ACB-15, Canterbury Basin, 3D Marine Seismic Survey 2015

Marine Mammal Impact Assessment and Marine Mammal Mitigation Plan

Anadarko New Zealand Company

January 2015

Final

0264205RP01_Rev 2

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ACB-15, Canterbury Basin, 3D Marine Seismic Survey 2015

Marine Mammal Impact Assessment and Marine Mammal Mitigation Plan

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ABBREVIATIONS

2D	2-Dimensional
3D	3-Dimensional
4D	4-Dimensional
AEI	Area of Ecological Importance
AIS	Automatic Identification System
ALARP	As Low As Reasonably Practical
Anadarko	Anadarko New Zealand Company
AOI	Area of Influence
BOD	Biological Oxygen Demand
BPA	Benthic Protection Area
the Code	*Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals*
COLREGS	*International Regulations for the Prevention of Collisions at Sea*
dB	Decibels
dB re 1 μPa	Decibels referenced to 1 microPascal
dB re 1 μPa/m	Decibels referenced to 1 microPascal at 1 meter
dB re 1 $\mu Pa^2.s$	Decibels referenced to 1 microPascal squared second
DOC	Department of Conservation
the DOC Listing	the New Zealand Threat Classification System Listing
EEZ	Exclusive Economic Zone
the EEZ Act	*Exclusive Economic Zone and Continental Shelf (Environment Effects) Act 2012*
ERM	Environmental Resources Management
FMA	Fisheries Management Area
Hz	Hertz
IA	Impact Assessment
IMO	International Maritime Organization
IOPPC	International Oil Pollution Prevention Certificate
IUCN	International Union for Conservation of Nature
kg	kilograms
kHz	kiloHertz
km	kilometers
km/h	kilometers per hour
km^2	square kilometers
l	liters
London Convention	*Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter*
m	meters
m^3	cubic meters
MARPOL	*International Convention for the Prevention of Pollution from Ships*

ml	milliliter
mm	millimeters
mg l^{-1}	milligrams per liter
mg m^{-3}	milligrams per cubic meter
MMIA	Marine Mammal Impact Assessment
MMO	Marine Mammal Observer
MMMP	Marine Mammal Management Plan
MMS	Marine Mammal Sanctuary
MNZ	Maritime New Zealand
MPA	Marine Protected Areas
MPI	Ministry for Primary Industries
MSS	Marine Seismic Survey
MNZ	Maritime New Zealand
NABIS	National Aquatic Biodiversity Information System
NIWA	National Institute of Water and Atmospheric Research
nm	Nautical mile
OSCP	Oil Spill Contingency Plan
PAM	Passive Acoustic Monitoring
PEP	Petroleum Exploration Permit
ppm	parts per million
psi	pounds per square inch
the Regulations	*Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013*
rms	root mean squared
RVIM stretches	Stretches of the streamer cable at the head and tail that act as a "shock absorber" reducing the effect of the vessel's movement upon the deployed streamer in the water.
SOPEP	Shipboard Oil Pollution Emergency Plan
STLM	sound transmission loss modelling
UNCLOS	*United Nations Convention on the Law of the Sea*
VSP	Vertical Seismic Profiling
World Heritage Convention	*Convention Concerning the Protection of the World Cultural and Natural Heritage*

EXECUTIVE SUMMARY

This Marine Mammal Impact Assessment (**MMIA**) and Marine Mammal Management Plan (**MMMP**) have been prepared for Anadarko New Zealand Company (**Anadarko**) by Environmental Resources Management (**ERM**), a recognized independent international environmental consulting company.

Anadarko plans to undertake a 3-Dimensional marine seismic survey (**MSS**), ACB-15, located within the area of Petroleum Exploration Permit (**PEP**) Block 38264 of the Canterbury Basin, off the east coast of the South Island of New Zealand (hereafter, **'the Project'**). This MMIA and MMMP is specific to the Project, and has been prepared to inform the applicant, decision makers, and affected parties about potential environmental, social and cultural issues relating to the Project.

The Project is currently planned to commence on 1 February 2015 and is anticipated to take approximately 90 days to complete. This time estimate includes a ten percent (10 %) contingency for downtime due to weather, shipping, cetacean presence and other uncontrollable influences. An additional ten percent (10 %) downtime has been allowed for technical equipment issues.

The MMIA process included the engagement of existing interests 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, are fully examined and addressed in line with regulatory requirements.

This MMIA was conducted over a series of phases, with each phase providing increased layers of rigor, and included:

- Project Screening;
- Project Scoping;
- Project and Baseline Definition; and
- Impact Assessment (IA).

Screening was conducted by Anadarko to identify any IA requirements for the Project. The process assessed all legislative and internal corporate regulations and standards to determine if the proposed development requires an IA. As a result of this process it was determined that, under *the Exclusive Economic Zone and Continental Shelf (Environment Effects) Act 2012* (**the EEZ Act**), the project would need to comply with the Department of Conservation *Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations* (**the Code**). Further, under the Code, the Project was considered a Level 1 Survey and therefore an MMIA was required.

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 previous MSS. Through this research the area was found to be generally typical of its locale and water depth.

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 MMIA 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 Survey Vessels	• Marine mammals - *Negligible*
Vessel Lighting	• Seabirds - *Negligible*
Presence of In-Water Equipment	• Commercial fishing - *Negligible* • Marine vessels - *Negligible*
Underwater Noise from 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*
Impacts from Unplanned Events	
Minor Spills of Hydrocarbons and Chemicals	• *As Low As Reasonably Practical (ALARP)*
Collisions	• *ALARP*
Loss of Streamers or Other Equipment	• *ALARP*
Introduction of Invasive Species	• *ALARP*

1 INTRODUCTION

1.1 PURPOSE OF THIS REPORT

This Marine Mammal Impact Assessment (**MMIA**) and Marine Mammal Management Plan (**MMMP**) have been prepared for Anadarko New Zealand Company (**Anadarko**) by Environmental Resources Management (**ERM**), a recognized independent international environmental consulting company.

Anadarko plans to undertake a 3-Dimensional (**3D**) marine seismic survey (**MSS**), ACB-15, located within the area of Petroleum Exploration Permit (**PEP**) Block 38264 of the Canterbury Basin, off the east coast of the South Island of New Zealand (hereafter, '**the Project**'). This MMIA and MMMP is specific to the Project, and has been prepared to inform the applicant, decision makers, and affected parties about potential environmental, social and cultural issues relating to the Project.

The MMIA fulfils the impact assessment (**IA**) requirements of the Department of Conservation (**DOC**) *Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations* ('**the Code**'). Compliance with the Code is a requirement for MSS activities to be classified as a permitted activity under the *Exclusive Economic Zone and Continental Shelf (Environment Effects) Act 2012* ('**the EEZ Act**').

The MMIA process included the engagement of people considered to have potential existing interests 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, are fully examined and addressed in line with regulatory requirements.

1.2 OVERVIEW OF THE PROJECT

Anadarko intends to acquire a total of **3,527** square kilometers (**km²**) of 3D seismic data within PEP 38264 of the Canterbury Basin, off the east coast of New Zealand's South Island. Two separate surveys (Wherry 3D at 1,827 km² and Gondola 3D at 1,700 km² in size) will be acquired. Some data have previously been collected within PEP 38264, so the purpose of this MSS is to obtain additional data to fill in current data gaps and allow Anadarko to further assess the potential for hydrocarbon recovery within PEP 38264.

Depending upon the survey results, follow-up MSS and exploration drilling activities might be necessary to further detail the hydrocarbon potential of the basin. The environmental impacts of potential future exploration drilling activities within PEP 38264 that may result from the MSS data are not within the scope of this MMIA and will be discussed in subsequent IAs.

1.2.1 *The Canterbury Basin*

The Canterbury Basin lies offshore from the coast of Canterbury, to the east of the South Island of New Zealand and covers an area of 360,000 km^2 (Uruski, 2010). Six offshore wells have been drilled in the basin since 1970, the most recent of which was the Anadarko Caravel-1 well drilled at water depth of 1,100 meters (m) in early 2014.

1.2.2 *PEP 38264 Exploration History*

PEP 38264 was originally granted on 8 November 2006 to Origin Energy Resources NZ Limited. Anadarko subsequently acquired a 50% share in the PEP and assumed operatorship on 13 July 2010. The PEP was extended to incorporate areas of the adjacent PEP 38262 on 15 October 2012. On 13 December 2013, Discover Exploration Canterbury NZ B.V. acquired a 10% share of the PEP, with Origin Energy Resources Limited and Anadarko reducing their holding to 45% each. The PEP was originally awarded for a 10 year term, however this was extended by five years on 5 August 2014 through to 7 November 2021. The current extent of the PEP is 17492.860 km^2.

A number of exploration activities have previously been undertaken in PEP 38264 prior to the planned MSS, including exploration drilling and additional 2D and 3D MSS. Further MSS activities may be undertaken in subsequent phases of the exploration program to further support Anadarko's exploration and appraisal objectives. Details of the currently planned MSS are described below.

1.3 *PROJECT APPLICANT*

The Applicant is a joint venture comprising Anadarko (45%), Origin Energy Resources NZ Limited (45%), and Discover Exploration Limited (10%) with Anadarko being the operator.

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.

Data from previous exploration activities in the area have been investigated and it was concluded that seismic work is required to determine the hydrocarbons potential in PEP 38264.

1.4.2 *Alternative Locations*

The potential resource which the Project is investigating is located within PEP 38264. The location of the resource as well as the extent of the PEP is 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 *SV Polarcus Naila*, 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, Seismic Vessel*.

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 based on the water depth and Anadarko's understanding of the geological formations and target strata depths for the survey. In this instance, it is proposed to have the option of up to 4,240 cubic inches to ensure the optimal balance is achieved as use of a smaller seismic source may result in the need to resurvey the area. More information on the acoustic source can be found in *Section 2.4.5, Seismic Survey Equipment*.

Type of Survey

The selection of the 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 3D. 2D and 3D surveys are used primarily for prospecting, exploration and characterization of undeveloped resources. Typically, 2D surveys are conducted over wide areas with survey lines spaced at 2 to 10 kilometer (**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 spaced at 300 to 800 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 3D data due to the need for more detailed submarine strata delineation within a defined spatial extent. More information on the survey can be found in *Section 2.4, Marine Seismic Survey*.

1.4.4 Do Nothing Option

As part of the work program for the PEP, Anadarko is required to commit to exploration activities, thereby furthering investigations into the resource potential of the PEP as well as the wider Canterbury Basin. If Anadarko were not to undertake the seismic survey they would need either to surrender the PEP 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 ENGAGEMENT ACTIVITIES

The Code requires operators to:

- Identify persons, organizations or *tangata whenua* with specific interests or expertise relevant to the potential impacts on the environment;
- Describe any consultation undertaken with persons described above and specify those who have provided written submissions on the proposed activities;
- Identify the actual and potential effects of the activities on the existing interests, including any conflicts with existing interests; and
- Include copies of any written submissions from the consultation process.

Since assuming operatorship of its New Zealand interests, Anadarko has undertaken an ongoing program of stakeholder engagement to support and inform its exploration activities. This has involved engagement of a range of stakeholders, from central and regional government representatives through to iwi and academia. As part of the specific preparations for its 2015 MSS program in the Canterbury basin, Anadarko prepared a notification letter that outlined details of the proposed MSS program and provided an opportunity for recipients to provide further input to the program. The letter was issued to a range of stakeholders including iwi, academia and fisheries interests in November 2014. A full list of parties that this letter was issued to is provided in *Annex A*. At time of issue of this MMIA, no formal response to the notification letter has been received. Should any correspondence be received prior to the initiation of the MSS, Anadarko will seek to incorporate specific mitigation measures within the marine mammal mitigation plan provided as *Annex B*. Any additional information will also be used to inform future exploration impact assessments or activity planning as appropriate.

2 PROJECT DESCRIPTION

2.1 OVERVIEW

Anadarko intends to acquire a total of 3,527 km^2 of 3D seismic data within PEP 38264 of the Canterbury Basin, off the east coast of New Zealand's South Island. Some data have previously been collected within PEP 38264, so the purpose of this MSS is to obtain additional data to fill in current data gaps and allow Anadarko to further assess the potential for hydrocarbon recovery within PEP 38264.

Depending upon the survey results, follow-up MSS and exploration drilling activities might be necessary to further detail the hydrocarbon potential of the basin. The environmental impacts of potential future exploration drilling activities within PEP 38264 that may result from the MSS data are not within the scope of this MMIA and will be discussed in subsequent IAs.

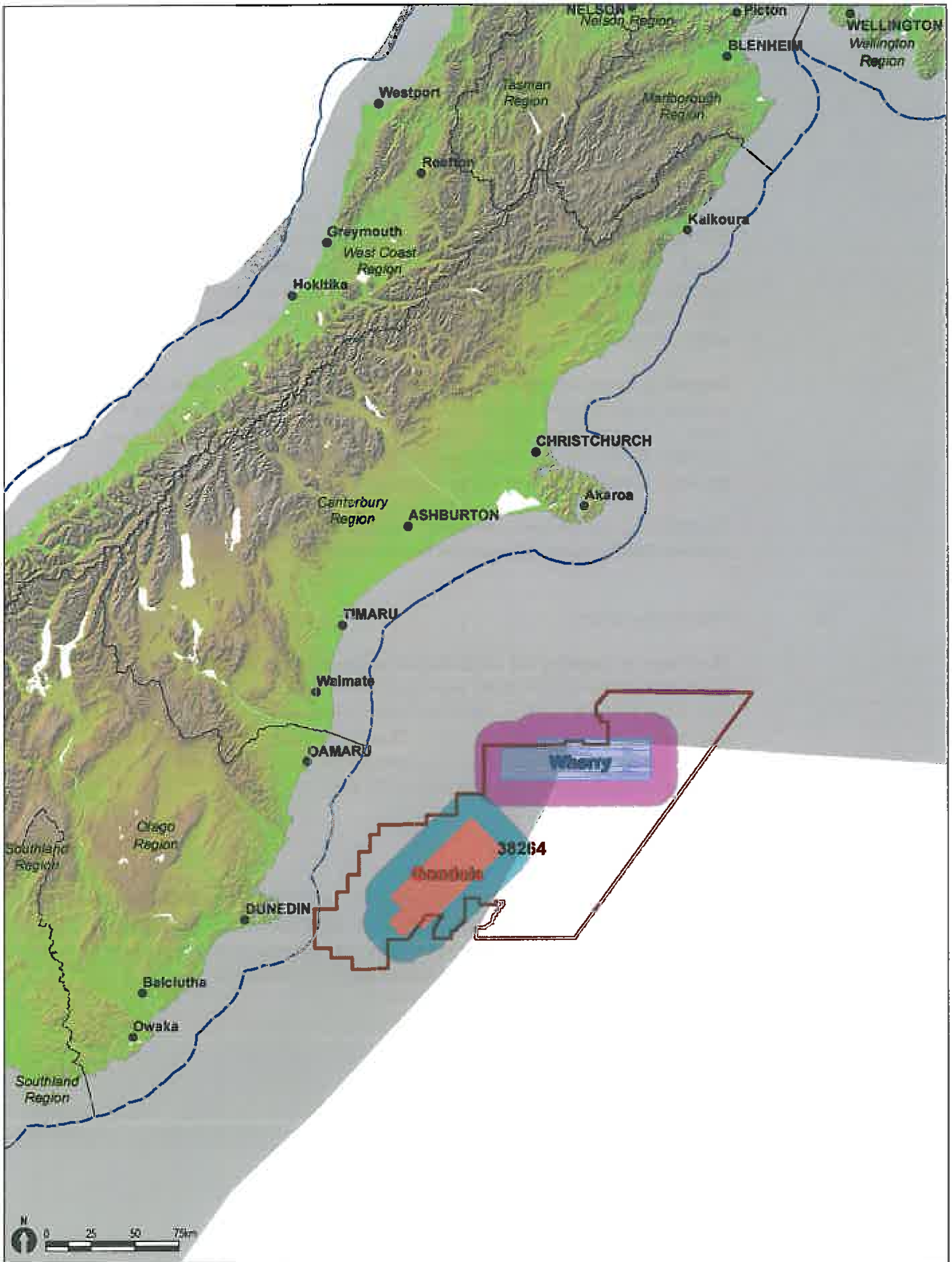
The MSS will be executed on behalf of Anadarko by specialist contractors Polarcus DMCC, using the vessel *SV Polarcus Naila.*

2.2 PROJECT LOCATION

The Project is targeting the acquisition of seismic data in the south-west and north-east portion of PEP 38264 (see *Figure 2.1*). Water depths across the PEP vary from 700 m to 1,600 m, however water depths in these target areas for seismic acquisition are at least 1,200 m. The closest point of the Project to land is approximately 48 km from Cape Saunders on the South Island and the total coverage of the Project is approximately 3,527 km^2.

2.3 PROJECT TIMING

The Project is currently planned to commence on 1 February 2015 and is anticipated to take approximately 90 days to complete. This time estimate includes a twenty percent (20 %) contingency for downtime due to weather and/or the presence of cetaceans, as well as technical downtime.



Legend

- Gondola - Seismic Lines
- Gondola - Operational Area
- Wherry - Seismic Lines
- Wherry - Operational Area
- PEP 38264
- NZ Exclusive Economic Zone
- New Zealand Territorial Limit
- NZ Regional Boundaries
- Area of Ecological Importance

Client:	Anadarko New Zealand Company
Drawing No:	0264205s_IA_G003_R0.mxd
Date:	18/12/2014 — Drawing Size: A4
Drawn By:	GC — Reviewed By: AT

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 2.1 - Project Location and New Zealand's Jurisdictional Boundaries

0264205 Canterbury 2015 MMIA

Environmental Resources Management ANZ

Auckland, Brisbane, Canberra, Christchurch, Melbourne, Newcastle, Perth, Port Macquarie, Sydney

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2.4 *MARINE SEISMIC SURVEY*

MSS are routinely conducted in offshore exploration and production operations worldwide to define subsurface geological structures. These surveys are currently the best feasible technology to accurately prospect for offshore hydrocarbons.

2.4.1 *Seismic Survey Operations*

MSS are carried out by purpose-built survey vessels that collect subsurface geological data along a set grid of transect lines and can be 2D, 3D, or 4-Dimensional (4D). The proposed MSS program incorporates a 3D survey. This type of survey is used primarily for exploration and characterization of undeveloped resources. The seismic vessel will tow twelve (12) hydrophone streamers below the water spaced 120 m apart from each other, which will measure up to 8,100 m in length. When surveying equipment is in the water, vessel speed will likely be no less than 3.5 knots (6.5 kilometers per hour (km/h)) and no more than 5.5 knots (10 km/h). The initial deployment of the streamers can take up to 6 days with the potential for extra time being required for troubleshooting.

MSS use 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 along the transect grids. The pulses travel through the geological strata and are reflected from the boundaries of geological strata in the subsurface. The reflected pulses are subsequently recorded by receivers (hydrophones) near the water surface (*Figure 2.2*). The depths of the reflecting geological strata are calculated from the time elapsed between the sound generation and detection of the reflected signal by the hydrophone. Analysis of the return time and character of signals allows the definition of the underlying geological structures.

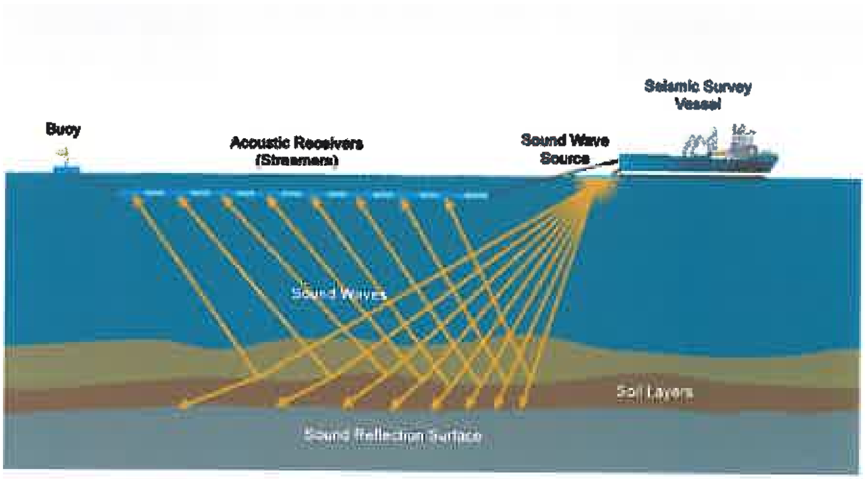


Figure 2.2 ***Graphical Representation of a Marine Seismic Survey***
Source: http://fishsafe.eu/media/7477/seismic_surveys_02.gif

In its most basic form, MSS equipment consists of an acoustic source, an acoustic receiver, and a data storage device. Airguns are commonly used as an energy source. A seismic airgun is an impulsive underwater transducer that produces sound energy 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 pounds per square inch (psi)) is supplied continuously to the airgun.

Airgun arrays are designed to direct a high proportion of the energy vertically downwards. However, energy is also projected horizontally into the water, and can be detected at different distances from the source (depending on hydrographical conditions and level of background noise).

With increasing distance from the source, pulses received from an airgun array decrease in amplitude. The pulses from the guns are broad band, with most energy concentrated in the 10 to 200 Hertz (Hz) frequency range, with lower levels in the 200 to 1000 Hz range. Depending upon how many guns are fired together, sound levels at the source range from 237 to 262 decibels (dB) referenced to 1 microPascal at 1 m (re 1 µPa/m).

The seismic signals reflected by boundaries in the subsurface geology are received by hydrophones (pressure sensors) carried in the streamer cable towed behind the seismic vessel. The cable sections are buoyant and connected together with electronic modules in which the signals from the hydrophones are digitized and put onto an optical carrier, which returns the signals to the recording system on board the vessel.

2.4.2 *Crewing and Logistics*

It is anticipated that a crew of around 60 personnel will be required for the Project, rotating approximately every five (5) weeks. The Project will have helicopter support and be able to perform an urgent Medevac, if needed. The vessel will also be equipped with a full hospital and an on-board paramedic as required for extended offshore voyages. The seismic vessel may return to Dunedin, New Zealand, taking around 24 hours to conduct the crew change as well as refuel and resupply the vessel in the event that bad weather prevents helicopter crew changes. Refueling of Marine Diesel Oil, Light Fuel Oil and Heavy Fuel Oil can occur within this port.

Emergency Plans for Refueling

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 refueling, the refueling 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, or Environment Canterbury, takes command 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 (**MNZ**) takes command, and resources are brought from other regions. There will be a contingency plan in place for refueling 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 *SV Polarcus Naila (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 90.8 m in length and use a diesel-electric propulsion system with a fuel capacity of 1,540 cubic meters (m^3).

Figure 2.3 ***SV Polarcus Naila***
Source: http://www.polarcus.com/en-us/our-fleet/our-fleet.php

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 liters (l) per person per day. Based on an anticipated crew of 60 persons, volumes generated and discharged to sea will consequently be approximately 1,200 l per day over the duration of the proposed seismic survey.

Garbage wastes can similarly be estimated to be generated at a rate of approximately 120 kilograms (kg) per day (assuming a 2 kg per person per day average). *Table 2.1* summarizes garbage disposal restrictions under the *International Convention for the Prevention of Pollution from Ships* (**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 parts per million (**ppm**)). The aqueous phase will be discharged after treatment.

2.4.4 *Chase/Support Vessel*

Chase/support vessels 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. These chase/support vessels will be in constant communication with the primary survey vessel. The chase vessels that will be used for the MSS is the *Sea Pelican* utility tug (*Figure 2.4*), whilst supply vessel support will be provided by the *OSV Sealink 161* (*Figure 2.5*)or the *MV Amaltal Apollo* (*Figure 2.6*), dependent on availability.

Figure 2.4 **Sea Pelican Utility Tug**
Source: http://photos.marinetraffic.com/ais/showphoto.aspx?mmsi=-8950873&size=

Figure 2.5 **OSV Sealink 161**
Source: http://cdn2.shipspotting.com/photos/middle/5/9/5/1974595.jpg

Figure 2.6 ***MV Amaltal Apollo***
Source: http://www.talleys.co.nz/divisions/seafood/amaltal-offshore/#amaltal-apollo

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 8.5 m and a distance of 300 m behind the vessel. Each of the two airgun arrays will be equipped with a total of fifteen (15) cluster airguns and three (3) single airguns, which are the seismic source. These air-guns are steel cylinders charged with compressed air of approximately 2,000 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 4,240 cubic inches and will be positioned and fired in a precise sequence, expected to be every 10.0 seconds, 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 minimize the pressure wave and frequencies emitted into the surrounding marine environment.

Further behind the air guns, extending to a distance of approximately 8.1 km, the seismic vessel will tow twelve (12) slanted streamers equipped with numerous hydrophones. Streamers consist of tubular sections that contain the hydrophones and electrical conductors to carry the received signals. The streamer will be towed at around 20 m below the surface at the vessel end, slanting down to around 28 m below the surface at the furthest extent. The streamer will be foam-filled (solid) a small amount of silicone gel is located where the hydrophones are located. The sections are connected by electronic modules in which the signals from the hydrophones are digitized and sent by telemetry to the recording system on board the vessel. Each of the three 'RVIM stretches' located at the head and tail of the streamer are filled with gel. 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.

Table 2.2 ***Summary Table of Seismic Survey Vessel and Equipment Specifications***

Vessel Size	90.8 m overall
Duration of Survey	Approximately 90 days
Survey Area	Approximately 3,527 km^2
Seismic Source Size	Up to 4,240 cubic inches
Peak to peak in bar-m	134.42
Zero to peak in bar-m	66.41
Number of Streamers	12
Length of Streamers	Approximately 8,100 m
Towing Depths of the Source and Streamers	Source – 8.5 m (± 0.5 m); Streamers – slanting 20 m – 28 m deep (± 1.0 m)
Towing Speed	Approximately 4.5 knots

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 to 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 *Mobilization of the Vessels to the Marine Seismic Survey Area*

Anadarko currently plans to undertake mobilization from Dunedin, New Zealand. The vessels will be fully provisioned and bunkered before mobilization.

2.5 MARINE MAMMAL OBSERVATION

As per the *Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013* (**the Regulations**), MSS are a permitted activity if they comply with the Code. As such, the MSS will be planned and executed in accordance with the version of the Code that is applicable at the time of the survey. At the time this MMIA was produced the 2013 version of the Code was in force, thus the following relates to this version.

2.5.1 *2013 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.
- 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 and its requirements can be found in *Section 3, Administrative Framework*. Further information on mitigation measures that will be implemented during the Project are outlined in *Section 7, Impact Assessment*, and the MMMP provided as *Annex B.*

3 ADMINISTRATIVE FRAMEWORK

3.1 INTRODUCTION

The administrative framework, under which the Project will be regulated, includes international conventions and regulations as well as New Zealand 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 seismic activities in marine waters off New Zealand.

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 General Conference on the 16 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. New Zealand ratified the convention in 1984.

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

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 by the International Maritime Organization 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. New Zealand ratified the COLREGS in 1972. The COLREGS are implemented in New Zealand under the *Maritime Transport Act 1994*.

United Nations Convention on the Law of the Sea, 1982

The objective of the *United Nations Convention on the Law of the Sea* **(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. New Zealand ratified UNCLOS in 1996, and it is in force in New Zealand 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. New Zealand 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 the *Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter* **(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 London Convention and, eventually, replace it. In New Zealand, dumping standards within and outside the 12 Nautical mile **(nm)** limit are derived from the 1996 London Protocol. Under the London Protocol all dumping is prohibited, except for possibly acceptable wastes on the so-called "reverse list".

