. marine diesel or marine gas oil) will be used by the Seismic Survey vessel and the support vessel. The vessel and support vessel will comply with MARPOL 73/78 Annex VI - Air standards relating to air emissions.
- All propulsion systems, exhausts systems, and power generation equipment will be well maintained for optimal operational efficiency.
- The fuel consumption of the vessels will be regularly monitored as a check to further ensure the combustion efficiency of all systems.
- Only low sulphur diesel will be utilised.

Residual Impact

The impact magnitude of these emissions was found to be ***small*** due to the small reduction to local air quality and good conditions for aerial dispersion at the offshore location. The sensitivity of local receptors to atmospheric emissions was found to be ***low***. Accordingly, the overall impact significance of vessel emissions is considered to be ***negligible***.

Category	Impact before Mitigation	Residual Impact
Magnitude of Atmospheric Emission Impacts	Small	Small
Sensitivity of Air Quality to Emissions	Low	Low
Significance of Atmospheric Emissions on the Air Quality	Negligible	Negligible

7.8 POTENTIAL IMPACTS FROM UNPLANNED EVENTS

7.8.1 *Potential Sources of Impact*

There is a potential for adverse consequences on both environmental and human receptors in the event of non-routine or accidental events (e.g. spills, leaks or collisions). The primary upset conditions, hazardous events and major accident hazards that could potentially occur include the following:

- Oil, fuel and chemical spills - spills of chemicals or fuel during transfer, handling, storage and use, topside process leaks, or bunker fuel spills in the event of a vessel incident;
- Introduction of invasive species – the introduction of invasive species by the seismic survey vessel or support vessels;

- Collisions - vessel collisions, given that the area is within the vicinity of where fishing activities occur; and
- Streamer cable break and cable content release.

Should these events happen, the following impacts could occur:

- Risks to human life;
- Reduction in water quality and consequent impacts on ecology;
- Direct impacts on marine fauna from oil or chemicals;
- Impacts on fisheries resulting from actual or perceived contamination of fish stocks;
- Reduction of air quality; and
- Damage to property.

7.8.2 *Evaluation of Potential Impacts - Minor Spills of Fuels, Oils and Chemicals*

Potential Impact Description

The most likely unplanned spill or release during survey operations is the accidental spillage of fuel products during transfer operations. Spill volumes for this kind of unforeseen event, are typically small (ranging from around a few litres) however bunkering spills may be more substantial. The seismic survey vessel and the support vessels will use marine diesel or marine gas oil. Marine diesel is a middle petroleum distillate that typically undergoes rapid dispersion and evaporation in the marine environment when subjected to weathering. Consequently, any small releases are likely to break up and disperse in a short space of time especially in the high energy offshore environment of the project area. However, a larger spill has the potential to affect local fish populations, seabirds, and marine mammals including the potential for direct toxicity where oil is ingested, fouling of birds and seals leading to loss of waterproofing and the potential for hypothermia and drowning, and inhalation of vapours by surface breathing mammals. If a spill were to occur close to shore, coastal habitats and communities could also be affected, although this is unlikely given the remote location of the Project.

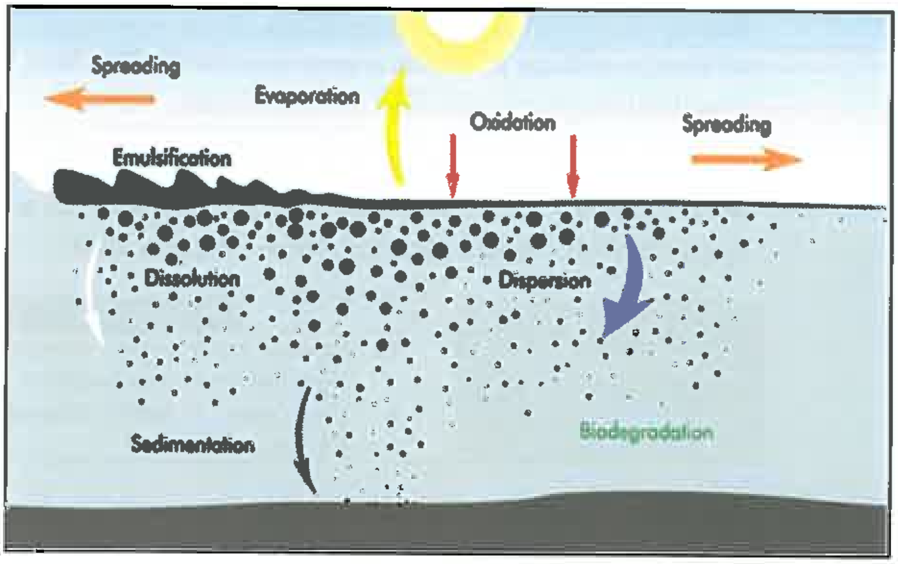

Figure 7.2: ***Fate of oil spilled at sea showing the main weathering processes***
(Source: ITOPF, 2013)

Table 7.3: ***Hydrocarbon fate processes***
(Source: ITOPF, 2013)

Process	Description
Drifting	Physical movement of surface hydrocarbon from one location to another due to the combined effects of water current, tides, waves and wind. Hydrocarbons on the water surface typically moves at 100% of the current speed and direction and 3% of wind speed and direction.
Spreading	Increase in the length and breadth of the hydrocarbon slick as it spreads and thins on the sea surface.
Evaporation	Evaporation of lighter hydrocarbons to the atmosphere.
Emulsification/ mousse formation	Formation of water in hydrocarbon emulsions, resulting in an increase in hydrocarbon viscosity. Hydrocarbons with a high asphaltene content are more likely to form stable emulsions.
Entrainment/ dispersion	The formation of hydrocarbon droplets due to breaking waves, resulting in transport of hydrocarbon from the sea surface into the water column.
Dissolution	Physical chemical process resulting in hydrocarbon from the hydrocarbon slick or from suspended oil droplets dissolving into the water column.
Shoreline interaction/ stranding	Increase in density of hydrocarbon due to weathering and interaction with suspended sediments or material of biological origin. Deposition of material to the sea floor. Tar balls may be formed, which could roll along the seabed.
Submergence/ sinking/ sedimentation	Impact of hydrocarbon on the shoreline where it may strand on the surface, or become buried in layers, or may refloat and move elsewhere. The rate of weathering of stranded hydrocarbon depends on several factors, in particular the amount of exposure to waves.
Photo oxidation/ photolysis	Chemical transformation of petroleum hydrocarbons caused by sunlight.
Biodegradation	Biological chemical process altering or transforming hydrocarbons through the action of microbes and/or the ingestion by plankton and other organisms.

Failure of equipment such as hydraulic hoses or storage drums can cause the accidental spillage of hydrocarbons and chemicals. Such spills are generally contained on the vessel due to their small size.

Given the localised nature of the accidental spills outlined above, due to the small quantities considered, the severity of impacts from the accidental spill of hydrocarbons or chemicals is considered to be ***medium***.

Severity of Impact	Low	Medium	High
Applicable Criteria	• Localised environmental damage • No sensitive resources impacted • Degradation of spilled materials and full recovery of affected resources		

Due to the range of operations that could result in an accidental spill, it is considered possible that a small accidental spill may occur at some stage during the Project.

Likelihood of Occurrence	Extremely Unlikely	Unlikely	Possible	Likely
Applicable Criteria	The event is likely to occur at some time during normal operating conditions			

Mitigation and Control Measures

Shell is committed to adoption of the following measures aimed at reducing the potential risk of accidental fuel, oil or chemical spills:

- The following equipment design measures will be in place:
  - Quick disconnect couplings for all transfer hoses;
  - Use of dry break couplings and drip trays;
  - Double valves on all systems prone to leakage;
  - All fuel tankers will be inspected and approved as fit for purpose; and
  - All fuel, oil and chemicals will be stored in special bunded and lined areas designed to hold the full volume of the product being stored.
- The following systemic measures will be in place:
  - Routine maintenance and inspection of storage facilities;
  - Refuelling at port will use established port bunkering facilities for which a current Tier 1 oil spill contingency plan (OSCP) and equipment are in place;
  - Refuelling or transfer only when sea and weather conditions are sufficiently calm, as determined by the vessel Master;

    - Refuelling during the hours of darkness will be avoided where possible;

    - Review of job hazard analysis for bulk transfer of diesel before transfer commences;

    - Use of a detailed checklist to confirm correct valve line up, quality of equipment and communications arrangements;

    - Pressure testing of hoses before use;

    - Continuous visual monitoring of hoses, couplings and the sea surface during refuelling or transfer;

    - Continuous monitoring of flow gauges on both the seismic vessel and supply vessel;

    - Continuous contact between the seismic vessel and the supply vessel;

- The following management measures will be in place:

    - Project vessels will have a valid SOPEP in accordance with MNZ requirements and a valid Emergency Response Plan, with all crew trained in their roles and responsibilities under the plans and regular exercises of the plans in accordance with the IOPPC requirements;

    - Project vessels will be equipped with appropriate Tier 1 oil spill containment and clean-up equipment;

    - Any spills will be immediately reported to MNZ, together with the response actions taken; and

    - All chemicals used will be selected based on the least environmentally harmful locally available alternative. Therefore there will be limited eco-toxicological impacts to the environment in the event of a spill.

With these mitigation and control measures in place, the likelihood of an accidental spill of fuels, oils and chemicals, is considered to be ***unlikely***.

Likelihood of Occurrence	Extremely Unlikely	Unlikely	Possible	Likely
Applicable Criteria	The event is unlikely but may occur at some time during normal operating conditions			

With the implementation of the above mitigation measures, the severity of an impacts from the accidental spill of fuel, oil or chemicals, is considered to be ***Low***.

Severity of Impact	Low	Medium	High
Applicable Criteria	• Some damage to the environment/ very localised • No sensitive resources impacted • Rapid degradation of spilled materials and rapid recovery of affected resources		

Residual Potential Impact

In the absence of Shell's mitigation and control measures the impact significance of impacts from the accidental spill of fuel, oil or chemicals is considered to be m***oderate***. With the implementation of the above mitigation and control measures the likelihood of an accidental spill of fuel, oil and chemicals is reduced to ***unlikely***, and the severity of the impact to ***low***. As a result, the overall impact significance from the accidental spill of fuel, oil or chemicals is considered to be ***negligible***.

Category	**Ranking**	**Residual Impact**
Severity of Impact	Medium	Low
Likelihood of Occurrence	Possible	Unlikely
Significance	Moderate	**Negligible**

7.8.3 *Evaluation of Potential Impacts – Collisions*

Potential Impact Description

Impacts that may result from a vessel collision are death and injury of vessel crew involved in the incident, damage to the vessels involved, and the potential for this damage to lead to the sinking or either vessel. Damage to the vessel may also result in a loss of containment of bunker fuels, leading to a marine oil spill. The loss of part or a vessel's entire fuel inventory resulting from rupture of the vessel's fuel tanks in a collision would be categorised as a Tier 2 or Tier 3 spill by Maritime NZ depending on the location and extent of the spill. The maximum spill size would depends on the maximum fuel capacity of the vessel involved, and it is possible that the leak could arise from breaching of fuel tanks of a larger vessel (not forming part of the Project contingent) following collision with a Project vessel.

Incidents resulting from vessel collisions with Project vessels are highly unlikely due to the low density of marine traffic expected at the AOI and the navigational systems and procedures in use on the vessels. In practice, usually only part of a vessels fuel inventory is lost in the case of a bunker tank rupture, with ingress of water into the tank displacing oil away from the hole and the ability of most vessels to transfer fuel internally or adjust ballast to minimise leakage.

