Marine Mammal Impact Assessment

2016 Scientific Geophysical and Geological Survey

Chatham Rise (New Zealand): Gondwana Breakup and Chatham Rise Structure

Alfred Wegener Institute for Polar Research (Germany) and GNS Sciences (New Zealand)

Gardline Project Ref. 10670

Marine Mammal Impact Assessment Document

Prepared For

Project

2016 Scientific Geophysical and Geological Survey
Chatham Rise (New Zealand): Gondwana Breakup and Chatham Rise Structure

Date

12th January 2016

Published by

Gardline Environmental (New Zealand) Ltd
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Non-Technical Summary

The Alfred Wegener Institute Helmholtz-Centre for Polar and Marine Research (AWI) in collaboration with the Helmholtz-Centre for Ocean Research (GEOMAR), both in Germany will be conducting a geophysical and geological survey as part of a scientific research project. GNS Science from New Zealand has been invited to participate in the voyage and two scientists plus a Victoria University Masters student will join the voyage. The project will focus on the southeast Chatham Rise - the region of initial breakup, in the New Zealand region, of the long-lived (300 to 100 million years ago) Gondwana supercontinent. The aim of the survey is to improve understanding of the processes controlling the disassembly of a supercontinent, in particular Gondwana, the structure of the Chatham Rise, as well as the nature of the continental-ocean transitional crust to the southeast of the Chatham Rise. The findings will contribute to understanding of the development of submarine continental plateaus and fill in the knowledge gaps of the changes from subduction and convergence to extension of continental crust resulting in rifting and the generation of oceanic basins within a short geological epoch.

It is anticipated that the whole survey will take place between 1st February and 22nd March 2016 lasting 51 days in total. The survey programme includes seismic surveying, gravity/magnetic surveying, geothermal heat-flow measurements and hard rock dredging. The seismic data acquisition will occupy on 16 out of 51 days of survey time although this will be spread over a greater number of days and will cover seismic profiles of 1,920 nm in total. The survey will be conducted using the research vessel *R.V. Sonne* which is owned and operated by the Federal Ministry of Education and Research (BMBF), Germany.

In order to acquire seabed data, the seismic survey will utilise two airgun arrays with an operational capacity of 600 and 4,160 cu in. The Department of Conservation (DOC) released the *'2013 Code of Conduct for minimising acoustic disturbance to marine mammals from seismic survey operations'* (hereafter "the 2013 Code") which defines three levels of seismic surveys based on a clear demarcation of the acoustic source capacity. Based on that classification, the seismic activity associated with the proposed survey has been classified as "Level 1". Seismic surveys undertaken from a foreign research vessel are exempt from the regulatory requirements of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act (the EEZ Act) and consequently mandatory provisions of the 2013 Code, however AWI, with GNS Science's assistance, wishes to voluntarily adopt provisions of the 2013 Code in order to protect marine mammals in the survey area. Therefore, as per the 2013 Code, a Marine Mammal Impact Assessment (MMIA) has been conducted prior to commencement of the survey.

A MMIA is the process of identifying, quantifying and evaluating the potential impacts of a defined activity (seismic survey), on marine mammals and determining how these will be appropriately managed. The methodology used to evaluate the potential ecological effects includes the following components:

- identify the ecological features that could potentially be affected;
- determine the sensitivity of relevant ecological features;
- identify mitigation inbuilt within the survey;
- initially assess impacts affecting each species;
- from the initial assessment: identify any mitigation, compensation or enhancement that should be incorporated into the survey;

- assess potential residual effects following the incorporation of mitigation, compensation and enhancement; and

- after all mitigation efforts, identify any residual likely significant impacts on marine mammals.

Part of the assessment is consultation with communities considered to be able to make a useful contribution to the technical assessment, or which may have views on the project or its potential impacts on marine mammals.

The impact assessment is based on robust ecological impact assessment methods whereby each species is assigned a value (comprised of its *conservation status* and *abundance* within a defined Zone of Influence), with the magnitude of each potential effect also being determined (based on the *severity of the effect* and the *proportion of the population potentially affected*). The assessment results in determination of the significance of each effect on each species. The results of this are used to determine if any unacceptable effects are likely and/or if further mitigation is required. The assessment includes consideration of both in-combination and cumulative effects from other projects/developments/surveys where synergistic effects could occur.

As mentioned above, the first stage of the MMIA is to identify the species that could potentially be affected. The available literature shows that at least 25 species of marine mammals use the waters around the Chatham Rise as both a general feeding area and as a migratory corridor. The most common species seem to be sperm whales, long-finned pilot whales and killer whales. Overall, due to water depth and seabed topography, the presence of deep diving species such as beaked whale species is very likely. Encounters of oceanic dolphins are expected to be sporadic and patchy while the presence of baleen whales will mainly depend on their migration patterns.

The most significant potential impact from this seismic survey is considered to be the introduction of anthropogenic noise. This impact will be mitigated through a range of standard measures which will be adhered to during the entire duration of the survey, including:

- Two Marine Mammal Observers (MMOs) and two Passive Acoustic Monitoring (PAM) Operators as per the 2013 Code. They will be responsible for:

  - monitoring seismic activity and ensuring that operations are carried out in a safe manner for marine mammals in the area;

  - conducting pre-start observations before any seismic activity commences;

  - delaying the start of operations for marine mammals within their respective mitigation zones;

  - monitoring 'soft starts' during which the power of the acoustic array is gradually increased to allow animals to leave the area before operations reach full power;

  - requesting shut-downs of operations for marine mammals identified as Species of Concern (SoC) that come within specific distances of the acoustic source.

To further minimise any potential impacts, additional mitigation measures will be put in place for the duration of the survey, including:

- Two Qualified Marine Mammal Observers (MMOs) will be on watch during all pre-start observations during daylight hours and any other key times (health and safety permitting).

- To avoid any risk of collision with baleen whales during transit, at least one MMO is to be on watch during transits or at any times of increased vessel speed (i.e. above usual survey speed). If any baleen whales are sighted in the vicinity ahead of the vessel and if judged by the MMO that the animal/s is/are not responsive (i.e. during times of resting, feeding, socialising), the vessel's course will be altered to avoid collision with the animal/s.

- Immediate notification of the Director-General of DOC if SoC are encountered in unusually high numbers.
- Immediate notification of the Director-General of DOC if any SoC, identified as unlikely to be present in the survey area (especially baleen whales), is encountered during the survey.
- Extended mitigation zones to 2 km for southern right whales if there are more than two sightings within a 24-hour period. This will last for 24 hours after the second and any other consecutive sighting within that period.
- Compliance with the 2013 Code within the New Zealand Extended Continental Shelf (ECS)

However it should be noted that if, for whatever reason, the mitigation measures proposed by the MMIA become incompatible with the primary cruise objectives, e.g. both PAM systems failing (PAMS), then the cruise leader will discuss alternative mitigation measures with DOC which enables the survey to proceed and these measures will be implemented.

As part of this MMIA, sound transmission loss modelling has been conducted using industry standard software. The modelling results suggested that injury in marine mammals is only likely to occur within 8 m of the airgun array source, while behavioural disturbance is only likely to occur within 162 m and 55 m for cetaceans and pinnipeds respectively (based on peak noise criteria derived by Southall *et al.*, 2007). Moreover, the sound levels during the survey are predicted not to exceed 171 dB re 1 SEL at distances corresponding to the relevant mitigation zones for SoC (1.5 km and 1 km), nor will they exceed 186 dB re 1 SEL at a distance of 200 m. Therefore, present mitigation zone distances as detailed in the 2013 Code are deemed to be sufficient for this survey.

Overall, taking into account all the management measures in place as well as the relatively short duration of the seismic activity, the overall impact assessment of this survey is considered to be "minor" or "not significant" for all of the species identified.