3.1.2 National Legislation

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 nm 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 in this area is 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 New Zealand's oceans and to protect them from the potential environmental risks.

The EEZ Act came into force on 28 June 2013 when 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 Code (see below).

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

The Code was developed by the DOC and came into effect on 1 August 2012. It has since been updated and a revised 2013 version of the Code is in force. The objective of the Code is to minimize acoustic disturbance to marine mammals from seismic survey operations. The guidelines outlined aim to minimize potential impacts without unduly affecting normal operations. These guidelines have been endorsed by the Petroleum Exploration and Production Association of New Zealand.

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 MMIA;
- Requirements for two qualified MMOs and two qualified 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 Project Area of Influence (**AOI**, see *Section 4.3.2, Phase Two – Establishing the Preliminary Area of Influence*) overlaps with the AEI (see *Figure 2.1*). According to DOC, under normal circumstances MSS are not to be planned in any sensitive, ecologically important areas or during key biological periods where "Species of Concern" (as defined in Schedule 2 to the Code) 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 MSS 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 minimize 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 can lead to the development of an appropriate MMMP (see *Annex B* to this MMIA) 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.

Sound Transmission Loss Modelling and Ground Truthing

In this instance, Anadarko has identified the optimal balance of achieving the data acquisition objectives of the survey while minimizing the disturbance to the marine environment. Anadarko is able to proceed providing sound transmission loss modelling (**STLM**) and this has been incorporated into this MMIA (see *Annex C for the STLM report*); specifically the Code requires for sound levels of 171 dB referenced to 1 microPascal squared second (**re 1 μPa².s**) at distances corresponding to the relevant mitigation zones for Species of Concern and 186 dB re 1 μPa².s at 200 m to be modelled. As per these requirements, STLM was conducted as part of this MMIA and is discussed below in *Section 7.5.3, Evaluation of Impacts – Firing of Airgun Arrays.*

The outputs of the STLM will be ground-truthed during the MSS in accordance with the requirements of the Code using the vessel's seismic streamers towed at a depth and angle to reduce vessel noise interference. The ground-truthing will be conducted on the seismic lines in the general vicinity of where the sound loss model was conducted. Anadarko will coordinate with the seismic contractor to determine the most effective way to increase the frequencies to cover species of concern frequencies.

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 New Zealand 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.*

4 IMPACT ASSESSMENT METHODOLOGY

4.1 INTRODUCTION

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

- Project Screening;
- Project Scoping;
- Project and Baseline Definition; and
- IA.

4.2 IMPACT ASSESSMENT SCREENING

Screening was conducted by Anadarko to identify any IA requirements for the Project. The process assessed all legislative and internal corporate regulations and standards to determine if the proposed development requires an IA.

4.3 IMPACT ASSESSMENT 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 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 IA.

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

To initiate the scoping process, the preliminary 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 vessels). 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 IA, 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. loss of equipment), 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 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.

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 judgment 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 color-coded matrix (see *Table 4.1* below as an example). The different colors 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 IA 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 IA, the determination of the AOI consisted of the four key aspects described in *Section 4.3.2, Phase Two – Establishing the Preliminary Area of Influence* above.

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

This took into account:

- The physical extent of the project activities (i.e. 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.

4.4.3 *Environmental, Social and Health Baseline Definition*

The below was considered sufficient information in order to align with the information principles detailed within Section 61 of the EEZ Act under which the Code is enforced. The sources have been cited in the text throughout the IA and a detailed reference list has been provided in *Section 9, List of References*.

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

- Desktop data from DOC sightings database, including MMO reports produced as part of previous seismic surveys in the area;
- The National Aquatic Biodiversity Information System (NABIS; MPI, 2014a);
- Internet websites; and
- Primary literature.

4.5 *IMPACT ASSESSMENT*

This section describes the IA methodology adopted for identifying and assessing impacts from the Project 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 under which the Code if enforced. There were four phases to the IA 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 Categorized 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 (e.g. 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 (e.g. 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 (e.g. 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 (e.g. 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.

Type of Impact	Definition
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 were also considered. 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 IA, 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 IA process.

4.5.2 *Phase Two – Developing Mitigation Measures*

A key component of the IA process, and a requirement of the Code, centers on exploring practical ways of avoiding or reducing potentially significant impacts of the proposed drilling activities. These mitigation measures are aimed at preventing, minimizing or managing significant negative impacts to 'As Low As Reasonably Practicable' (**ALARP**) as well as optimizing and maximizing 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 4.1*. 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 minimization

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 4.1 ***Mitigation Hierarchy for Planned Project Activities***

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, i.e. 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 IA, 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 IA 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 4.2*) 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 (e.g. a water body) its quality, sensitivity to change and importance are considered. Where the receptor is ecological its sensitivity to the impact and its importance (for example its local, regional, national or international importance) 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.

For this assessment, four impact significance categories have been applied being: *Negligible, Minor, Moderate* and *Major*. These categories of significance for environmental receptors are defined in *Table 4.3*. 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 ALARP before the Project proceeds.

Table 4.3 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.
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 (i.e. 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.

Impacts from Planned Activities

For impacts from planned activities, 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 4.4* and *Table 4.5*.

Table 4.4 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 meters; and / or Discharges are well within benchmark discharge limits	Affects a specific group of localized 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	Localized and/or short term disturbance of seabed	Temporary or localized 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 4.5 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 4.6*. Likelihood has been considered for the assessment of all unplanned events (e.g. spill), but only after the impact of the event is determined using the IA matrix shown in *Table 4.6*.

Table 4.6 ***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

Impacts from Unplanned Activities

For impacts from unplanned activities, the approach adopted in this assessment considered the likelihood of an unplanned event occurring and if it does, the likely consequence on the environment and public health and safety. A qualitative approach to impact prediction was adopted. Criteria to assess the likelihood and severity of impacts from unplanned events are presented in *Table 4.7* and *Table 4.8*.

Table 4.7 ***Likelihood Categories***

Likelihood	Definition
Extremely Unlikely	The event is extremely unlikely to occur under normal operating conditions but may occur in exceptional circumstances
Unlikely	The event is unlikely but may occur at some time during normal operating conditions
Possible	The event is likely to occur at some time during normal operating conditions
Likely	The event will occur during normal operating conditions (is inevitable)

Table 4.8 ***Severity Criteria for Unplanned Events***

Severity	Definition
Low	• Some damage to the environment/very localized • No sensitive resources impacted • Rapid degradation of spilled materials and rapid recovery of affected resources
Medium	• Localized environmental damage • No sensitive resources impacted • Degradation of spilled materials and full recovery of affected resources
High	• Severe environmental damage • Sensitive resources impacted • Recovery of affected resources is very slow

The overall significance was then determined through a matrix of severity vs. likelihood as shown in *Table 4.9*.

Table 4.9 ***Unplanned Event Impact Significance Matrix***

		Severity of Impact		
		Low	**Medium**	**High**
Likelihood	**Extremely Unlikely**	ALARP	ALARP	ALARP
	Unlikely	ALARP	Minor	Moderate
	Possible	Minor	Moderate	Major
	Likely	Moderate	Major	Major

4.5.3 *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 ALARP.

4.6 *LIMITATIONS*

Any IA 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, MSS 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 IA team has used its professional experience to judge whether a significant impact is likely to occur or not.

5 SCREENING AND SCOPING

5.1 PROJECT SCREENING

Screening was conducted by Anadarko to identify any IA requirements for the Project. The process assessed all legislative and internal corporate regulations and standards to determine if the proposed development requires an IA.

As a result of this process it was determined that, under the EEZ Act the project would need to comply with the Code. Further, under the Code the project was considered a Level 1 Survey and therefore an IA was required.

5.2 PROJECT SCOPING

5.2.1 *Baseline Data*

It was identified during the scoping stage of the project, through both high-level desktop studies as well as discussions with DOC and other experts, that there is a general paucity of environmental data in the area of the Project. Accordingly, in addition to desktop searches, there were three main data sources that would be utilized to inform the baseline as follows:

- MMO sighting data from DOC sightings database, including previous seismic surveys around the area;
- Stranding data from the regions of Canterbury and Otago; and
- Fisheries catch data.

Both the MMO sighting data and the stranding data were provided by DOC and the fisheries data were provided by Ministry for Primary Industries (MPI).

5.2.2 *Area of Influence (AOI)*

For the environmental baseline definition, the AOI of the Project is defined as the extent of the seismic lines, along with a conservative operational buffer (the 'operational area' of the MSS) to allow for the full extent of the streamer (streamer length of 8.1 km) to pass through each end of the line and to account for sound transmission (see *Section 7.5.3, Evaluation of Impacts – Firing of Airgun Arrays*). The extent of the AOI is shown in *Figure 2.1*.

Project Interactions

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 colored 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									
	Ecological				Physical		Social			
	Marine Mammals	Seabirds	Fish	Benthic Communities	Water Column	Atmosphere	Commercial Fishing	Marine Vessels	Cultural Values	Tourism
Planned Activities										
Operation of the seismic and support vessels and towing of in-water equipment	Significant Interaction	Significant Interaction	No Interaction	No Interaction	No Interaction	Interaction Possible, but not Likely to be Significant	Significant Interaction	Significant Interaction	Interaction Possible, but not Likely to be Significant	No Interaction
Underwater noise from the firing of the airgun arrays	Significant Interaction	Interaction Possible, but not Likely to be Significant	Significant Interaction	Significant Interaction	No Interaction	No Interaction	Significant Interaction	No Interaction	Significant Interaction	No Interaction
Waste discharges from the survey and support vessels	Interaction Possible, but not Likely to be Significant	Interaction Possible, but not Likely to be Significant	Interaction Possible, but not Likely to be Significant	No Interaction	Significant Interaction	No Interaction	No Interaction	No Interaction	Interaction Possible, but not Likely to be Significant	No Interaction
Unplanned Activities										
Minor spills of fuels, oils and chemicals	Significant Interaction	Significant Interaction	Significant Interaction	Significant Interaction	Significant Interaction	No Interaction	Significant Interaction	No Interaction	Significant Interaction	No Interaction
Collisions	Significant Interaction	Significant Interaction	Significant Interaction	Significant Interaction	Significant Interaction	Interaction Possible, but not Likely to be Significant	Significant Interaction	Significant Interaction	Significant Interaction	No Interaction
Accidental loss of streamers or other equipment	Significant Interaction	Significant Interaction	Significant Interaction	Interaction Possible, but not Likely to be Significant	No Interaction	No Interaction	Significant Interaction	No Interaction	No Interaction	No Interaction
Introduction of invasive marine species	No Interaction	No Interaction	Significant Interaction	Significant Interaction	No Interaction	No Interaction	Significant Interaction	No Interaction	Significant Interaction	No Interaction

Legend

No Interaction — *Interaction Possible, but not Likely to be Significant* — *Significant Interaction*

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 from Planned Activities 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 in-water equipment	
Atmosphere	As the project site is located offshore and a significant distance from any potentially sensitive receptors, the air quality in the area is expected to be of very high quality, with the only likely current impacts coming from occasional passing shipping. Emissions from the operation of the project vessels, will impact air quality with such impacts relating to reduced air quality in the immediate area. Within the offshore environment where high winds are frequent, rapid dispersion of any emissions will minimize any impacts. This, coupled with the lack of receptors due to the remote nature of the Project and the temporary nature of the Project, supports the conclusion that any impacts will not lead to significant impacts.
Cultural values	Due to the distance of the vessel offshore, any impacts on cultural values will be indirect (i.e. upon their interests not communities directly), and are accounted for through assessment of impacts upon other receptors such as marine species and commercial fishing.
Tourism	The transitory nature of the Project, short duration and distance from shore of the AOI is such that there is unlikely to be significant interactions between the Project and coastal recreation/tourism activities. Physical interactions between the Project and ocean-based tourism activities, such as whale watching, are considered in parallel with the physical impacts of other marine vessels. The physiological impacts of underwater noise on marine mammals which could be the subject of tourism activities are considered separately.
Underwater noise from the firing of the airgun arrays	
Seabirds	Underwater noise generated by the firing of airgun arrays may affect seabirds that are diving and feeding on fish in the vicinity of the seismic survey operation. 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.
Operational discharges from the survey and support vessels	
Marine mammals, Seabirds and Fish	Discharges of grey water and sewage from the seismic vessel may interact with marine mammals, fish and plankton 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.
Cultural values	Due to the distance of the vessel offshore, any impacts on cultural values will be indirect (i.e. upon their interests not communities directly), and are accounted for through assessment of impacts upon other receptors such as marine species and commercial fishing.

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 main sections to the chapter as follows:

- *Section 6.3, Physical Environment;*
- *Section 6.4, Biological Environment;* and
- *Section 6.5, Existing Interests.*

The information contained in each of the following sections was obtained through desktop analysis.

6.2 EXTENT OF EXISTING DISTURBANCE

A 2D MSS was undertaken by Anadarko in PEP 38264 in February 2011 in order to supplement data gathered during previous MSS of the region. Numerous MSS have also been undertaken in adjacent PEP in recent years, including within the Great South Basin to the south of the PEP and the Pegasus Basin to the north.

The Caravel exploration well was also drilled by Anadarko in PEP 38264 between February and March 2014 and an accompanying pre-drill monitoring survey was undertaken in line with Anadarko's requirements under Part 200 of the Marine Protection Rules. Vertical seismic profiling (**VSP**) of the exploration well was also undertaken as part of the drilling program, with an accompanying MMIA developed in line with the requirements of the Code.

6.3 PHYSICAL ENVIRONMENT

6.3.1 Climate and Atmosphere

Temperature, Humidity and Precipitation

Detailed climatological data, such as mean air temperature and precipitation, are unavailable for the AOI; therefore, the following description is based on data from the south east region of New Zealand, specifically for the Dunedin region (approximately 20 km from the AOI). This location was selected to represent the AOI due to the availability of data for this location and its proximity to the AOI.

Peak summer mean daily air temperature in the vicinity of the AOI is 15.1°C in February, whilst the winter low is 5.5°C in June (NIWA, 2014). Mean monthly humidity peaks in June at 90.1% and reaches its minimum in October at 72.0%. Mean monthly rainfall, relative humidity, and air temperature for Dunedin (from February 2013 to January 2014) are presented in *Table 6.1*.

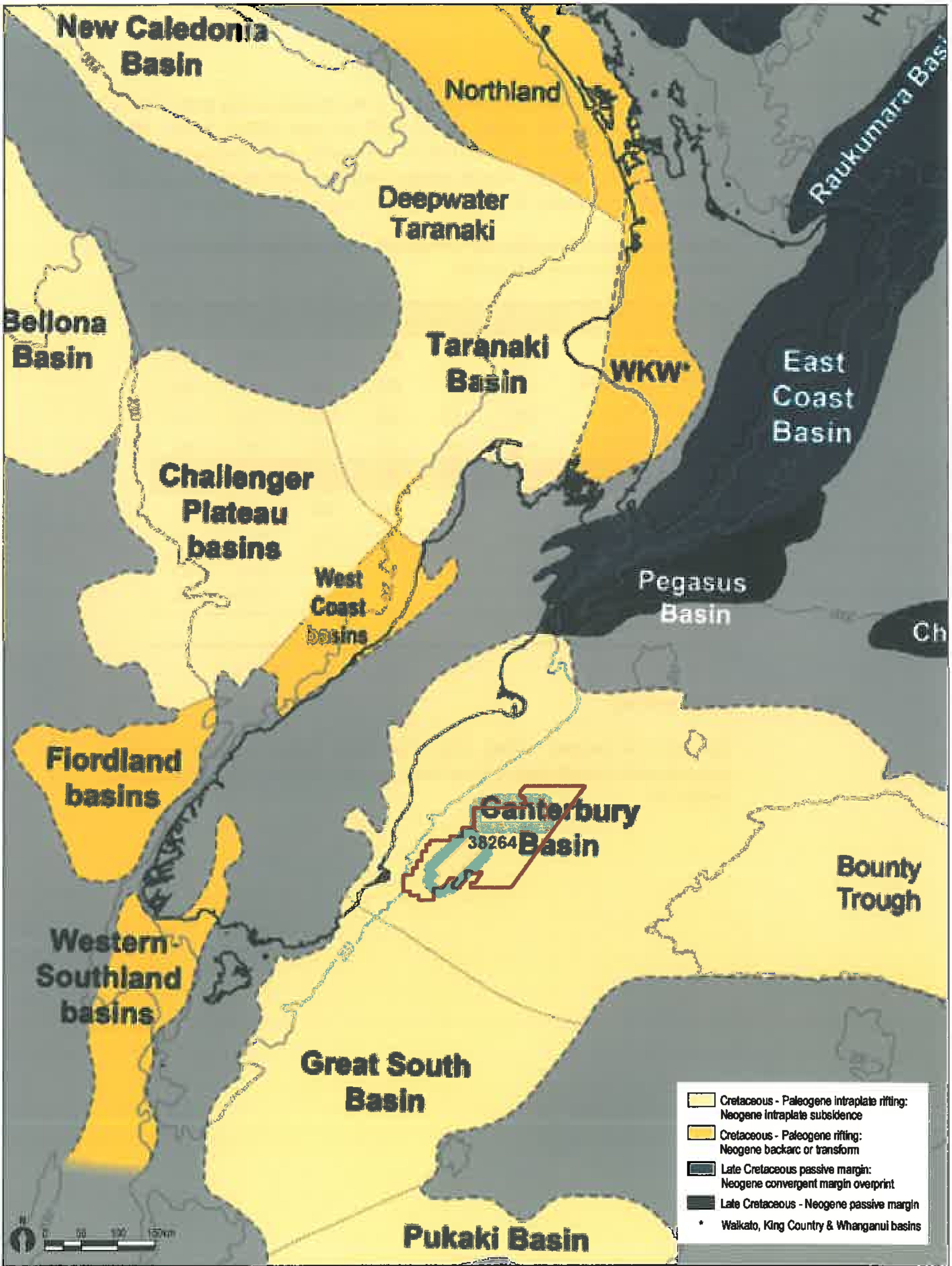
Table 6.1 ***Mean temperature, humidity and precipitation for the Dunedin region, Indicative for the Area of Influence***

Parameter	Jan	Feb	Mar	Apr	May	Jun
Rainfall (mm)	56.8	33.2	31.6	45.3	116.6	124
Relative Humidity (%)	76.1	85.2	87.1	86.8	87.9	90.1
Temperature (°C)	13.9	15.1	14.8	10.3	7.8	5.5
Wind Speed (m/s)	4.4	2.9	2.6	2.8	2.9	3.1
Parameter	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Rainfall (mm)	27.2	15.6	45.4	63.4	12.8	95
Relative Humidity (%)	84.8	86.8	81.9	72	78.6	81.9
Temperature (°C)	6.7	7.9	8.2	11.4	13.2	14.3
Wind Speed (m/s)	2.9	2.7	3.5	3.8	3.3	3.4

Source: NIWA, 2014

6.3.2 *Oceanography*

The AOI is located within the Canterbury Basin, an area covering approximately 360,000 km² offshore from the eastern coast of South Island (see *Figure 6.1*).



Legend

- Gondola - Seismic Lines
- Gondola - Operational Area
- Wherry - Seismic Lines
- Wherry - Operational Area
- PEP 38264

Source:
Map of New Zealand's sedimentary basins (2011).
Image from Mike Issac, GNS Science.

Client:	Anadarko New Zealand Company		**Figure 6.1 - Sedimentary Basins of New Zealand**
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Date:	18/12/2014	Drawing Size: A4	
Drawn By:	GC	Reviewed By: AT	0264205 Canterbury 2015 MMIA
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.			Environmental Resources Management ANZ Auckland, Brisbane, Canberra, Christchurch, Melbourne, Newcastle, Perth, Port Macquarie, Sydney

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Tides and Currents

The currents of New Zealand's EEZ are globally interlinked. As part of the South Pacific Ocean, the anti-clockwise south-pacific gyre influences New Zealand's currents through the transport of warmer, tropical waters around the New Zealand coast (*Figure 6.2*). Driven by the Southern Ocean's circumpolar current, the South Pacific Ocean's deep currents are driven northward up the coast of South America toward the tropical waters of the equator. Here, the currents travel west across the South Pacific Ocean as the water warms and rises to the surface. With the influence of the trade winds, the currents are driven southward down the east and west coast of New Zealand, were the water begins to cool and sink from the surface. The currents re-join southeast of 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.

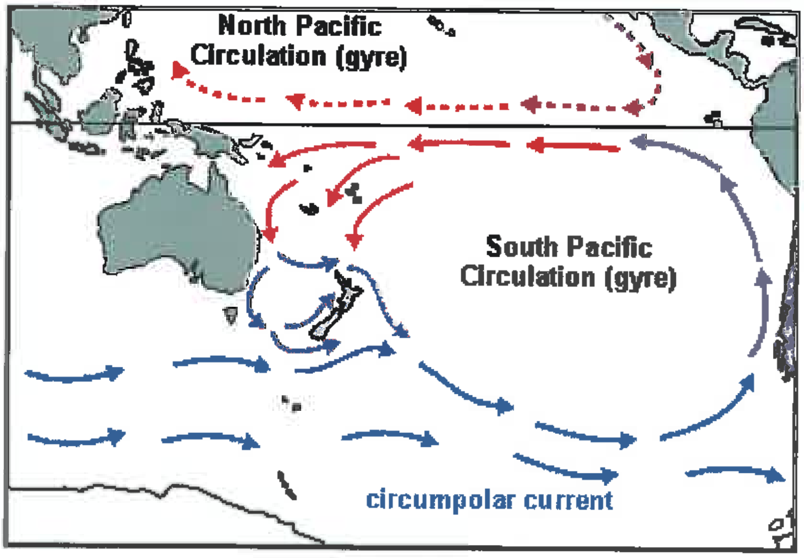

Figure 6.2 ***South-Pacific Gyre Circulating Water Toward and Away from New Zealand***
Source: http://www.seafriends.org.nz/oceano/special.htm

Of more local influence to the AOI are a series of currents traversing New Zealand's south eastern region. There are three such currents, as seen in *Figure 6.3*, each of which influence New Zealand's oceanic features differently. These are the Tasman Front, the subtropical front and the sub-Antarctic front. It is the subtropical front and the sub-Antarctic front (STF and SAF as indicated in *Figure 6.3* respectively) that influence the AOI, providing both cool water from the south as well as some warmer water from the east.

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 sub-Antarctic 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.

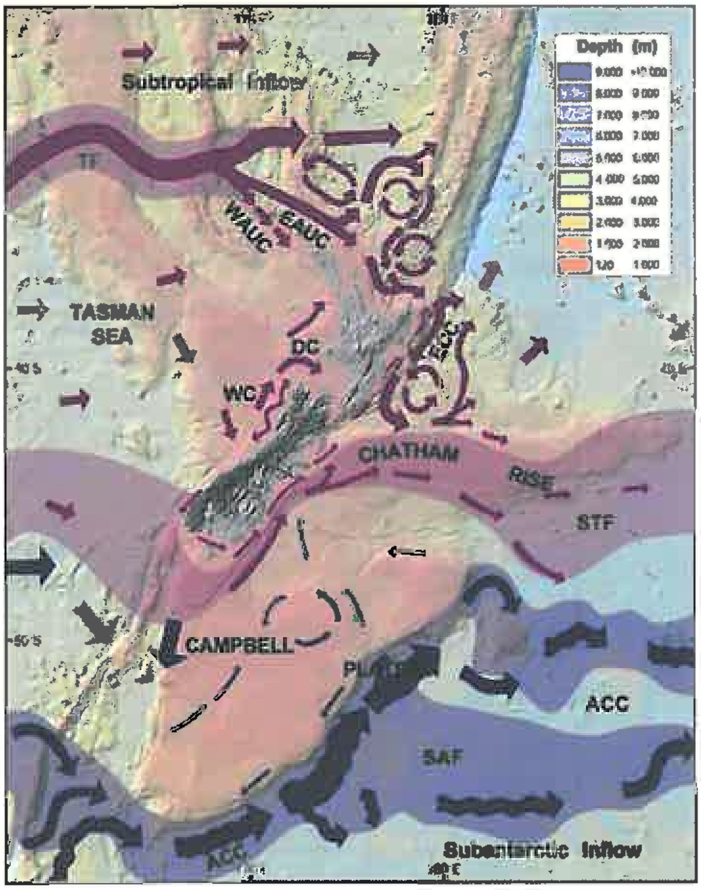

Figure 6.3 ***Major Water Masses Crossing through New Zealand***
Source: http://www.teara.govt.nz/en/ocean-currents-and-tides/1/1

6.3.3 *Bathymetry and Seabed Features*

The AOI is located within Canterbury Basin (see *Figure 6.1*), located offshore approximately 20 km from the coast of Dunedin. The Canterbury Basin is located offshore between Port Robinson and Brighton off the east coast of the South Island and north of the Great South Basin.

The Canterbury Basin covers an area of approximately 360,000 km² in water depths of up to 1,600 m (Uruski, 2010). The National Institute of Water and Atmospheric Research (NIWA) surveyed the bathymetrical features of the Canterbury and Great South Basins in 2012, illustrating the Otago Fan Complex within the Canterbury Basin, a series of nearshore canyons that bisect the continental shelf – consisting of nine major and many minor submarine canyons along the long stretch of the eastern South Island continental slope (NIWA, 2012a) (see *Figure 6.4*). These canyons can reach 750 m in depth and extend out towards the Bounty Channel. Sediments within this region are composed mainly of alternating mud with thin sand/clay rich intervals (Bender & Baily, 2012). These sediments are potentially sourced from large onshore river systems originating from the Southern Alps (Bender & Baily, 2012).

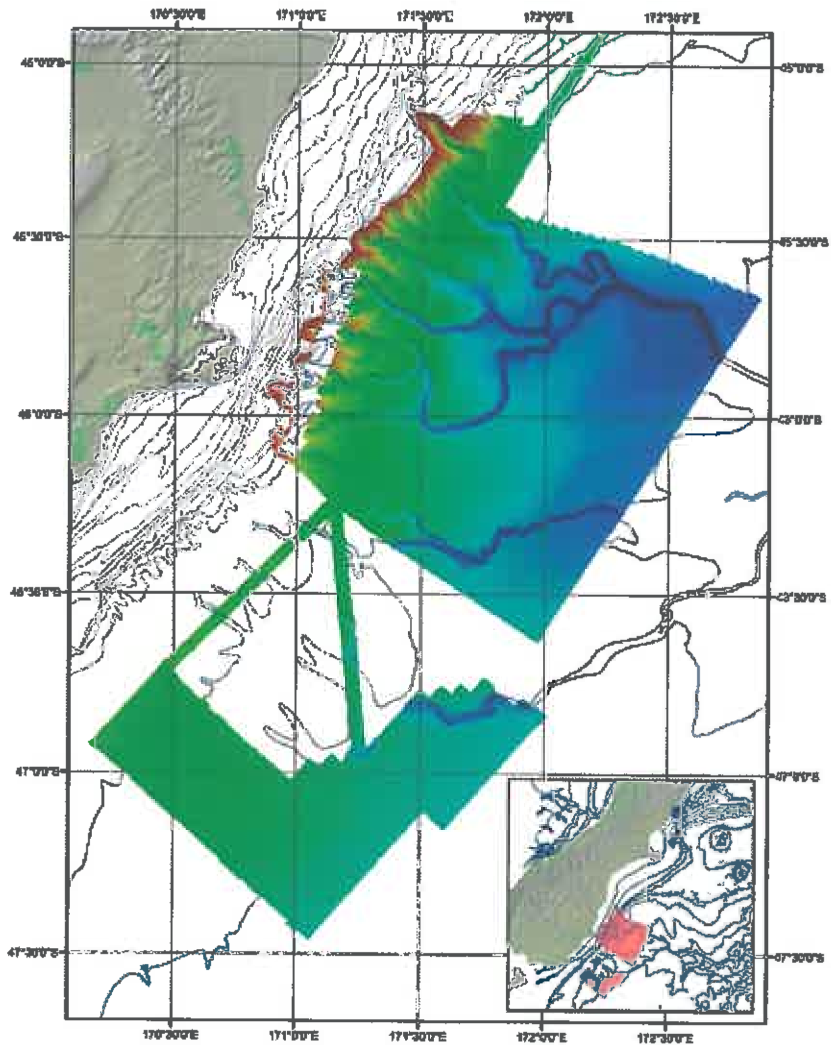

Figure 6.4 ***Bathymetry of the Area of Influence***
Source: NIWA, 2012a

6.3.4 *Noise Conditions*

Noise in the marine environment comes from a variety of natural (e.g. wind, waves) and anthropogenic sources (e.g. shipping, seismic events) 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 to 100 Hz (Coates, 2002; *Figure 6.5*). Echo-sounders (labelled ES in *Figure 6.5*) 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 6.5*).