In the unlikely event that the seismic vessel sinks or is involved in a collision, environmental impacts may also arise from the vessel contact with the sea floor and the release of any on-board hazardous materials or solid wastes that may cause a hazard to other vessels in the area or could be ingested by marine fauna (e.g. plastics). In terms of the environmental impacts associated with support vessel collision or sinking, the quantities of the hazardous materials carried on the vessels are relatively small and are likely to be rapidly dispersed should accidental spillage occur. Nonetheless there will be short-term impacts to water quality. The extent of these impacts will depend on the quantity of the materials lost overboard, but it is most likely impacts will remain local.

Collisions from Project vessels with marine mammals, during transit to and from the project area, are also possible. Physical impacts from boat-strikes include the potential for injury, and possibly mortality in severe instances. A global study collated all known ship strikes up until 2002, listing a total of 292 records of confirmed or possible strikes of which 48 were fatal (Jensen & Silber, 2003). Most fatal or serious whale injuries involve strikes from larger vessels (Laist *et al.*, 2001).

Speed is considered a key factor in ship strikes of cetaceans and one study recording the mean speed of the vessels at the point of strike at greater than 18 knots (Jensen & Silber, 2003). It is not expected that any vessels associated with the Project will travel at speeds much greater than ~12 knots. Additionally, there will not be small, fast moving vessels that are more commonly associated with marine mammal disturbance, and intentional approaches of marine mammals by Project vessels will not occur.

Given consideration to the above, overall impacts severity of potential impacts from collisions is considered to be ***high*** and the likelihood of a collision occurring is considered to be ***unlikely***.

Severity of Impact-Collisions	Low	Medium	High
Applicable criteria	• Severe environmental damage • Sensitive resources impacted • Recovery of affected resources is very slow		

Likelihood of Occurrence	Extremely Unlikely	Unlikely	Possible	Likely
Applicable Criteria	The event is unlikely but may occur at some time during normal operating conditions			

Mitigation and Control Measures

To minimise the likelihood of a collision the following measures will be adopted during the project:

- Compliance with *Maritime Rules Part 22: Collision Prevention* (Maritime NZ, 2009), in terms of obligatory appropriate radio, navigational aids e.g. lights, flags and other visible signals, and good navigational practices and seamanship;

- Warnings of the proposed survey activities will be issued (Coastal Navigation Warning) and a vigilant watch will be maintained throughout survey activities (radio, AIS, radar and visual). Both English and signal code protocols will be employed to allow multi-lingual communication streams;

- Limiting offshore vessel movements to levels that are required for safe and efficient operations;

- No direct approach to marine mammals by vessels and avoidance action taken where possible when a marine mammal is observed in the area of vessel operations;

- Establishing and enforcing a safety buffer zone with a 500 m radius around the Project area; and

- Support vessel to act as liaison with any vessels approaching the seismic vessel.

With these mitigation and control measures in place, the likelihood of a collision is considered to be ***extremely unlikely***

Likelihood of Occurrence	Extremely Unlikely	Unlikely	Possible	Likely
Applicable Criteria	The event is extremely unlikely to occur under normal operating conditions but may occur in exceptional circumstances			

In the unlikely event a collision does occur, Shell is committed to adoption of the following measures aimed at reducing any subsequent impacts on the marine and coastal environment:

- A fully trained and exercised vessel SOPEP in place prior to the Project commencing;

- The seismic vessel will have on-board containment in case of chemical spills (as well as leaks).

- All chemical and fuel containers including the vessels fuel tanks s will be inspected and maintained for the duration of the Project;

- Project vessels will be equipped with appropriate Tier 1 oil spill containment and clean-up equipment;
- Any spills will be immediately reported to Maritime NZ, together with the response action taken and Shell will work with Maritime NZ to facilitate any required spill response activities;
- All chemicals used will be selected based on the least environmentally harmful locally available alternative.

With the implementation of the above mitigation measures, the severity of impacts from a vessel collision is considered to be ***medium***.

Severity of Impact	Low	Medium	High
Applicable Criteria	• Localised environmental damage • No sensitive resources impacted • Degradation of spilled materials and full recovery of affected resources		

Residual Potential Impact

In the absence of Shell's mitigation and control measures the impact severity of potential impacts from a collision are considered to be ***high***. However, the implementation of mitigation and control measures reduces the likelihood of a collision to ***extremely unlikely***, and the severity of the impact to ***medium***. This results in the overall impact significance from collisions, to be ***negligible***.

Category	Ranking	Residual Impact
Severity of Impact	High	Medium
Likelihood of Occurrence	Unlikely	Extremely Unlikely
Significance	Moderate	Negligible

7.8.4 *Evaluation of Potential Impacts - Loss of Steamers or Other Equipment*

Potential Impact Description

Impacts on ecological communities from the physical presence of Project vessels may include the risk of the loss of streamers or other equipment. Streamers may become tangled or break during rough weather, snagging on floating debris or rupturing from interaction with marine species such as sharks or seals. The streamers that will be utilised are mainly gel-filled (solid). These streamers have a very small amount of fluid where the hydrophones are located in the streamer which amounts to approximately 6 L in each 150m section. In each of the three stretches, located head and tail of the streamer, there is approximately 250-300L of the chemical Isopar M, which provides electrical insulation and neutral buoyancy.

Isopar M is a low odour, low aromatic hydrocarbon solvent. The major components include normal alkanes, isoalkanes, and cycloalkanes. Isopar M fluid biodegrades at a moderate rate and will not persist in the marine environment. This compound is insoluble in water and is not expected to cause short-term toxicity to fish or other organisms (Exxon, 2011). Chronic toxicity is not expected because of its low solubility in water and volatility (Exxon, 2011).

The seismic survey vessel is also fitted with MARPOL compliant pollution control devices and operates under a SOPEP which details actions to be taken in the event of a shipboard oil spill emergency. General emergency response is undertaken in accordance with the MV Aquila Explorer Offshore Emergency Response Procedure (ERP, 2010).

Streamers are solid and neutrally buoyant so if a break should occur they would not pose a risk to benthic habitats. If a broken streamer is not recovered however, streamers may become tangled in fishing nets or ship propellers.

Should any other equipment be lost overboard, the resultant impact would be dependent on the specific item. Foreign items could result in impacts on water quality, harm to marine life by ingestion or impacts on benthic organisms and benthic structure.

Should a streamer break or equipment loss occur, the resultant impact is expected to be minimal and of a temporary duration. As such, the severity of such potential impacts is considered to be ***low***

Severity of Impact	Low	Medium	High
Applicable Criteria	• Some damage to the environment/ very localised • No sensitive resources impacted • Rapid degradation of spilled materials and rapid recovery of affected resources		

Despite the use of quality and durable streamers, rough seas and interactions with marine species increases the risk of streamer breaks. Rough seas also increase the risk of equipment loss. Therefore the likelihood of occurrence is ***possible.***

Likelihood of Occurrence	Extremely Unlikely	Unlikely	Possible	Likely
Applicable Criteria	The event is likely to occur at some time during normal operating conditions			

Mitigation and Control Measures

- All streamers and towed and towing equipment will be kept in good condition and stored appropriately. Regular checks will be carried out for leaks or cracks in streamers and towed and towing equipment;

- When deploying or recovering the streamers, any leaks or cracks will be immediately resealed;
- Only qualified technicians will deploy or retrieve streamers and other towed equipment and will adhere to strict handling guidelines;
- A reasonable effort will be made to retrieve any lost floating equipment, and any other equipment lost overboard will be recorded.
- All equipment on board will be stored and secured to minimise the risk of overboard loss.
- Streamer design facilitates identification and recovery if lost;
- A workboat to assist with streamer or equipment recovery is available at all times; and
- A record will be kept of all equipment on board and any loss of equipment will be reported immediately and, if possible, retrieved as soon as safely possible.

With these mitigation and control measures in place the likelihood of loss of streamers or other equipment is considered to be ***unlikely***

Likelihood of Occurrence	Extremely Unlikely	Unlikely	Possible	Likely
Applicable Criteria	The event is unlikely but may occur at some time during normal operating conditions			

Residual Potential Impact

In the absence of Shell's mitigation and control measures the impact severity of potential impacts from lost streamers or equipment was considered to be ***minor***. While the severity remains unchanged, the implementation of the above mitigation and control measures reduced the likelihood of any break of loss to ***unlikely***. This results in the overall impact significance to ***negligible***.

Category	Ranking	Residual Impact
Severity of Impact	Low	Low
Likelihood of Occurrence	Possible	Unlikely
Significance	Minor	Negligible

7.8.5 *Evaluation of Potential Impacts – Introduction of Invasive Species*

Potential Impact Description

Impacts on ecological communities from physical presence of the Project vessels may include the risk of introduced marine species, some of which may have the potential to become established in a new location. All marine vessels pose some risk of transporting marine species through hull fouling and ballast water.

Invasive species, such as non-native mussels, crabs, seaweeds, worms and sea squirts, could become a nuisance or threaten local industries such as aquaculture by settling on submerged structures such as marine farms and out-competing native species. Should invasions succeed, the resultant impact could be widespread and long-term or permanent. As such, the severity of such potential impacts is considered to be ***high***.

Severity of Impact	Low	Medium	High
Applicable Criteria	• Severe environmental damage • Sensitive resources impacted • Recovery of affected resources is very slow		

The seismic survey vessel will be sourced from overseas, thus poses a risk of transporting invasive species into NZ waters. Even for vessels sourced from within New Zealand there is potential for the translocation of marine species, such as the marine algae *Undaria pinnatifida* from other areas to the Project site. Given the remote location and water depth of the AOI, the potential for invasion within this specific deepwater environment is very limited. The likelihood of an invasive marine species becoming established in the area as a result of hull fouling or ballast water discharge is considered ***unlikely***.

Likelihood of Occurrence	Extremely Unlikely	Unlikely	Possible	Likely
Applicable Criteria	The event is unlikely but may occur at some time during normal operating conditions			

Mitigation and Control Measures

- A Senior Marine Advisor within the Border Standards team of Ministry for Primary Industries will be consulted with and a Biosecurity Management Plan will be produced to effectively manage the risk of invasive species.

- The survey and support vessel hulls will be cleaned and anti-fouled prior to transport into New Zealand waters thus minimising the possibility of the presence of invasive invertebrates.

- Any support vessels that are sourced from outside New Zealand waters will be inspected for hull fouling prior to engagement on the project, and all vessels will be required to have recent evidence of antifouling.

- Project vessels will not anchor within the AOI.

With these mitigation and control measures in place the likelihood of a successful invasion from pest species is considered to be ***extremely unlikely***

Likelihood of Occurrence	Extremely Unlikely	Unlikely	Possible	Likely
Applicable Criteria	The event is extremely unlikely to occur under normal operating conditions but may occur in exceptional circumstances			

Residual Potential Impact

In the absence of Shell's mitigation and control measures the impact severity of potential impacts from invasive species was considered to be ***high***. While the severity remains unchanged, the implementation of the above mitigation and control measures reduced the likelihood of the successful invasion from pest species to ***extremely unlikely***. This results in the overall impact significance from collisions, to be ***negligible***.

Category	Ranking	Residual Impact
Severity of Impact	High	High
Likelihood of Occurrence	Unlikely	Extremely Unlikely
Significance	Moderate	Negligible

7.9 CUMULATIVE IMPACTS

It is understood that across the 2013/2014 summer season there will be other seismic surveys being conducted off the east coast of the South Island, in the Canterbury and Pegasus Basins. While Shell is not privy to the exact nature or timing, there is potential for there to be an element of accumulation in the impacts of the surveys. However any cumulative impacts experienced are likely to be indirect given the spatial attenuation of the sound and the fact that there will not be concurrent surveys within hundreds of kilometres of each other. As discussed above in *Section 7.5*, as the magnitude of underwater noise decreases across space, so does the significance of any of the impacts. The results of the sound transmission loss modelling completed for this MMIA show that the direct impacts on marine mammals will be limited to the mitigation areas the Code enforces (*Section 7.5.3*). As such, it is expected that the other surveys operating in the region, will have similar, if not the same, impact scales across space. Given the distance between this survey and the Canterbury Basin is > 60 km and to the Pegasus Basin is > 400 km, the spatial extent of any direct impacts are high unlikely to overlap.