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AEI	Area of Ecological Importance
AWI	Alfred Wegner Institute
BOEM	The Bureau of Ocean Energy Management (USA)
BSEE	The Bureau of Safety and Environmental Enforcement (USA)
cu in	Cubic inch
DOC	Department of Conservation
EcIA	Ecological Impact Assessment
EEZ	Exclusive Economic Zone
ECC	East Cape Current
ECS	Extended Continental Shelf
EIA	Environmental Impact Assessment
EPA	Environmental Protection Authority
GEL	Gardline Environmental Limited
GENZL	Gardline Environmental New Zealand Limited
GIS	Geographic Information Systems
GPS	Global Positioning System
HRS	High Resolution Seismic
Hz	Hertz
IAGC	International Association of Geophysical Contractors
IEMA	Institute of Environmental Management and Assessment
kHz	Kilohertz
IEEM	Institute of Ecology and Environmental Management
JNCC	Joint Nature Conservation Committee (UK)
km	Kilometres
m	Metres
MMIA	Marine Mammal Impact Assessment

MMO	Marine Mammal Observer
MMS	Marine Mammal Sanctuary
MWD	Marine Wildlife Department
NABIS	National Aquatic Biodiversity Information System
NGO	Non-governmental organisation
NPWS	National Parks and Wildlife Service
NZ	New Zealand
NZMEC	New Zealand Marine Environment Classification
nm	Nautical miles
OBS	Ocean-Bottom Seismometer
PAM(S)	Passive Acoustic Monitoring (System)
PoPA	Proportion of Population Affected
PPE	Personal Protective Equipment
Ppt	Parts per thousand
PSO	Protected Species Observer
PTS	Permanent Hearing Threshold Shift
RAM	Range Dependent Acoustic Model
RL	Received Level
SCP	Senior Contact Person
SEL	Sound Exposure Level
SoC	Species of Concern
SPL	Sound Pressure Level
SST	Sea Surface Temperature
STC	Subtropical Convergence
STW	Southland Current
TL	Transmission Loss
USA	United States of America
ZoI	Zone of Influence

1. Introduction

1.1 Background Information

Gardline Environmental (New Zealand) Limited (GENZL) has been contracted by the Alfred Wegener Institute Hemholtz Centre for Polar and Marine Research (AWI) and GNS Science to conduct a Marine Mammal Impact Assessment (MMIA) for a geophysical and geological survey planned in the Chatham Rise, New Zealand. The purpose of this assessment is to identify, quantify and evaluate the potential impacts of the survey on marine mammals potentially present within any Zone of Influence (ZoI) of the seismic survey. As per the requirements of the New Zealand Department of Conservation's (DOC's) '*2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals From Seismic Survey Operations*' (hereafter "the 2013 Code"), this document also includes a description of the existing environment with detailed descriptions of other marine megafauna i.e. seabirds, sea turtles and sharks.

The project will focus on the southeast Chatham Rise - the region of initial breakup, in the New Zealand region, of the long-lived (300 to 100 million years ago) Gondwana supercontinent. The aim of the survey is to improve understanding of the processes controlling the disassembly of a supercontinent, in particular Gondwana, the structure of the Chatham Rise, as well as the nature of the continental-ocean transitional crust to the southeast of the Chatham Rise. The finding will contribute to understanding of the development of submarine continental plateaus and fill in the knowledge gaps of the changes from subduction and convergence to extension of continental crusts resulting in rifting and the generation of oceanic basins within a short geological epoch. Ultimately there are several project goals including better understanding of the relationships between the collision/subduction of a large igneous province; the break-up mechanism of a super-continent; the magmatic processes in context with early rifting; and the paleoceanograophic implications of the continental break up. These goals will be achieved by conducting seismic reflection and seismic refraction profiling, gravity/magnetic surveying, multi-beam mapping, geothermal heat-flow measurements and hardrock dredging.

The survey programme includes surveying within an area located mainly east of Chatham Island. It is anticipated that the whole survey will take place between 1st February and 22nd March 2015 lasting 51 days in total. The seismic data acquisition will occur on approximately 16 out of 51 days of survey covering seismic profiles of 1,920 nm in total. The survey will be conducted using the research vessel *R.V. Sonne* which is owned and operated by Federal Ministry of Education and Research (BMBF), Germany.

1.2 Legislative Framework

1.2.1 The 2013 Code of Conduct

The New Zealand Marine Mammal Protection Act was introduced by the DOC in 1978 and is aimed at protecting, conserving and managing marine mammals in New Zealand waters. Under these obligations the "*2006 Guidelines for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations*" was introduced, with the intention of mitigating the impact of seismic sound in marine mammals. The original document was reviewed twice (2010 and 2012) and the outcome was the inception of the updated and amended "*2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations*".

The primary objectives of the 2013 Code are as follows:

- Minimise disturbance to marine mammals from seismic survey activities;
- Minimise noise in the marine environment arising from seismic survey activities;

- Contribute to the body of scientific knowledge on the physical and behavioural impacts of seismic surveys on marine mammals through improved, standardised observation and reporting;
- Enable seismic surveys to take place in New Zealand continental waters in an environmentally responsible and sustainable manner; and
- Build effective working relationships between government, industry and research stakeholders.

The 2013 Code applies to all marine seismic survey operations in New Zealand continental waters (from the coast to the outer edge of the 200 nm Exclusive Economic Zone (EEZ) and includes the extended continental shelf). Within this area, the 2013 Code is a mandatory measure in the EEZ while voluntary in the territorial waters and outside the exclusive economic zone, but over the continental shelf.

The key element of the 2013 Code is the requirement for submission of a comprehensive MMIA to the DOC. Through the assessment process, the potential effects of particular seismic survey programmes on marine mammal species occurring in New Zealand waters can be identified and further mitigation measures can be specified if required.

1.2.2 The Exemptions from Permitted Activity Conditions

The EEZ Act provides a framework for environmental management in New Zealand's EEZ and Continental Shelf. Its purpose is to promote the sustainable management of the natural resources in this area. All seismic surveys conducted in New Zealand's EEZ must comply with this Act or obtain a marine consent from the Environmental Protection Authority (EPA). The permitted activities regulations require operators to comply with the "*2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations*".

However, there are certain exemptions from permitted activity conditions, including surveys undertaken from foreign state vessels used by the foreign state for wholly-governmental purposes. The EPA has confirmed that proposed survey which will be conducted using the research vessel *R.V. Sonne* owned and operated by the German government is exempt from the EEZ Act.

Despite the exemptions in place, AWI with GNS Science's assistance wishes to voluntarily adopt provisions of the 2013 Code in order to protect marine mammals in the survey area. Therefore, a MMIA will be conducted prior to the survey with the aim of identifying the potential impacts to marine mammals in the area from the seismic operations, and determine steps to avoid, remedy or mitigate any negative effects.

1.3 Objectives of this Assessment

As outlined in the 2013 Code, this document aims to identify potential effects of the proposed activity on marine species and habitats in the receiving environment - in particular marine mammals - and consequently propose the implementation of measures that are necessary to minimise these impacts to acceptable levels. To fulfil this objective the following will be covered in this document

The 2013 Code Requirements	Applicable Sections within this Document
Describe the activities related to the proposed marine seismic survey	Section 1, 2
Describe the state of the local environment in relation to marine species and habitats, with particular focus on marine mammals, prior to the activities being undertaken	Section 5
Identify the actual and potential effects of the activities on the environment and existing interests, including any conflicts	Section 3, 7
Identify the significance (in terms of risk and consequence) of any potential negative impacts and define the criteria used in making each determination	Section 3, 7
Identify persons, organisations or tangata whenua with specific interests or expertise relevant to the potential impacts on the environment	Section 3, Appendix A
Describe any consultation undertaken with persons described above and specify those who have provided written submissions on the proposed activity	Section 3, Appendix A
Include copies of any written submissions from the consultation process	Appendix A
Specify any possible alternative methods for undertaking the activity to avoid, remedy or mitigate any adverse effects	Section 2
Specify the measures that the operator intends to take in order to avoid, remedy, or mitigate the potential adverse effects identified	Section 6, 8
Specify a monitoring and reporting plan	Section 10
Specify means of coordinating research opportunities, plans, and activities relating to reducing and evaluating environmental effects	Section 11
Sound transmission noise modelling	Section 4, Appendix B

1.4 MMIA Team

This MMIA has been compiled by an experienced technical team from the Marine Wildlife Department (MWD) within GENZL.