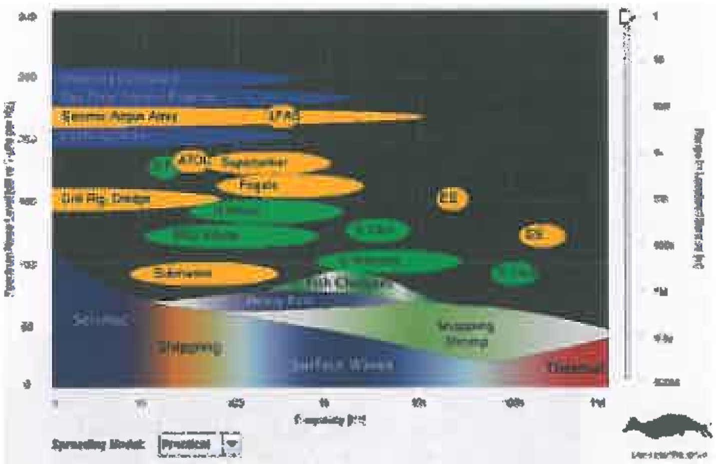

Figure 6.5 ***Ambient and Localized Noise Level from Various Sources in the Ocean, at a range of 1 m***
Source: www.seiche.com; © Seiche Ltd. 2006

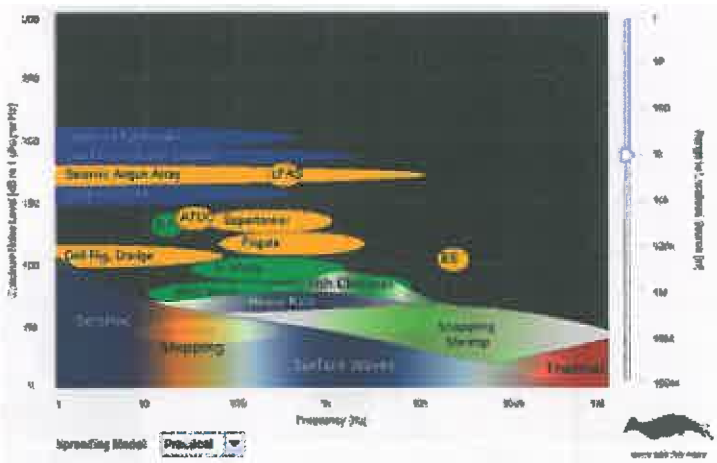

Figure 6.6 ***Ambient and Localized Noise Level from Various Sources in the Ocean, at a range of 1 km***
Source: www.seiche.com; © Seiche Ltd. 2006

Ambient noise conditions within the vicinity of 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 meters from the source and by a distance of 1,000 m the detectable sound is significantly lower (see *Figure 6.6* in comparison to *Figure 6.5*) (Coates, 2002).

6.3.5 *Islands, Reefs and Shoals*

There are no islands, or known reefs or shoals located within the AOI. The closest island is the South Island mainland itself, located only 20 km west from the edge of the PEP. Stewart Island is the closest offshore island (around 250 km to the south west).

6.3.6 *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 off the coast of the South Island. However, only four of these are located on the east coast, and none are located within the AOI (*Figure 6.7*). The closest MPA on the east coast is the Akaroa Marine Reserve and Pōhatu Marine Reserve, both located approximately 100 km to the north of the AOI (*Figure 6.7*).

The Banks Peninsula Marine Mammal Sanctuary (**MMS**) is the closest MMS to the AOI, with its southern extent being approximately 90 km to the north of the AOI (*Figure 6.7*). This MMS extends from the mouth of the Waipara River to the mouth of the Rakaia River. The sanctuary's offshore boundary extends to the 12 nm territorial sea limit. The total area of the sanctuary is approximately 413,000 hectares, extending over approximately 390 km of coastline (DOC, 2014a). The sanctuary was established in 1998 to protect endangered Hector's dolphins (*Cephalorhynchus hectori*) from bycatch in set nets. Within the sanctuary boundaries restrictions were placed on amateur and commercial set netting activities and commercial trawling (DOC, 2014a).

In November 2007, the government established 17 Benthic Protection Areas (**BPAs**) that exclude bottom trawling from specific areas within New Zealand's EEZ. These BPAs protect the biodiversity within about 1.1 million km^2 of seabed which equates to approximately 30% of the EEZ. There are two BPA's located on the mid and east Chatham Rise, over 500 km to the north-east of the AOI. There are no BPAs located inside the AOI (*Figure 6.7*).

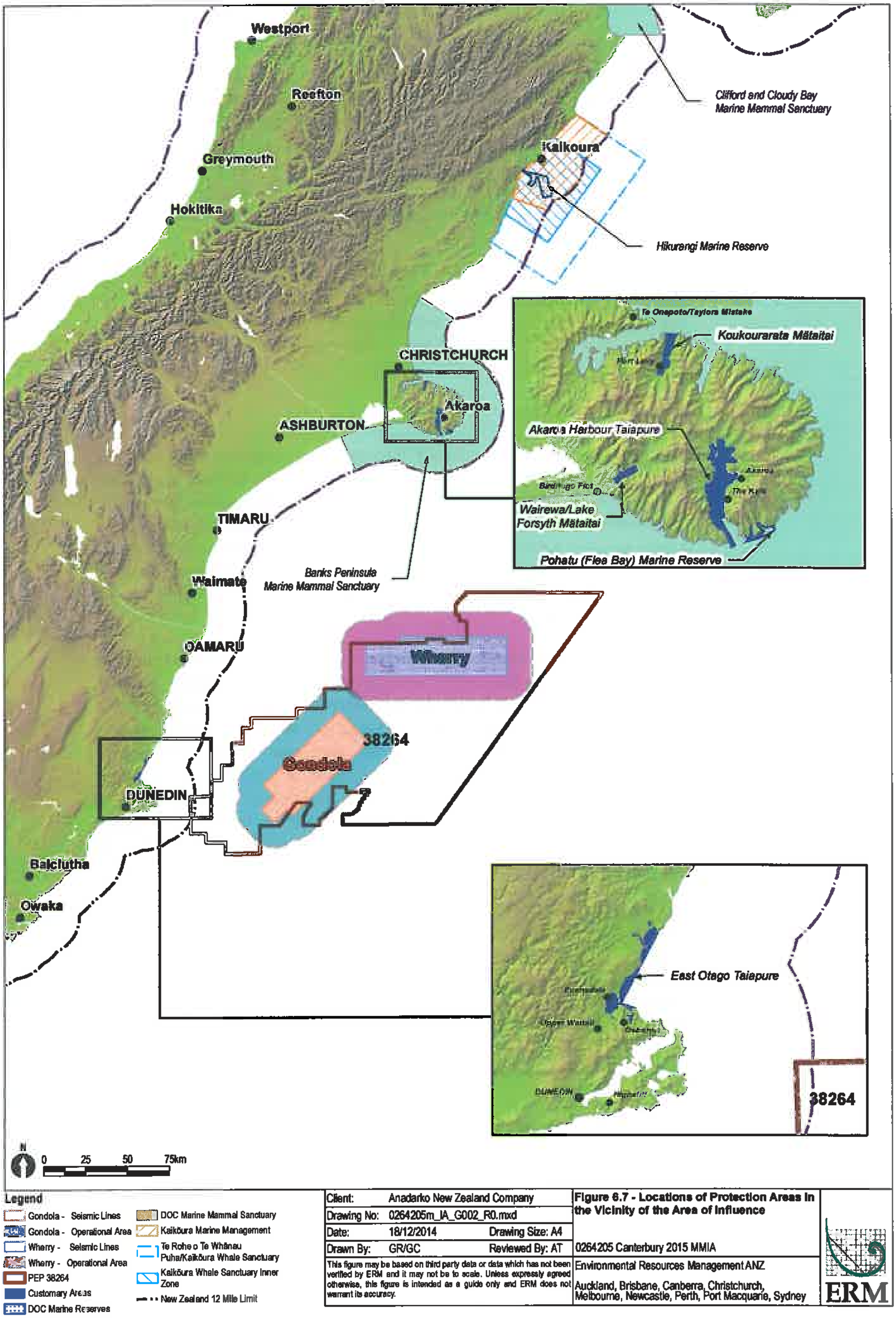

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Figure 6.7 - Locations of Protection Areas in the Vicinity of the Area of Influence

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6.4 BIOLOGICAL ENVIRONMENT

6.4.1 Introduction

Generally considered to include the sea and seabed below a depth of ~200 m, 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.

6.4.2 Plankton

Plankton can be broadly categorized 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. Because phytoplankton are at the bottom of the food-chain linking to the broader marine ecosystem via the trophic linkages, the abundance of phytoplankton provides an indication of the overall levels of productivity within a study area. 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 over large areas can be most effectively achieved by satellite remote sensing. Multispectral sensors can estimate chlorophyll-*a* concentration at the sea surface, which can be used as a proxy for phytoplankton abundance. While *in situ* sampling of phytoplankton is an alternative method, such single cast sampling provides only a spatially and temporally limited 'snapshot' of a population that varies significantly through time and undergoes seasonal and diurnal migration patterns.

Using the NASA Giovanni system (SeaWIFS), the chlorophyll-*a* concentration within the region of the AOI was estimated across a five year period (between 2005 and 2010). More recent data on chlorophyll-*a* concentration is currently unavailable through the system. Satellite imagery indicates low concentrations of between 0.2 – 0.5 milligrams (mg) chlorophyll-*a* per m^{-3} which is considered to have an accuracy of ±35% (*Figure 6.8*) (NASA, 2014).

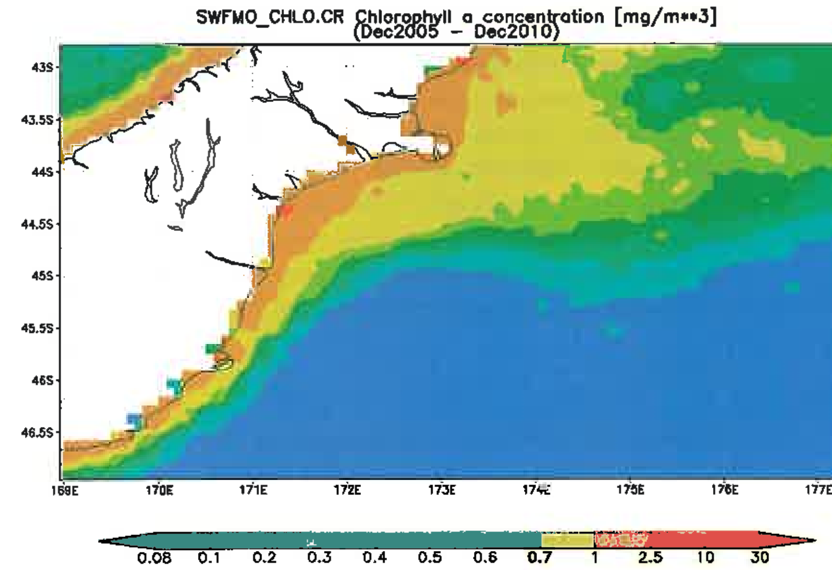


Figure 6.8 ***Chlorophyll-a Concentration (mg m^{-3}) within the Region of the Area of Influence, November 2005 – November 2010***

NOTE: Analyses and visualizations used in this report were produced with the Giovanni online data system, developed and maintained by the NASA GES DISC

Source: http://disc.sci.gsfc.nasa.gov/giovanni

6.4.3 *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) analyzed this relationship with fish species, using an extensive dataset 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 in waters of between 900 m and 1,100 m depth, shallower than the majority of the waters of the AOI (see *Figure 6.4*). The study also concluded that areas of high primary productivity (i.e., high chlorophyll-*a*) also resulted in high species richness. Given the relatively low level of productivity within the AOI (see *Section 6.4.2, Plankton* and *Figure 6.8*) it 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.

Listed Fish Species

The DOC classifies threatened species according to their risk of extinction using criteria developed specifically for New Zealand conditions. The New Zealand Threat Classification System Listing (hereafter, the '**DOC Listing**') is updated every three years, with the last complete listing cycle from 2008 to 2011. Marine fish species were not however included in this cycle and thus the 2005 listing, published in 2007, still applies (DOC, 2007). In the DOC listing, 45 species of marine fish (not including sharks, which are addressed in *Section 6.4.6, Sharks*) are identified as being in *Gradual Decline*, *Sparse*, or *Range Restricted*. Only a few of these listed fish species have known distributions, although none of these known distributions intersect with the AOI. It is therefore possible that some of these species may be found in the AOI. Thus, it has been assumed that some individuals of these species may occur within the AOI.

Commercial Fisheries

There are over 1,000 species of fish known to occur in New Zealand waters; approximately 130 of these species are commercially exploited from within the New Zealand EEZ (MPI, 2014a). The AOI is located within the Fisheries Management Area (**FMA**) 3 (South East (Coast)) and covers five statistical reporting areas (022, 023, 024, 301 and 302). There are three major commercial ports on the eastern coast of New Zealand's South Island, adjacent to the AOI: Lyttleton (Christchurch), Port Otago (comprising Dunedin and Port Chalmers) and Timaru. Port Otago is the closest port to the AOI, approximately 30 km west of the western edge of the PEP. The anticipated initial shore base for the MSS is Dunedin.

The total tonnage of catch from the three statistical areas surrounding the AOI between 2008 and 2013 is detailed in *Table 6.2* and is displayed relatively in *Figure 6.10*.

Table 6.2 Reported Commercial Catch for all Fisheries in the Three Statistical Areas Surrounding the Area of Influence (2008/2009 - 2011/2012 – fishing years).

Statistical Area	Total Catch (t)
022	96,675
023	64,862
024	18,585
301[1]	-
302	513

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

Source: Data supplied directly by MPI; October 2014.

Within these areas, the most commonly caught species (constituting > 58% of all catch) are hoki, barracouta, red cod, silver warehou and black oreo (see *Table 6.3*).

Table 6.3 ***Top Five Species Reported as Commercial Catch for Deepwater Fisheries in the Area of Influence Statistical Areas (2008/2009 - 2011/2012 – fishing years)***

Common Name	Total Catch (t)
Hoki	58,900
Barracouta	35,846
Red cod	10,799
Silver warehou	8,993
Black oreo	7,824

Source: Data supplied directly by MPI; October 2014.

As the key commercially caught fish species in the AOI, Hoki is discussed in greater detail below.

Hoki

Hoki (*Macruronus novaezelandiae*) reach adult maturity between 5 and 20 years (*Figure 6.9*). 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, where hoki spawn from late June to mid-September, releasing multiple batches of eggs. 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. The hoki trawl fishery, largely due to its size, is the most commercially valuable fishery in New Zealand (Ministry of Fisheries, 2010).

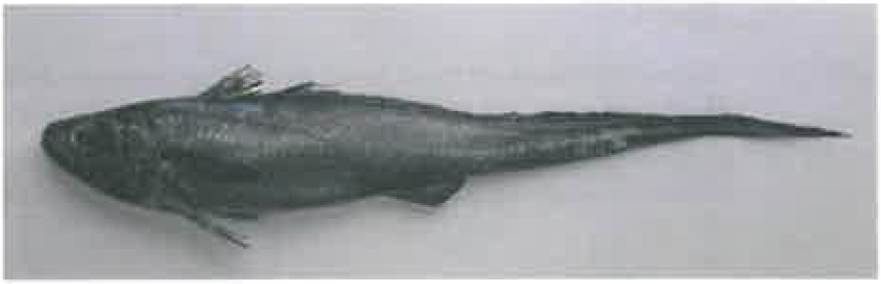
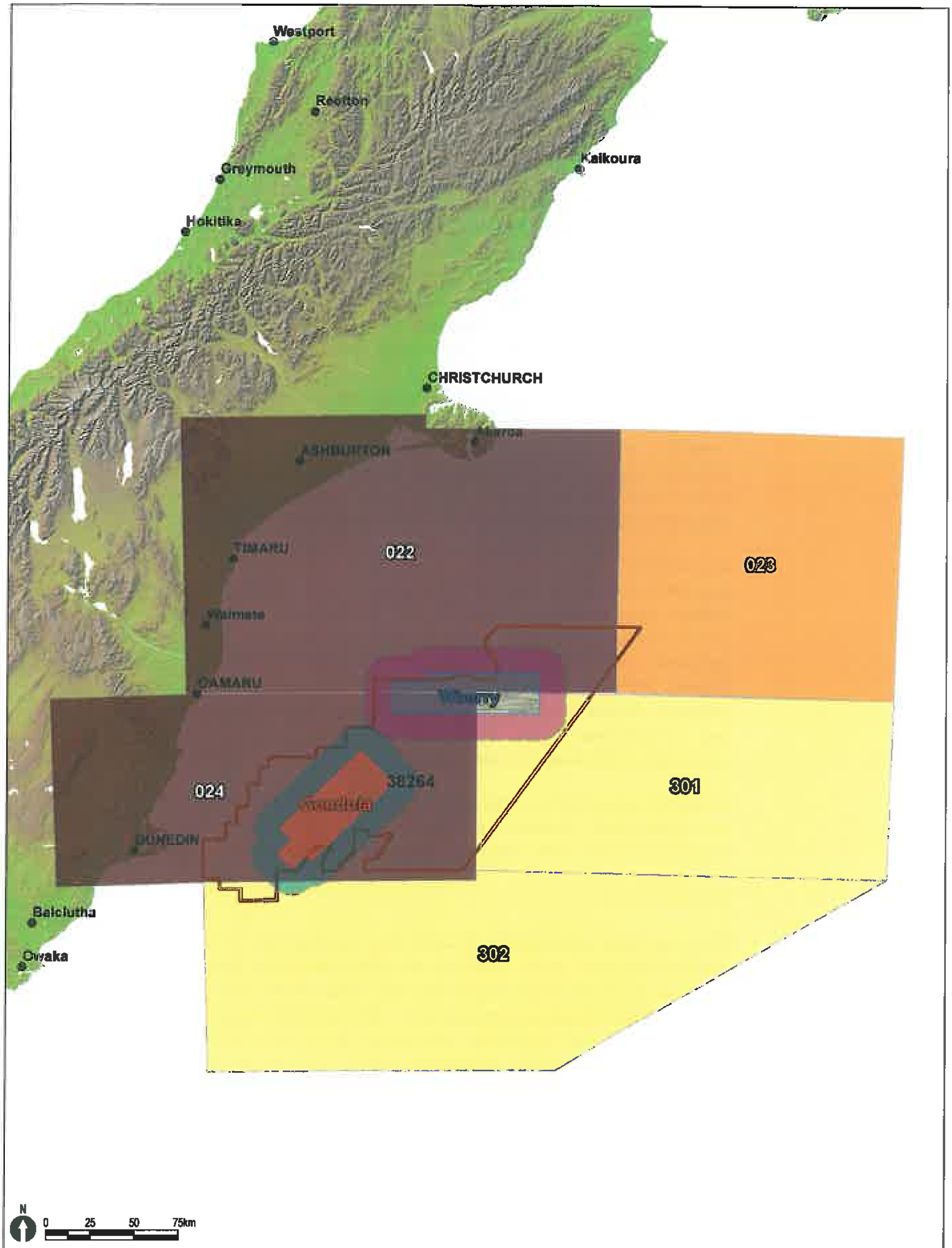


Figure 6.9 **Hoki**
Source: www.deepwater.co.nz



Legend

- Gondola - Seismic Lines
- Gondola - Operational Area
- Wherry - Seismic Lines
- Wherry - Operational Area
- PEP 38264

Commercial Fishing Effort

- Highest
- Lowest

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Figure 6.10 - Commercial Fishery Statistical Areas and Associated Catch Levels within the Region of the Area of Influence

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6.4.4 *Macrobenthic Communities*

Benthic Infauna

In 2012, the MPI 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 across 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 (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 assemblages were associated with muddy sediment; depths from 462 to 1,693 m included Holothuroidea, Echinoidea and Ophiuroidea; depths from 799 to 2,039 m included Ophiuroidea, Asteroidea, Echinoidea and Gastropoda.

Given the region has low chlorophyll-*a* levels (i.e. low primary productivity; see *Section 6.4.2, Plankton* and *Figure 6.8*), 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 the 'cold-water' coral communities: hard (stony) corals of the order Scleractinia; 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 photosynthesizing 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 (Freiwald *et al.*, 2004). As they lack this reliance on photosynthesis, cold-water corals can be found below the photic zone of approximately 200 m and into the deeper reaches of the ocean (Freiwald *et al.*, 2004). See *Table 6.4* for a summary of some differences between warm- and cold-water coral.

Table 6.4 ***Similarities and Differences between Cold-Water and Warm-Water Coral Reefs***

	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	284,300 km²
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 to 13°C	20°C to 29°C
Depth Range	39 to >1,000 m	0 to 100 m
Number of reef building species	Estimated six 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

Source: Freiwald et al., 2004

Cold-water coral communities can range in size from solitary 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 (NOAA, 2013). Such reef systems create niche habitat for an array of other marine species including sponges, polychaete worms, crustaceans, echinoderms, bryozoans and fish (Freiwald *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* (Freiwald *et al.*, 2004). *G. dumosa* and *S. variabilis* are the most prominent reef builders in New Zealand waters (Freiwald *et al.*, 2004). All "black corals" and "stylasterid 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 & 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 deep water ecosystems (Snelgrove *et al.*, 1997; Consalvey *et al.*, 2006). As discussed in *Section 6.3.3, Bathymetry and Seabed Features*, the AOI and surrounding area appears to be flat with low levels of bathymetric complexity. The only feature of interest is a large flat topped feature to the east of the AOI. Accordingly it is expected that majority of the AOI will not contain deepwater coral communities. However, given the paucity of benthic data in the area, this MMIA still considers impacts from the Project on deepwater corals (*Section 7.5, Firing of the Airgun Arrays* and *Section 7.7, Potential Impacts from Unplanned Events*).

6.4.5 *Marine Mammals*

New Zealand supports 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 New Zealand waters (Suisted & Neale, 2004).

Table 6.5 outlines the marine mammal species listed as of concern in the Code. Some of these species have been excluded from this MMIA, and the reasons for their inclusion or exclusion are also identified in *Table 6.5*. The ecology of the listed marine mammal species potentially present in the AOI are provided in greater detail in *Annex D*.

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

Two seismic surveys have recently been conducted within the area of the AOI. These comprised a VSP survey, undertaken by Anadarko in 2014 (PEP 38264) and a MSS undertaken by NZOG Devon Ltd in 2013 (PEP 52717). All marine mammal sightings during these MSS were submitted to DOC, in accordance with the Code and subsequently requested by ERM for this assessment.

No cetaceans were sighted during the one-day VSP survey. Data was not made available to ERM from the MSS in PEP 52717 (data was unable to be extracted by DOC in the format submitted).

Table 6.5 ***Marine Mammal Species of Concern Included or Excluded from this Impact Assessment***

Common and Scientific Name	Biology	Local Distribution	Timing of Appearance in the AOI	Included in the IA (Y/N)	Justification if species excluded from further assessment
Humpback Whale (*Megaptera novaeangliae*)	Humpback whales pass through New Zealand waters between their summer feeding grounds in the Antarctic and winter breeding grounds in sub-tropical waters (DOC, 2014b). These whales travel south down the west coast, and are reported to travel further from shore during their southward migration than when travelling north up the east coast. The humpbacks' northern migration route may pass through the AOI.	Likely occurs as a transient species in the AOI during northern migration.	More likely to occur within the proximity of the AOI between May and August.	Y	Not Applicable
Sei Whale (*Balaenoptera borealis*)	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 such as Sei 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).	May occur within the AOI as this species has been recorded at the eastern end of the Chatham Rise, within 250 km of AOI.	More likely to occur within the proximity of the AOI between May-July and November December.	Y	Not Applicable
Bryde's Whale (*Balaenoptera edeni*)	Bryde's whales are found year-round in waters between 40° S and 40° N, primarily in temperatures exceeding 16.3 °C (Kato, 2002). Generally a coastal species although can occur in the open ocean. Bryde's whales prefer more temperate waters and are seen off the New Zealand east coast in and north of the Bay of Plenty (Baker & Madon, 2007).	Unlikely to be encountered in the AOI as populations are generally confined to the North Island.	Unlikely to occur	N	Unlikely to be encountered in the AOI due to mainly east coast North Island distribution.