Given the above, any cumulative impacts are likely to be limited to migratory species transiting through the multiple AOI's or commercial fishers that have interests in more than one of the AOI's. In such instances they could experience the impacts described in this MMIA on more than one occasion.

Cumulative Impact Ranking

As discussed above, the most severe potential cumulative impact is from the overlap of the sound from the surveys operating at the same time. The most sensitive receptor to such an overlap would be marine mammals and their sensitivity to underwater sound is considered to be ***high***. Yet, given the distance between the surveys is so great, the likelihood of such an overlap is considered to be ***extremely unlikely***. This results in the overall cumulative impact significance to be ***negligible***.

Category	**Impact**
Severity of Impact	High
Likelihood of Occurrence	Extremely Unlikely
Significance	**Negligible**

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Annex A

List of Project Commitments

Commitment	Section
Seismic activities will be undertaken within PEPs 54863 and 50119 of the Great South Basin (GSB).	1.2
As part of the work programme for each of the PEPs, Shell commit to exploration activities, thereby furthering investigations into the resource potential of the PEPs as well as the wider GSB.	1.4.4
The seismic vessel will return to Port Chalmers, Dunedin, taking around 24 hours to conduct the crew change as well as refuel and resupply the vessel.	2.4.2
The seismic vessel to be used in the project is the *MV Aquilla Explorer*	2.4.3
Shell will comply with MARPOL restrictions for garbage disposal restrictions	2.4.3
Rainwater that falls in places with exposed equipment or fuel storage will be collected and treated in an oil-water separator to meet MARPOL requirements (oil content <15 ppm).	2.4.3
A support vessel will be used to support the seismic survey by scouting for navigation hazards such as fishing gear or other debris and will assist in liaison with other vessels in the area as required.	2.4.4
The support vessel will be in constant communication with the primary survey vessel.	2.4.4
The air guns are of varying size up to a maximum of 6200 in^3 and will be positioned and fired in a precise sequence.	2.4.5
The streamer will be mainly gel-filled (solid) and a small amount of fluid where the hydrophones are located.	2.4.5
At the end of each streamer cable is a tail buoy with radar reflectors to act as a warning beacon to nearby marine vessels.	2.4.5
The vessels will be fully provisioned and bunkered before mobilisation.	2.4.7
The MSS will be planned and executed in accordance with the *2013 DOC Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations* (the Code of Conduct)	2.5
…the outputs of the model will be ground-truthed during the seismic survey. Drifting hydrophones will be used for ground truthing. These will be deployed from the support vessel at the direction of Shell's independent environmental advisors. In addition, at the suggestion of Curtin University experts, it is proposed to test a method of acquiring the data required for ground truthing using data acquired from the towed hydrophone production streamer using high sample rate data acquisition. If this method is successful it will prove easier and safer to ground truth future models. The support vessel in this case is used primarily as a safety contingency for the survey vessel and is required to remain on-site in the deep water as much as possible. However, if operational circumstances allow, drifting	3.1.2

Commitment	Section
hydrophone data in shallow water can also be acquired.	
As a Category B Project, Shell commits to completing a Screening note, Aspect and impact register, Stakeholder engagement plan, Scoping report, Environmental, Social and Health Baseline Report, Impact Assessment Report and an Environmental, Social and Health Management Plan.	5.1
Regular consultation with the project's identified interested parties will continue throughout the project's lifespan of Shell's GSB interest, ensuring that queries and concerns raised are addressed and, where feasible, appropriate responses are built and into the design and/or management plans.	6.4.1
With regards to the MMIA, Jim [at DoC] requested that we consider the following:	6.4.1
1. Supplying a copy of the MMIA to him;	
2. Supply the results of the sound modelling being undertaken by Curtin University; and	
3. Agree to undertake necropsy (by Massey Uni) for any unexplained marine mammal fatality during the Project.	
Shell agreed to all of the above requests. Points one and two have been fulfilled through the submission of this MMIA to DoC.	
In relation to point three, Shell agree that if a marine mammal fatality occurs during the survey and for 2 weeks after it ends, which cannot be attributed to natural causes (i.e. shark attack) they will fund the necropsy. The spatial extent of the area this commitment applies is from Stewart Island and Bluff in the south, to Timaru in the north.	
A Marine Mammal Management Plan (MMMP) will be produced for the Project, prior to any seismic activities commencing. The MMMP will incorporate all of the mitigation measures outlined in this MMIA, as well as any additional measures identified as necessary, through consultation with DoC and the contracted MMO's, after completion of this MMIA. The MMMP will be an operational document for use during the survey and a copy will be provided to DoC.	7.3
Vessels working on the Project will abide by the guidelines outlined in the *Marine Mammals Protection Act 1978* and will not intentionally approach marine mammals and, where safely possible, vessel operators will take evasive action such as reducing speed or changing course to avoid close interactions with whales.	7.4.3
Only lighting required for safe navigation and operations will be utilised.	7.4.4
Communications will occur between Shell, commercial fisheries and marine traffic, both prior to and during the Survey. This communication will be conducted through a Notice to Mariners following the guidelines outlined in the *Maritime Rules Part 22: Collision Prevention.*	7.4.5
Streamer will have a tail buoy attached with radar reflectors to ensure that all vessels can visualise the tail of the streamer.	7.4.5

Commitment	Section
An on board AIS will ensure the vessel is tagged as a seismic vessel while at sea, alerting all surrounding vessels to the potential for streamers.	7.4.5
The 2013 Code of Conduct will be abided by during the survey.	7.5.3
Only uncontaminated deck drainage water can be discharged overboard, all deck drainage from areas that may be contaminated will be directed to bilges for treatment prior to discharge.	7.6.3
Oily water discharges will be fitted with continuous monitoring equipment and automatic valves to ensure that oil content in effluent being discharged does not exceed 15 ppm.	7.6.3
Any waste oil transfers will be logged and recorded in the vessels' Oil Record Book and all transfer records held for the required period.	7.6.3
Vessels will maintain a valid International Oil Pollution Prevention (IOPP) Certificate and Oil Record Book (ORB) and will have onboard IMO-type approved oily water separators and piping arrangements.	7.6.3
All waste will be handled and disposed of in accordance with the Waste Management Plan (to be developed prior to project initiation) and in full compliance with MARPOL Annexes IV and V.	7.6.4
All sewage and organic kitchen waste generated on-board Project vessels will either be treated in an approved on-board wastewater treatment facility and discharged more than 12 nautical miles from shore (in compliance with MARPOL Annex V), or contained and discharged at appropriate onshore facilities when the vessels call into port.	7.6.4
No marine pollutants will be discharged in operational waste streams.	7.6.4
Clinical waste will be stored separately and will not be placed into the sewage or grey water waste stream	7.6.4
Any discharges of controlled (non-hazardous) wastes and effluent from the washing or rinsing of containers or equipment will meet acceptable standards for marine discharge in accordance with the relevant regulations.	7.6.4
Only light grades of fuel oil (e.g. marine diesel or marine gas oil) will be used by the Seismic Survey vessel and the support vessel.	7.7.3
The vessel and support vessel will comply with MARPOL 73/78 Annex VI – Air standards relating to air emissions.	7.7.3
All propulsion systems, exhausts systems, and power generation equipment will be well maintained for optimal operational efficiency.	7.7.3
Only low sulphur diesel will be utilised.	

Commitment	Section
The fuel consumption of the vessels will be regularly monitored as a check to further ensure the combustion efficiency of all systems.	7.7.3
Quick disconnect couplings for all transfer hoses will be utilised to reduce the potential risk of accidental fuel, oil or chemical spills.	7.8.2
Dry break couplings and drip trays will be utilised to reduce the potential risk of accidental fuel, oil or chemical spills.	7.8.2
Double valves on all systems prone to leakage will be utilised to reduce the potential risk of accidental fuel, oil or chemical spills.	7.8.2
All fuel tankers will be inspected and approved as fit for purpose to reduce the potential risk of accidental fuel, oil or chemical spills.	7.8.2
All fuel, oil and chemicals will be stored in special bunded and lined areas designed to hold the full volume of the product being stored to reduce the potential risk of accidental fuel, oil or chemical spills.	7.8.2
Routine maintenance and inspection of storage facilities will be conducted to reduce the potential risk of accidental fuel, oil or chemical spills.	7.8.2
Refuelling at port will use established port bunkering facilities for which a current Tier 1 oil spill contingency plan (OSCP) and equipment are in place in order to reduce the potential risk of accidental fuel, oil or chemical spills.	7.8.2
Refuelling or transfer will only occur when sea and weather conditions are sufficiently calm, as determined by the vessel Master, in order to reduce the potential risk of accidental fuel, oil or chemical spills.	7.8.2
Refuelling during the hours of darkness will be avoided where possible in order to reduce the potential risk of accidental fuel, oil or chemical spills.	7.8.2
Review of job hazard analysis for bulk transfer of diesel before transfer commences in order to reduce the potential risk of accidental fuel, oil or chemical spills.	7.8.2
Detailed checklists will be utilised to confirm correct valve line up, quality of equipment and communications arrangements in order to reduce the potential risk of accidental fuel, oil or chemical spills.	7.8.2
Pressure testing of hoses will be conducted before use in order to reduce the potential risk of accidental fuel, oil or chemical spills.	7.8.2
Continuous visual monitoring of hoses, couplings and the sea surface during refuelling or transfer will be conducted in order to reduce the potential risk of accidental fuel, oil or chemical spills.	7.8.2
Continuous monitoring of flow gauges on both the seismic vessel and supply vessel will be conducted in order to reduce the potential risk of accidental fuel, oil or chemical spills.	7.8.2

Commitment	Section
Continuous contact between the seismic vessel and the supply vessel will be conducted in order to reduce the potential risk of accidental fuel, oil or chemical spills.	7.8.2
Project vessels will have a valid SOPEP in accordance with MNZ requirements and a valid Emergency Response Plan, with all crew trained in their roles and responsibilities under the plans and regular exercises of the plans in accordance with the IOPPC requirements in order to reduce the potential risk of accidental fuel, oil or chemical spills.	7.8.2
Project vessels will be equipped with appropriate Tier 1 oil spill containment and clean-up equipment in order to reduce the potential risk of accidental fuel, oil or chemical spills.	7.8.2
Any spills will be immediately reported to MNZ, together with the response actions taken	7.8.2
All chemicals used will be selected based on the least environmentally harmful locally available alternative	7.8.2
Shell will comply with *Maritime Rules Part 22: Collision Prevention* (Maritime NZ, 2009), in terms of obligatory appropriate radio, navigational aids e.g. lights, flags and other visible signals, and good navigational practices and seamanship;	7.8.3
Warnings of the proposed survey activities will be issued (Coastal Navigation Warning) and a vigilant watch will be maintained throughout survey activities (radio, AIS, radar and visual). Both English and signal code protocols will be employed to allow multi-lingual communication streams	7.8.3
No vessel will approach marine mammals and avoidance action taken where possible when a marine mammal is observed in the area of vessel operations	7.8.3
A safety buffer zone of a 500 m radius around the survey area will be established and enforced	7.8.3
The support vessel will act as liaison with any vessels approaching the seismic vessel.	7.8.3
A fully trained and exercised vessel SOPEP in place prior to the Project commencing	7.8.3
The seismic vessel will have on-board containment in case of chemical spills (as well as leaks).	7.8.3
All chemical and fuel containers including the vessels fuel tanks s will be inspected and maintained for the duration of the Project	7.8.3
Project vessels will be equipped with appropriate Tier 1 oil spill containment and clean-up equipment;	7.8.3
Any spills will be immediately reported to Maritime NZ, together with the response action taken and Shell will work with Maritime NZ to facilitate any required spill response activities	7.8.3