Since 2008, the MWD has been providing advice on various aspects of marine mammal mitigation for offshore activities (seismic surveys, piling and the use of explosives) to various government agencies, environmental consultants and oil and gas operators and clients. Our specialist team offers a range of services including consultation on protocols, procedures and monitoring and mitigation applications. The MWD also offers comprehensive reporting which includes specialist Geographic Information System (GIS) mapping. We employ our detailed knowledge of seismic surveys and combine it with expertise on marine mammals and environmental legislation which gives us a unique understanding on all aspects of mitigation. Additionally, the

MWD has extensive experience with desk-based consultancy work across a wide range of fields within marine mammal science, marine mammal mitigation and conservation. Additional expertise on Environmental Impact Assessment (EIA) methodology is also provided by our in-house experts.

GENZL's experience includes participation in the consultation, revision and design of the following marine mammal mitigation guidelines:

- Joint Nature Conservation Committee (JNCC) Guidelines and Mitigation Protocols for Seismic Surveys, Piling and use of Explosives 2004, 2009 and 2010;
- DOC's Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations 2012, 2013;
- International Association of Geophysical Contractors (IAGC) Recommended Mitigation Measures for Cetaceans during Geophysical Operations 2011; and
- National Parks and Wildlife Service (NPWS) Code of Practice for the Protection of Marine Mammals during Acoustic Seafloor Surveys in Irish Waters, 2007.

The MWD also runs Marine Mammal Observer (MMO) and Passive Acoustic Monitoring (PAM) training courses: Pro-MMO (JNCC approved), Pro-PSO (BOEM/BSEE approved) and the DOC-approved full length MMO and PAM training course for New Zealand, Pro-MMO NZ and Pro-PAM NZ.

2. Project Description

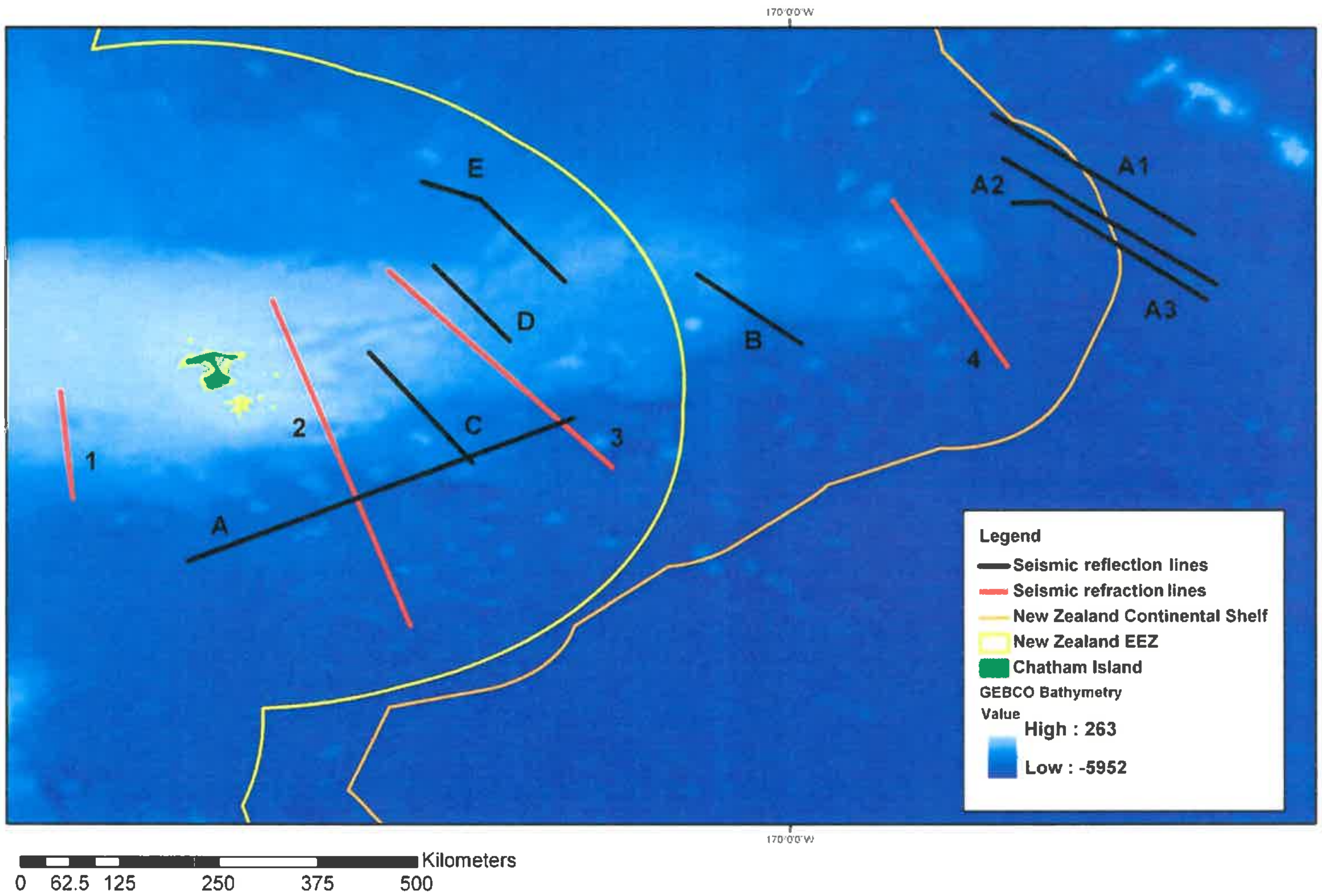
2.1 Survey Area

The survey area mainly encompasses the eastern side of the Chatham Rise with water depths ranging between 179 and 5,250 m. The survey scope of work encompasses 12 high resolution seismic lines consisting of four seismic refraction and wide-angle reflection profiles with ocean-bottom seismometers (OBS) and eight parallel seismic reflection lines (Figure 2.1). These long, single transect regional seismic profiles will be spaced 50 to 250 km apart with the total length of approximately 1,920 nm. In addition to seismic data acquisition, gravity/magnetic surveying, multi-beam mapping, parametric sediment echo sounding, geothermal heat-flow measure and hardrock dredging will be conducted at predefined profiles and sample stations.

The operational area is defined in the 2013 Code as the total area where acoustic source activation could occur, including seismic acquisition lines, airgun tests and soft starts. This area will be larger than the survey area (the area enclosed by the survey lines alone) as the source vessel will require additional space in which to manoeuvre, perform tests, and conduct line run-ins. No acoustic sources will be activated outside the specified operational area without consultation with DOC. The coordinates of the designated operational area are given below (Table 2.1) and a map of the operational area is displayed in Figure 2.2.