Common and Scientific Name	Biology	Local Distribution	Timing of Appearance in the AOI	Included in the IA (Y/N)	Justification if species excluded from further assessment
Antarctic Minke Whale (*Balaenoptera bonaerensis*)	The Antarctic minke whale is found throughout the Southern Hemisphere from 55° S to the Antarctic ice edge during the austral summer. Although some individuals have been recorded to over-winter in the Antarctic, most retreat to breeding grounds at mid-latitudes between 30° S and 10° S. In these areas, the distribution of the Antarctic Minke Whale is mainly oceanic, beyond the continental shelf break (Environment Australia, 2014). Mature Antarctic minke whales feed primarily on Antarctic krill, although smaller krill species and occasional copedods are also consumed. In 1989 the global population of Minke Whales in the Southern Hemisphere was estimated at 761,000 individuals (±5%) (IWC 2006). Antarctic Minke Whales have undergone extensive population reductions, including as a result of historic and continuing hunting (Environment Australia, 2014).	Due to broad distribution, while no DOC sighting records exist for the minke whale within and nearby the AOI, there is still a possibility Antarctic minke whales may occur within the AOI.	Year round*	Y	Not Applicable
Dwarf Minke Whale (*Balaenoptera acutorostrata subsp.*)	Dwarf minke whales prefer more temperate waters and are seen off the northern New Zealand coast (MPI, 2014a). This species is generally found in shallower water in coastal areas and over the continental shelf (MPI, 2014a).	These whales prefer more temperate waters and are known to occur around the North Island (Bay of Plenty) and Antarctic waters (Reilly, 2008a). Their distribution is generally undefined, however strandings have been recorded along the southern extent of the South Island and therefore this species may occur within the AOI.	Year round*	Y	Not Applicable

Common and Scientific Name	Biology	Local Distribution	Timing of Appearance in the AOI	Included in the IA (Y/N)	Justification if species excluded from further assessment
Blue Whale (*Balaenoptera musculus*)	The blue whale is part of the baleen suborder, and has four recognized 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). The blue whale is distributed throughout nearly all oceans (Reilly *et al.*, 2008b). While considered a migratory species, some remain residents year round where high oceanic productivity provides regular food source. Little is known about their movement in New Zealand waters; 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 (Torres, 2013).	Likely occurs as a transient species in the AOI during migrations between feeding and breeding grounds.	More likely to occur within the proximity of the AOI during migration.	Y	Not Applicable
Pygmy Blue Whale (*Balaenoptera musculus brevicauda*)	Pygmy blue whales are listed as *migrants* within New Zealand waters, occurring predominantly in the sub-Antarctic zone of the Indian ocean between 0°E and 80°E (Cetacean Specialist Group, 1996). While considered a migratory species, the migratory patterns of this species are not well understood (Reilly *et al.*, 2008b). The winter range for this species is virtually unknown, with scattered records from South Africa and Australia (Rice, 1998).	Listed as *Migrant* in New Zealand. There are a small number of records of these whales within Cook Strait (Museum of New Zealand, 1998). Therefore, there is the possibility that this species may occur within the AOI.	Year round*	Y	Not Applicable

Common and Scientific Name	Biology	Local Distribution	Timing of Appearance in the AOI	Included in the IA (Y/N)	Justification if species excluded from further assessment
Fin Whale (*Balaenoptera physalus*)	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). 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° to 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), however the location and season in which pairing and calving occurs remains largely unknown (Mackintosh, 1965).	The location and season in which pairing and calving occurs remain largely unknown (Mackintosh, 1965). Unlike other large cetaceans, calving does not appear to take place in distinct inshore areas (Reeves *et al.*, 2002; Jefferson *et al.*, 2008).	Year round*	Y	Not Applicable
Southern Right Whale (*Eubalaena australis*)	Feeds on planktonic crustaceans such as copepods (DOC, 2014b). This species is migratory and circumpolar mainly between 20°S and 55°S (DOC, 2014b). Most commonly recorded in the waters around the sub-Antarctic Auckland and Campbell Islands (DOC, 2014b), however the species is present offshore and inshore and mating occurs in warm waters in winter (DOC, 2014b). Southern right whales may move far out to sea during feeding season; however give birth in coastal areas.	NABIS indicated that the AOI is within this species' 'Normal Range'. Likely occurs as a transient species in the AOI during feeding.	Year Round, but more frequently in Winter and Spring.	Y	Not Applicable

Common and Scientific Name	Biology	Local Distribution	Timing of Appearance in the AOI	Included in the IA (Y/N)	Justification if species excluded from further assessment
Pygmy Right Whale (*Caperea marginata*)	The Pygmy right whale 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. The analysis of the stomach contents of three pygmy right whales revealed that this species mainly feeds on cephalopods (Ivashin, 1972; Sekiguchi *et al.*, 1992).	Strandings of pygmy right whales have been recorded on both the North and South Islands (Kemper, 2002a,b; Rice, 1998).	Year round	Y	Not Applicable
Southern Right-whale Dolphin (*Lissodelphis peronei*)	The southern right-whale dolphin is a poorly known species, with an assumed distribution across the cool sub-Antarctic waters of the Southern Hemisphere, between 30°S and 65°S (Hammond *et al.*, 2014). Southern right-whale dolphins are most often observed in cool, deep, offshore waters with temperatures of 1 to 20°C (Hammond *et al.*, 2014), 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).	Within New Zealand waters, southern right-whale dolphins are seen year-round around Chatham Island (Stanley & Podzikowski, 2013). It is assumed this species may occur within the AOI year round.	Year round	Y	Not Applicable
Long-finned Pilot Whale (*Globicephala melas*) Short-finned Pilot Whale (*Globicephala macrorhynchus;*)	Two species of pilot whales occur in New Zealand waters being the long-finned pilot whale and the short-finned pilot whale. 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, 2012a). Pilot whales eat mostly squid, but they also eat octopus, cuttlefish, herring, and other small fish (Bernard & Reilly, 1999).	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 long finned species prefers the cooler waters of the south (thus more likely in the AOI), while the short finned species prefers the warmer waters of the north (thus less likely in the AOI).	Year round*	Y	Not Applicable

Common and Scientific Name	Biology	Local Distribution	Timing of Appearance in the AOI	Included in the IA (Y/N)	Justification if species excluded from further assessment
Melon-headed Whale (*Peponocephala electra*)	The melon-headed whale has pantropical distribution (Perryman, 2002) between about 40°N and 35°S (Jefferson & Barros, 1997). Melon-headed whales are known to feed on pelagic squid and fishes, and occasionally crustaceans (Jefferson & Barros, 1997). Most of the fishes eaten by melon-headed whales consist of mesopelagic species, found in waters up to 1,500 m deep, suggesting that feeding takes place deep in the water column (Jefferson & Barros, 1997).	The range of this species is limited to at least 500 km north of the North Island (IUCN, 2008a) and is therefore not expected to occur within the AOI.	N/A	N	Unlikely to occur within the AOI as it is out of the range of this species.
Sperm Whale (*Physeter macrocephalus*) Dwarf Sperm Whale (*Kogia sima*) Pygmy Sperm Whale (*Kogia breviceps*)	Sperm whales are globally distributed and all three known species of sperm whale (large, pygmy and dwarf) have been recorded in New Zealand waters. Typical habitats for sperm whales include open ocean environments and areas on the seaward edge of the continental shelf or in the vicinity of deep canyons where depths may reach 3,000 m. Females and offspring prefer waters warmer than 15°C and are rarely seen south of latitude 45° S or close to land. Pygmy and dwarf sperm whales occur mainly in tropical and temperate latitudes (McAlpine, 2002).	Resident males are known to occur within the waters off Kaikoura, approximately 250 km north of the AOI. Stranding records for Pygmy Sperm Whales indicate they could be present within the AOI year round. Dwarf sperm whales 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.	Sperm whales and Pygmy Sperm whales may occur year round.	Y	Not Applicable

Common and Scientific Name	Biology	Local Distribution	Timing of Appearance in the AOI	Included in the IA (Y/N)	Justification if species excluded from further assessment
Beaked Whales: Numerous species (*Mesoplodon grayi; Berardius arnuzii; Ziphius cavirostris; Mesoplodon layardii; Hyperoodon planifrons; Mesoplodon bowdoini; Mesoplodon mirus; Mesoplodon densirostris; Mesoplodon gingkodens; Mesoplodon hectori; Mesoplodon peruvianus; Tasmacetus shepherdi*)	Little is known about the distribution of beaked whales, and due to limited sightings at sea, it is difficult to identify specific habitat types and behaviors for individual species (Hutching, 2012a). Most of the data gathered on this species has been collected from strandings, which are also rare. Beaked whales are renowned for their deep-diving ability and the majority of sightings and strandings of species in the genus Mesoplodon have been reported east and south of the South Island, with a potential hotspot between the South and Chatham Islands (MPI, 2014a).	Little is known, but several species appear to be largely restricted to southern New Zealand waters. Stranding records of Beaked Whales exist for the North and South Island.	Year round*	Y	Not Applicable
Orca (*Orcinus orca*)	Orca or killer whales feed on other marine mammals at sea and mostly fish in near-shore waters. It is estimated that there are three killer whale populations in New Zealand waters, one off the North Island, one off the South Island, and a third group that spends its time in both regions (Hutching, 2012b). They are reported to be common during the summer New Zealand fur seal breeding season.	Largely unknown. Killer whales are widespread throughout the temperate South Pacific. Likely to occur as a transient species in the AOI.	Year round*	Y	Not Applicable

Common and Scientific Name	Biology	Local Distribution	Timing of Appearance in the AOI	Included in the IA (Y/N)	Justification if species excluded from further assessment
False Killer Whale (*Pseudorca crassidens*)	False killer whales occur in tropical and temperate waters worldwide (Stacey *et al*, 1994; Odell & McClune, 1999), generally in relatively deep, offshore waters. However, some animals may move into shallow and higher latitude waters. This species is known to occur throughout New Zealand waters (Taylor *et al*., 2008).	Historically, most knowledge of false killer whales is from large, but infrequent stranding events. However, a more recent study has identified a total of 61 individuals so far, with 85 per-cent repeatedly re-sighted in coastal waters off north-eastern New Zealand over several years, and hundreds of kilometers. All individuals identified are linked in a single social network, suggesting they all form part of the same population (Zaeschmar *et al*., 2013).	Recent research reveals that false killer whales regularly appear in New Zealand waters between December and May, before departing to waters unknown (Zaeschmar *et al*., 2013).	Y	Not Applicable
Pygmy Killer Whale (*Feresa attenuata*)	The pygmy killer whale is a tropical/subtropical species, inhabiting oceanic waters generally between 40°N and 35°S (IUCN, 2008b).	This species is not expected to occur within the vicinity of the project.	N/A	N	This species is not expected to occur within the vicinity of the project due to its distribution.

Common and Scientific Name	Biology	Local Distribution	Timing of Appearance in the AOI	Included in the IA (Y/N)	Justification if species excluded from further assessment
Hector's Dolphin (*Cephalorhynchus hectori*)	Generally an inshore species, although they have been sighted 20 nm from the coast. Several winter sightings of Hector's dolphin were observed on or near the 20 nm boundaries within both Pegasus Bay and Canterbury Bight suggesting that the survey limit of this study may not fully encompass the offshore limits of this species (MacKenzie & Clement, 2014). Hector's dolphins are found around the coast of the South Island but distribution is patchy. Populations are concentrated between Haast and Farewell Spit in the west, around Banks Peninsula in the east, and Te Waewae Bay and Porpoise Bay/Te Whanaga in the in the south (DOC, 2014b). The AOI is in relatively close proximity to the Banks Peninsula MMS. The most recent East Coast South Island survey undertaken by MPI found the Hector's dolphin offshore distribution to be near the survey limit 20 nautical miles offshore (~33 km offshore) in the southern distribution around Oamaru. As a result it is possible for Hector's dolphins are extending their range south towards Dunedin to be within the AOI.	Patchily distributed around the South Island coast (DOC, 2014b). May potentially occur within the AOI.	Year round	Y	Not Applicable

Common and Scientific Name	Biology	Local Distribution	Timing of Appearance in the AOI	Included in the IA (Y/N)	Justification if species excluded from further assessment
Maui's Dolphin (*Cephalorhynchus hectori*)	Generally an inshore species (DOC, 2014b). Maui's dolphins are considered a subspecies of Hector's dolphin (Slooten *et al.*, 2006). Maui's dolphins are known to live up to 20 years. Females are not sexually mature until 7 to 9 years old, and produce just one calf every 2 to 4 years. Endemic to the West Coast North Island of New Zealand, the dolphins' distribution ranges from Maunganui Bluff in the north trailing off to Whanganui in the south. Within this range, the core distribution of the dolphin is thought to stretch from Kaipara harbor to just south of Kawhia harbor. The Maui's dolphin is listed as *Critically Endangered* under the IUCN Red List and *Nationally Critical* through the DOC Listing.	Thought to remain close to shore (within 4 nm) and on the North Island of New Zealand only. Unlikely to occur in the AOI due to affinity for coastal areas.	Unlikely to occur	N	This species is not expected to occur within the AOI due to its affinity for coastal areas.
Bottlenose Dolphin (*Tursiops truncatus*)	Globally, the bottlenose dolphin is distributed throughout most tropical and temperate inshore, coastal, shelf and oceanic waters (Leatherwood & Reeves, 1990; Wells & Scott 1999; Reynolds *et al.*, 2000). This species lives for 40 to 50 years, reaching sexual maturity ranging from 5 to 14 years of age (NOAA, 2012b). Calving occurs around every 3 to 6 years in this species, peaking in New Zealand between spring and summer/autumn months (DOC, 2014b).	Bottlenose dolphins 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.	Year round	Y	Not Applicable

Common and Scientific Name	Biology	Local Distribution	Timing of Appearance in the AOI	Included in the IA (Y/N)	Justification if species excluded from further assessment
New Zealand Sea Lion (*Phocarctos hookeri*)	The New Zealand sea lion feeds on fish, invertebrates, and occasionally birds or other seals (DOC, 2014b). Breeding occurs in summer, pupping occurs in December (DOC, 2014b).	Primary range includes the Auckland and, Campbell Islands. A small reproductive colony recently established on the Otago Peninsula (DOC, 2014b). Potential to occur within the AOI year round.	Year round	Y	Not Applicable

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

6.4.6 *Sharks*

The NABIS database (MPI, 2014a) identifies 15 shark species with distributions that include the AOI. These species are shown in *Table 6.6* below.

Table 6.6 Fifteen Shark Species with Distributions including the Area of Influence as listed in NABIS

Common Name	Scientific Name	DOC Listing	IUCN Red List
Blue shark	*Prionace glauca*	*Not Listed*	*Near Threatened*
Bronze whaler shark	*Carcharhinus brachyurus*	*Not Threatened*	*Near Threatened*
Dark ghost shark	*Hydrolagus novaezealandiae*	*Not Threatened*	*Least Concern*
Hammerhead shark	*Sphyrna zygaena*	*Not Threatened*	*Vulnerable*
Mako shark	*Isurus oxyrinchus*	*Not Threatened*	*Vulnerable*
Northern spiny dogfish	*Squalus griffin*	*Not Listed*	*Least Concern*
Pale ghost shark	*Hydrolagus bemisi*	*Not Threatened*	*Least Concern*
Porebeagle shark	*Lamna nasus*	*Not Threatened*	*Vulnerable*
Rig	*Mustelus lenticulatus*	*Not Threatened*	*Least Concern*
School shark	*Galeorhinus galeus*	*Not Threatened*	*Vulnerable*
Seal shark	*Dalatias licha*	*Not Threatened*	*Near Threatened*
Shovelnose dogfish	*Deania calcea*	*Not Threatened*	*Least Concern*
Spiny dogfish	*Squalus acanthias*	*Not Threatened*	*Vulnerable*
Thresher shark	*Alopias vulpinus*	*Not Threatened*	*Vulnerable*
Great white	*Carcharodon carcharias*	*Gradual Decline*	*Vulnerable*

Source: MPI, 2014a

All of these species aside from the great white shark (which is detailed below) are classified as *Not Threatened* in the DOC Listing. However, the International Union for Conservation of Nature (IUCN) Red List categorizes five of these as *Least Concern*, three as *Near Threatened* with the remaining seven being classified as *Vulnerable*, as shown in *Table 6.6*.

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* and Appendix II of the *International Convention on Trade in Endangered Species*.

Figure 6.11 ***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 programs as migrating from Stewart Island to New Caledonia in both 2009 and 2011 (NIWA, 2012b). 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 kilometers before returning to the same location between December and May (NIWA, 2012b). 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.

6.4.7 *Seabirds*

Introduction

With a total of 84 seabird species (96 different taxa including sub-species) 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 IUCN criteria (*Critical*, *Endangered*, or *Vulnerable*) and four taxa are listed as *Data Deficient* under the DOC Listing. 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 *et al*., 2003).

NABIS (MPI, 2014a) identifies the offshore waters in the vicinity of the AOI as a 'Hot Spot'[1] for eight seabird species:

- Gibson's albatross (*Diomedia gibsoni*);
- Hutton's Shearwater (*Puffinus huttoni*);
- Northern royal albatross (*Diomedea sanfordi*);
- Salvin's albatross (*Thalassarche salvini*);
- Sooty shearwater (*Puffinus griseus*);
- Southern royal albatross (*Diomedia epomophora*);
- White capped albatross (*Thalassarche steadi*);
- Little-blue penguin (*Eudyptula minor*); and
- Yellow-eyed penguin (*Megadyptes antipodes*).

Furthermore, a number of seabirds including albatrosses, petrels, and shearwaters have normal ranges which span across the South Pacific and include the AOI (MPI, 2014a). These groups 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 New Zealand, and 14 of these only breed in New Zealand (Wilson, 2012).

According to the NABIS database, five petrel species have normal ranges that include the AOI. While not exhaustive of all species potentially present within the AOI at any one time, *Table 6.7* outlines these five species alongside their conservation status in New Zealand and globally.

[1] A distribution "hotspot" for New Zealand seabirds is defined as "an area of increased abundance of a species, as considered by the expert compiling the species account".

Table 6.7 ***The Petrel Species (not including Albatrosses) with a Normal Range that includes the Area of Influence, with Key Information***

Petrel Species	DOC Listing[1]	IUCN Red List	Estimated Global Population[2]
Bullers shearwater (*Puffinus bulleri*)	*Naturally Uncommon*	*Vulnerable*	2,500,000
Flesh-footed shearwater (*Puffinus carneipes*)	*Declining*	*Least Concern*	650,000
Grey petrel (*Procellaria cinerea*)	*Declining*	*Near Threatened*	160,000
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

Sources: [1] Miskelly et al., 2008; [2] IUCN, 2013

Albatrosses

Albatrosses belong to the family *Diomedeidae*. Globally there are as many as 24 different species of albatross of which 14 are found in New Zealand (DOC, 2014c). Albatross, the world's largest seabirds, sometimes referred to as mollymawks, are from the *Diomedeidae* family and the *Procellariiformes* order. Albatross spend a large portion of their life at sea (at least 85%), foraging on fish, squid, krill, and barnacles (IUCN, 2013) and they travel vast distances from their breeding grounds to feed. The royal albatross, for example, with its massive wingspan of up to 3.3 m, flies an estimated 190,000 km a year.

Their naturally low productivity, combined with changes in climate and habitat conditions and certain fishing practices, make albatrosses vulnerable. Often with exposed and specific breeding locations, events such as a storm can significantly threaten their reproductive capability at least in the short term (DOC, 2001). Albatrosses feed by searching the sea surface for dead squid and fish. Many albatrosses have learnt that fishing vessels offer an easy food source and follow them, feeding on fish bait and scraps. Usually they take the bait without coming to any harm, but occasionally they get caught on a hook and are taken down with the line and drown (DOC, 2014c). Drift nets, oil spills and rubbish dumped at sea are also threats for albatrosses.

Table 6.8 provides a list of the two albatross species with annual distributions (normal range) including the AOI, according to NABIS, as well as the associated DOC Listing and IUCN Red List and some key life history information. An additional five species of albatross have the offshore waters within the vicinity of the AOI identified as a 'Hot Spot'.

Table 6.8 ***Albatross Species with Normal Ranges Include the Area of Influence according to NABIS***

Albatross Species	DOC Listing[1]	IUCN Red List[2]	Average Maturity Age[3]	Adult Survival Average[3]	Estimated New Zealand Population[3]	Reproductive Frequency (per year)[3]
Antipodean albatross (*Diomedea antipodensis*).	*Naturally Uncommon*	*Vulnerable*	9	95.4	5,186	0.5
Grey headed albatross (*Thalassarche chrysostoma*)	*Nationally Critical*	*Vulnerable*	10	95	7,803	0.5

Sources: [1] Miskelly et al., 2008; [2] IUCN, 2013; [3] MPI, 2014a

Penguins

The little blue (*Eudyptula minor*) and yellow-eyed penguin (*Megadyptes antipodes)* will possibly occur within the AOI.

The yellow-eyed penguin or *hoiho* (*Māori* name) 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 sub-Antarctic 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 6.12*).

Figure 6.12 ***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, 2014b). Nest sites are selected in August and normally two eggs are laid in September (MPI, 2014b). 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 to 6 kg (MPI, 2014b).

The population of yellow-eyed penguins is estimated to be 1780 to 2090 breeding pairs with over 1,000 on the sub-Antarctic Auckland and Campbell Islands, around 300 on the South Island and around another 500 on Stewart Island (McKinlay, 2001; *Figure 6.13*). 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 6.13 Distribution of the Yellow-Eyed Penguin

Source: www.yellow-eyedpenguin.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 (McKinlay, 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.

The little blue penguin (*Eudyptula minor*) is also known as the blue penguin, fairy penguin, little penguin or *korora* (*Māori* name) (DOC, 2012; *Figure 6.14*). 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, 2012). Little blue penguins only come ashore at night and live underground in burrows, natural holes, or even under human structures (DOC, 2012).

Figure 6.14 ***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, 2012). Left alone from around three weeks while their parents' source food, chicks become completely independent after around eight weeks (DOC, 2012). 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 *Nationally Vulnerable* 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, 2012).

6.4.8 *Marine Reptiles*

Eight species of marine reptiles are known to occur off New Zealand's coast (DOC, 2014d). 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*). Of these species, four are referenced in the 2005 edition of the DOC Listing (reptiles were not included in the 2008 to 2011 update) as *Vagrant* or *Migrant*, due to their status on the IUCN Red List, with the leatherback turtle and hawksbill turtle listed as *Critically Endangered* and the green turtle and loggerhead turtle listed as *Endangered*.

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 (DOC, 2014d). Marine reptiles are likely to breed on beaches located in tropical or subtropical areas outside of the New Zealand region (DOC, 2014d). The leatherback turtle is unique among sea turtles in its ability to withstand cooler waters, and consequently it is the most widely distributed marine reptile off New Zealand (DOC, 2014d). Leatherback turtles are thought to have resident feeding grounds within the New Zealand region and sightings have been recorded as far south as Fiordland; however breeding grounds in the Pacific are located in Australia and the Solomon Islands (DOC, 2014d). It is possible that marine reptiles (particularly the leatherback turtle) may occur within the AOI, but lack of nearby breeding habitat, for many species, and distance from known concentrations mean that they are likely to be rare.

6.4.9 *Introduced Marine Species*

From available records of surveys conducted in the area on behalf of various oil and gas companies, and information available from Biosecurity New Zealand, there are no records of introduced marine species currently present within the AOI. All vessels and rigs entering New Zealand are subject to the provisions of *Import Health Standards* to minimize the risk of translocation of marine pest species in ballast water or hull fouling. The MPI has recently released a *Craft Risk Management Standard* for vessel biofouling. This sets standards for the permissible level of hull fouling and acceptable measures for meeting the requirements. This requirement will become mandatory for all arriving vessels in 2018.

Between 2001 and 2005, the New Zealand government implemented a nationwide program of biological surveys in ports to manage biosecurity risks. Surveys have been completed in Lyttelton, Timaru, and Dunedin (Port Otago and Port Chalmers) and an overview of the findings from these ports is provided below. Given the close distance to the AOI, the above ports could potentially act as staging points for these species.

In Lyttelton Port a total of 246 species or higher taxa were identified, including 20 non-indigenous species, 22 cryptogenic species (those whose geographic origins are uncertain) and 54 species indeterminata. Fourteen species collected have not previously been described from New Zealand waters. Two of these were non-indigenous (a crab, *Cancer gibbosulus* and an ascidian, *Cnemidocarpa sp.)*, while the remaining 12 were considered cryptogenic (seven species of amphipod and 5 species of sponge) (NIWA, 2006a).

Sixteen non-indigenous species were recorded from the Port of Timaru. Three of these species, the crab *Cancer gibbosulus*, the amphipod *Caprella mutica* and the ascidian *Cnemidocarpa sp.*, were not previously know from New Zealand (NIWA, 2006b).

A total of 275 species or higher taxa were identified from the Dunedin Port survey. Twenty-five species of marine organisms collected from this survey had not previously been described from New Zealand waters. Two were newly discovered non-indigenous species (a polychaete worm, *Spirobranchus polytrema*, and a sponge, *Leucosolenia* cf. *discovery)* and 23 were considered cryptogenic. One species identified in this survey was on the New Zealand register of unwanted organisms (the Asian kelp, *Undaria pinnatifida)* (NIWA, 2006c).

6.5 *EXISTING INTERESTS*

Existing interests are defined in the EEZ Act as:

"the interest a person has in –

a. Any lawfully established existing activity, whether or not authorized by or under any Act or regulations, including rights of access, navigation and fishing;

b. Any activity that may be undertaken under the authority of an existing marine consent granted under section 62;

c. Any activity that may be undertaken under the authority of an existing resource consent granted under the Resource Management Act 1991;

d. The settlement of a historical claim under the Treaty of Waitangi Act 1975;

e. The settlement of a contemporary claim under the Treaty of Waitangi as provided for in an Act, including the Treaty of Waitangi (Fisheries Claims) Settlement Act 1992;

f. A protected customary right or customary marine title recognized under the Marine and Coastal Area (Takutai Moana) Act 2011."

This section describes the socio-economic and cultural aspects of the southern New Zealand region and identifies the existing interests that could be affected by the activity as per the requirements of Section 39(d) of the EEZ Act. As such, the discussion is limited to the socioeconomic components of the environment that could impact, or be impacted, by the proposed exploration activities. Particular emphasis is placed on the socio-economic and cultural conditions of the Canterbury and Otago regions, which are located on the east coast of the South Island, and are the nearest regions of the country to the AOI.

6.5.1 *General Demographics*

The Canterbury region occupies an estimated land area of 45,238 km^2 and is New Zealand's largest region (Environment Canterbury, 2014). It is bounded by the Pacific Ocean to the east, the Marlborough and Tasman regions to the north and northwest, the West Coast region to the west and the Otago region to the South (*Figure 6.15*).

The Otago region is the second largest New Zealand region by land area, occupying approximately 32,000 km^2 or 12% of New Zealand's land area (Otago Regional Council, 2009). It is bounded to the southwest by Southland region, to the northwest by the West Coast region, to the north by Canterbury region and to the east by the Pacific Ocean.

Figure 6.15 ***Regions of the South Island of New Zealand***
Source: http://www.lgnz.co.nz/assets/South-Island-PNG.PNG

Population

According to the 2013 census data, the population of New Zealand was 4,242,048, and had grown 5.3% since 2006 (Statistics New Zealand, 2014a). The Canterbury region was the second largest New Zealand region by population, accounting for 539,436 persons, approximately 13% of the total national population. The Otago region had a population of 202,467 persons (5% of the New Zealand population), ranking seventh in population size out of New Zealand's 16 regions (Statistics New Zealand, 2014b). The main settlement in the Canterbury region is Christchurch, the largest settlement on the South Island, whilst Otago's main settlement is Dunedin.

Ethnic Composition

The largest ethnic group in New Zealand in 2013 was the "New Zealand European" group, which accounted for approximately 2.97 million people, or 70% of the population. The next largest ethnic group nationwide was Māori, which accounted for 598,602 people, or 14.1% of the population. The remainder of the population was comprised of people of Asian, Pacific, Middle Eastern, Latin American, African, or other origins. In 2013, New Zealand had a rather large and growing immigrant population: almost one quarter (23.6%) of people living in New Zealand in 2013 were born overseas, compared with 22.9% in 2006, 19.5% in 2001, and 17.5% in 1996 (Statistics New Zealand, 2014b).

In 2013, the Canterbury region was slightly less ethnically diverse than New Zealand as a whole. In 2013, people of New Zealand European descent accounted for 83.2% of the Canterbury region's population. The 2013 census results also indicated that the next largest ethnic group in the Canterbury region was Māori (7.8%), followed by Asians, Pacific peoples, then Middle Eastern/Latin American/African and people of other unspecified descent, which generally reflected the ethnic composition of the national population. 18.6% of the Canterbury population was immigrants, having been born overseas, compared with 23.6% for New Zealand as a whole. In the Otago Region, 84.8% of the population was of European descent, with 7.1% belonging to the Māori ethnic group. 17.2% of the Otago population was immigrants.

Income

The median personal income for people aged 15 and over in New Zealand was NZ$28,500 in 2013. This figure was up 16% from NZ$24,400 in 2006 (Statistics New Zealand, 2014b). The regions with the highest median annual personal incomes in 2013 were Wellington, Canterbury, and Auckland, while the regions with the lowest median annual personal incomes were Northland, Gisborne, and Manawatu-Wanganui. Median annual incomes in the Canterbury (NZ$30,100) were higher than the national median, likely due to the Christchurch rebuild, whilst the median annual income in Otago was slightly below the national median annual at NZ$26,300 respectively.