Commitment	Section
All chemicals utilised on board will be selected based on the least environmentally harmful locally available alternative.	7.8.3
All streamers and towed and towing equipment will be kept in good condition and stored appropriately. Regular checks will be carried out for leaks or cracks in streamers and towed and towing equipment	7.8.4
When deploying or recovering the streamers, any leaks or cracks will be immediately resealed	7.8.4
Only qualified technicians will deploy or retrieve streamers and other towed equipment and will adhere to strict handling guidelines	7.8.4
A reasonable effort will be made to retrieve any lost floating equipment, and any other equipment lost overboard will be recorded.	7.8.4
All equipment on board will be stored and secured to minimise the risk of overboard loss.	7.8.4
Streamer utilised have a design that facilitates identification and recovery if lost;	7.8.4
A workboat to assist with streamer or equipment recovery will be available at all times.	7.8.4
A record will be kept of all equipment on board and any loss of equipment will be reported immediately and, if possible, retrieved as soon as safely possible	7.8.4
A Senior Marine Advisor within the Border Standards team of Ministry for Primary Industries will be consulted with and a Biosecurity Management Plan will be produced to effectively manage the risk of invasive species.	7.8.5
The survey and support vessel hulls will be cleaned and anti-fouled prior to transport into New Zealand waters thus minimising the possibility of the presence of invasive invertebrates.	7.8.5
Any support vessels that are sourced from outside New Zealand waters will be inspected for hull fouling prior to engagement on the project, and all vessels will be required to have recent evidence of antifouling.	7.8.5
Project vessels will not anchor within the AOI	7.8.5

Annex B

Sound Transmission Loss Modelling Report

Curtin University

Centre for Marine Science and Technology

Sound Transmission Loss Modelling Report of Shell's Great South Basin II, Carina 2D, Marine Mammal Impact Assessment

Prepared for:

ERM New Zealand

Prepared by:

PROJECT CMST 1265
REPORT 2013-54

15th November 2013

Abstract

This report describes acoustic propagation modelling that was carried out to predict received sound exposure levels from Shell's Great South Basin II, Carina 2D seismic survey. The modelling method used to produce these results accurately deals with both the horizontal and vertical directionality of the airgun array, and with variations in water depth and seabed properties.

Modelling predicted that the maximum sound exposure levels produced by the Aquila Explorer 4230 cubic inch array operating within the Carina survey area will be below 186 dB re 1 $\mu Pa^2.s$ at a range of 200m, and below 171 dB re 1 $\mu Pa^2.s$ at a range of 1km and that the array will therefore meet the sound exposure level requirements of the New Zealand Department of Conservation 2012 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations. At a range of just over 100m, 95% of received sound exposure levels are predicted to be below 186 dB re 1 $\mu Pa^2.s$, and at a range of just over 500m, 95% of received sound exposure levels are predicted to be below 171 dB re 1 $\mu Pa^2.s$.

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1 Introduction

This report describes acoustic propagation modelling which was carried out to predict received sound exposure levels from Shell's Great South Basin 2D seismic survey. The modelling was carried out in order to establish whether the survey meets the sound exposure level requirements of the New Zealand Department of Conservation 2012 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations. The Code requires modelling to determine whether received sound exposure levels will exceed 186 dB re 1 $\mu Pa^2.s$ at a range of 200m from the source, or 171 dB re 1 $\mu Pa^2.s$ at ranges of 1km and 1.5km.

The survey area is offshore of New Zealand's South Island and is shown in Figure 1. The detailed bathymetry of the area, plotted in Figure 2, shows that the seabed is quite flat, with water depths of about 1000m over most of the area, increasing to a maximum of just over 1500 m in the southeast corner.

Section 2 describes the methods used to carry out the modelling and the results are presented in Section 3. Conclusions are given in Section 4.

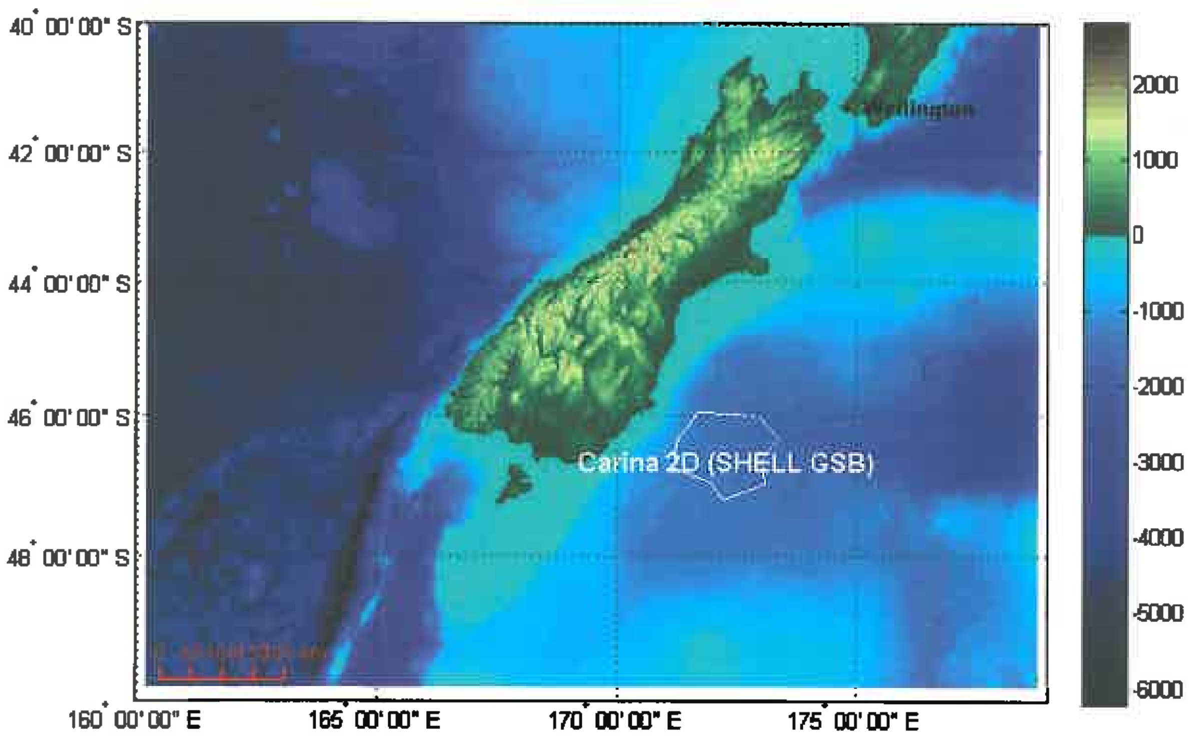

Figure 1. Map the New Zealand South Island showing the survey area.

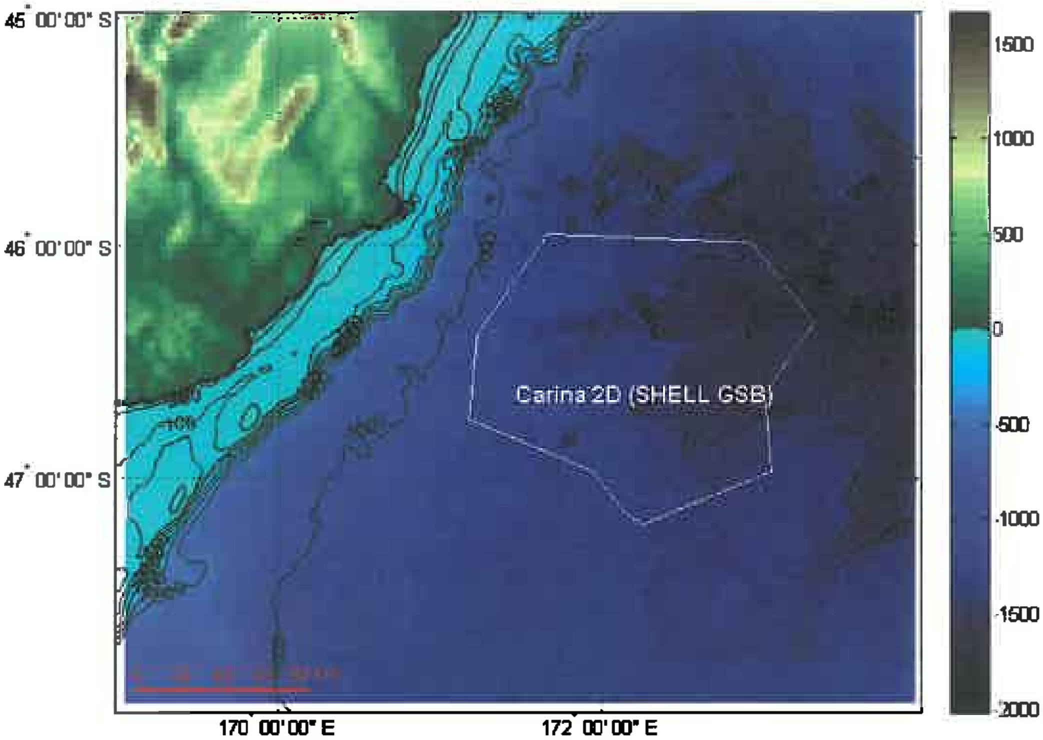

Figure 2. Survey bounding polygon (white) showing detailed bathymetry contours. Bathymetry is from the ETOPO2v2 database (U.S. Department of Commerce, 2006)

2 Methods

2.1 Source modelling

The airgun array proposed for this survey is the Aquila Explorer 4230 cubic inch array shown in Figure 3.