Table 2.1 Operational area coordinates for the survey

Site	Latitude	Longitude	Coordinate System
Chatham Rise	- 40.5	181.0	GCS_WGS_1984
	- 40.5	195.2	
	- 47.0	181.0	
	- 47.0	195.2	



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bathymetric Source: General Bathymetric Chart of teh Ocean (GEBCO) Digital Editions 2003, published by OIC, IHO and BODC. Depths are indicative and shoulsd not be used for navigation

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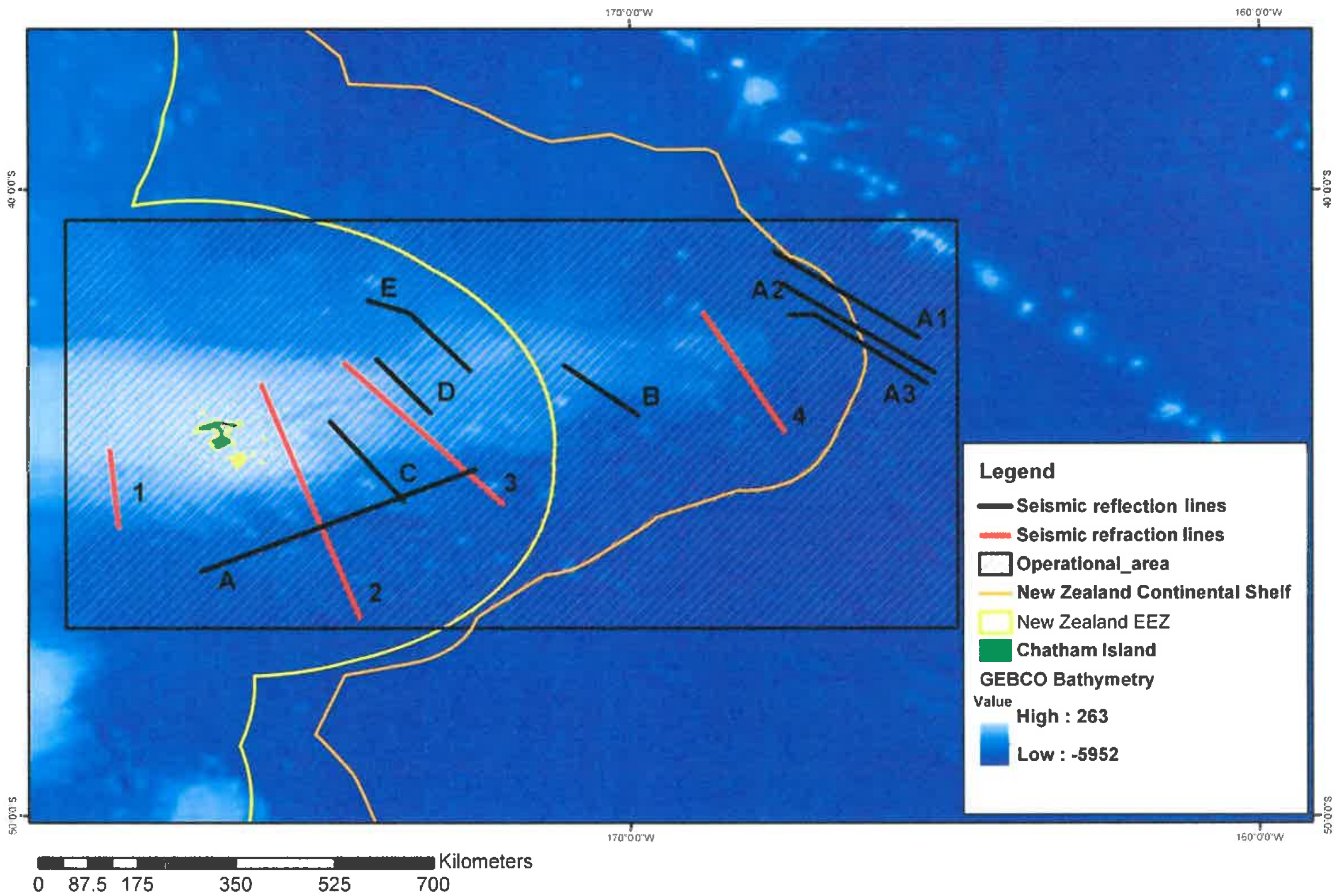
Figure 2.1 Map of the survey area with the survey lines



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bathymetric Source: General Bathymetric Chart of teh Ocean (GEBCO) Digital Editions 2003, published by OIC, IHO and BODC. Depths are indicative and shoulsd not be used for navigation.

Figure 2.2 Map of the designated operational area and survey lines for the proposed survey

2.2 Survey Vessel

The proposed survey will be carried out onboard the *R.V. Sonne.* The vessel details are displayed in Table 2.2.

Table 2.2 Survey vessel specifications

R.V. Sonne

Owner and Operator	Federal Ministry of education and Research (BMBF)
Flag / Port Of Registry	Germany
Year of Construction	1969
Class	100 A5 E NAv-OC special ship DP1 BWM +MC E AutRP 3 (50%) 'Blue Angel'
Length (overall)	116 m
Draught	6.4 m
Beam	20.2 m
Scientific load	300 t
Cruising Speed	12 kn
Maximum trial speed	15 kn
Endurance	50 days
Range	7,500 nm
Stabilisation	Retractable fin stabilization system with active fins during cruising and interring anti-rolling tanks during stations
Ship's crew	40/36 persons
Engines	4 Wartsilla diesel engines 1620 kW each and 2 electrical engines 2350 kW each
Thrusters	1 Schottel retractable bow-thruster 860 kW and 1 Schottel retractable stern-thruster 860 kW

2.3 Survey Parameters

Survey operations will continue 24 hours per day covering both daylight and night time.

2.3.1 Seismic survey

Seismic survey is an exploration method used to derive an image and information on the nature of the structures beneath the seabed. Acquisition of seismic data involves the transmission of controlled acoustic energy into the seabed and the recording of the energy that is reflected back from, and refracted along geologic boundaries in the subsurface (Figure 2.3). In the marine environment, the seismic energy source is predominantly an array of airguns towed below the sea surface behind a survey vessel. The airguns contain high pressure air in a firing chamber which is released through portholes by the action of a sliding shuttle with pistons at each end, which produces a primary energy pulse and an oscillating bubble. The airguns are fired at regular intervals as the vessel travels along pre-determined survey lines (Figure 2.1). Multiple airguns are towed in an array of different chamber volumes designed to generate an optimal tuned energy output of desirable frequencies. The energy reflected is detected by numerous hydrophones inside neutrally buoyant streamers also towed behind the vessel.

More specifically, crustal seismic reflection and seismic refraction data will be acquired where the seismic signals are recorded from both the streamer (seismic reflection) and the OBS systems at the seafloor (seismic refraction). The seismic reflection is undertaken using equipment as described above targeting images of crustal structure beneath the seabed. On the other hand, for seismic refraction the vessel will deploy 30-40 OBS systems along each line. The vessel will then run the line with the shot point interval approximately four times longer than during the seismic reflection (i.e. 60 sec). The arrival times of the signals that travel along different horizons, are used to model the velocity of the various layers imaged. The velocity information derived will provide details on rock structure and its nature (Figure 2.4).

During the proposed seismic survey, crustal seismic reflection and seismic refraction equipment will be used with two different airgun configurations depending on the water depth. The proposed airgun configurations will include a large volume array of 4,150 cu in and a small volume array of 600 cu in. Both airgun volumes of this capacity are defined as Level 1 survey equipment in the 2013 Code. Details of the seismic equipment that will be used to acquire data during the survey can be found in Table 2.3 while airgun configurations are schematically presented in Figures 2.5 and 2.6.

2.3.2 Ancillary survey

In addition to seismic data acquisition, a number of fracture zone-parallel running magnetic survey lines are planned for the area between the eastern margin of Chatham Rise and Bounty Trough in the transition between the Rise and the crust generated by ocean spreading. Furthermore, geothermal heat-flow measurements will be taken at various stations in the transition from the continental plateau to the oceanic crust. All profile and transit tracks will be accompanied by continuous swath bathymetric recording (EM122), parametric sediment echo sounding (Parasound) and recording of the gravity field.

As a part of the geological survey, a systematic hard rock sampling using chain bag dredges will be conducted at volcanic seamounts, ridges, continental blocks and along fault zones of the ocean crust in the area south of the eastern Chatham Rise at a total of 25 dredge stations.