6.5.2 *Maritime Traffic, Ports and Harbors*

Lyttelton Port is the South Island's major deep-water port and is located approximately 160 km from the AOI. Lyttelton Port has four heavy duty concrete berths suitable for handling containerized cargo, multi-purpose vessels, roll-on/roll-off and conventional vessels as well as a further eight berths available for general cargo and an oil berth (Lyttelton Port of Christchurch, 2005).

The most centrally located South Island port is PrimePort Timaru, located approximately 110 km from the AOI. The port has seven berths capable of handling a range of cargoes, from bulk liquids, diesel bunkers and containers, to reefer exports, bulk chemicals and grain (Prime Port Timaru, 2004).

Otago Harbor is located on the eastern seaboard of the South Island, adjacent to Dunedin (approximately 30 km from the AOI). Port Otago is the second largest port in the South Island and operates two wharf systems - Port Chalmers and Dunedin. The Port Chalmers container facility handles the largest container vessels that call at New Zealand's ports. Port Chalmers has four berths, suitable for handling containerized, multipurpose and conventional or RoRo vessels. The Dunedin wharf system is suitable for vessels with a lower draught. Tankers, fishing vessels and smaller conventional vessels are the principal users (Port Otago Limited, 2004).

There are no designated shipping lanes within the vicinity of the AOI. As the majority of vessels accessing these east coast ports have origins or destinations either within New Zealand or further afield (e.g. Australia, Japan, Korea, Singapore), the most travelled routes are north or south along the coast within the 12 nm limit. Some local fishing vessels may pass through the AOI but this is expected to be a very low volume. There are no areas in the proximity of the AOI that have been identified by MNZ as precautionary areas to be avoided.

6.5.3 *Fishing*

Three primary types of fishing are practiced in New Zealand's coastal waters: commercial fishing; recreational fishing; and traditional or customary fishing as practiced by Māori.

Commercial Fisheries

Commercial marine fisheries in New Zealand's Territorial Sea and EEZ are managed under the national quota management system, which divides the area into several FMAs. Under this system, commercial fishers are assigned a catch limit designed to provide for continued sustainable harvest. Data on the fish species of principal commercial interest in the AOI and the levels of catch for these fisheries is discussed in *Section 6.4.3*, Fish.

Commercial fishing activities are the most intensely monitored fishing activities in New Zealand, and commercial fishers are the only sector of fishers for which accurate catch valuations exist. The total asset value of New Zealand's commercial fish resource for the year to September 2008 was estimated at NZ$3.97 billion (Statistics New Zealand, 2009), which represented a 45% increase over the twelve years since 1996. Twenty species contributed over 90% of the value of the national commercial fishery in 2007-8.

The exact number of professional fishers is not known because the government tracks agriculture, forestry, and fishing employment together as a single category. These industries together were however seventh-largest employment categories in New Zealand in the 2013 census (Statistics New Zealand, 2014a). Approximately twice as many men are employed in these industries as women. The Canterbury and Otago regions employed the second and sixth highest number of people in the agriculture, forestry and fishing sector respectively (Statistics New Zealand, 2014b), although the proportion of fishers within this category is not known.

Recreational Fisheries

Recreational fishers are not managed under a quota system, but are subject to catch limits and minimum sizes established by the government to prevent overexploitation of certain fish stocks.

Recreational fishers are not currently required to report recreational catches of managed species, so tracking recreational harvest of marine fish in New Zealand is difficult. Sufficient information does not currently exist to value recreational fishery assets, but for some stocks recreational harvest accounts for a significant proportion of the total annual harvest (Statistics New Zealand, 2009).

Customary Fisheries

Under the terms of the *Fisheries Settlement Act 1992* and the *Māori Fisheries Act 2004*, Māori own a share of the commercial fish quota. Māori also may govern non-commercial customary fishing activities jointly with the New Zealand government, or independently within established *mātaitai* reserves (Statistics New Zealand, 2009). No data are currently available on customary fishing harvests.

The *Kaimoana Customary Fishing Regulations 1998* and the *Fisheries (South Island Customary Fishing) Regulations 1998* strengthen some of the rights of tangata whenua to manage their fisheries. No customary areas as established under the *Fisheries Act 1996* and *Kaimoana Customary Fishing Regulations 1998* have been identified in the vicinity of the AOI, either through literature review, or during engagement of iwi. Various special management areas (*mātaitai* reserves and *taiapure*) have however been identified in the coastal areas along the east coast of the South Island of New Zealand (see *Figure 4.3*).

6.5.4 *Oil and Gas Activity*

As noted previously, a 2D MSS was undertaken by Anadarko in PEP 38264 in February 2011 in order to supplement data gathered during previous MSS' of the region. Numerous MSS have also been undertaken in adjacent PEP in recent years, including within the Great South Basin to the south of the PEP and the Pegasus Basin to the north.

The Caravel exploration well was also drilled by Anadarko in PEP 38264 between February and March 2014 and an accompanying pre-drill monitoring survey was undertaken in line with Anadarko's requirements under Part 200 of the Marine Protection Rules. VSP of the exploration well was also undertaken as part of the drilling program.

The Canterbury Basin has a proven petroleum system and large mapped structures; however the region remains very lightly explored. To date, 11 wells have been drilled in the Canterbury Basin. Onshore wells drilled have been dry, including the recent Arcadia-1 and Ealing-1 wells. Four offshore wells drilled during the 1970s and 1980s, Endeavour-1, Resolution-1, Clipper-1, and Galleon-1 are more indicative of the basin's potential.

Both Galleon-1 and Clipper-1 contained significant hydrocarbon shows in Late Cretaceous coal measure sands (New Zealand Petroleum and Minerals, 2013). Galleon-1 flowed gas at 10 million standard cubic feet per day with 2300 barrels per day condensate, but was plugged and abandoned as the calculated recoverable reserve was considered uneconomic. No further information on Endeavour-1, Resolution-1 or Clipper-1 was identified.

6.5.5 *Munitions Dump*

Information collected from MNZ and the Royal New Zealand Navy notes the presence of a munitions dumping ground in the south western corner of the AOI, adjacent to the Otago Peninsula. Further correspondence with MNZ and the Royal New Zealand Navy, along with the acquisition and review of naval archives regarding offshore dumping revealed that approximately two tons of World War II era anti-aircraft munitions were potentially dumped in the identified dumping ground.

6.5.6 *Tourism*

Various tourism companies operate from coastal locations including the Otago Peninsula, Banks Peninsula and Kaikoura. Popular activities include wildlife cruises, hiking, natural heritage and historical sightseeing, canoeing and kayaking. While many activities are based on land, within inland waters or within harbors such as Akaroa Harbor and Lyttelton Harbor at Banks Peninsula, some companies operate further offshore to provide whale and albatross tours and offshore fishing charters. For example, Kaikoura (240 km north of the AOI) is a popular whale watching area as the continental shelf is close to shore and upwellings in the area attract numerous bird species, whales and dolphins. Banks Peninsula (100 km north of the AOI) also provides some offshore wildlife cruises. However, the rough seas, changeable weather and distance from the coast limit tourism in offshore waters near the AOI.

6.5.7 *Other Uses*

No specific information is available on other users of the ocean near or within the AOI; however maritime shipping, recreational/tourism, and military vessels have the potential to traverse the AOI during the exploration and optional appraisal well drilling activity. There are no known shipwrecks or sites of heritage significance within the AOI.

6.5.8 *Cultural Environment*

As highlighted previously, the 2013 census identified that Māori comprise 7.1% and 7.8% of the population in Otago and Canterbury respectively. *Te Kāhui Māngai*, a directory of iwi and Māori organizations developed by *Te Puni Kokiri* (the Ministry of Maori Development), highlights that the main iwi in the South Island of New Zealand are Ngāi Tahu. According to Ngāi Tahu, the iwi hold the rangatiratanga or tribal authority over 80% of the South Island (Ngāi Tahu, no date). Within the iwi, there are five primary hapū, being Kāti Kurī, Ngāti Irakehu, Kāti Huirapa, Ngāi Tūāhuriri and Ngāi Te Ruahikihiki (Ngāi Tahu, no date).

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).

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 Anadarko's exploration activities, Anadarko initiated an ongoing program of iwi engagement. Anadarko's iwi engagement activities have focused on building and maintaining open and effective relationships with iwi, providing iwi with information on the nature of the proposed MSS and identifying concerns relating to the potential impacts of the activities such that management and mitigation measures can be developed to avoid or minimize these impacts. Specific engagement activities undertaken in relation to the proposed MSS is outlined in *Annex A*.

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 MMIA considers impacts of the Project on relevant environmental and social resources and receptors. It addresses all impacts that will occur and may occur during the seismic survey program, both within the AOI and in the broader region where secondary impacts may occur.

In *Section 5, Screening and Scoping*, this MMIA has been scoped to focus on those project aspects that are considered to be of likely significance. This section addresses the impacts of significance. The remainder of impacts, which are not considered to be of significance, are outlined in *Table 5.2*.

The Project has been broken down to the following components that may result in significant impacts:

- Operation of the seismic and support vessels and towing of equipment;
- Underwater noise from the firing of the airgun arrays;
- Waste discharges from the survey and support vessels; 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 MSS program 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		
Operation of the seismic and support vessels and towing of equipment	• Marine Mammals • Seabirds • Commercial Fishing • Marine Vessels	*7.4*
Underwater noise from the firing of the airgun arrays	• Marine Mammals • Fish • Benthic Communities • Commercial Fishing • Cultural Values	*7.5*
Waste discharges from the survey and support vessels	• Water Column	*7.6*
Impacts from Unplanned Events		
Minor spills of fuels, oils and chemicals	• Marine Mammals • Seabirds • Fish • Benthic Communities • Water Column • Commercial Fishing • Cultural Values • Tourism	*7.7.2*
Collisions	• Marine Mammals • Seabirds • Fish • Benthic Communities • Water Column • Commercial Fishing • Marine Vessels • Cultural Values	*7.7.3*
Loss of streamers and associated equipment	• Seabirds • Commercial Fishing	*7.7.4*
Introduction of invasive marine species	• Fish • Benthic Communities • Commercial Fishing • Cultural Values	*7.7.5*

7.3 *ASSESSMENT METHODOLOGY*

As discussed in *Section 4*, 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 7.7, 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 (criteria for the rankings can be found in *Section 4, Impact Assessment Methodology*). In all instances, mitigation and control measures are considered after the initial MMIA, and residual impact significance is then provided.

As the MSS is taking place within the prescribed Area of Ecological Importance, a MMMP is required under the Code. The MMMP for this MSS is provided as *Annex B* to this MMIA. The final 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 *OPERATION OF THE SEISMIC AND SUPPORT VESSELS AND TOWING OF IN-WATER EQUIPMENT*

7.4.1 *Impact Sources*

The key impact sources from the operation of the seismic and support vessels and the towing of the equipment include:

- The presence of the seismic survey and support vessels;
- Vessel lighting; and
- The spatial extent of the towed airgun and streamer array.

7.4.2 *Sensitivity of Receptors*

The key receptors potentially subject to physical impacts are:

- Marine mammals;
- Seabirds;
- Commercial fishing; and
- Marine vessels (including tourism vessels).

Marine Mammal Sensitivity

Although the records of actual sightings of marine mammals in the AOI area indicate that numbers are likely to be very low, a total of 31 marine mammal species have been identified as being present or potentially present within the AOI. It is possible that these will include marine mammal species that 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 operation of the vessels and towing of the 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.		

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 support vessels. 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). There will be no discharge of food wastes during the survey that may attract seabirds to the MSS vessel. 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 2012c). 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.		

Commercial Fisheries Sensitivity

There is potential that the physical presence of the seismic vessel and support vessels 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 90 days and across a small proportion of the total 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 6.10*). Any impact is therefore expected to be temporary and localized. 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 (including Tourism Vessels) Sensitivity

As discussed in *Section 6.4.3, Fish*, the Project is located within FMA 3 (South-East Coast), which is rated of high significance for recreational and customary fisheries (MPI, 2014a). During the Project, marine traffic will be able to move through the region despite the 500 m Non-Interference Zone established around petroleum operations, including seismic survey vessels, under amendments to the *Crown Minerals Act* in 2013. 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 maneuverability 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.		

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

Impact Description

The only receptors considered likely to be affected by the movement of the seismic and support vessels are marine mammals. Vessel collision with other vessels or marine mammals has been assessed as an unplanned event and is covered in *Section 7.7.3 Evaluation of Potential Impacts – Collisions.*

The potential for behavioral changes of marine mammals as a result of vessel presence vary between species, locations and vessel activity. A variety of behavioral changes of cetaceans has been recorded in studies throughout New Zealand. Behavioral 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; Ritcher *et al.* 2003). 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 and, due to the nature of the industry, there are likely to be multiple vessels and interactions within a limited area or time period. When vessels slowed their approaches and limited sudden changes in speed and direction around the mammals, less behavioral impacts on sperm whales were observed (Gordon *et al.*, 1992).

Given the localized 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 90 days) it is expected this impact will be limited to a specific group of localized 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 localized 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. MMOs and/or PAM operators will be on watch at all times during the survey and MMOs will generally be on watch during vessel transits to and from port.

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 reduce to ***negligible*** with the implementation of the above mitigation measures. Accordingly, the impact significance from physical disturbance relating to the presence of the seismic and support vessels on marine mammals is considered to be ***negligible***.

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

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 (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 90 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 localized nature of the impact, coupled with the limited number of vessels, 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 localized 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 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. As a result, the effects of the survey vessel lighting are expected to be less than those typically associated with offshore fishing vessels.

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 support vessel decks following implementation of the mitigation measures described above was found to reduce to ***negligible***. Accordingly, the residual impact significance from deck lighting is considered to be ***negligible***.

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

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 8.5 km 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 far more limited commercial fishing activity is reported in the AOI when compared to the broader fishing statistical areas (refer to *Section 6.4.3, Fish*), 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 Anadarko, 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 visualize the tail of the streamer. On board, an Automatic Identification System (AIS) will ensure the vessel is tagged as a seismic vessel while at sea, alerting all surrounding vessels to the potential for streamers. Support vessels will be available at all times to facilitate communications with other vessels and remove fishing gear from the water that may entangle the streamer.

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 MSS is considered to be the only significant underwater noise source for the Project. MSS 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 utilize their highly sensitive acoustic sense to monitor their environment, communication, socializing, 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 kiloHertz (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;
- Sei whale;
- Antarctic minke whale;
- Dwarf minke whale;
- Blue whale;
- Pygmy blue whale;
- Fin whale;
- Southern right whale; and
- 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:

- Southern right-whale dolphin;
- Long-finned Pilot whales;

- Short-finned Pilot whales;
- 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;
- True's beaked whale;
- Shepherd's beaked whale;
- Orca;
- False killer whale;
- Bottlenose dolphin; and
- The New Zealand sea lion.

The work of Southall *et al.* (2007) 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 dB re 1 µPa (peak)[2]. Behavioral changes as a result of noise can include cessation of normal activities such as regular diving patterns and commencement of avoidance or 'startle' behavior, particularly when the noise source is intermittent. Such behavioral 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 pulsed sounds such as will be generated by the Project, avoidance behavior is more likely.

[2] Note, different units for sound level are used within this discussion (dB re 1 µPa; dB re 1 µPa (peak); dB re 1 µPa (rms) and dB re 1 $\mu Pa^2.s$). These different units are not directly intercomparable, but rather are reflective of the different scientific and technical studies referenced within the discussion.

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 localized avoidance behavioral responses of migrating humpback whales to a 3D seismic vessel was to take avoidance maneuvers of greater than 4 km then allowing the vessel to pass no closer than 3 km. Resting pods with females showed an even greater avoidance response of between 7 and 12 km. 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 behavioral 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 east coast occur between May and August (Gibbs & Childerhouse 2000). Other baleen whales have shown behavioral responses to received sound levels of 120-150 dB re 1 µPa (root mean square (rms)) for pulsed 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 behavioral 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) (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 dB re 1 µPa	120 dB re 1 µPa (rms)
Toothed whales (mid-frequency hearing)	230 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. 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 6.4.5, Marine Mammals*) and the disturbances associated with most seismic programs are likely to be transitory as the survey vessel moves through a particular area and would affect only those cetaceans within the range of the temporary impact threshold as the vessel moves through a particular area. Where whales are located towards the edge of the impact threshold area, they are able to move away from the noise source if disturbed, and although this may result in a temporary behavioral change, the whale can resume normal movement and feeding patterns once the vessel has passed through the area.. As such, the effects on marine mammals are therefore expected to be minimal. 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 ***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.		

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 *et. al.*, 2000a). 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 behaviors are expected to return some 14 to 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 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, no date). Other studies have identified developmental impacts on invertebrate larvae as a result of sound impacts (Aguilar 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 $\mu Pa^2.s$ induce avoidance behavior but that a gradual increase in acoustic intensity and prior exposure to air gun noise, decreases the severity of the alarm responses (Fewtrell & 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 *et al.*, 2003). 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). 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 behavioral 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, 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 high commercial fishing activity (see *Figure 6.10*), therefore there is potential that the sound produced from the seismic survey may cause a temporary localized reduction in fish abundance in the area during the Project. Accordingly, while there is an impact, it is temporary and localized in nature therefore the sensitivity of commercial fisheries to physical disturbance is considered ***low***.

Commercial Fisheries Sensitivity	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 to 200 Hz frequency range, with lower levels in the 200 to 1000 Hz range. Sound levels at the source can range from 237 to 262 dB re 1μPa/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 meters, 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 to 1 kHz) interspersed, depending on the Project requirements (Richardson *et al.*, 1995).

The STLM results for the 4,240 cubic inch array predicted that the maximum sound exposure levels produced by the seismic source would be 183.3 dB re 1 μPa^2.s at a range of 200 m, and 169.5 dB re 1 μPa^2.s at a range of 1.0 km, and that the surveys would therefore meet the requirements of the Code. A comparison with free-field results indicated that the combination of 1000 m deep water and a soft, low reflectivity seabed, resulted in the seabed reflections and refraction contributing only about 0.5 dB to the received levels. The full modelling report prepared by Curtin University Centre for Marine Science and Technology is provided in *Annex C* of this MMIA.

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 localized 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 localized 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

In accordance with the Code the following mitigation measures 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 addresses Level 1 surveys which requires, but is not limited to, the following:
  - The completion of a MMIA will completed and provided to the Director-General of DOC (this MMIA fulfils this requirement);
  - At least two (2) qualified MMO and PAM operators will be on board the source vessel;
  - Continuous pre-start observations for 30 minutes will be undertaken by a MMO and PAM;

- Continuous pre-start PAM will be undertaken for 30 minutes at night or during poor sighting conditions;
- There shall be no sightings of marine mammals within the respective mitigation zones for at least 30 minutes before start up;
- Seismic activity will not occur where species of concern with a calf are located within 1.5 km of the source;
- Seismic activity will not occur where concern are located within 1 km of the source during seismic activity; and
- Seismic activity will not occur where any marine mammals are located within 200 m of the source.

- 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; and
  - 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 will be implemented 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 will only be activated where:
  - 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 200 m, if, during pre-start observations prior to initiation of a Level 1 acoustic source soft start, a qualified observer detects a marine mammal within 200 m 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 200 m 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 200 m 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 ***medium*** 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 ***minor*** and ***negligible*** respectively.

The significance of impacts on fish will remain unchanged after the implementation of the above mitigation measures. The application of mitigation measures will substantially reduce the likelihood of marine mammals being exposed to noise, however there is some potential that underwater noise may affects a specific group of localized individuals within a population over a short time period, and so the potential magnitude of the impact is unchanged. 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	Medium	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	Minor	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 6.3.2, Oceanography*) 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.		

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

Impact Description

Any potentially contaminated seawater 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. Where practicable, all oily water will be returned to shore for disposal. Based on a maximum concentration of 15 ppm oil-in-water and the nature of the vessel having limited machinery on the deck, any impact will be highly localized 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 meters; 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 Certificate (IOPPC) and Oil Record Book and will have onboard International Maritime Organization (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 localized 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	Small
Sensitivity of water quality	Low	Low
Sensitivity of fish	Low	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.

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 localized 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 AOI (see *Section 6.3.2, Oceanography*). 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 ~90 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 millimeters (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 meters; and / or discharges are well within benchmark effluent discharge limits			

Mitigation Measures

- All sewage and garbage 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 nm 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.

- The treatment standard for any sewage discharge at sea will be not more than 100 fecal coliforms per 100 milliliter (ml), total suspended solids of less than 35 milligrams per liter ($mg\ l^{-1}$) and the 5-day BOD of less than 25 $mg\ l^{-1}$.

- 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*** both before and after the application of mitigation measures.

Category	Impact before Mitigation	Residual Impact
Magnitude of sewage and grey water discharge impacts	Small	Small
Sensitivity of water quality	Low	Low
Sensitivity of fish	Low	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 POTENTIAL IMPACTS FROM UNPLANNED EVENTS

7.7.1 *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:

- Hydrocarbon and/or chemical spill – 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.

7.7.2 *Evaluation of Potential Impacts – Minor Spills of Hydrocarbons 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 (e.g. while refuelling generators or topping up hydraulic fluids). 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 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.

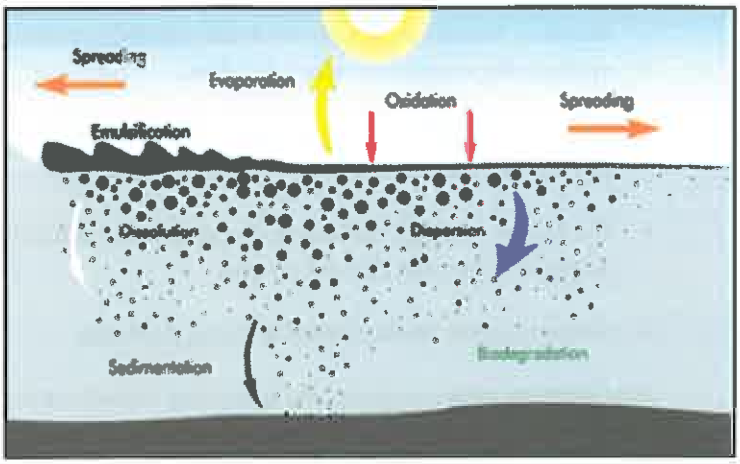

Figure 7.1 ***Fate of Hydrocarbons Spilled at Sea Showing the Main Weathering Processes***
Source: ITOPF, 2013

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.
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.
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.

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.			

Given the localized 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	• Localized environmental damage • No sensitive resources impacted • Degradation of spilled materials and full recovery of affected resources		

Mitigation and Control Measures

Anadarko is committed to adoption of the following measures aimed at reducing the potential risk of accidental hydrocarbon or chemical spills:

- The following systemic measures will be in place:
  - Refuelling will occur only when sea and weather conditions are conducive and can be carried out safely, as determined by the vessel Master;
  - 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 during the hours of darkness will be avoided where possible;
  - Vessels will use only marine diesel or marine gas oil;
  - 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; and
  - Continuous contact between the seismic vessel and the supply vessel.
- The following equipment design measures will be in place:
  - 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 management measures will be in place:
  - Project vessels will have a valid SOPEP in accordance with MARPOL Annex I requirements, 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
  - There will be very limited chemicals held on board vessels, consisting principally of small quantities of substances required for cleaning and maintenance. Potentially hazardous chemicals (e.g. paint and solvents) will be stored in secure areas on the vessel. 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 hydrocarbons or chemicals, is considered to be ***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			

With the implementation of the above mitigation measures, the severity of any impacts from the accidental spill of hydrocarbons or chemicals, is considered to be ***low***.

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

Residual Potential Impact

In the absence of Anadarko's mitigation and control measures the impact significance of impacts from the accidental spill of hydrocarbons or chemicals is considered to be ***moderate***. With the implementation of the above mitigation and control measures the likelihood of an accidental spill of hydrocarbons or 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 hydrocarbons or chemicals is considered to be ***ALARP***.

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

7.7.3 *Evaluation of Potential Impacts – Collisions*

Potential Impact Description

Impacts that may result from a vessel collision with another vessel 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 of 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 and responded to by the relevant Regional Council or MNZ 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 *et al.*, 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 *et al.*, 2003). It is not expected that any vessels associated with the Project will travel at speeds much greater than approximately 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	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 minimize the likelihood of a collision the following measures will be adopted during the project:

- MMOs and PAM operators will provide notification to the vessel master of any marine mammals in the area of the vessel, including continuing the watch during transits wherever practicable;
- Compliance with *Maritime Rules Part 22: Collision Prevention*, in terms of obligatory appropriate radio, navigational aids e.g. lights, flags and other visible signals, and good navigational practices and seamanship;
- Vessel speeds during the survey will be very slow, generally in the order of 4 knots;
- 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; and
- Support vessels 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, Anadarko is committed to adoption of the following measures aimed at reducing any subsequent impacts on the marine and coastal environment:

- The seismic vessel will use marine diesel in place of heavier fuel products;
- A fully trained and exercised vessel SOPEP in place prior to the Project commencing;
- All chemical and fuel containers including the vessels fuel tanks will be inspected and maintained for the duration of the Project; and
- Any incidents will be immediately reported to MNZ, together with the response action taken and Anadarko will work with MNZ to facilitate any required response activities.

With the implementation of the above mitigation measures, the severity of impacts from a vessel collision is reduced to ***medium*** principally due to the use of light fuel products that will rapidly disperse and weather in typical offshore conditions.

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

Residual Potential Impact

In the absence of Anadarko'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 ***ALARP***.

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

7.7.4 *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 utilized are mainly foam filled (solid). These streamers have a very small amount of silicone gel where the hydrophones are located in the streamer. In each of the three RVIM stretches, located head and tail of the streamer, there is approximately 250-300 l of the chemical Isopar M the RVIM stretches are filled with gel (conathane a cured polyurethane), which provides electrical insulation and neutral buoyancy.

Streamers are solid and neutrally buoyant and fitted with streamer recovery devices, 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 localized. • 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, other vessel movements through the survey area and wildlife interactions (e.g. sharks biting equipment) 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 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 ***ALARP***.

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

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

Potential Impact Description

Impacts on ecological communities from physical presence of 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 mobilizing to the project area from within New Zealand waters, however 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 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 the MPI will be consulted with and a Biosecurity Management Plan will be produced to effectively manage the risk of invasive species.

- Any vessels that are sourced from outside New Zealand waters will have recent evidence of antifouling.

- Any vessels that are sourced from outside New Zealand waters will be meet the 'Clean Hull' requirements for Long-Stay Vessels established in the voluntary *Craft Risk Management Standard: Biofouling on Vessels Arriving to New Zealand*. This will be implemented through:

  - Cleaning prior to the vessel; or

  - Continual maintenance using best practices such as the use of antifoul coatings and operation of marine growth prevention systems and backed up with inspections; or

  - Application of approved treatments; or

  - Development of a Craft Risk Management Plan.

  With the selection of option being dependent on the type and condition of the vessel.

- Advance notice of arrival and supporting documents for vessels entering New Zealand for the project will be provided to the Ministry for Primary Industries.

- 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 Anadarko'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 *ALARP.*

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

7.8 CUMULATIVE IMPACTS

Anadarko is aware that a number of operator-led and multi-client MSS in New Zealand's EEZ are currently in planning for the summer 2014/15 season and beyond. While Anadarko is not privy to the exact nature, extent or timing of these MSS, there is potential for there to be an element of accumulation in the impacts of the surveys.