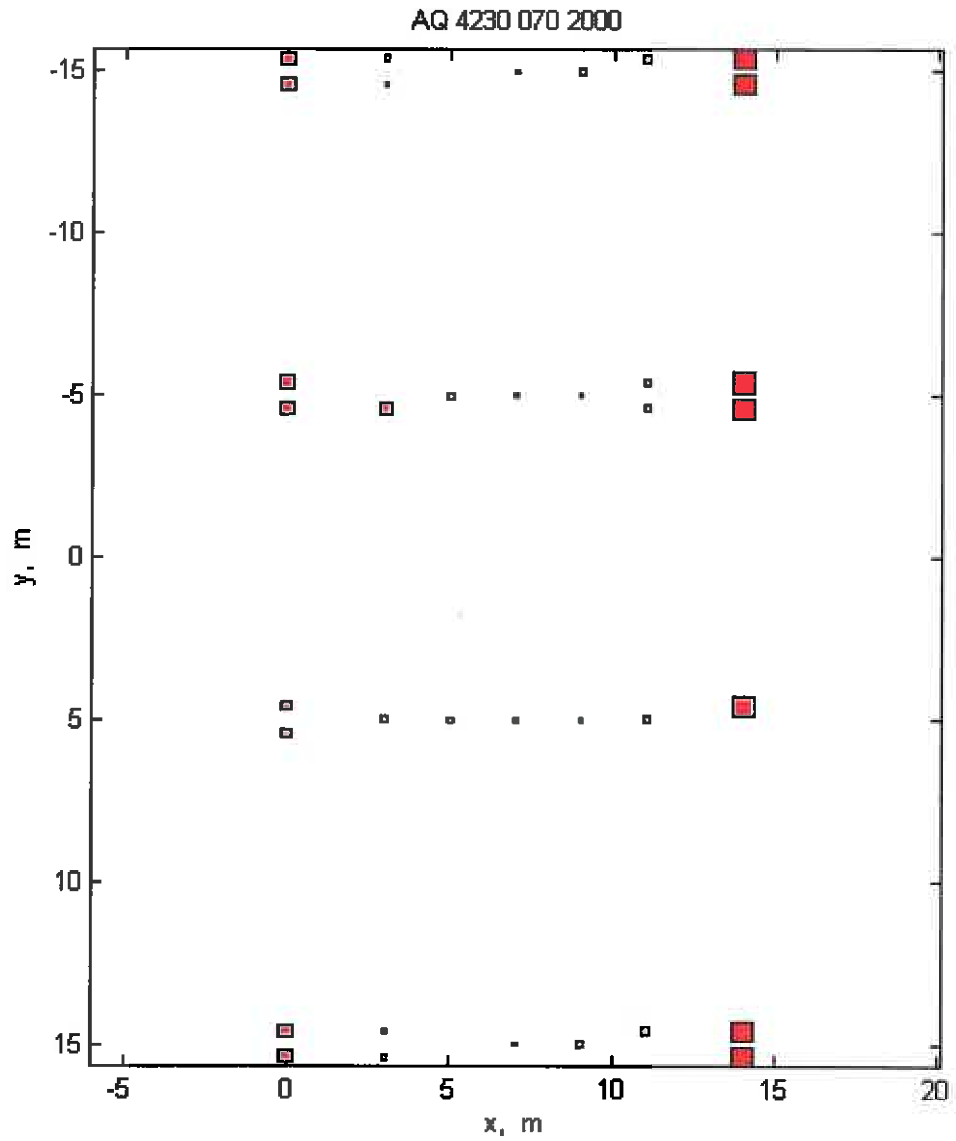

Figure 3. Plan view of the Aquila Explorer 4230 cui array. Array elements are shown much larger than actual size but are scaled proportional to the cube root of their volume.

2.1.1 Modelling and calibration methods

Acoustic signals required for this work were synthesised using CMST's numerical model for airgun arrays. The procedure implemented for each individual source element is based on the bubble oscillation model described in Johnson (1994) with the following modifications:

- An additional damping factor has been added to obtain a rate of decay for the bubble oscillation consistent with measured data;
- The zero rise time for the initial pressure pulse predicted by the Johnson model has been replaced by a finite rise time chosen to give the best match between the high frequency roll-off of modelled and measured signal spectra;
- For the coupled-element model used in this work, the ambient pressure has been modified to include the acoustic pressure from the other guns in the array and from the surface ghosts of all the guns. Including this coupling gives a better match between the modelled signal and example waveforms provided by seismic contractors, but only has a minor influence on the spectrum of this signal and hence on the modelled received levels.

The model is subjected to two types of calibration:

- The first is historical and was part of the development of the model. It involved the tuning of basic adjustable model parameters (damping factor and rise time) to obtain the best match between modelled and experimentally measured signals, the latter obtained during sea trials with CMST's 20 in^3 air gun. These parameters have also been checked against several waveforms from larger guns obtained from the literature.
- The second form of calibration is carried out each time a new array-geometry is modelled, the results of which are presented below. Here, the modelled gun signals' amplitudes are scaled to match the signal energy for a far-field waveform for the entire array computed for the nadir direction (including ghost) to that of a sample waveform provided by the Client's seismic contractor. When performing this comparison the modelled waveform is subjected to filtering similar to that used by the seismic contractor in generating their sample, or additional filtering is

applied to both data sets to emphasise a section of the bandwidth of the supplied data which CMST regards as being most reliable.

Beam patterns for the calibrated array were built up one azimuth at a time as follows:

- The distances from each gun to a point in the far-field along the required azimuth were calculated. (The far-field is the region sufficiently far from the array that the array can be considered a point source);
- The corresponding time delays were calculated by dividing by the sound speed;
- Computed signals for each gun were delayed by the appropriate time, and then these delayed signals were summed over the guns;
- The energy spectral density of the resulting time domain waveform was then calculated via a Fourier transform;
- During this procedure care was taken to ensure that the resulting spectrum was scaled correctly so that the results were in source energy spectral density units: dB re 1 $\mu Pa^2 s/Hz$ @ 1m.

2.1.2 Source modelling results

Figure 4 shows a comparison between the example waveform and spectrum for the vertically downward direction provided by the client and those produced by the CMST airgun model after calibration. There are differences in detail but the general agreement is excellent.

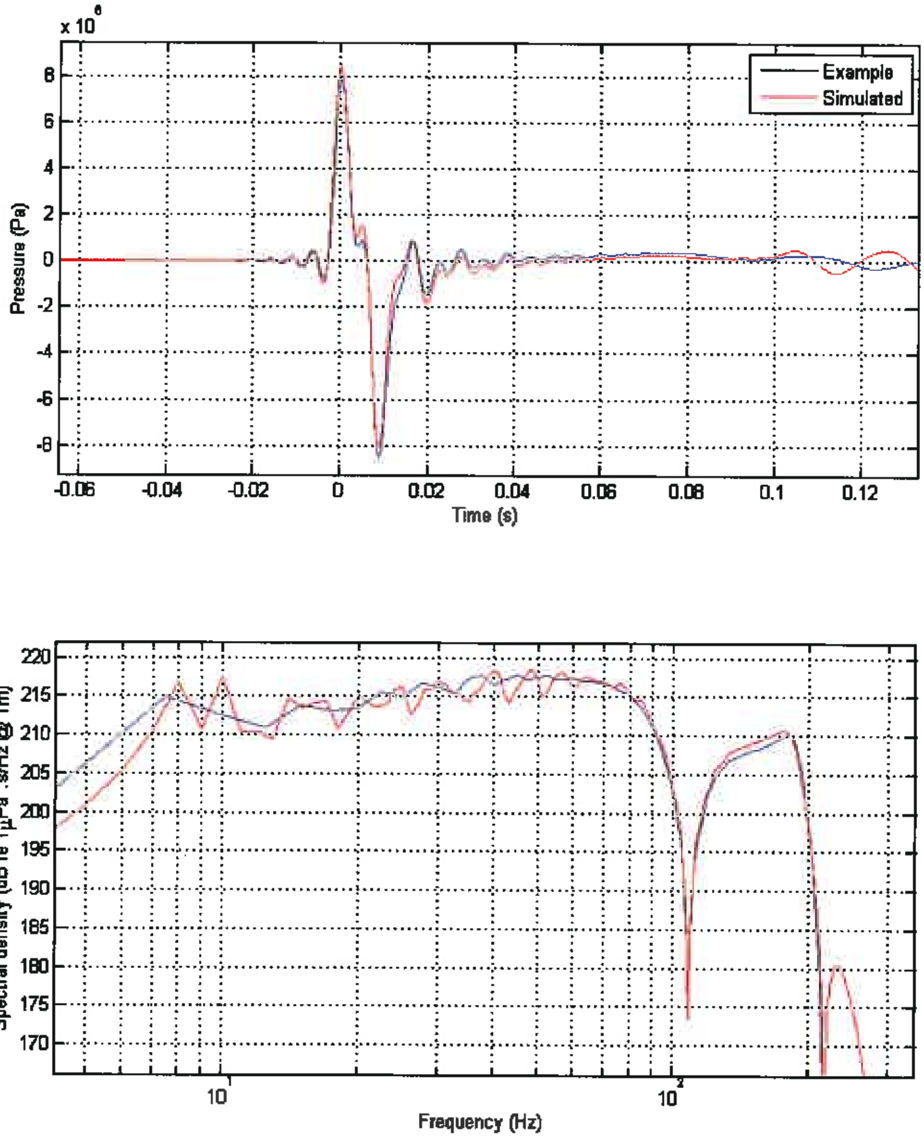

Figure 4. Comparison between the waveforms (top) and spectra (bottom) of the example signal for the vertically downward direction provided by the client (blue) and the signal produced by CMST's airgun array model (red).

Vertical and horizontal cross-sections through the frequency dependent beam pattern of the array are shown in Figure 5. These beam patterns demonstrate the strong angle and frequency dependence of the radiation from the airgun arrays. The horizontal beam pattern shows that, as is typically the case with airgun arrays, in the horizontal plane the bulk of the high frequency energy is radiated in the cross-line direction.

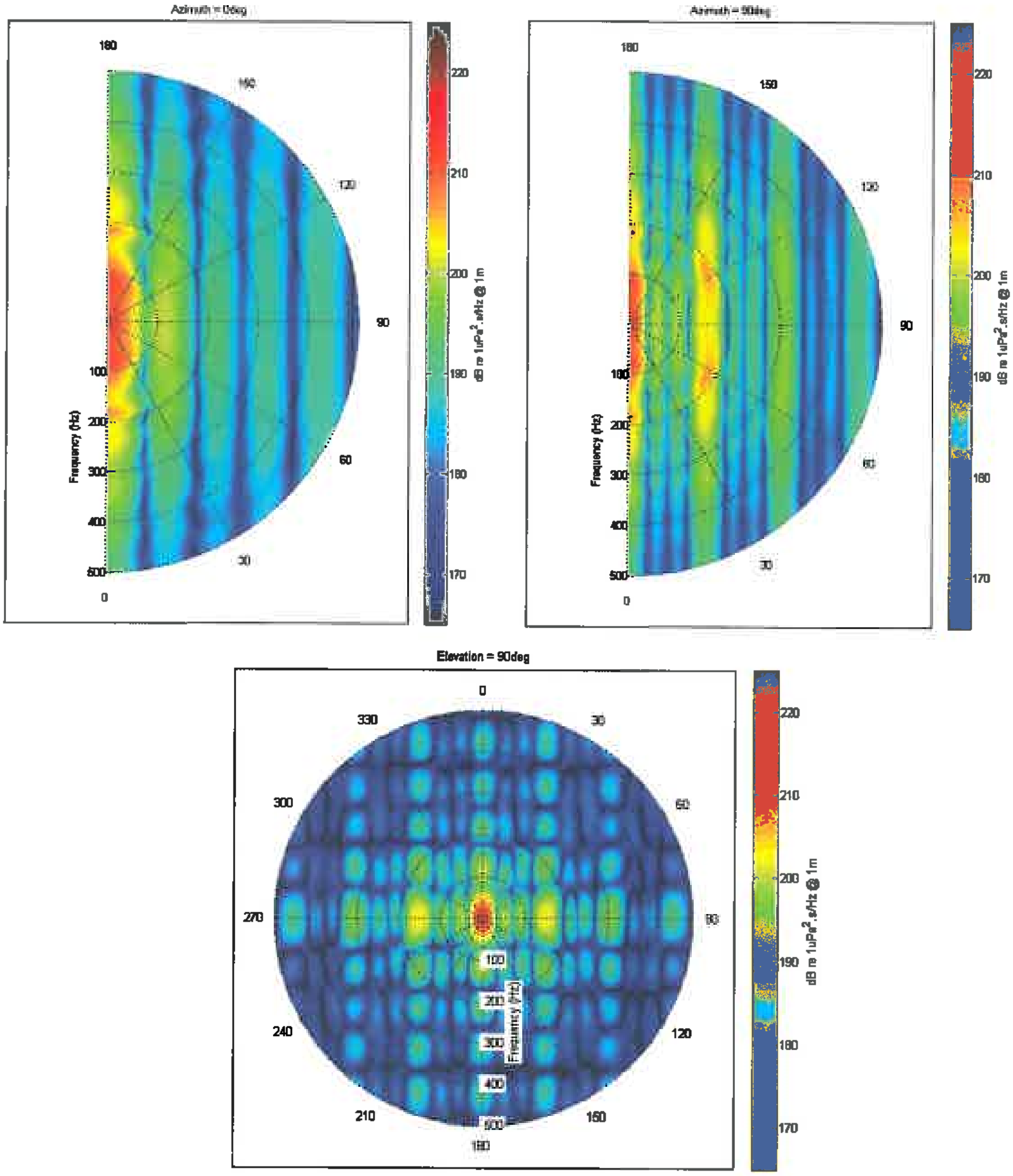

Figure 5. Array far-field beam patterns as a function of orientation and frequency (radial coordinate). The top two plots are for the vertical plane for the in-line direction (left) and cross-line direction (right). Zero elevation angle corresponds to vertically downwards. The bottom plot is for the horizontal plane with 0 degrees azimuth corresponding to the in-line direction.