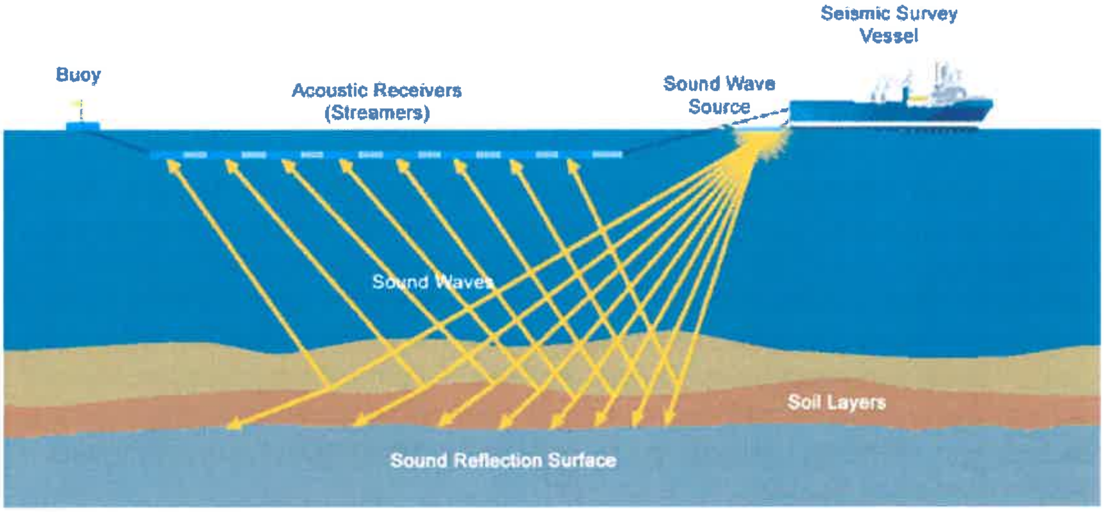


Figure 2.3 Schematic showing typical marine seismic survey (source: Fishsafe.eu)

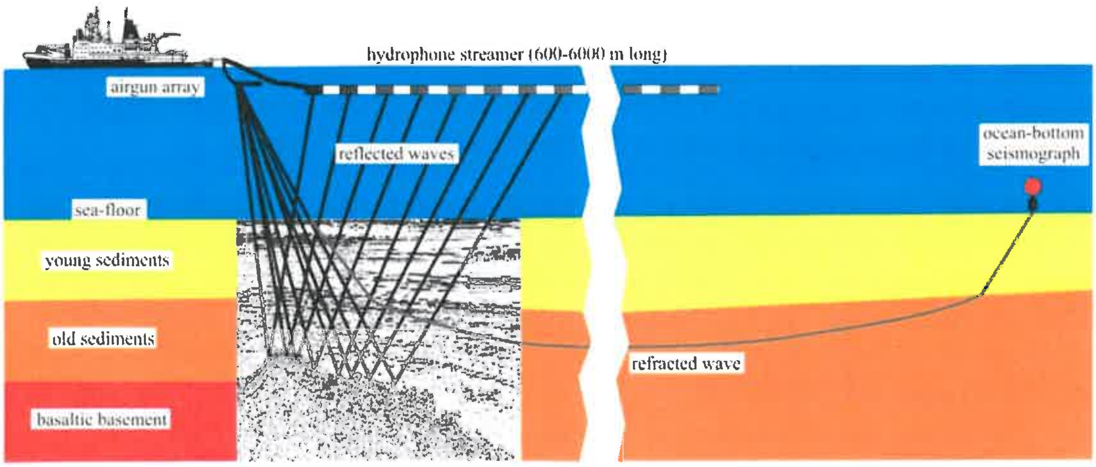


Figure 2.4 The principles of marine seismic reflection and refraction surveying (source: K. Gohl, AWI)

Table 2.3 Seismic equipment specification

Source 1	
Type	G-Gun 520 (Sercel)
Number or airguns	8 (4 clusters of 2 G-Guns)
Total volume	4,160 cu in
Tow depth	5 m seismic reflection profiling / 10 m seismic refraction surveying
Shot point interval	10 - 15 sec seismic reflection profiling / 60 s seismic refraction surveying
Operating pressure	210 bar
Source 2	
Type	GI-Gun 150 (Sercel)
Number or airguns	4 (2 clusters of 2 GI-Guns)
Total volume	600 cu in
Tow depth	2 m
Shot point interval	8 - 12 s
Operating pressure	210 bar
Streamer	
Length	1 x 3,000 m
Maximum number of seismic/auxiliary channels	240 / 60
Hydrophones per group	8
Groups per section	12
Group interval	12.5 m
Recording	
Sample rate	¼ - 4 ms
Maximum Recording capacity	240 channels @ 12.5m, 1/4 ms (1 ms for regular seismics)
Maximum record length	99 s

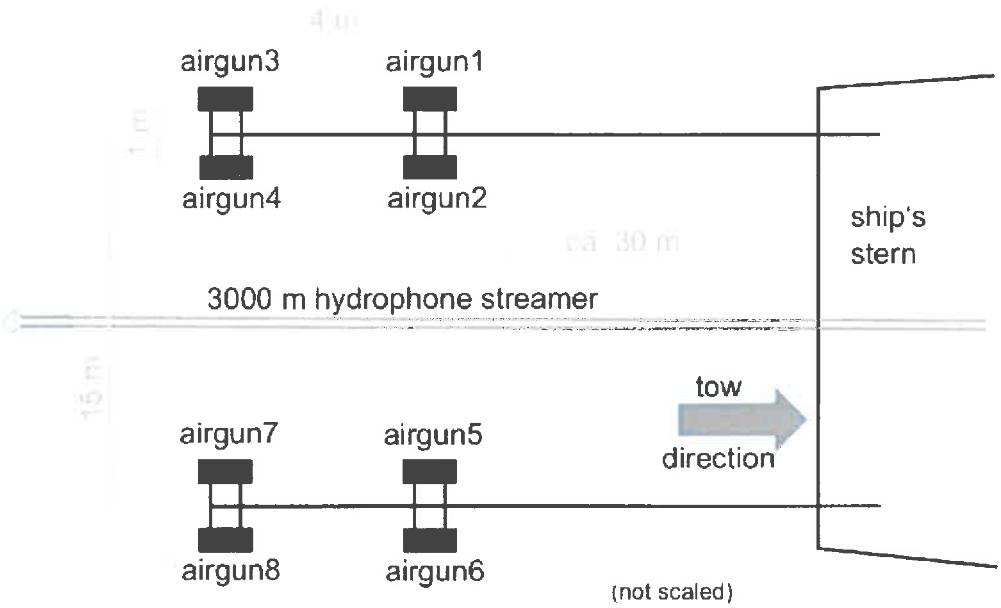


Figure 2.5 Large (G-Gun type 520) seismic source configuration

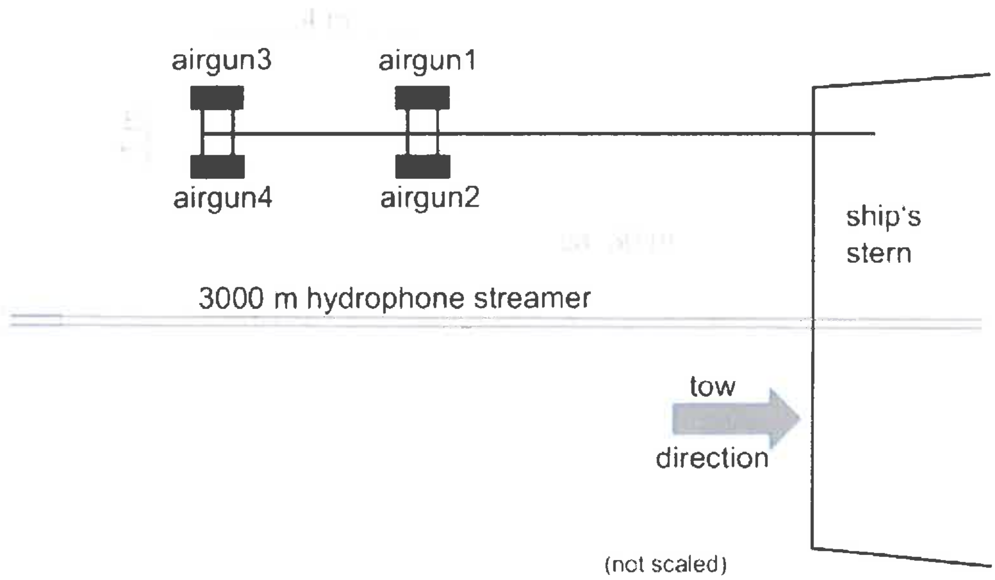


Figure 2.6 Small (GI-Gun type 150) seismic source configuration

2.4 Alternatives Considered

During the planning of the survey, a number of potential alternative approaches, techniques and operational ways of working have been considered. These are discussed below.