As discussed above in *Section 7.5, Firing of the Airgun Arrays,* as the magnitude of underwater noise decreases across space, so does the significance of any of the impacts. The results of the STLM completed for this MMIA show that the sound exposure levels are in line with the mitigation zones that the Code enforces (*Section 7.5.3, Evaluation of Impacts – Firing of Airgun Arrays*). However, it is acknowledged that the Code anticipates behavioral disturbance outside these zones as animals to move away and thus reduce their own risk of injury. Thus animals (even non-migratory animals) can be exposed to multiple sources of potential disturbance, even if the MSSs are distant from one another. As such, it is expected that the other surveys operating in the region, will have similar, if not the greater, impact scales across space.

Furthermore, the outputs of MSS can be affected by background noise an interference such as that produced by other survey vessels, therefore it is general practice for survey vessels to avoid one another to reduce such impacts on data quality. Once indicative timing of the Project is confirmed and the scheduling of any other MSS in the AOI has been identified, Anadarko will work with other operators to ensure that such cumulative impacts are minimized.

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.

8 CONCLUSIONS AND SUMMARY OF IMPACTS

The MMIA 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 8.1* provides a summary of the impacts, receptors and a significance ranking of the impacts.

Table 8.1 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 Survey Vessels	• Marine mammals - *Negligible*
Vessel Lighting	• Seabirds - *Negligible*
Presence of In-Water Equipment	• Commercial fishing - *Negligible* • Marine vessels - *Negligible*
Underwater Noise from 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*
Impacts from Unplanned Events	
Minor Spills of Hydrocarbons and Chemicals	• *ALARP*
Collisions	• *ALARP*
Loss of Streamers or Other Equipment	• *ALARP*
Introduction of Invasive Species	• *ALARP*

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Annex A

Stakeholder Engagement Register and Associated Documents

A.1 OVERVIEW

This Annex provides a register of stakeholder engagement activities undertaken by Anadarko New Zealand Company (**Anadarko**) in relation to its planned Marine Seismic Survey (**MSS**) within the area of Petroleum Exploration Permit (**PEP**) Block 38264 of the Canterbury Basin, off the east coast of the South Island of New Zealand (hereafter, **'the Project'**).

The stakeholder engagement register and supporting documentation is current at time of issue of the associated MMIA, however Anadarko intends to continue engaging with interested parties leading to, during and following the project activities.

The Annex includes the following supporting documentation:

- Project notification letter issued between 6 and 10 November 2014.
- Update letter providing interested parties with details of the vessels to be used during the Project issued 18 December 2014.

Table A.1 Stakeholder Engagement Register

Name	Organisation/Role	Response Received
Local, Regional and Central Government		
Rt Hon John Key	Prime Minister of New Zealand	No response to date
Hon Dr Nick Smith	Minister for the Environment	No response to date
Hon Simon Bridges	Minister of Energy, Transport	No response to date
Hon Steven Joyce	Minister of Business, Innovation & Employment	No response to date
Hon Michael Woodhouse	MP, List	No response to date
Andrew Little	Leader of the Opposition	No response to date
Hon David Parker	Acting Leader of the Opposition	No response to date
Stuart Nash	Labour Party Energy Spokesperson	No response to date
Dr David Clark	Labour Party Economic Development Spokesperson MP, Dunedin North	No response to date
Dr David Shearer	Former Labour Party Energy Spokesperson	No response to date
Grant Roberston	Former Labour Party Economic Development Spokesperson	No response to date
Clare Curran	MP, Dunedin South	No response to date
Jacqui Dean	MP, Waitaki	No response to date
Rino Tirakatene	MP, Te Tai Tonga	No response to date
Peter Bodeker	Otago Regional Council, Chief Executive	No response to date
Stephen Woodhead	Otago Regional Council, Chairman	No response to date
Dame Margaret Bazley	Environment Canterbury, Chairperson	No response to date
Mayor Gary Kircher	Oamaru City Council	No response to date
Mayor Damon Odey	Timaru City Council	No response to date
Mayor Dave Cull	Dunedin City Council	No response to date
Des Adamson	Dunedin City Council, Acting Manager, Economic Development Unit	No response to date
Sue Bidrose	Dunedin City Council, Chief Executive	No response to date
Des Adamson	Dunedin City Council, Economic Development Unit	No response to date
Iwi		
Chris Rosenbrock	Kai Tahu ki Otago	No response to date
Edward Ellison	Otakou Marae	No response to date

Name	Organisation/Role	Response Received
Matapura Ellison	Kāti Huirapa ki Puketeraki	No response to date
Sir Mark Solomon	Te Runanga o Ngai Tahu	No response to date
Patrick Tipa	Te Rūnanga o Moeraki	No response to date
David Higgins	Te Rūnanga o Moeraki	No response to date
Fisheries		
Grant Prinsep	Independent Fisheries, Operations Manager / Director	No response to date
Andre Kotzikas	United Fisheries	No response to date
Eric Barratt	Sanford Limited, Managing Director	No response to date
Greg Buckett	Talleys Group Ltd	No response to date
Academia		
Dr Karen Stockin	Massey University, Co-Director Coastal-Marine Research Group	No response to date
Dr Rochelle Constantine	University of Auckland, Senior Lecturer, School of Biological Sciences	No response to date
Associate Professor Liz Slooten	University of Otago, Associate Professor, Department of Zoology	No response to date
Professor Steve Dawson	University of Otago, Professor, Department of Marine Science	No response to date
Dr Will Rayment	University of Otago, Department of Marine Science	No response to date
Other Groups		
John Scandrett	Employers Otago Southland, Chief Executive	No response to date
John Christie	Otago Chamber of Commerce, General Manager	No response to date
	Project Jonah	No response to date

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Anadarko New Zealand Company

Dear Sir,

Earlier this year Anadarko drilled an exploration well some 60 kilometres off the Otago coast to test for the presence of commercial quantities of hydrocarbons. While the results of the well were disappointing we continue to believe the basin has potential and are committed to further exploration on the Permit.

The next step in our work programme is the acquisition of approximately 4000 line kilometres of two dimensional seismic data <u>or</u> 3500 square kilometres of three-dimensional seismic data which will reveal details of geological structures beneath the seafloor. The results of this survey will be incorporated into our geological models for further evaluation and to help determine whether an additional exploration well is warranted.

Anadarko is currently working to contract a seismic vessel to carry out this work in the first quarter of 2015. As well as the scientific crew aboard, we will contract environmental consultants and trained Marine Mammal Observers who will record details of any marine mammal sightings and ensure the operations run according to the Marine Mammal Impact Assessment (MMIA) regulated by Department of Conservation's Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals.

Once a contract is in place we will write to you again with specific details of the survey, including timing. In the meantime, if you have any questions or concerns about this survey please contact us directly on the number provided. Alternatively, please submit any written comments to us at PO Box 10735, Wellington 6143.

Yours Sincerely

Alan Seay Anita Ferguson

ANADARKO NEW ZEALAND COMPANY PO BOX 10735 • WELLINGTON 6143, NEW ZEALAND • +64-4-471-2506
1201 LAKE ROBBINS DRIVE • THE WOODLANDS, TEXAS 77380
Anadarko
New Zealand Company

Dear Sir,

Further to our letter of 10 November, Anadarko is pleased to confirm details of our upcoming three dimensional seismic survey in the Canterbury Basin.

Anadarko has contracted Polarcus and its vessel the SV Naila to carry out the 3500 square kilometre survey which we expect to take around 80 days beginning in early February of 2015.

The vessel will be crewed by New Zealand seamen and the scientific operations will be performed by Polarcus employees in conjunction with contracted environmental consultants and trained Marine Mammal Observers who will record details of any marine mammal sightings and ensure the operations run according to the Marine Mammal Impact Assessment (MMIA) regulated by Department of Conservation's Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals.

If you have any questions or concerns about this survey please contact us directly on the number provided. Alternatively, please submit any written comments to us at PO Box 10735, Wellington 6143.

Alan Seay
Anadarko New Zealand

Anita Ferguson
Anadarko New Zealand

Annex B

Marine Management Mitigation Plan

MARINE MAMMAL MITIGATION PLAN

B.1 OVERVIEW

Anadarko New Zealand Company (**Anadarko**) plans to undertake a 3-Dimensional (**3D**) marine seismic survey (**MSS**) located within the area of Petroleum Exploration Permit (**PEP**) Block 38264 of the Canterbury Basin, off the east coast of the South Island of New Zealand (hereafter, **'the Project'**). The proposed project is scheduled to commence on 1 February 2015, over a period of approximately 90 days.

As per the requirements of the *Exclusive Economic Zone and Continental Shelf (Environment Effects) Act 2012* (**the EEZ Act**), as a MSS activity, the Project must comply with the requirements of the Department of Conservation's *Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations* (**the Code**). Due to the characteristics and geographic extent of the Project, these provisions require the development of a Marine Mammal Impact Assessment (**MMIA**) and an associated Marine Mammal Mitigation Plan (**MMMP**) for the Project.

This Annex to the MMIA forms the required MMMP and has been prepared to demonstrate how the requirements of the Code will be implemented on-board the vessel during the Project, including protocols that will be followed to minimize impacts on marine mammals.

The measures detailed below will be implemented in full throughout the MSS.

B.2 LEVEL ONE SURVEY REQUIREMENTS

B.2.1 Pre-Survey Planning

Anadarko is required to produce and submit an MMIA to the DOC Director-General one month prior to commencing seismic activities. This MMIA fulfils this requirement.

Anadarko will make this MMIA available to any *iwi* engaged through the MMIA development process that requests a copy, once accepted by DOC.

B.2.2 Observer Requirements

The minimum qualified observer requirements will be:

- At all times there will be at least two qualified MMOs on board;
- At all times there will be at least two qualified PAM operators on board. Details of the PAM system to be used during the MMS are provided in Annex C and are considered appropriate by Anadarko's MMO contractor to meet the requirements of the Code;

- The qualified observers will be dedicated in that their roles on the vessel are strictly for the detection and data collection of marine mammal sightings, and instructing crew on their requirements when a marine mammal is detected within the relevant mitigation zone (extended from the standard radius set out in the Code to incorporate the results from the sound transmission loss modelling), and

- At all times while the acoustic source is in the water, at least one qualified MMO (during daylight hours) and at least one qualified PAM operator will maintain watches for marine mammals.

Observations by qualified observers will be encouraged at all other times where practical and possible.

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 repaired 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; and,

- 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.

B.2.3 *Pre-Start Observations*

Normal Requirements

The acoustic source will only be activated if it is within the specified operational area, and no marine mammals have been observed or detected in the relevant mitigation zones as outlined in the below *Delayed Starts and Shutdowns* section.

The source will not be activated during daylight hours unless:

- At least one qualified MMO has continuously made visual observations all around the source for the presence of marine mammals, from the bridge (or preferably an even higher vantage point) using both binoculars and the naked eye, and no marine mammals (other than fur seals) have been observed in the relevant mitigation zone for at least 30 minutes, and no fur seals have been observed in the relevant mitigation zones for at least 10 minutes, and

- Passive Acoustic Monitoring for the presence of marine mammals has been carried out by a qualified PAM operator for at least 30 minutes before activation and no vocalizing cetaceans have been detected in the relevant mitigation zones.

The source will not be activated during night-time hours or poor sighting conditions unless:

- PAM for the presence of marine mammals has been carried out by a qualified PAM operator for at least 30 minutes before activation, and
- The qualified observer has not detected vocalizing cetaceans in the relevant mitigation zones.

Additional Requirements for Start-up in a New Location in Poor Sighting Conditions

In addition to the normal pre-start observation requirements outlined above, when arriving at a new location in the survey program for the first time, the initial acoustic source activation will not be undertaken at night or during poor sighting conditions unless either:

- MMOs have undertaken observations within 20 nautical miles of the planned start up position for at least the last 2 hours of good sighting conditions preceding proposed operations, and no marine mammals have been detected; or
- 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.

B.2.4 *Delayed starts and shutdowns*

Species of Concern with Calves within a Mitigation Zone of 1.5 km

If, during pre-start observations or while a Level 1 acoustic source is activated (which includes soft starts), a qualified observer detects at least one cetacean with a calf within 1.5 km of the source, start up will be delayed or the source will be shut down and not be reactivated until:

- A qualified observer confirms the group has moved to a point that is more than 1.5 km from the source, or
- Despite continuous observation, 30 minutes has elapsed since the last detection of the group within 1.5 km of the source, and the mitigation zone remains clear.

Species of Concern within a Mitigation Zone of 1.0 km

If, during pre-start observations or while a Level 1 acoustic source is activated (which includes soft starts), a qualified observer detects a Species of Concern within 1.0 km of the source, start up will be delayed or the source will be shut down and not reactivated until:

- A qualified observer confirms the Species of Concern has moved to a point that is more than 1.0 km from the source, or
- Despite continuous observation, 30 minutes has elapsed since the last detection of the Species of Concern within 1.0 km of the source, and the mitigation zone remains clear.

Other Marine Mammals within a Mitigation Zone of 200 m

If, during pre-start observations prior to initiation of a Level 1 acoustic source soft start, a qualified observer detects a marine mammal within 200 m 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 200 m 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 200 m of the source, and the mitigation zone remains clear.

If all mammals detected within the relevant mitigation zones are observed moving beyond the respective areas, there will be no further delays to initiation of soft start.

B.3 COMMUNICATIONS FLOW

Figure B1 summarizes the communications process between the MMO and survey personnel in the event of marine mammal sightings.

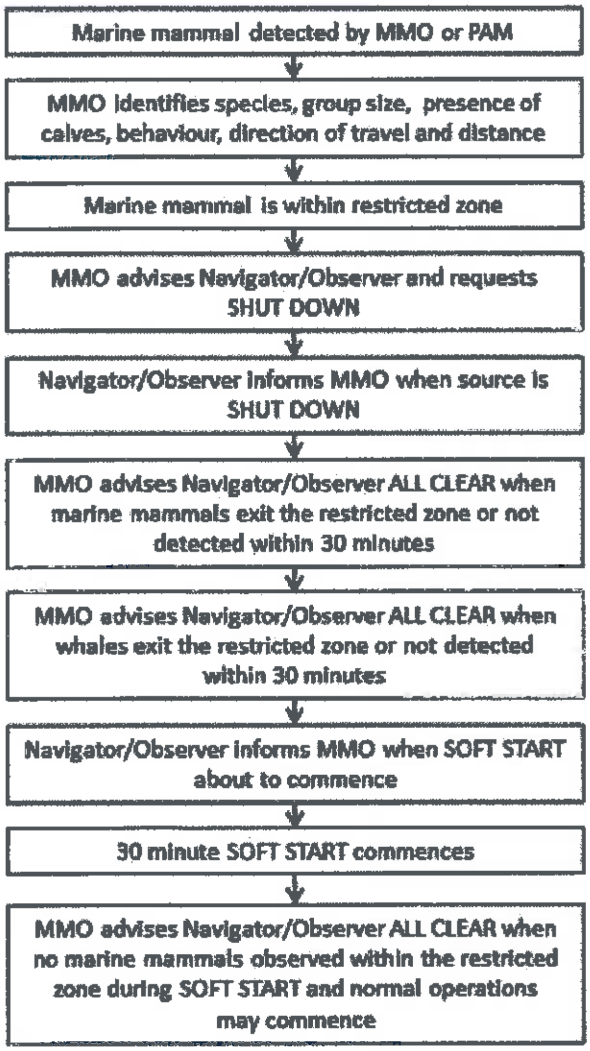


Figure B1 Communication Process in the Event of Marine Mammal Sighting

B.4 *Marine Mammal Observer and Passive Acoustic Monitor Operator Training and Experience*

Prior to commencing the Survey, the MMO and PAM Operators will have:

- Successfully completed the respective marine mammal observation course or PAM operator course recognized by the Director-General as being consistent with DOC standards, or
- Demonstrated all required competencies through an assessment process recognized by the Director-General as being consistent with DOC standards; and
- Logged a minimum of 12 weeks' relevant sea-time engaged in MSS operations in New Zealand continental waters, either as an MMO or PAM operator under the supervision of an appropriately qualified observer.

No survey vessel crew will be considered as qualified observers irrespective of training or experience.

PAM operators with 3 years' professional experience and a minimum of 12 weeks' relevant international sea-time may be engaged if no other suitable qualified observer is available.

B.5 *Operational Detailed Requirements*

B.5.1 *Observer Effort*

While two qualified MMO will be on board at all times, as a minimum one will be on watch during daylight hours while the acoustic source is in the water in the operational area. Of the two qualified PAM operators will also be on board at all times, and a minimum of one will be on watch while the acoustic source is in the water in the operational area.

One qualified observer and one trained observer in each observation role (MMO/PAM) may be on board. In such an instance, an appropriately qualified observer will act in a mentoring capacity to a trained observer for the duration of the MSS.

If the acoustic source is in the water but inactive for extended periods, such as while waiting for bad weather conditions to pass, the qualified observers have the discretion to stand down from active observational duties and resume at an appropriate time prior to recommencing seismic operations. This strictly limited exception must only be used for necessary meal or refreshment breaks or to attend to other duties directly tied to their observer role on board the vessel, such as adjusting or maintaining PAM or other equipment, or to attend mandatory safety drills.

So long as it does not cause health and safety issues, both qualified MMO will be on watch during pre-start observations during daylight hours, or at any other key times where practical and possible.

If one of the MMO with adequate understanding of the PAM system in operation is not required for visual observation duties, they may provide temporary cover in place of a qualified PAM operator to ensure continuation of 24-hour monitoring. This strictly limited exception will only be applied in order to allow for any necessary meal or refreshment breaks. In such an occurrence, a direct line of communication will be maintained between the MMO and the supervising PAM operator at all times. Furthermore, the qualified PAM operator will remain ultimately responsible for the duration of the duty watch.

The maximum on-duty shift duration for observers will not exceed 12 hours in any 24-hour period and the schedules will provide for completion of reporting requirements detailed in *Section B.5.13.*

B.5.2 Marine Mammal Observer Duties

While acting in their designated role, MMOs will:

- Give effective briefings to crew members, and establish clear lines of communication and procedures for on board operations;
- Continually scan the water surface in all directions around the acoustic source (not the vessel) for presence of marine mammals, using a combination of the naked eye and high-quality binoculars, from optimum vantage points for unimpaired visual observations with minimum distractions;
- Use GPS, sextant, reticle binoculars, compass, measuring sticks, angle boards, or any other appropriate tools to accurately determine distances/bearings and plot positions of marine mammals whenever possible throughout the duration of sightings;
- Record and report all marine mammal sightings, including species, group size, behavior/activity, presence of calves, distance and direction of travel (if discernible);
- Record sighting conditions (Beaufort Sea State, swell height, visibility, fog/rain, and glare) at the beginning and end of the observation period, and whenever the weather conditions change significantly;
- Record acoustic source power output while in operation, and any mitigation measures taken;
- Communicate with the Director-General to clarify any uncertainty or ambiguity in application of the Code;

- Record and report any instances of non-compliance with the Code; and
- Notify the Director-General immediately if higher numbers of cetaceans and/or species of concern are encountered than predicted in the MMIA and in the event of a non-compliance with the Code.

B.5.3 *Passive Acoustic Monitor Operator Duties*

While acting in their designated role, PAM operators will:

- Give effective briefings to crew members, and establish clear lines of communication and procedures for on board operations;
- Deploy, retrieve, test and optimize hydrophone arrays;
- On duty watch, concentrate on continually listening to received signals and/or monitoring PAM display screens in order to detect vocalizing cetaceans, except for when required to attend to PAM equipment;
- Use appropriate sample analysis and filtering techniques;
- Record and report all cetacean detections, including, if discernible, identification of species or cetacean group, position, distance and bearing from vessel and acoustic source;
- Record type and nature of sound, time and duration heard;
- Record general environmental conditions;
- Record acoustic source power output while in operation, and any mitigation measures taken;
- Communicate with the Director-General to clarify any uncertainty or ambiguity in application of the Code; and
- Record and report any instances of non-compliance with the Code.

B.5.4 *Authority to Shut Down or Delay Starts*

Any qualified observer on duty will have the authority to delay the start of operations or shut down an active survey according to the provisions of this MMIA.

Where MMO are supported by PAM or other alternative technology operators during surveys, marine mammal detections by any means will initiate a process of dialogue between the qualified observers on duty at the time. Such dialogue will ensure that decisions potentially affecting survey operations are made in a robust and mutually supportive manner, based on the skills, experience, capability and professional judgment of the observers. However, either qualified observer has the authority to act independently in each instance, if necessary.

As cetacean calves may be present during the survey, vocalizing cetacean detections by PAM will be assumed to be emanating from a cow/calf pair. In this case the more stringent mitigation zone provisions will be applied, unless determined otherwise by the MMO during good sighting conditions.

Due to the limited detection range of current PAM technology for ultra-high frequency cetaceans (<300 m), any such bioacoustic detections will require an immediate shutdown of an active survey or will delay the start of operations, regardless of signal strength or whether distance or bearing from the acoustic source has been determined. Shutdown of an activated acoustic source will not be required if visual observations by a qualified MMO confirm that the acoustic detection was of a species falling into the category of 'Other Marine Mammals'.

B.5.5 Observer Deployment

The preference for operational deployment of observers is on the survey vessel. However, if there are critical operational constraints in positioning observation teams on the survey vessel, they may be redeployed onto any support vessels that may be used during the survey, providing that their ability to perform in their specific roles is not compromised and they will remain in direct communications with the survey vessel. The qualified observers affected will be involved in any discussions in this regard and agree to any redeployment arrangements. The Director-General must give approval for the observers to be re-deployed prior to any such action being taken.

B.5.6 Crew Observations

If a crew member on board any vessel involved in survey operations observes what may be a marine mammal, he or she will promptly report the sighting to the qualified MMO, and the MMO will try to identify what was seen and determine their distance from the acoustic source.

In the event that the MMO is not able to view the animal, they will provide a sighting form to the crew member and instruct them on how to complete the form. Vessel crew can relay either the form or basic information to the MMO. If the sighting was within the mitigation zones, it is at the discretion of the MMO whether to initiate mitigation action based on the information available.

Sightings made by members of the crew will be differentiated from those made by MMOs within the reports.

B.5.7 Acoustic Source Power Output

Anadarko will ensure that information relating to the activation of an acoustic source and the power output levels employed throughout survey operations is readily available to support the activities of the qualified observers in real time by providing a display screen for acoustic source operations.

Anadarko will immediately notify the qualified observers if operational capacity is exceeded at any stage.

B.5.8 *Soft Starts*

Acoustic sources will not be activated at any time except by soft start, unless the source is being reactivated after a single break in firing (not in response to a marine mammal observation within a mitigation zone) of less than 10 minutes immediately following normal operations at full power, and the qualified observers have not detected marine mammals in the respective mitigation zones. This means a gradual increase of the source's power, starting with the lowest capacity gun, over a period of at least 20 minutes and no more than 40 minutes.

The 10-minute break exception from soft start requirements by sporadic activation of acoustic sources at full or reduced power within that time will not be repeated.

Soft starts will be scheduled so as to minimize, as far as possible, the interval between reaching full power operation and commencing a survey line.

B.5.9 *Acoustic Source Tests*

Seismic source tests will be subject to the relevant soft start procedures for each survey level, though the 20-minute minimum duration does not apply. Where possible, power will be built up gradually to the required test level at a rate not exceeding that of a normal soft start.

If undertaken, seismic source tests with a maximum combined source capacity of <2.49 liters or 150 cubic inches, will not be subject to soft start procedures, and will be undertaken following relevant pre-start observations.

Acoustic source tests will not be used for mitigation purposes, or to avoid implementation of soft start procedures.

B.5.10 *Line Turns*

If possible and practical, Anadarko will shut down at the end of a line and reactivate the acoustic source according to the applicable soft start procedures and pre-start observations, in accordance with the Code.

B.5.11 *Recording and Reporting Requirements*

All sightings of marine mammals during the survey period, including any beyond the maximum mitigation zone boundaries or while in transit, will be recorded in a standardized format. A written trip report will be submitted by

Anadarko to the Director-General no longer than 60 days after completion of the survey. In addition, daily and weekly reports will be provided by the MMO's to Anadarko.

Recording and reporting of observations of other marine species will also be taken.

In addition to the above summary report, the qualified observers will submit all raw datasheets directly to the Director-General, no longer than 14 days after completion of each deployment. Anadarko understands that proprietary information provided to the Director-General through these reporting processes will be treated in confidence. Only data on marine mammal detections will be made publicly available, primarily in summary form through updates to information resources for Areas of Ecological Importance, but potentially also for detailed analytical research.

The Director-General will be informed immediately, if the qualified observers consider that higher numbers of cetaceans and/or Species of Concern than predicted in the MMIA are encountered at any time during the survey. In such instances where the Director-General determines that any additional measures are necessary, these will be implemented without delay. The Director-General will also be informed immediately about any instances of non-compliance with the Code.

B.5.12 Report Contents

The following will be included in the trip report being produced:

- The identity, qualifications and experience of those involved in observations;
- Observer effort, including totals for watch effort (hours and minutes);
- Observational methods employed;
- Name of the operator and any vessels/aircraft used;
- Specifications of the seismic source array, and PAM array;
- Position, date, start/end of survey, GPS track logs of vessel movements;
- Totals for seismic source operations (hours and minutes) indicating respective durations of full-power operation, soft starts and acoustic source testing, and power levels employed, plus at least one random soft start sample per swing;
- Sighting/acoustic detection records indicating:
    - Method of detection;

- Position of vessel/acoustic source;
- Distance and bearing of marine mammals related to the acoustic source;
- Direction of travel of both vessel and marine mammals;
- Number, composition, behavior/activity and response of the marine mammal group (plotted in relation to vessel throughout detection);
- Confirmed identification keys for species or lowest taxonomic level;
- Confidence level of identification;
- Descriptions of distinguishing features of individuals where possible;
- Acoustic source activity and power at time of sighting;
- Environmental conditions;
- Water depth, and
- For PAM detections, time and duration heard, type and nature of sound.

- General location, time, duration and reasons where observations were affected by poor sighting conditions;
- Position, time and number of delays and shutdowns initiated in response to the presence of marine mammals;
- Position, duration and maximum power attained where operational capacity is exceeded;
- Any instances of non-compliance with the Code, and
- Differentiation will be made between data derived from:
  - MMO and PAM operators;
  - Qualified observers and others; and
  - Watches during survey operations (ON Survey) or at other times (OFF Survey).

Data will be recorded in a standardized format, which can be downloaded from the DOC website at http://www.doc.govt.nz/notifications.

Annex C

Sound Transmission Loss Modelling Report

Curtin University

Centre for Marine Science and Technology

Received underwater sound level modelling for the Wherry and Gondola seismic surveys, New Zealand

FINAL

Prepared for:

ERM New Zealand

Prepared by: Alec Duncan

PROJECT CMST 1363
REPORT 2014-64

16th December 2014

Summary

This report describes acoustic propagation modelling that was carried out to predict received sound exposure levels from the proposed Wherry and Gondola seismic surveys in the Canterbury Basin, off the east coast of New Zealand's South Island. The same seismic source will be used for both surveys, and the minimum water depths within the survey areas are both very close to 1000 m, with similar seabed geology. A single source location was therefore chosen for modelling the worst case sound levels applicable to both survey areas.

The modelling results predicted that the maximum sound exposure levels produced by the seismic source would be 183.3 dB re 1 $\mu Pa^2.s$ at a range of 200 m, and 169.5 dB re 1 $\mu Pa^2.s$ at a range of 1.0 km, and that the surveys would therefore meet the requirements of the New Zealand Department of Conservation 2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations.

A comparison with free-field results indicated that the combination of 1000 m deep water and a soft, low reflectivity seabed, resulted in the seabed reflections and refraction contributing only about 0.5 dB to the received levels.

Contents

List of Figures

1 Introduction

This report describes acoustic propagation modelling that was carried out to predict received sound exposure levels from the proposed Wherry and Gondola seismic surveys in the Canterbury Basin, off the east coast of New Zealand's South Island. The boundaries of these surveys are shown in Figure 1.