2.2 Propagation modelling

2.2.1 Source locations & bathymetry

The bathymetry data shown in Figure 2 was obtained from the ETOPO2v2 global elevation and bathymetry database (U.S. Department of Commerce, 2006). A single representative source location was chosen at the shallowest water depth to model sound propagation. This location was chosen to maximise the contribution of the signal reflected from the seabed and therefore to model the scenario where the greatest amount of energy would propagate in the ocean.

2.2.2 Water-column properties

Several sound velocity profiles were compared to obtain the best estimate of the environmental conditions at the time of the proposed survey. CMST's standard modelling procedure is to obtain a sound velocity profile from the World Ocean Atlas (NOAA, 2005) from the nearest grid point. For this survey, temperature and salinity data from 7 CTD casts were also provided by ERM New Zealand. These measurements were used to calculate the sound speed as a function of depth using the formula from Medwin (1975). The CTD sample locations are shown in Figure 6 and the resulting sound velocity profiles calculated from the CTD data and that obtained from the World Ocean Atlas are shown in Figure 7.

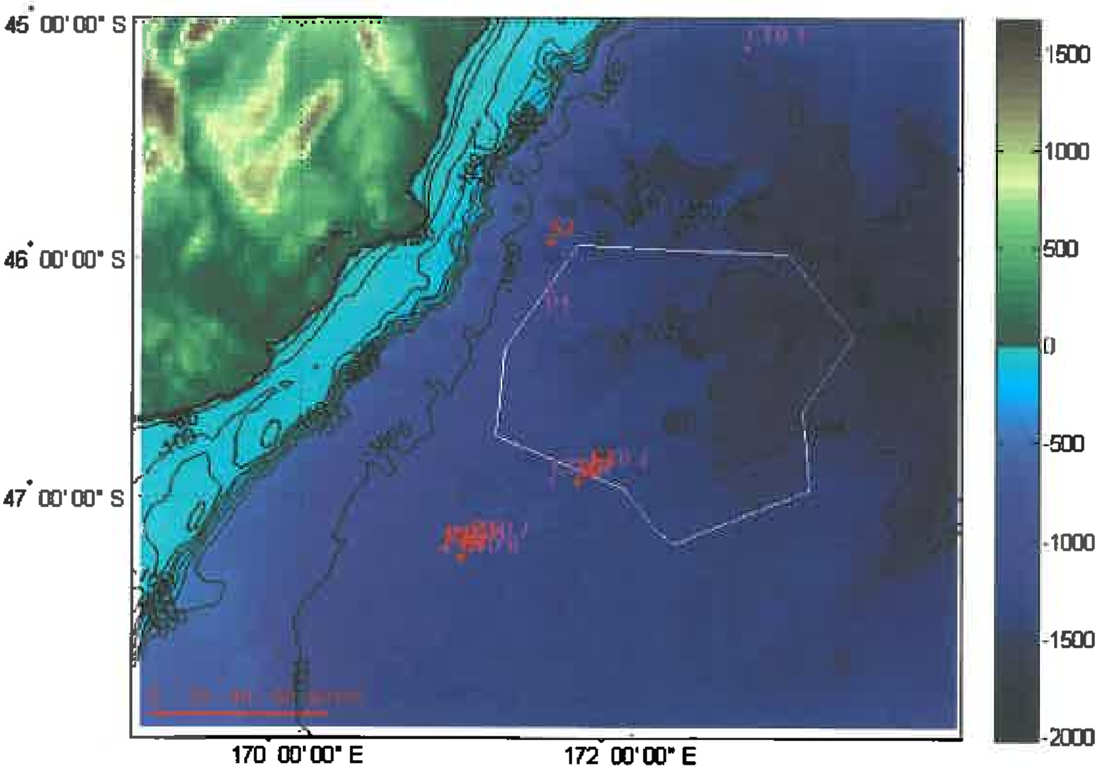

Figure 6. Locations of shallow water modelling point (P1), CTD casts (magenta CTD points) and sediment grabs (red stars) provided by ERM New Zealand.

All sound velocity profiles presented in Figure 7 are very similar, the bold blue curve was chosen as the sound velocity profile for the following modelling work. This profile was chosen as part of a conservative modelling approach because it displayed the greatest amount of ducting potential to trap sound signal in the waster column due to the minimum in the sound speed seen between 100 m and 400 m depth.

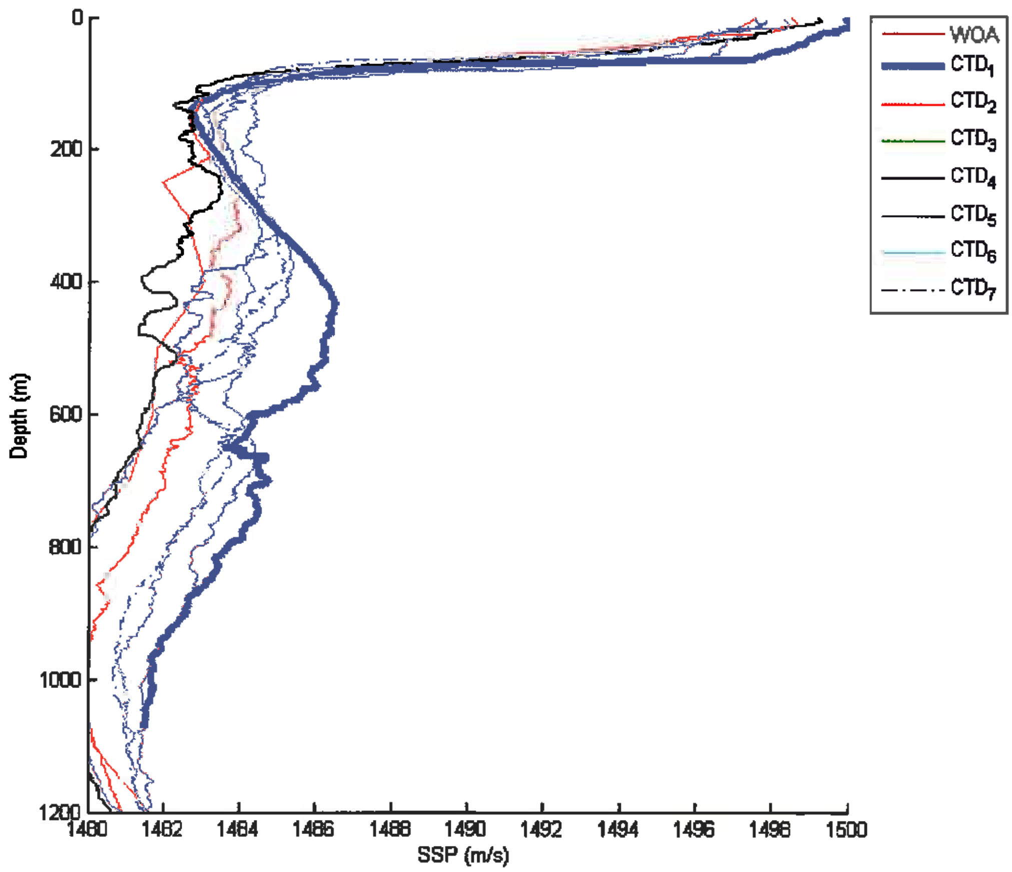

Figure 7. Various water column sound velocity profiles and the chosen profile for this modelling work (bold blue curve)

2.2.3 Seabed Properties

The seabed geoacoustic model was based on information provided by ERM New Zealand (Mitchell, Neil, & Pallentin, 2012) and from studies published in peer-reviewed literature. The assumed seabed properties are presented in Table 1. Sediment data provided by ERM indicated that seafloor sediments are primarily composed of approximately 50% sand and 50% silt as seen in Figure 8. The approximate sediment sample locations are shown above in Figure 6. Both borehole and shallow seismic cross sections in literature indicated a thick layer sediment in the region (Carter, Carter, & Davy, 1994; Fulthorpe & Carter, 1989; Griggs, Carter, James, & Carter, 1983).This layer was estimated to be composed of a 400 m thick layer of silty–sandy pelagic ooze (Carter et al., 1994). Hamilton (1980) discussed reasonable estimates for the sound propagation parameters associated with this type of sediment.

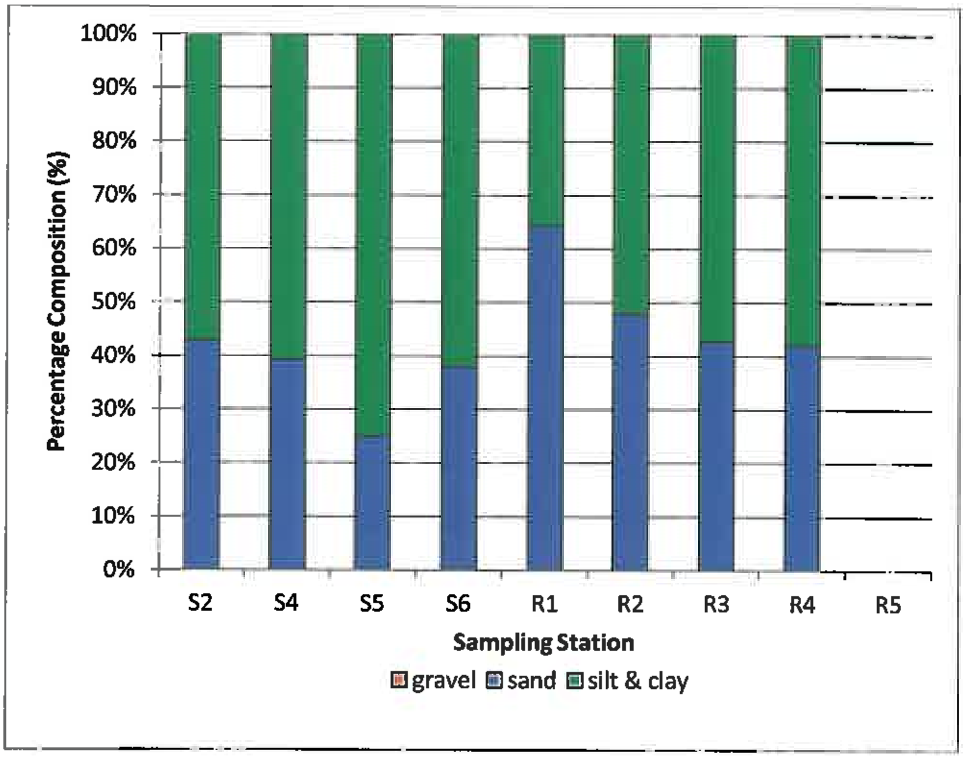

Figure 8. Seafloor sediment data collected from the survey area.

However, for thick layers of sediments, compaction and porosity reduction can change the sound propagation parameters within a layer (Jensen, Kuperman, Porter, & Schmidt, 1994). Consequently both the sound speed (Hamilton, 1979) and density (Hamilton, 1976) were increased linearly with depth into the sediment layer. Studies on the regional geology near the survey area (Carter et al., 1994; Lu, Lu, Fulthorpe, & Mann, 2003) indicate that various limestone units underlie these sediments. Therefore a limestone basement was inserted at the bottom of the assumed geoacoustic model. The limestone compressional wave speed was obtained by an average estimate of sonic log data from Lu et al. (2003) and the shear speed was calculated from Hamilton (1982). Representative values for the densities and attenuations were obtained from Jensen et al. (1994).