2.4.1 Do Nothing

This survey is a part of an international survey programme which aims to fulfil the knowledge gaps associated with geological processes of super-continent (Gondwana) breakup in the Cretaceous. The findings of this survey will also greatly contribute to the current knowledge of oceanic gateway development between the separating New Zealand and Antarctic margins and the tectonic development and nature of the long-lived Gondwana subduction margin along the Chatham Rise. Therefore undertaking the survey is the only option as there is no other way of fulfilling the aims of the project associated with studying the compressional and extensional processes of Chatham Rise and its surrounding earth's crust.

2.4.2 Alternative Methods

Alternative sound sources have been considered – equipment such as sparkers, pingers, boomers or any seismic acoustic source with a smaller volume would emit quieter sounds into the marine environment. However, in such water depths and with such geology as is seen in the survey area, these alternative sources would not be adequate to image the deep crustal and sedimentary structures needed to achieve the objectives of the survey. The proposed airgun arrays of 4,160 cu in and 600 cu in respectively have been selected as they provide sufficient seismic energy to acquire the differing geological objectives of the survey, and they are the minimum source volumes which will be able to do this.

2.4.3 Alternative Vessel

The R.V. *Sonne* is the only research vessel with the appropriate geophysical equipment and technical expertise onboard which is available to conduct the proposed survey work.

2.4.4 Alternative Parameters

To ensure good quality data collection, the following parameters have been determined by the project's geophysicists: tow depth of airguns, shot point interval, number of channels on the streamers, depth of the streamer, line position, line length as well deployment spacing of ocean-bottom seismometers. Any changes in these parameters will mean that the survey will not fulfill its purpose; therefore the use of alternative parameters is not possible.

2.4.5 Alternative Locations

The line locations have been chosen using available geophysical data, to optimise collection of data which will best answer questions about the structure of the earth's crust and basins in the region and how it has evolved over the last 250 million years. Therefore, the location of the seismic survey is pre-determined and cannot be changed.

2.4.6 Alternative Timing and Duration

The research cruise is planned to occur between 1st February and 22nd March 2016. The date of the cruise has been planned in advance to minimise any logistical issues arising from organising an international research programme involving scientists from different institutions and countries. The seismic survey, as part of the cruise, will total approximately 16 days of airgun shooting time although they may take the length of the cruise to complete in between other scientific activities and transiting between lines. This is the shortest period over which the data can be collected assuming weather conditions are favourable, therefore it is not possible to adjust the duration or timing of the survey.

3. Assessment Methodology

3.1 Method Overview

This MMIA is a form of Ecological Impact Assessment (EcIA), which is defined as "the process of identifying, quantifying and evaluating the potential impacts of defined actions on ecosystems of their components" (Treweek, 1999). In this specific case the ecological components being assessed are mainly marine mammals.

The methodology used to evaluate the potential ecological effects arising from the survey has been derived in accordance with the principles laid down in the Guidelines for Ecological Impact Assessment in Britain and Ireland – Marine and Coastal (UK Institute of Ecology and Environmental Management (IEEM), 2010). Whilst this document was originally published to assist with EcIA in the UK, the concepts and overarching strategic methods are suitable for transfer to other nations as they provide a well thought out and rigorous mechanism for impact assessment specific for the marine environment. By considering marine mammal populations in New Zealand waters, as well as national and international conservation designations within the overall framework of the IEEM guidance, it is considered that a comprehensive and robust assessment has been carried out. The assessment process includes the following components:

- Identify the ecological features that could potentially be affected;
    - including the establishment of a ZoI of the survey;
- Determine the value of relevant ecological features;
- Identify mitigation inbuilt within the survey;
- Initially assess impacts affecting each receptor;
    - such an assessment is based on the 'magnitude' of any potential effect and, once combined with the value of a receptor the 'significance' of an effect is identified;
- From the initial assessment identify any mitigation, compensation or enhancement incorporated into the survey;
- Assess potential residual effects following the incorporation of mitigation, compensation and enhancement; and
- Identify any residual likely significant impacts on marine mammals.

3.2 Consultation

A consultation process targeted at organisations or groups who may either have useful contributions to the technical assessment, or views on the project or its potential impact on marine mammals, has been run in parallel with the technical assessment phases described above. The advice and information provided by the consultees should shape both the assessment methodology and the scope of the assessment. Engagement has been made with the following groups:

- Iwi/hapū;
- Commercial fishing groups;

- Local councils and government;
- NGOs and Institutions.

The full list of consultees is provided in Appendix A.

Consideration of all consultation responses has been made within this MMIA and the key issues raised during the consultation are provided in Table 3.1.

Table 3.1 Consultations – key issues raised

Comment	Organisation (s)	Response
Potential survey area overlap with important fishing grounds for scampi and orange roughy. Concerns related to the noise impact and potential loss of fish catch rate.	Deepwater Group	Seismic survey lines coordinates were provided to assess if there is any overlap with important fishing grounds. Also, consultee was assured that position of the survey vessel will be announced via 'notice to mariners' during the survey. Further commutation channels are to be established prior to the survey commencement. The assessment identified only insignificant temporal behavioural changes (i.e. short-term displacement) of fish in close proximity to the acoustic source mostly in shallow waters. Several scientific papers were provided to the consultee in support of this assessment.

3.3 Scoping

An early stage of the assessment process is to identify species or groups where significant effects are likely to occur, a process known as scoping. By undertaking this exercise the assessment only concentrates on those receptors where effects are potentially likely, thus eliminating the need to look at a very wide range of receptors which are not threatened by this seismic survey to any significant degree.

Table 3.2 identifies a range of receptors excluded from further assessment. It should be noted that the baseline characterisation (Section 5) includes all receptors considered at the scoping stage so the reader has a full understanding of the baseline.