The requirement was to model received sound exposure levels (SELs) in order to check compliance with the sound exposure level requirements of the New Zealand Department of Conservation 2013 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 200 m from the source, or 171 dB re 1 $\mu Pa^2.s$ at ranges of 1 km and 1.5 km.

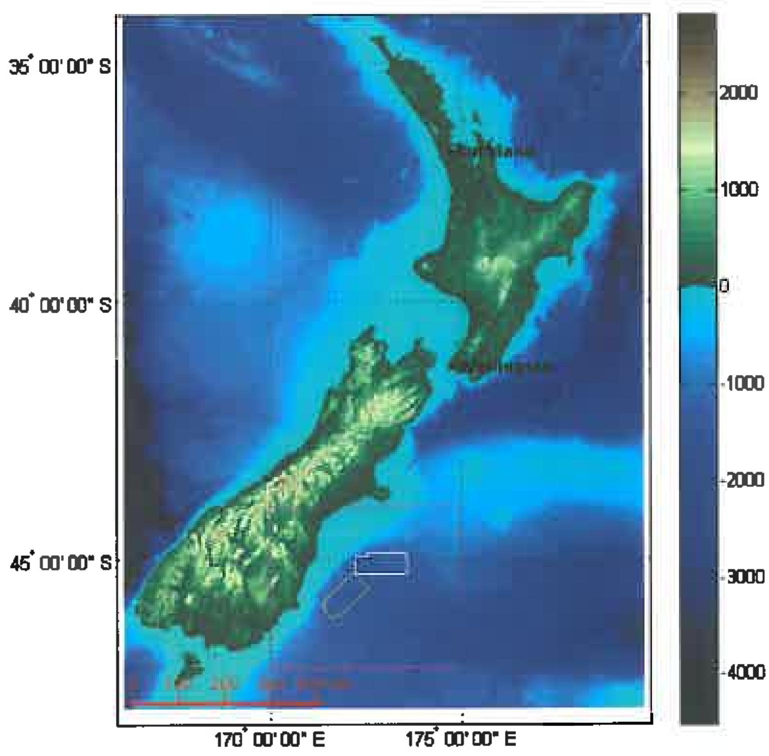


Figure 1. Map of New Zealand showing the Wherry (white polygon) and Gondola (yellow polygon) survey areas. The magenta rectangle delineates the area shown in Figure 7.

2 Methods

2.1.1 Source modelling

The airgun array proposed for this survey is the Polarcus 4240 cui array shown in Figure 2, which is to be operated at a depth of 8.5 m.

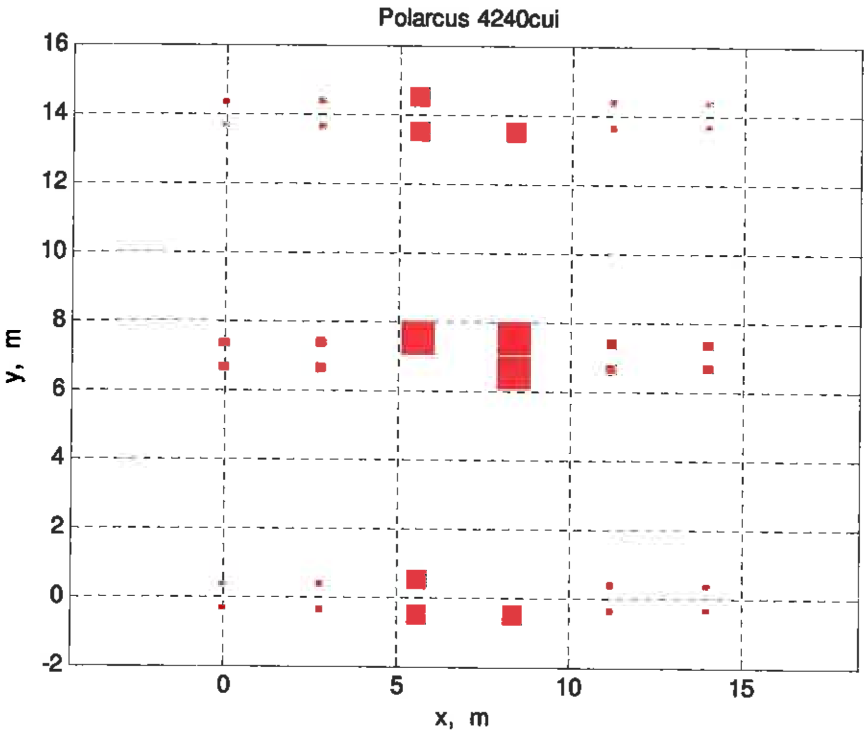


Figure 2. Plan view of the Polarcus 4240 cui array. Array elements are shown much larger than actual size but their linear dimensions are scaled proportional to the cube root of their volume. Inline direction is to the left.

2.1.2 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 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.

2.1.3 Source modelling results

Figure 5 shows comparisons between the example waveforms and spectra 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.

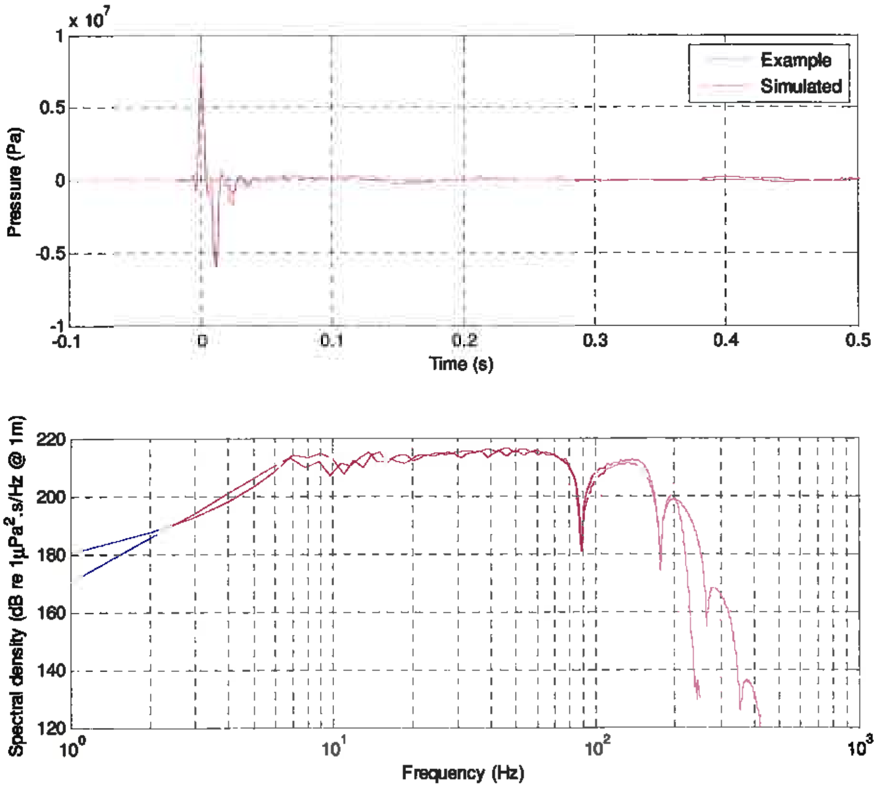


Figure 3. Comparison between the waveforms (top) and spectra (bottom) for the Polarcus 4240 cui array. The example signal for the vertically downward direction provided by the client (blue) and the signal produced by CMST's airgun array model (red).

Vertical and horizontal cross-sections through the frequency dependent beam pattern of the array are shown in Figure 7. These beam patterns demonstrate the strong angle and frequency dependence of the radiation from airgun arrays. The horizontal beam pattern shows that in the horizontal plane a large amount of the high frequency energy is radiated in the cross-line direction, particularly in the 150 Hz to 250 Hz frequency band. There is also a maximum in the in-line direction for frequencies below 100 Hz.

An initial indication of the sound levels produced by this seismic source was obtained by computing the free-field sound exposure level that would be produced by the source in the absence of seabed reflections or refraction caused by vertical variations in sound speed. (Sea surface reflections were included.) The results are shown in Figure 5 and indicate that in these conditions the sound levels produced by the array would be below 186 dB re

1 μPa^2.s at a range of 200 m from the source, and below 171 dB re 1 μPa^2.s at a range of 1 km.

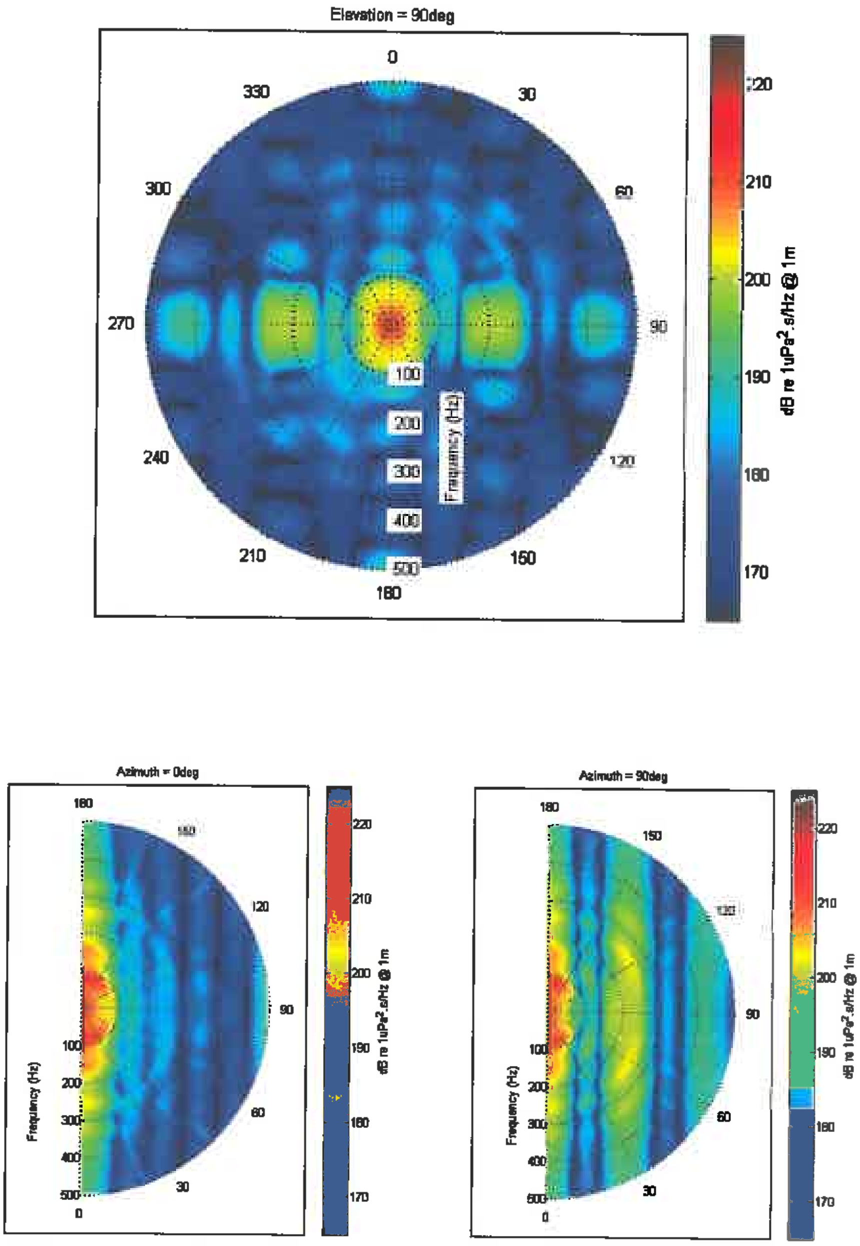
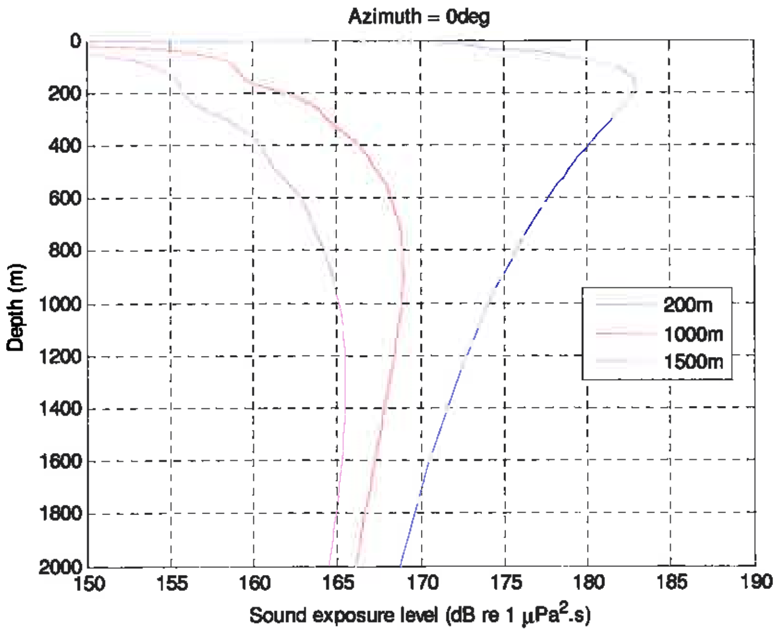


Figure 4. Array far-field beam patterns as a function of orientation and frequency. The top plot is for the horizontal plane with 0 degrees azimuth corresponding to the in-line direction. The bottom two plots are for the vertical plane for the in-line direction (left) and cross-line direction (right). Zero elevation angle corresponds to vertically downwards.



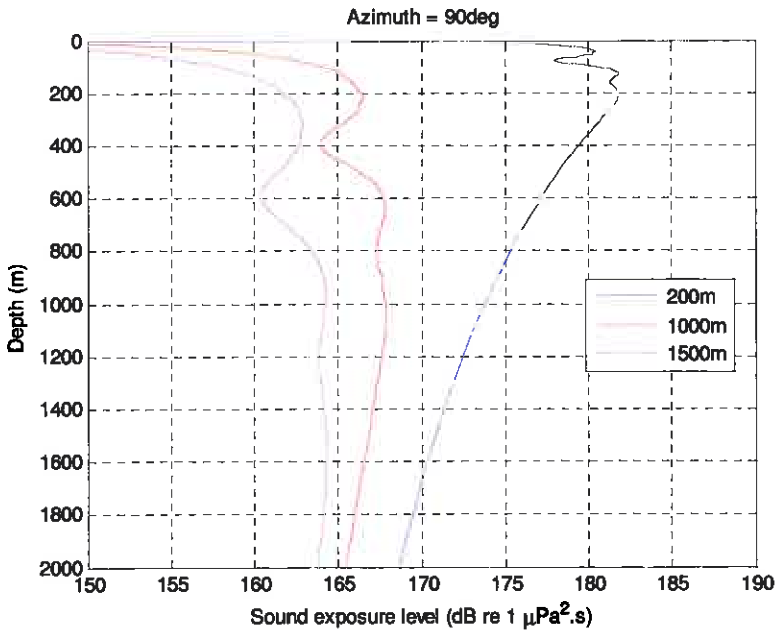


Figure 5. Plots of free-field sound exposure level vs depth for horizontal ranges shown in the legend. Top plot is for the in-line direction, bottom plot is for the cross-line direction.

2.1.4 Propagation modelling

2.1.4.1 Water-column properties

The water column sound speed profile used for modelling was the January to March profile from the nearest grid point of the World Ocean Atlas (Locarnini et. al., 2006), which is plotted in Figure 6.

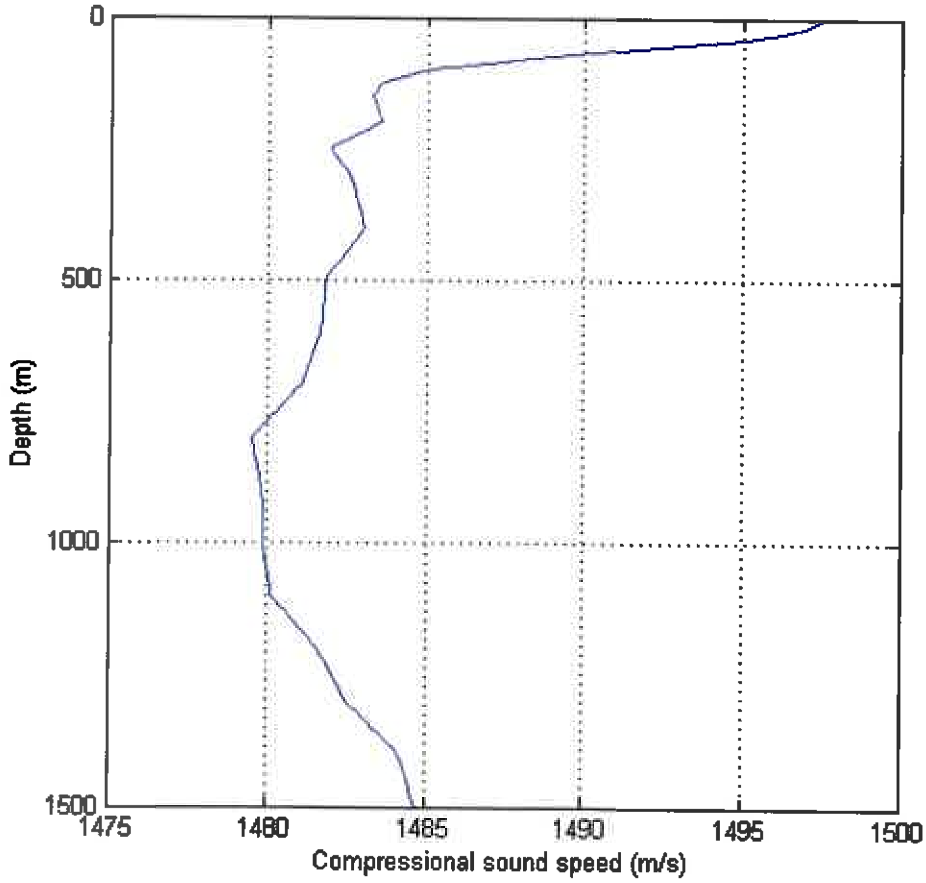


Figure 6. Sound velocity profile used for modelling. Locarnini et. al. (2006), January to March.

2.1.4.2 Geoacoustic models & bathymetry

The two survey areas are close together, in very similar water depths and are in geologically similar settings at the transition between the Canterbury Terrace and the Bounty Trough (Figure 7).

The sedimentology of this area has been reasonably well studied (Carter, 1975; Davey, 1977; Herzer, 1977; Carter et. al. 1994, ODP, 1999; and Lu et. al. 2005) and is known to consist of thick layers of sandy silt / silty clay on the slope, grading to fine silt/hemipelagic clay in the Bounty Trough. It is unclear where in this continuum the shallowest locations in the survey areas would lie, both of which are close to the 1000 m contour. Consequently, the sandy silt / silty clay seabed was chosen for modelling as it represents the most acoustically reflective seabed likely to be encountered at these locations.

The resulting seabed geoacoustic properties, obtained from Hamilton (1980) and Jensen (2011), are given in Table 1. The upper layer includes a compressional wave speed and density that increases linearly with depth due to the greater compaction of the sediment that occurs at greater depth (Hamilton, 1979) and (Hamilton, 1976).

Table 1: Seabed geoacoustic Properties used for modelling

Layer Sediment Description	Thickness (m)	ρ ($kg.m^{-3}$)	c_p ($m.s^{-1}$)	α_p (dB/λ)
R1: Taranaki - Northland Continental Shelf [Fine Sand]				
Sandy silt / Silty clay Layer	400	1629 2094	1573 2064	0.4
Sandy silt / Silty clay Layer Half Space	N/A	2094	2064	0.4

Symbol key for Table 1:
ρ = density, c_p = compressional wave speed, α_p = compressional wave attenuation, λ = wavelength

2.1.4.3 Transmission loss modelling code

The short ranges involved in the 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 fluid and/or solid seabed layering. It cannot, however, deal with changes of water depth with range, and is therefore considered a range independent model.

2.1.4.4 Source Locations

The intention was to model a seismic source at the shallowest point within the two survey areas so as to maximise contributions from seabed reflections.

As can be seen in Figure 7, the shallowest depth within each of the two survey areas is close to 1000 m. Bottom types at these two locations are expected to be similar and so the decision as to which to use was somewhat arbitrary. At 997.5 m, the shallowest point within the Gondola survey area is slightly shallower than the shallowest point within the Wherry survey area (1004m), and so was chosen as the source location to be modelled. This point is labelled S1 in the figure.

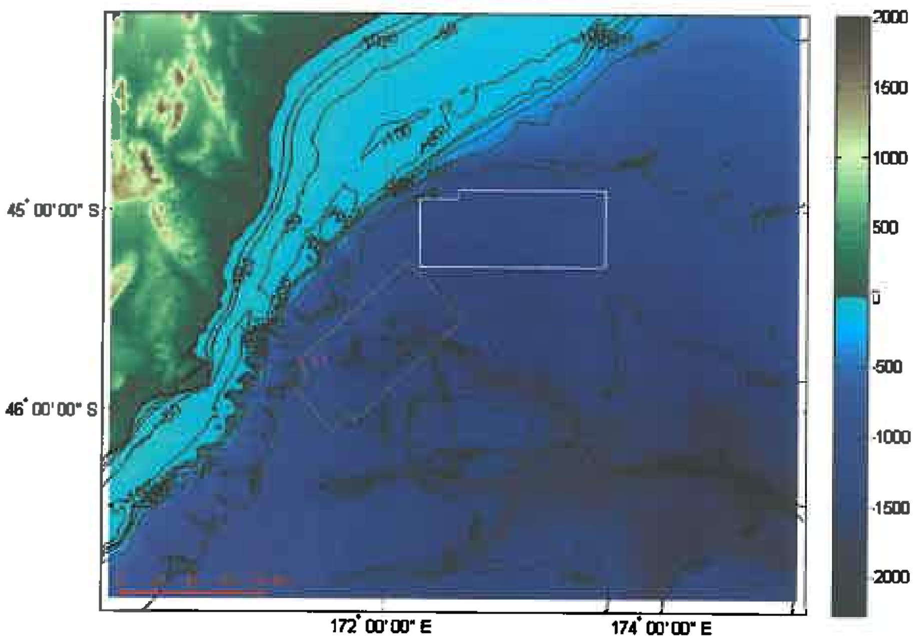


Figure 7. Map showing the bathymetry in the vicinity of the Wherry (white polygon) and Gondola (yellow polygon) survey areas. S1 is the source location chosen for short range modelling.

2.1.5 Sound exposure level (SEL) calculations

At short ranges it is important to include both the horizontal and vertical directionalities of the seismic source, which requires summing the signals from the individual array elements 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 1 Hz frequency steps from 1 Hz to 1000 Hz for a source depth corresponding to the depth of the seismic source (8.5 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 array element 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 - array element combination.
    b. These transfer functions were inverse Fourier transformed to produce the corresponding impulse response, which was then convolved with the signal from the array element to give a received signal due to that element.
    c. The received signals from all elements in the array were summed to produce a received pressure signal.

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

3 Results

3.1.1 Short Range Modelling Results

Maximum received sound exposure levels at any depth are plotted as a function of range and azimuth from the source in Figure 8. The directionality of received levels in the horizontal plane is due to the directionality of the array, which produces its highest levels in the cross-line and in-line directions.

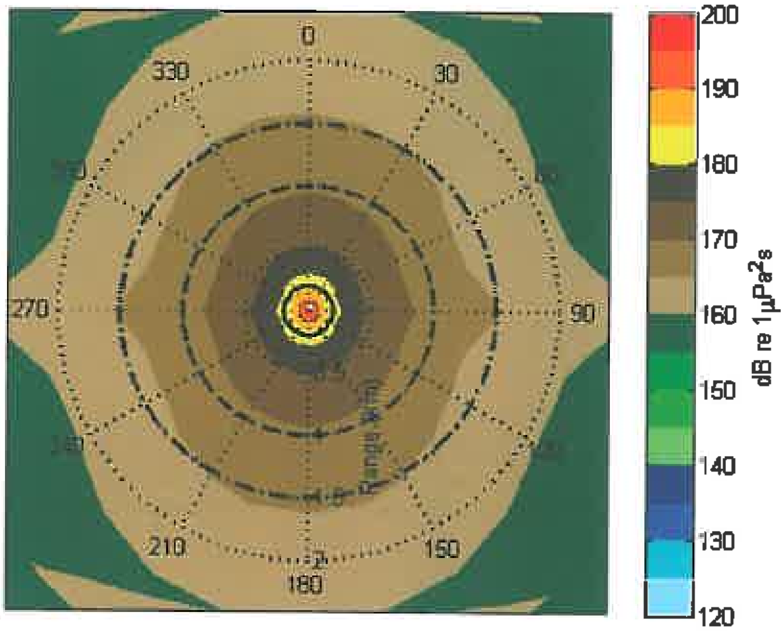


Figure 8. Predicted maximum received SEL at any depth as a function of azimuth and range from the source. An azimuth of 0° (up) corresponds to the in-line direction. The thick black circle corresponds to mitigation ranges of 200m (solid), 1km (dash), and 1.5km (dash-dot).

Figure 9 plots the maximum sound exposure level at any depth as a function of range, and includes data from all azimuths.

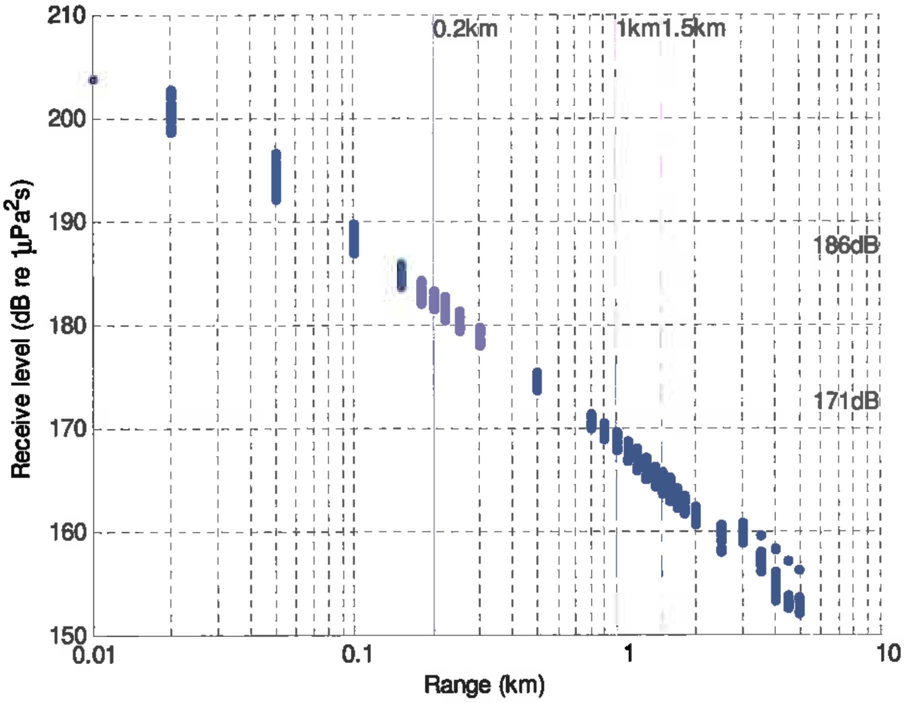


Figure 9. Scatter plot of maximum SEL at any depth as a function of range, plotted for all azimuths. Vertical magenta lines show mitigation ranges of 200m (solid), 1km (broken), and 1.5km (dash-dot). Horizontal green lines show mitigation thresholds of 171 dB re 1 $\mu Pa^2.s$ (solid) and 186 re 1 $\mu Pa^2.s$ (broken).