Table 1: Seabed acoustic data used in propagation modelling.

Layer	Thickness (m)	Density (kg.m^{-3})	Compress-ional wave speed (m.s^{-1})	Compress-ional wave attenuation (dB per wavelength)	Shear Wave Speed (m.s^{-1})	Shear wave attenuation (dB per wavelength)
Silt-Sand Layer	**400**	**1435**	**1556**	**0.47**	**N/A**	**N/A**
		1900	**2250**		**N/A**	**N/A**
Limestone Basement	**N/A**	**2.4**	**3380**	**0.1**	**1670**	**0.2**

2.2.4 Choice of propagation modelling codes

The relatively flat seabed in the survey area and the short ranges required for modelling made it possible to use the range independent propagation modelling code SCOOTER (Michael B. Porter, 2007) for this work. SCOOTER is a wavenumber integration code, which is stable, reliable, and can deal with arbitrarily complicated seabed layering. It cannot, however, deal with changes of water depth with range, but that is unimportant in this particular application.

2.3 Sound exposure level (SEL) calculations

At short ranges it is important to include both the horizontal and vertical directionalities of the airgun array, which requires summing the signals from the individual airguns at each receiver location. This process is accurate but very computationally demanding, and it is not feasible to apply it at ranges of more than a few kilometres.

Calculation of received sound exposure levels was carried out using the following procedure:

1. For each source location:

    a. SCOOTER was run at 2 Hz frequency steps from 2 Hz to 750 Hz for a source depth corresponding to the depth of the airgun array (7 m). The output of SCOOTER at each frequency and receiver location is the ratio of the received pressure to the transmitted pressure. The ratio is a complex number and represents both the amplitude and phase of the received pressure.

2. For each receiver location:

    a. The range from the receiver to each airgun in the array was calculated, and used to interpolate the results produced by the propagation modelling code, in order to produce a transfer function (complex amplitude vs. frequency) corresponding to that receiver - airgun combination.

    b. These transfer functions were inverse Fourier transformed to produce the corresponding impulse response, which was then convolved with the signal from the appropriate airgun to give a received signal due to that gun.

    c. The received signals from all guns in the array were summed to produce a received pressure signal.

    d. The sound exposure level (SEL) at the receiver was calculated by squaring and integrating the pressure signal.

3 Results

Plots of predicted maximum received sound exposure level at any depth as a function of range and azimuth from the source are given in Figure 9 and Figure 10 for maximum ranges of 500m and 2km respectively. The observed horizontal plane directionality is due to the directionality of the airgun array, which produces its highest levels in the cross-line direction.

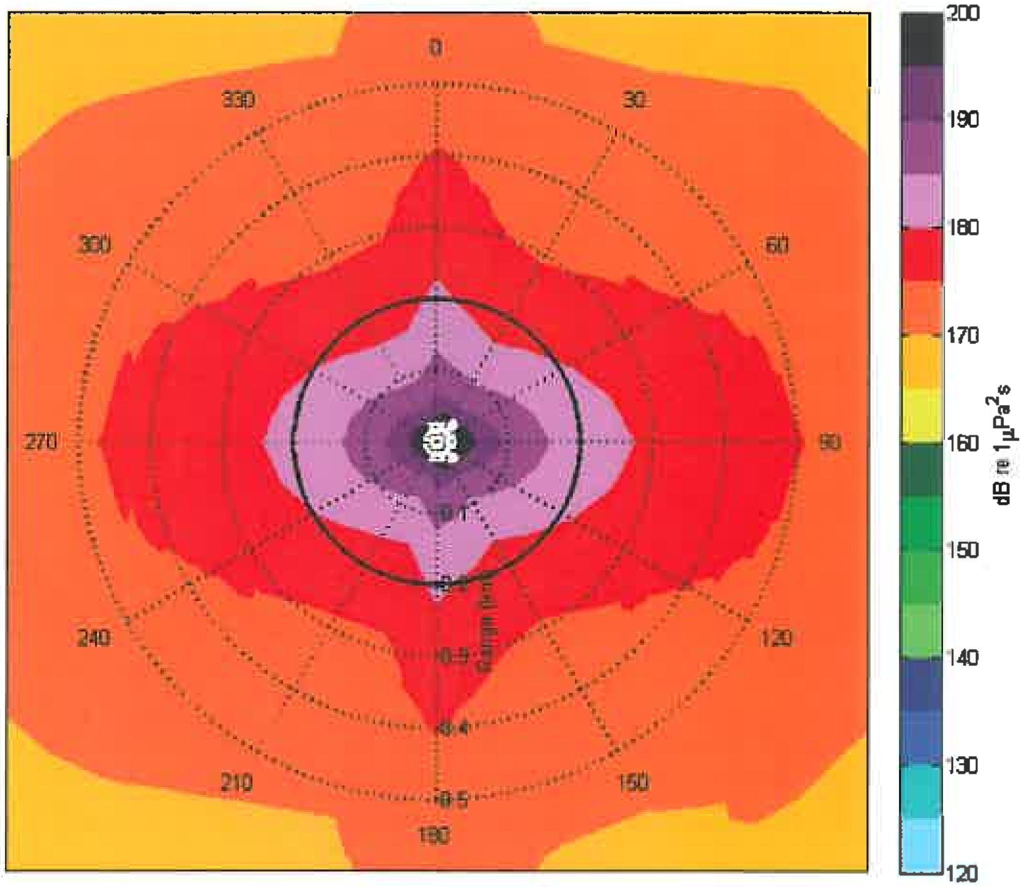

Figure 9. Predicted maximum received SEL at any depth as a function of azimuth and range from the source to a maximum range of 500m. An azimuth of 0° (up) corresponds to the in-line direction. The thick black circle corresponds to the 200m mitigation range.

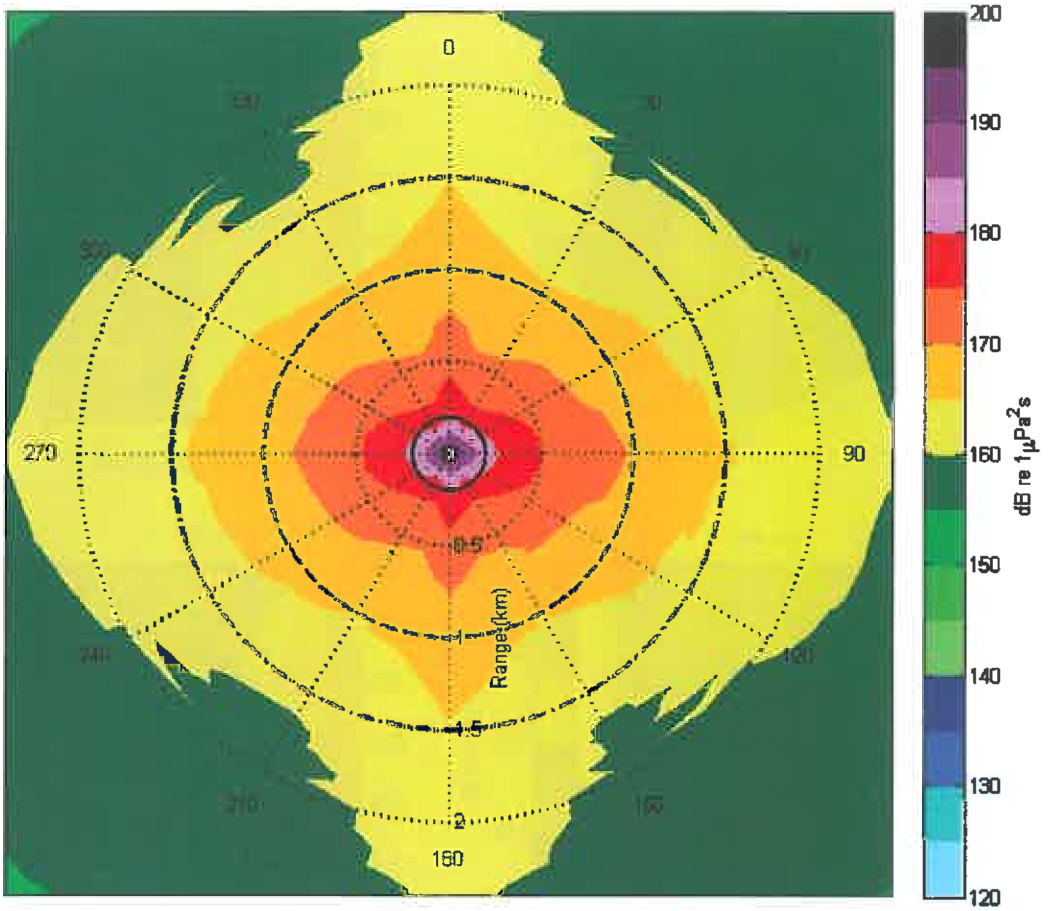

Figure 10. Predicted maximum received SEL at any depth as a function of azimuth and range from the source to a maximum range of 3km. An azimuth of 0° (up) corresponds to the in-line direction. The thick black circles corresponds to mitigation ranges of 200m (solid), 1km (dash), and 1.5km (dash-dot).

The dominant downward directivity can be seen in Figure 11. The 3 cross-sectional slices show that the majority of energy is transmitted downward and only a minimal amount is returned to the water column via reflection of the seabed. This result is consistent with the geoacoustic model used and is representative of the low reflectivity of soft sediment. There is some energy trapped in the small duct of the sound velocity profile (top right panel of Figure 11) between 100 – 400 m depth. However, the contribution of energy trapped and propagating in a duct does not significantly affect water column sound levels for this modelling scenario.