Table 3.2 Receptors scoped out of this assessment

Receptor	Rationale for Scoping Out
Seawater quality	The survey vessel will be operating under strict international regulations as set out in MARPOL Annex I (Prevention of Pollution by Oil), Annex IV (Prevention of Pollution by Sewage), and Annex V (Prevention of Pollution by Garbage). In addition, a Ship Oil Pollution Emergency Plan (SOPEP), along with a project-specific Environmental, Health and Safety Plan, will be followed to respond in the unlikely event of an oil spill from the vessel. As such, seawater quality should remain unchanged by the presence of the vessel. Furthermore, the vessel will be operating under the regulation set out in the Annex I of the International Convention of the Control of Harmful Anti-fouling Systems on Ships.
Sea turtles	The extent of potential impacts of anthropogenic noise to sea turtles is poorly understood. Their auditory system is considered less sensitive but the range of their best hearing seems to overlap with the low-frequency band of seismic airguns (DeRuiter & Doukara, 2012). The available evidence from literature suggests that sea turtles may show behavioural responses to an approaching operating airgun at a received level of around 166 dB re 1 μPa root mean square (rms) and avoidance responses at around 175 dB re 1 μPa rms (McCauley *et al.*, 2000). Both startle and avoidance responses to airguns have been documented by Weir (2007) and DeRuiter & Doukara (2012). Other potential effects include entrapment within seismic equipment and collision with the survey vessel. Out of five species of sea turtles that have been recorded in the waters of New Zealand - loggerhead turtle (*Caretta caretta*), olive ridley turtle (*Lepidochelys olivacea*), hawksbill turtle (*Eretmochelys imbricata*), green turtle (*Chelonia mydas*) and leatherback turtle (*Dermochelys coriacea*) - only the leatherback turtle has been occasionally recorded around the Chatham Islands (Gill, 1997). It is therefore not expected that high numbers of these marine vertebrates will be encountered during the survey resulting in no impact on these species.
Fish	The extent of noise exposure impacts to fish depends on many factors including the presence or absence of a gas bladder in their body. Species that contain a gas bladder are more susceptible to pressure-mediated injury to the ears and general body tissues than species lacking it. Fish egg and larvae are considered to be more sensitive to sound given their vulnerability, reduced mobility and small size (Popper *et al.*, 2014). Previous research has shown that a seismic source can cause physical damage to fish only in the immediate vicinity of the airguns, at distances of less than a few metres. Adult fish will most likely flee from the intense sound source causing temporary displacement, while greater effects can be expected on fish eggs and larvae which are not so mobile. However, mortality of fish eggs and larvae due to the impact of airguns is insignificant compared to the natural mortality for most species at this life stage (Sætre & Ona, 1996). Even though behavioural changes are likely to occur, the reported magnitude is variable. The impact on spawning, which is considered the most sensitive life stage for fish, will depend on the actual distance of

	behavioural impact. Overall, the potential for impact will depend on habitat, distribution and life histories of those species likely to be exposed to the sound source. Species least likely to be affected are deep dwelling soft bottom species and open water species that may occur within the survey area (Gausland, 2003). Therefore a certain level of temporal displacement can be expected mostly in shallow areas of the survey site and within a close range to the sound source. Overall, given the nature of the proposed survey which will consist of widely spaced single transects lines, the temporary impacts of the proposed activity as well as abundance and wide distribution of fish species, any expected impacts will be insignificant.
Seabirds	There are a number of ways that birds can be affected by the survey: • Seabirds can interact with the survey vessel hence there is a potential for injury through collision or entanglement with the vessel equipment, particularly at night. This interaction can also be positive, with birds using the vessel as loafing and perching platforms. • Artificial lights on the vessel can cause disorientation and interfere with their ability to navigate (Black, 2005). • Acoustic injury can occur if any birds dive in very close proximity to the operating airgun array or they can get alarmed by the passing vessel. Despite the impacts noted above, a study on the effects of seismic surveys on seabirds (Stemp, 1985) failed to document any significant effects or fatalities. Variation of seabird abundance was less than the normal variation caused by weather and seasonal conditions. Stemp (1985) pointed out that seabirds are likely to fly or swim out of the way of the approaching vessel and, since airguns are being towed behind the vessel, they are less likely to be found in the immediate vicinity of the airguns. Given the relatively simple towed equipment configuration for the proposed survey, and the low likelihood of finding birds within the harmful range of the airgun array, the potential effects on seabirds are considered to be insignificant. Also, it is likely that seabirds will avoid the area of seismic activity given that the abundance of their prey in the immediate vicinity of the operating airgun array is likely to be reduced due to avoidance reactions (Gausland, 2003).
Marine traffic	The survey area is distant from the coastal commercial shipping lanes that connect major ports in New Zealand. All vessels in the area will be notified about the vessel activity and position of the towed gear via a 'notice to mariners'. Therefore no significant impacts are expected for this receptor. Despite the intensive fishing effort in the Chatham Rise, any interference with offshore fishing activities and interaction with marine traffic is considered insignificant due to the relative short nature of the proposed survey with widespread focus of interest across a large area.

3.4 Identification of Ecological Receptors and Establishing the Baseline

An early stage of the assessment establishes those marine mammals ('receptors') that may be affected by the proposed activities. Such receptors can include populations of particular species, communities of species, and designated conservation sites for any marine mammal species that could potentially be affected by the environmental changes created by the proposed survey. In order to determine which receptors may be affected, a ZoI needs to be established for the survey. This is a method of quantifying the area within which impacts (positive and negative) are expected to occur. For a seismic survey, a ZoI is predominantly linked to the potential for underwater sound to propagate away from the sound source and influence potential marine mammal species at distance. Once the ZoI had been established for the proposed survey, potential marine mammal receptors were identified through a programme of desk based study, and a baseline established for each species taking into account the timing of the survey. It is the change from this baseline as a result of the survey activities which is assessed in order to quantify potential impacts. The baseline has been characterised using a desk-based approach using the following main data sources (Table 3.3).

Table 3.3 Baseline data sources

Data	Nature of Data	Source
Whale and dolphin international populations	Information on whale and dolphin species and their global threat classification	IUCN 2015. The IUCN Red List of Threatened Species. Version 2015.4
Whale and dolphin national populations	Data on the numbers of each marine mammal species present in New Zealand waters and their national threat classification	New Zealand Threat Classification System Lists – 2009. Department of Conservation.
Whale and dolphin distribution	Distribution maps of whale and dolphin species present in New Zealand waters	NABIS 2015. New Zealand's National Aquatic Biodiversity Information System (NABIS)
DOC stranding database for the Chatham Islands	Stranding data 1840-2015 for the Chatham Islands	Department of Conservation, 2015
DOC sighting database for the Chatham Rise	Sightings data for the Chatham Rise	Department of Conservation, 2015

3.5 Valuing Receptors

In order to fully assess effects on an ecological receptor, the receptor must first be valued. Valuation of species is based on a relatively straightforward application of the two key aspects: conservation status, and abundance of the receptor within the ZoI.

3.5.1 Conservation Status

The conservation status of each species (using accepted IUCN and New Zealand national criteria) is determined using the definitions and associated scores set out in Table 3.4. This method takes full account of populations important at both the international and national levels. It should be noted that the overall conservation status score for each identified species is based on whichever of the two scores (IUCN or National) is highest according to Table 3.4.

Where data is deficient for a particular species, a conservative assessment has been assumed and a relatively high score of '7' assigned. If species are classed as 'Migrant' or 'Vagrant' according to New Zealand national criteria their IUCN status has been taken into an account.

Table 3.4 Conservation score

Score	IUCN Red List Classification	National List	
10	Critically Endangered	Nationally Critical	Acutely Threatened
9			
8	Endangered	Nationally Endangered	
7	Data Deficient	Nationally Vulnerable or Data Deficient	
6	Vulnerable	Serious Decline	Chronically Threatened
5		Gradual Decline	
4	Near Threatened	Sparse	At Risk
3			
2	Least Concern	Range Restricted	
1			
0	Not Evaluated	Not Threatened	

3.5.2 Abundance within Zone of Influence

The abundance and trajectory of a population within the ZoI has been incorporated into the valuation. This parameter governs the ability of a population to tolerate or recover from an impact. For example, a species that is possibly (but unlikely to be) present is scored lower than a species that is almost certainly present during a key life stage. Equally, whether a population is currently increasing or declining will affect how it reacts to particular changes in the environment. Taking into account the species abundance and trajectory therefore results in a more rounded assessment that considers the value of the ZoI for a species rather than just considering the conservation importance of the species alone. Table 3.5 sets out the abundance scoring definitions.