The maximum predicted sound exposure levels at the mitigation ranges specified in the DOC code of conduct are listed in Table 2, and Table 3 lists the ranges at which the sound exposure levels are predicted to drop below the DOC thresholds. It can be seen that all received sound exposure levels are predicted to be below 186 dB re 1 $\mu Pa^2.s$ at a range of 200 m, and below 171 dB re 1 $\mu Pa^2.s$ at a range of 1 km.

By way of comparison, these tables also include corresponding values computed using the free-field response of the array, i.e. assuming a constant water column sound speed and ignoring the contribution of reflections from the seabed (see Figure 5). These results show that bottom reflections and refraction only result in an increase of about 0.5 dB in the received sound exposure levels, and that this slight increase adds 9 m to the range at which received sound exposure levels drop below 186 dB re 1 $\mu Pa^2.s$, and 107 m to the range at which they drop below 171 dB re 1 $\mu Pa^2.s$.

Table 2. Maximum sound exposure levels as a function of range from the source.

Range	Maximum Sound Exposure Level (dB re 1 µPa².s)	
	Modelled for a source at S1	Array free-field response (0° azimuth)
200 m	183.3	182.9
1.0 km	169.5	169.0
1.5 km	165.7	165.5

Table 3. Ranges at which SEL is predicted to drop below thresholds.

	Range beyond which SEL< 186 dB re 1 µPa².s	Range beyond which SEL< 171 dB re 1 µPa².s
Modelled for a source at S1 (Water depth = 997.5 m)	150 m	900 m
Array free-field response	141 m	793 m

4 Conclusions

The similarity in location, seabed geology and water depth, made it feasible to model the worst-case sound exposure levels in both the Wherry and Gondola survey areas using a single source location. The modelling results predicted that the maximum sound exposure levels produced by the seismic source would be 183.3 dB re 1 µPa².s at a range of 200 m, and 169.5 dB re 1 µPa².s at a range of 1.0 km, and that the surveys would therefore meet the requirements of the New Zealand Department of Conservation 2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations.

A comparison with free-field results indicated that the combination of 1000 m deep water and a soft, low reflectivity seabed, would result in the seabed reflections and refraction contributing only about 0.5 dB to the received levels.

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Annex D

Marine Mammals Potentially Observed In The Area Of Influence

D.1 HUMPBACK WHALE

The humpback whale (*Megaptera novaeangliae*) is a species of baleen whale (*Figure D.1*). 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 D.1 **Humpback Whale**
Source: http://www.redorbit.com/news/science/1112686986/humpback-whale-population-090412/

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, no date; *Figure D.2*). 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 *et al.*, 2006). The migration north of Group V is not well understood, although tagging, whale fluke identification 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.*, 2006).

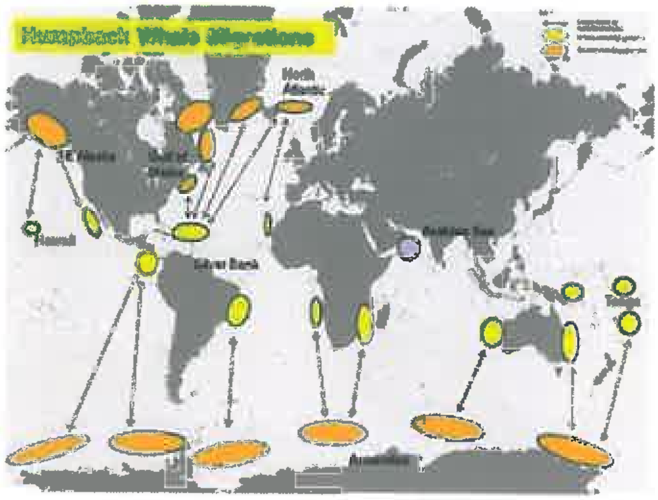

Figure D.2 ***Annual Migration of Humpback Whales***
Source: www.hwrf-uk.org/About-humpback-whales.html

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 D.3*). Both the northern and southern migrations follow the same pattern of a gradual increase in the numbers of whales passing through New Zealand 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). DOC sighting records exist for the humpback whale within and nearby the AOI. 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 International Union for Conservation of Nature (IUCN) status of *Endangered* to *Least Concern* today (Reilly *et al.*, 2008a).

Figure D.3 ***Humpback Whale Migration through New Zealand Waters and Approximate Locations of Sperm, Bryde's and Southern Right Whales***
Source: www.teara.govt.nz/en/whales/1/1

D.2 SEI WHALE

Sei whales (*Balaenoptera borealis*) are baleen whales of which two subspecies are recognized. In the northern hemisphere exists the subspecies *B. b. borealis* while in the southern hemisphere exist the subspecies *B. b. schlegellii* (Reilly *et al.*, 2008b; *Figure D.4*). Living between 50-70 years, sei whales filter feed, consuming copepods, krill, squid and small schooling fish (NOAA, 2012a).

Figure D.4 ***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 in New Zealand for baleen whales such as the sei whale 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). Sei whales may pass near the AOI during these migrations between feeding and breeding grounds.

Due to a significant population reduction (up to 80%), the IUCN Red List (IUCN, 2013) 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 to 1979 period (Reilly *et al.*, 2008b).

D.3 *MINKE WHALE*

Globally, there are now two recognized species of minke whale being the common minke whale (*Balaenoptera acutorostrata*) and the Antarctic minke whale (*Balaenoptera bonaerensis; Figure D.5*). 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, 2012b).

Figure D.5 ***Minke Whale***
Source: http://blog.diversiondivetravel.com.au Photographer: Rod Klein

Favoring temperate to boreal waters, the minke whale is most commonly found throughout the higher latitude oceans of the northern and southern hemispheres. The minke whale is a migratory species, however the migrations vary with age, reproductive status and sex. Mature males and females will migrate to polar waters for the summer feeding season, however the females will typically remain within coastal waters, while the males are typically found around the ice edge (NOAA, 2012b). The migratory patterns of minke whales, however, are poorly known (Reilly, 2008c). In the southern hemisphere minke whales 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 to 30°S in the central South Pacific and in much of the eastern and southern Indian Ocean down to 50°S (Miyashita *et al.*, 1996). Due to this broad distribution, while no DOC sighting records exist for the minke whale within and nearby the AOI, 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.

D.4 DWARF MINKE WHALES

Dwarf minke whales (*Balaenoptera acutorostrata; Figure D.6*) 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, 2008d). Dwarf minke whales prefer the more temperate waters and are seen off the New Zealand coast in and north of the Bay of Plenty (MPI, 2013). This species is found in both coastal and offshore waters, with breeding known to occur in New Zealand (MPI, 2013). There is the potential for dwarf minke whales to occur within the AOI. No DOC sighting records exist for the dwarf minke whales within and nearby the AOI. However, the species is known to occur around the North Island and Antarctic waters (MPI, 2013; Reilly, 2008d) and therefore their occurrence is possible and they have been included in this MMIA.

Figure D.6 ***Dwarf Minke Whale***
Source: http://www.uw3some.com/forum/viewtopic.php?f=16&t=100

D.5 BLUE WHALES

The blue whale (*Balaenoptera musculus*), is likely to be the largest animal to ever inhabit planet earth (Croll *et al.*, 2005; *Figure D.7*). Like the humpback whale, the blue whale is part of the baleen suborder, and has four recognized 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.*, 2008e).

Pygmy blue whales (*B. m. brevicauda*) are listed as migrants within New Zealand waters, 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). There are a small number of records of these whales within Cook Strait (Museum of New Zealand, 1998). A beached pygmy blue whale was found at Motutapu Island, off the North Island, in 1994.

Figure D.7 **Blue Whale**
Source: www.bbc.co.uk/nature/life/Blue_Whale

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.*, 2008e). While considered a migratory species, the migratory patterns of this species are not well understood (Reilly *et al.*, 2008e). However they are considered to be diverse with some remaining residents 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. A foraging population of pygmy and possibly Antarctic blue whales is thought to exist off the Taranaki coast, possibly a result of transient aggregations of zooplankton in the area (Torres, 2013).

The IUCN Red List notes blue whales as *Endangered*, verging on *Critically Endangered* (Reilly *et al.*, 2008e). 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% to 11% of the estimated 1911 population (Reilly *et al.*, 2008e). 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).

D.6 FIN WHALE

Fin whales (*Balaenoptera physalus; Figure D.8*) are baleen whales of which two subspecies are recognized. 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 D.8 **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 to 60°S in the southern Indian and South Atlantic oceans, and 50° to 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).

D.7 *SOUTHERN RIGHT WHALE*

The southern right whale (*Eubalaena australis*) is one of three baleen whale species classified as right whales (*Figure D.9*). This species has a circumpolar distribution typically between 20°S and 55°S (DOC, 2013). Migrating seasonally between higher latitudes and mid-latitudes the major calving grounds of the southern right whale is in near-shore waters (DOC, 2013). The female of this species is typically sexually active around eight years of age, generally calving every three years (DOC, 2013). 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, 2012c). Historical whaling records suggest summer feeding grounds off the Chatham Rise off the South Island, 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 harbors of both Auckland Islands and Campbell Island (Baker *et al.*, 2009).

Figure D.9 ***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, 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 1920s 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).

D.8 **PYGMY RIGHT WHALE**

The pygmy right whale (*Caperea marginate; Figure D.10*) 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. The analysis of the stomach contents of three pygmy right whales revealed that this species mainly feeds on cephalopods (Ivashin, 1972; Sekiguchi *et al.*, 1992).

Figure D.10 ***Pygmy Right Whale***
Source: http://www.marinespecies.org/photogallery.php?pic=22022

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. There are no DOC sighting records for this species within the region of the Project, however as their occurrence is possible, they have been included in this MMIA.

This species is listed as *Data Deficient* under both the IUCN Red List and the New Zealand Threat Classification System lists 2008-2011 (hereafter, the '**DOC Listing**' (DOC, 2007)).

D.9 **PILOT WHALE**

Two species of pilot whales occur in New Zealand waters being the long-finned pilot whale (*Globicephala melas; Figure D.11*) and the short-finned pilot whale (*Globicephala macrorhynchus;*). There are physical differences between the species, however 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 & Reilly, 1999).

Figure D.11 ***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, however, generally speaking, the long finned species prefers the cooler waters of the south (thus more likely in the AOI), while the short finned species prefers the warmer waters of the north (thus less likely in the AOI) (see *Figure D.12* and *Figure D.13*).

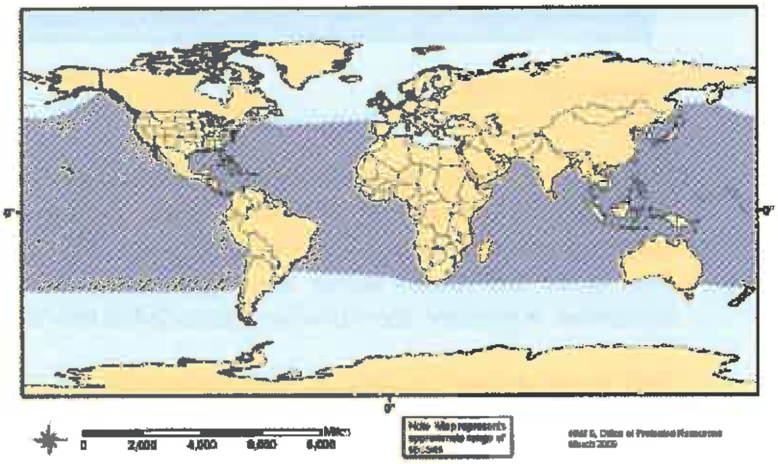

Figure D.12 ***Global Distribution of the Short-Finned Pilot Whale***
Source: http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/pilotwhale_shortfinned.htm

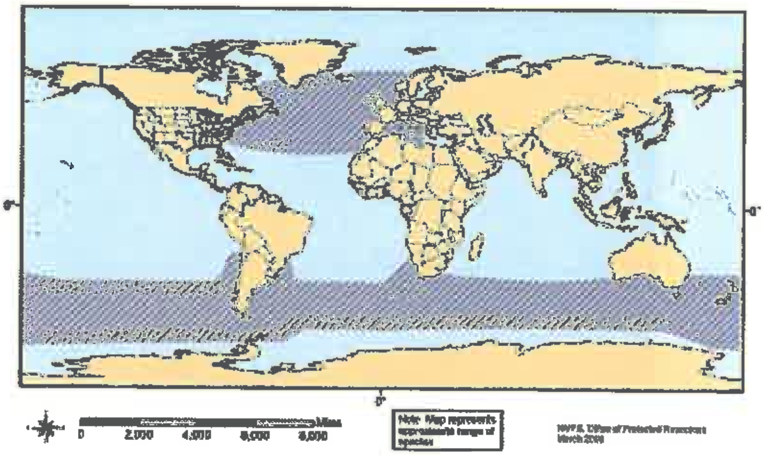

Figure D.13 ***Global Distribution of the Long-Finned Pilot Whale***
Source: http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/pilotwhale_longfinned.htm

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). There is DOC sighting records for the pilot whale within and nearby the AOI, as well as off the east and west coasts of the North Island. Pilot whales were identified during both of the seismic surveys for which data is available (Origin Energy, 2007; OMV, 2011).

D.10 SPERM WHALE

The sperm whale (*Physeter macrocephalus*) is a species of the toothed whale (Odontoceti) (*Figure D.14*). This species targets larger prey than the baleen whales, occurring in deep waters due to its capability to dive to depths of over 1,000 m, for up to 60 minutes at a time and preying upon large squid, sharks, skates and fishes (NOAA, 2012e).

Figure D.14 ***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, 2012e). Within the region of Australasia, the sperm whale is distributed mainly off the coast of Kaikoura (Larivière, 2001), east coast South Island, as well as northeast off the top of the North Island (*Figure D.3*). 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, 2012e). 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 localized 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).

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

D.11 PYGMY SPERM WHALE

The pygmy sperm whale (*Kogia breviceps; Figure D.15*) 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). 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 (McAlpine, 2002). Within New Zealand, East Coast/Hawke Bay is a key area for this species, where stranding events are quite common. There are few DOC sighting records for this species within the North Island, however as their occurrence is possible they have been included in this MMIA.

This species is listed as *Data Deficient* under both the IUCN Red List and in the DOC Listing.

***Figure D.15* Pygmy Sperm Whale**
Source: http://cetaceans.tumblr.com/page/4

D.12 BEAKED WHALES

There are twenty six species of beaked whale, with at least twelve of these known or thought to occur in New Zealand waters (Hutching, 2012b). These include:

- Gray's beaked whale;
- Arnoux's beaked whale;
- Cuvier's beaked whale (*Figure D.16*);
- Strap-toothed whale;

- Southern bottlenose whale;
- Andrew's beaked whale;
- True's beaked whale;
- Blainville's beaked whale;
- Ginkgo-toothed whale;
- Hector's beaked whale;
- Pygmy/peruvian beaked whale; and
- Shepherd's beaked whale.

Beaked whales in general are elusive 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 (Hutching, 2012b). Beaked whales are renowned for their deep-diving ability, with their diet presumed to consist largely of deep-water squid and fish species (MPI, 2013). Most sightings and strandings of species in the genus *Mesoplodon* have been reported east and south of the South Island, with a potential hotspot between the South and Chatham Islands (MPI, 2013). Beaked whales in New Zealand (11 species in 2 families) are listed as *Data Deficient* in both the DOC Listing and IUCN Red List except for the southern bottlenose whale and the Arnoux's beaked whale which are listed as *Lower Risk-Conservation Dependent* under the IUCN.

Figure D.16 ***Cuvier's Beaked Whale***
Source: www.cascadiaresearch.org

D.13 ORCA

The orca (*Orcinus orca*), also known as the killer whale, is the largest of the dolphin family (*Figure D.17*). 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 salmon, tuna, herring, cod), seals, sharks, stingrays, squid, octopus, sea birds and sea turtles (DOC, 2012a). Female orca first reproduce between the age of approximately 11 and 16, and continue to reproduce around every five years for the remainder of their ~25 year reproductive lifespan (DOC, 2012a). 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, 2012a).

Figure D.17 **Orca**

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

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). Scattered DOC sighting records exist for this species all around the North Island, with one historic record (1999) being within the AOI, and another record approximately 60km to the north of the AOI.

D.14 *FALSE KILLER WHALE*

False killer whales (*Pseudorca crassidens; Figure D.18)* are found in tropical and warm temperate zones, generally in in deep offshore waters of all major oceans (Taylor *et al.*, 2008b) in latitudes below 50°S. This species is known to occur throughout New Zealand waters (Taylor *et al.*, 2008b). 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.*, 2008b).

Figure D.18 ***False Killer Whale***
Source: http://www.arkive.org/false-killer-whale/pseudorca-crassidens/image-G35219.html

False killer whales are listed as *Data Deficient* under the IUCN red list b and as *Not Threatened* by DOC. DOC sighting records exist for this species in the Bay of Islands and off the northeast of the North Island. A mass stranding of false killer whales was recorded within the Dunedin region. No records exist for the false killer whale within the AOI, however as their occurrence is possible, they have been included in this MMIA.

D.15 *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 has been recorded to date off the South Island as well as in two instances recorded off the west coast of the North Island (Hamner *et al.*, 2012). Sightings of the Hector's dolphin have also been made in the Wellington Harbour, Hawkes Bay and the Bay of Plenty (DOC, *pers. comm.*).

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 (Baker *et al.* 2002). Differences over such a small geographic scale have not been observed in any other marine mammal (Dawson *et al.*, 2001). The current Hector's dolphin abundance in the east and north coasts of the South Island have been estimated at around 9,130 in summer and 7,456 in winter individuals (MacKenzie & Clement, 2014). A study of the south coast South Island population of Hector's dolphin estimated the numbers in this region to be 628 dolphins (Clement *et al.*, 2011), whilst the west coast population is estimated at around 5,000 individuals (DOC, *pers. comm.*).

Figure D.19 ***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, although sightings by MacKenzie & Clement (2014) of Hector's dolphins at the survey limit of 20 nm offshore implies that their true offshore distribution is not completely understood and they could have the potential to range further offshore. This species feeds on small fish and squid (Dawson, 2002). Hector's dolphins are listed as *Endangered* under the IUCN Red List and as *Nationally Endangered* in the DOC Listing.

D.16 MAUI'S DOLPHIN

Maui's dolphin (*Cephalorhynchus hectori maui)* are the world's smallest and New Zealand's rarest dolphins, they are listed by the IUCN as *Critically Endangered*. Approximately several thousand years ago a small group of Hector's dolphins are thought to have separated from the original population located in the South Island, travelling through the Cook Strait, and forming a sub-species (Ferreira & Roberts, 2003). The Maui dolphins are only found on the west coast of the north island, predominantly between Maunganui Bluff to Whanganui (Currey *et al.*; *Figure D.20*).

The geographical barrier may have affected the population size which Hanmer *et al.* (2012) notes as being between 48 and 69 individuals. Maui's dolphins are generally found close to shore in groups or pods of several dolphins (DOC, no date). They are often seen in water less than 20 meters deep but may also range further offshore. Both the Hectors and Maui's dolphins are fully protected by New Zealand law, however incidental 'takings' during commercial fishing operations is legally permissible as long as these are reported to the correct authorities (Wheen, 2012).

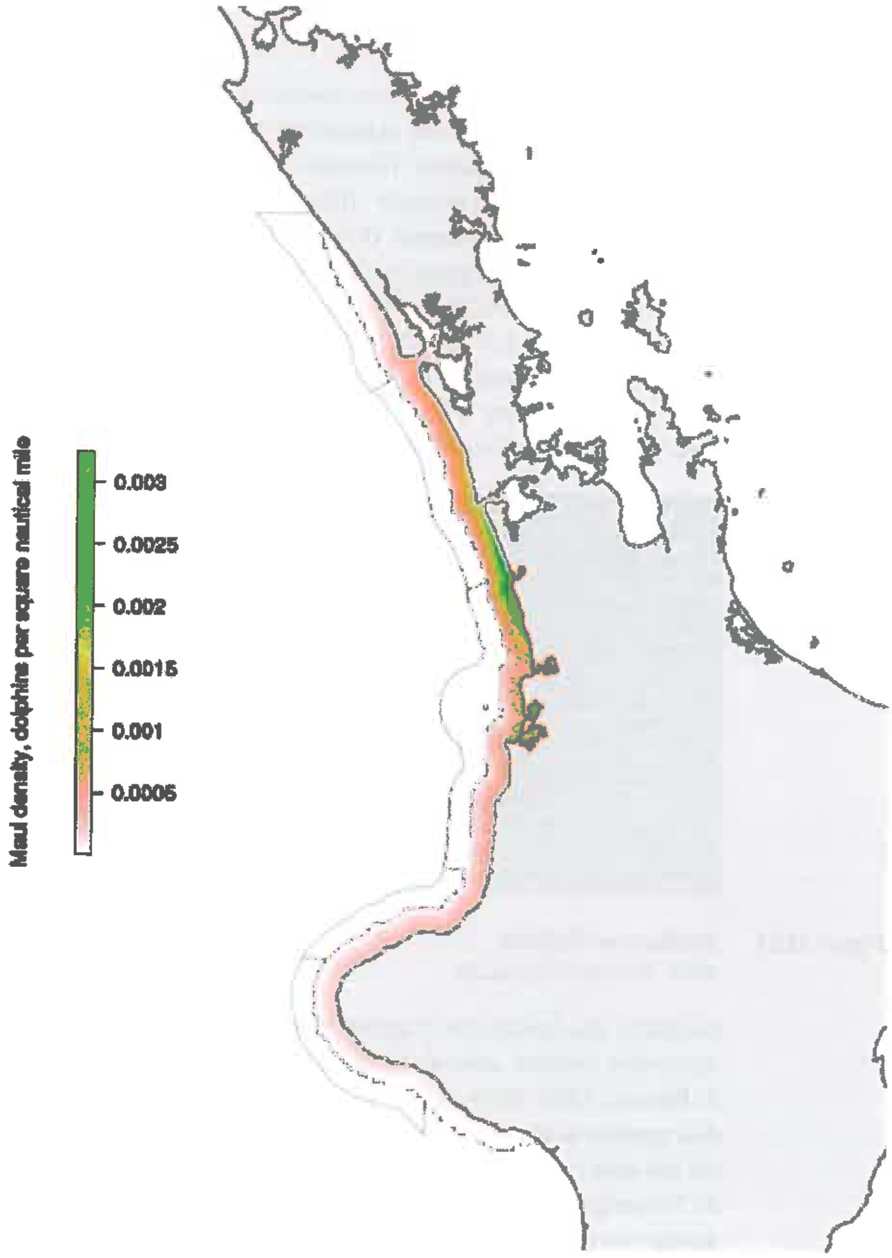

Figure D.20 Distribution of the Maui's Dolphin.

Source: Currey et al., 2012

D.17 BOTTLENOSE DOLPHIN

The bottlenose dolphin (*Tursiops truncatus*), one of the most widely recognized 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.*, 2012a; NOAA, 2012f; *Figure D.21*). 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.*, 2002). 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 D.21 **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 D.22*; Leatherwood & 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. DOC sighting data shows records of this species off the east coast of the North Island, as well as some records off the tip of the North Island and at least one record off the west coast in the North Taranaki Bight.

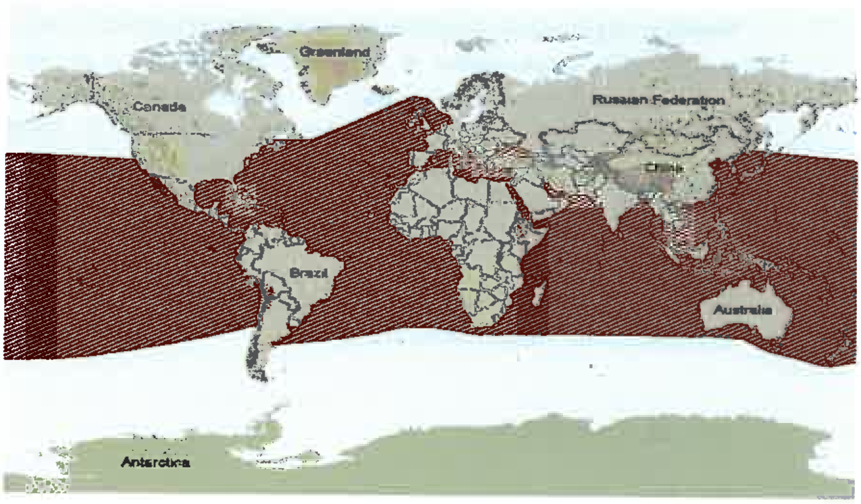

Figure D.22 ***Global Distribution of Bottlenose Dolphins***
Source: IUCN Red List

The IUCN Red List classifies this species as *Least Concern* due to their global estimated minimum population of 600,000 (Hammond *et al.*, 2012a), although the Fiordland sub-population is listed as *Critically Endangered* (Currey *et al.*, 2013).

D.18 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 750 km from the AOI) (Stanley & Podzikowski, 2013).

Figure D.23 ***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 (Hammond *et al.*, 2012b), with only occasional sightings in near shore environments (Jefferson *et al.*, 1994). This species feeds primarily on squid and fish (Jefferson *et al.*, 1994). This species was not sighted within the region of the AOI 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 and as *Not Threatened* by DOC.

D.19 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 New Zealand waters (*Figure D.24*; Baird, 2011). The New Zealand fur seal is 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. This species forages on a diverse range of sea animals including squid, octopus and several small fish species and are known to forage along shelf breaks at sea (Boren, 2010). Adult males arrive at breeding colonies first from late October, followed by females in late November. Pups are born around January and weaned in July/August when the females return to sea.

Figure D.24 ***New Zealand Fur Seal***
Source: www.scuba-equipment-usa.com

Sexually maturity of this species is reached around 4 to 6 years for females and 5 to 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). They return to the same breeding colony each year to give birth to pups between mid-November and January (DOC, 2012d; MPI, 2014). These pups are weaned in July/August when the females return to sea (DOC, 2012d; MPI 2013). Breeding areas predominantly occur on the coast of the South Island, but a small number of breeding areas are known from the North Island, such as Cape Palliser and Glenburn (MPI, 2014). Adult males arrive at breeding colonies first from late October, followed by females in late November.

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 IUCN Red List 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). 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).

D.20 *NEW ZEALAND SEA LION*

New Zealand sea lions (*Phocarctos hookeri*), also known as whakahao (male) or kaki (female) (*Māori* names) 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 (within the Great South Basin area) as a hotspot for these species, with breeding populations occurring along the Otago coast and on Auckland and Campbell Islands (DOC, 2012e).

Figure D.25 ***New Zealand Sea Lion***
Source: www.biopix.com

Female New Zealand sea lions can travel up to 175 km from the coast to feed, diving to depth of up to 700 m although most dives are only up to 200 m in depth (DOC, 2012e). This species was not sighted within the region of the Project during each of the MSS 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, 2012e). The New Zealand sea lion is listed as *Nationally Critical* under the DOC Listing and as *Vulnerable* under the IUCN Red List.

D.21 SOUTHERN ELEPHANT SEAL

The southern elephant seal (*Mirounga leonine*), also known as ihupuku or ihu koropuka (*Māori* name), is a member of the Phocidae family. Southern elephant seals range throughout the Southern Ocean around the Antarctic continent and on most sub-Antarctic islands (DOC, 2012f). 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, 2012f).

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 D.26 ***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 (Campagna *et al.*, 2007).

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 the DOC Listing and of *Least Concern* under the IUCN Red List.

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