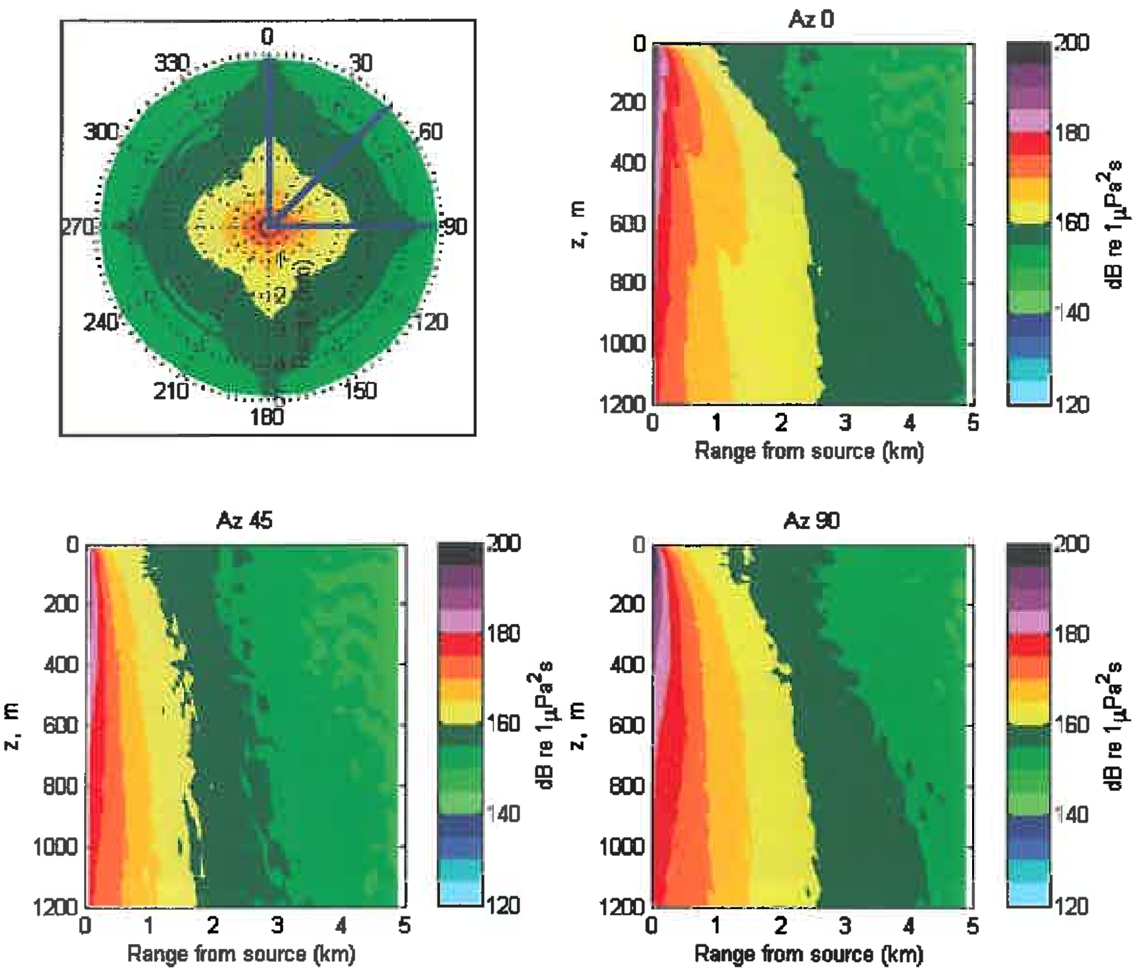

Figure 11. Slices of SEL that vary with depth and range for 3 different azimuths. *Top left:* Predicted maximum received SEL at any depth as a function of azimuth and range from the source this slice azimuths shown by the thick blue lines. *Top right:* 0° azimuth (in-line) SEL cross-section. *Bottom left:* 45° azimuth SEL cross-section. *Bottom right*: 90° azimuth (cross-line) SEL cross-section.

Figure 12 attempts to present the modelling results in a concise form by plotting the percentage of received shots below standard thresholds as a function of range. This plot shows that 95% of received levels are predicted to be below 186 dB re 1 μPa^2.s at a range of just over 100m, and below 171 dB re 1 μPa^2.s at a range of just over 500m.

The scatter plot in Figure 13 shows predicted received levels for all depths in the water column and all azimuths as a function of range. All of the predicted levels fall below 186 dB re 1 μPa^2.s at a range of 200m, and below 171 dB re 1 μPa^2.s at a range of 1km.

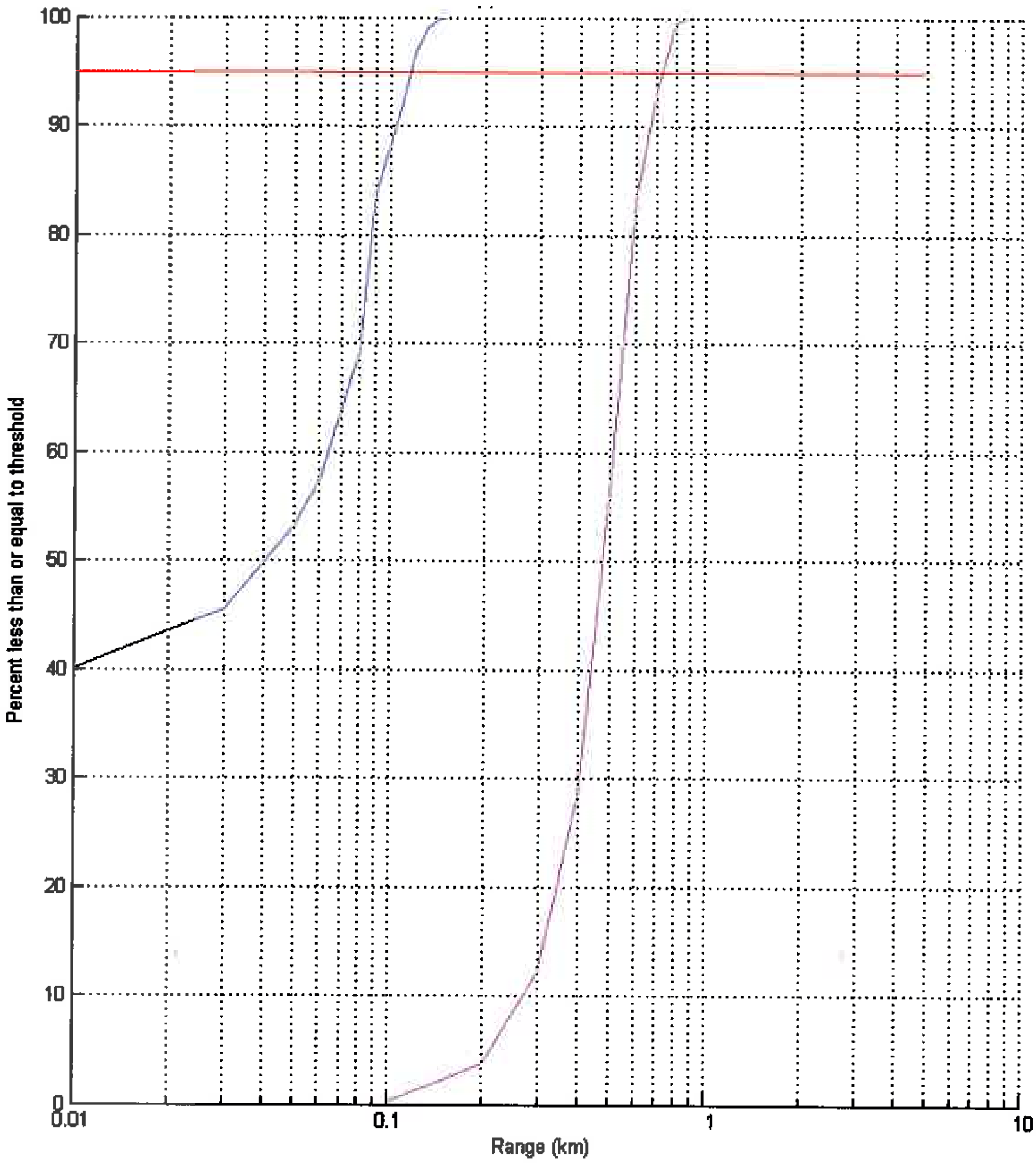

Figure 12. Percentage of received shots below thresholds of 186 dB re 1 μPa^2.s (blue) and 171 dB re 1 μPa^2.s (magenta) as a function of range. Percentages are calculated over all azimuths and depths.

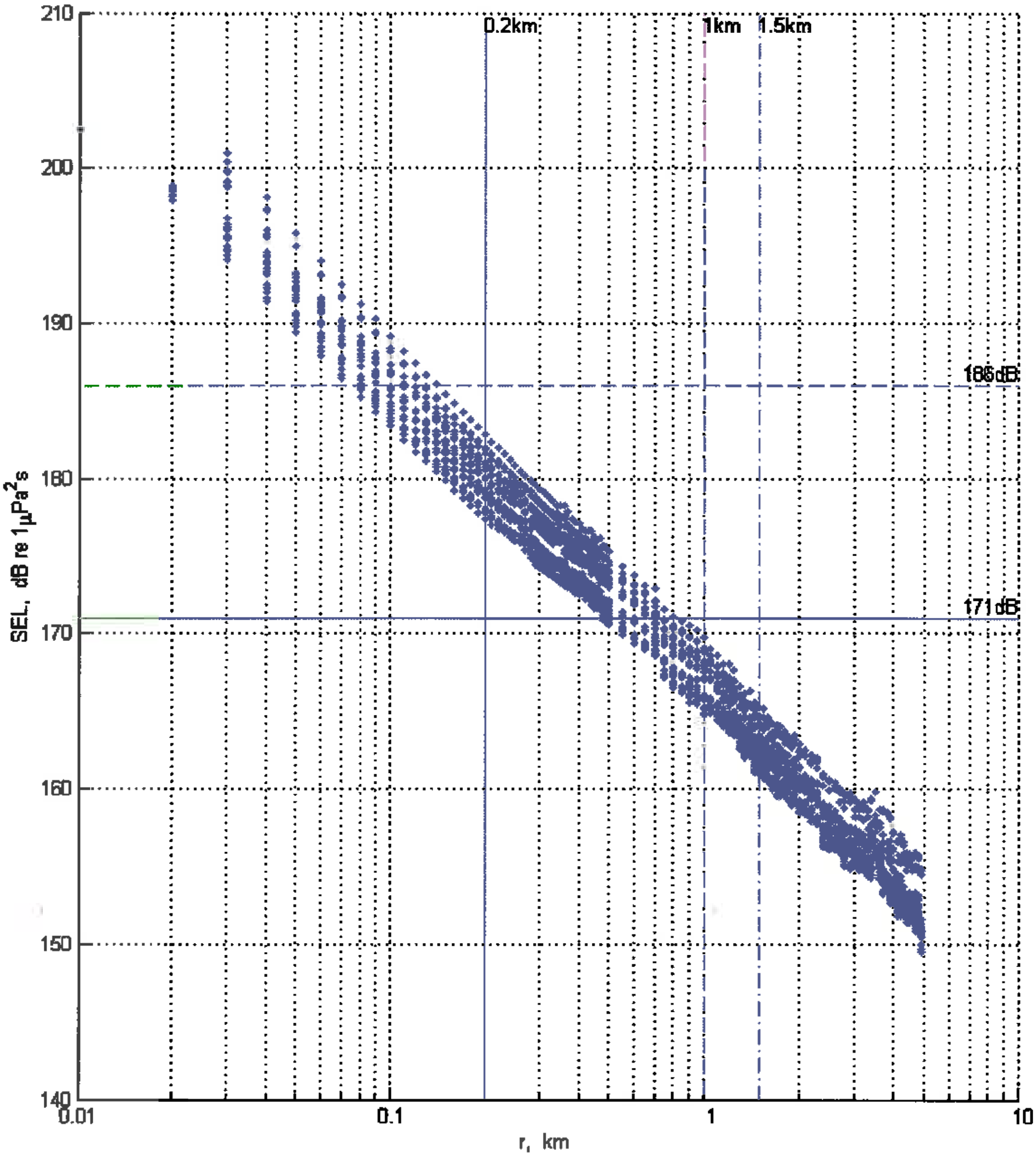

Figure 13. Blue dots are all predicted received levels as a function of range. Vertical magenta lines show mitigation ranges of 200m (solid), 1km (broken), and 1.5km (dash-dot). Horizontal green lines show mitigation thresholds of 171 dB re 1 $\mu Pa^2.s$ (solid) and 186 dB re 1 $\mu Pa^2.s$ (broken).

4 Conclusions

The modelling method used to produce these results is very computationally intensive but accurately deals with both the horizontal and vertical directionality of the airgun array, and with variations in water depth. The majority of the sound energy is transmitted downward and is absorbed by the seabed.

Modelling predicted that the Aquila Explorer 4230 cui array operating within the Carina 2D survey area will produce received sound exposure levels below 186 dB re 1 $\mu Pa^2.s$ at a range of 200m, and below 171 dB re 1 $\mu Pa^2.s$ at a range of 1km and will therefore meet the sound exposure level requirements of the New Zealand Department of Conservation 2012 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations. At a range of just over 100m, 95% of received sound exposure levels are predicted to be below 186 dB re 1 $\mu Pa^2.s$, and at a range of just over 500m, 95% of received sound exposure levels are predicted to be below 171 dB re 1 $\mu Pa^2.s$.

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