Table 3.5 Abundance valuation

Abundance	Population Trend	Score
Present in Internationally Important Numbers	Decreasing	10
	Unknown	9
	Stable	8
	Increasing	6
Present in Nationally Important Numbers	Decreasing	10
	Unknown	8
	Stable	7
	Increasing	5
Not present in Either Nationally or Internationally Important Numbers	Decreasing	4
	Unknown	3
	Stable	2
	Increasing	1

The overall value is determined numerically using the following formula:

$$Value = \frac{Conservation\ Score + Abundance\ Score}{20}$$

An overall valuation index of between 0 and 1 is therefore determined for each species (receptor) and Table 3.6 identifies the final value definitions used in this assessment.

For example, a species with a maximum conservation score of 10 (i.e. either IUCN critically endangered or nationally critical) and a maximum abundance score of 10 (i.e. present in the ZoI in internationally important, but declining, numbers) will score (10+10) / 20 = 1 (i.e. the maximum score) representing a species of high conservation value and with a low and declining abundance.

Table 3.6 Valuation of receptors

Valuation	Score
Very High	0.81 – 1.0
High	0.61 – 0.80
Medium	0.41 – 0.60
Low	0.21 - 0.40
Negligible	0 – 0.20

3.6 Identification of Mitigation Inbuilt Within the Survey Design

Two types of mitigation are considered within this MMIA:

- Mitigation inbuilt within the survey design and operating protocols; and
- Additional mitigation specifically designed to address issues not adequately covered by the inbuilt mitigation.

The first of these - inbuilt (or 'embedded') mitigation - is designed into the survey work from the outset as it is either a requirement of the 2013 Code which sets out the requirements for marine mammal mitigation for Level 1 surveys, or has been requested by the client as other mitigation they wish to follow. Such measures are identified and incorporated into the survey at the design stage and are therefore included in the initial assessment of effect magnitude as ignoring them would give a false view of the 'core' mitigation included within the survey.

3.7 Impact Magnitude

The magnitude of an effect is made up of two components: severity and the proportion of the population affected. When combined, these constitute the overall magnitude of effect on each receptor (species). Qualitatively, these two elements include consideration of the extent, duration, timing, reversibility and frequency of the effect and reflect a continuum of the potential consequences of a response by a receptor to a potential effect. These elements are key considerations in the determination of the magnitude of impacts as outlined in the IEEM (2010) guidance. The definitions for the different levels of severity range from 'no response' at the low end to 'death or injury leading to significant reduction in survival or fecundity of an individual' at the upper end (as set out in Table 3.7).

3.7.1 Severity of Effect

Severity is included as a key component as it describes the predicted nature of behavioural changes or injury to individuals as a result of each potential effect. Table 3.7 sets out definitions of severity used in this assessment.

Table 3.7 Impact severity

Definition	Score	Description
High	4	An effect which results in either long term (e.g. seasonal or yearly) behavioural responses by individuals that leads to avoidance of the survey area and/or permanent injury to individuals. Effects result in mortality or long term reductions in fecundity/populations.
Medium	3	Medium term (e.g. months) behavioural responses by individuals that lead to avoidance of the survey area resulting in medium term changes in foraging efficiency and possible reduction in fecundity. Permanent injury to individuals leading to medium term changes in foraging efficiency and possible reduction in fecundity.
Low	2	Short term (e.g. days) behavioural responses by individuals that may lead to avoidance of the survey area (or part of), leading to short term changes in foraging efficiency. Temporary injury to individuals leading to short term changes in foraging efficiency.
Negligible	1	Short term (e.g. hours) behavioural responses by individuals with no lasting avoidance of the survey area or impact on foraging efficiency. No injury to individuals.
None	0	No behavioural response or injury to any animal.

3.7.2 Proportion of Population Affected

A predicted effect may not affect all animals within the ZoI. For example, animals at the edge of the ZoI will not be subject to vessel collision risk or to the very highest impacts of noise (due to the dissipation of power level over distance). It is therefore considered appropriate to include a measure of the 'Proportion of Population Affected' (PoPA) within the magnitude calculations.

The PoPA incorporates largely the extent of the impact but also incorporates elements of duration and frequency i.e. more individuals are likely to be affected by an impact with a larger footprint. In addition, within a highly mobile and potentially responsive population, the frequency and duration of the effect will have a role in determining how many animals are affected. The flexibility in how the PoPA is calculated depending on the nature of the impact allows this framework to be applied across all potential impacts. For example, for noise impacts, the area over which noise impacts are expected to occur and the duration and frequency over which they occur are important elements in predicting how many animals may be at risk of auditory injury or behavioural disturbance.

For each potential effect, an assessment is made of the potential number of individuals that are likely to be affected. This assessment is quantitative, wherever possible, and a score is applied based on defined thresholds for the population concerned (see Table 3.8). In some instances, a quantitative assessment is not possible, either because there is uncertainty about the exact nature or mechanism of an impact on a receptor and therefore numbers affected cannot be calculated, or because data are lacking on the abundance of the appropriate reference population. In these cases assessment will be necessarily qualitative and is based on the available information on extent, duration, timing of impact, and expert opinion.

Table 3.8 Proportion of population affected

Definition	Score	Proportion of Population Affected
High	4	20.1%+
Medium	3	10.1 – 20%
Low	2	5.1 – 10%
Very Low	1	0.1 – 5%
Barely Perceptible or None	0	0 - 0.09%

The overall impact magnitude is determined numerically using the following formula:

$$Impact\ Magnitude = Severity\ of\ Effect\ X\ Proportion\ of\ Population\ Affected$$

An overall valuation index of between 0 and 16 is therefore determined for each species (receptor) and Table 3.9 identifies the final impact magnitude definitions used in this assessment.

Table 3.9 Impact magnitude

Valuation	Score
High	10 – 16
Medium	5 – 9
Low	2 – 4
Negligible	0 – 1

3.8 Significance

The determination of impact significance involves the interaction of the receptor value, together with the assessment of the overall magnitude of the various impacts upon the receptor. The more valuable a receptor, and the greater the magnitude of a given impact on that receptor, the higher the significance of the impact.

This MMIA is undertaken in relation to the baseline conditions that would be expected to occur if the proposed seismic survey were not to take place, and therefore may include possible predictions of future changes to baseline conditions, such as environmental trends and other completed or planned developments. Both beneficial and adverse effects are possible. It should be noted that only potentially adverse effects are predicted in this MMIA and the methodology therefore concentrates on characterising and defining such adverse (negative) effects (as defined in Table 3.11).

Table 3.10 identifies, in general terms, the way in which the significance of impacts is considered in this MMIA. It is important to appreciate that this does not represent a rigid framework for assessment - there are gradations between different categories of site and impact, and on occasion the significance of a particular impact may not be precisely in accordance with the categories shown below.

Table 3.11 provides descriptions of each of the significance descriptors used in Table 3.10. For the purpose of this assessment, only impacts identified as Major or Moderate are considered to be significant.

Table 3.10 Impact significance matrix

Value of Receptor	Magnitude			
	High	**Medium**	**Low**	**Negligible**
Very High	**Major**	**Major**	**Moderate**	Not Significant
High	**Major**	**Moderate**	Minor	Not Significant
Medium	**Moderate**	Minor	Minor	Not Significant
Low	Minor	Minor	Not Significant	Not Significant
Negligible	Not Significant	Not Significant	Not Significant	Not Significant

Table 3.11 Significance descriptions

Significance	Description
Major (Adverse)	An effect which, if adverse, gives rise to serious concern and is unacceptable in terms of the integrity of the receptor (site/species) or policy/legislative status. Additional mitigation is required to reduce the effect to an acceptable level.
Moderate (Adverse)	An effect which, if adverse, gives rise to some concern and is potentially unacceptable in terms of the integrity of the receptor (site/species) or policy/legislative status. Following the precautionary principle, additional mitigation is required to reduce the effect to an acceptable level.
Minor (Adverse)	An undesirable effect but of limited concern in terms of receptor integrity or policy/legislative status. No additional mitigation is required.
Not Significant	An impact of no concern in terms of receptor integrity or policy/legislative status. No additional mitigation is required.

3.9 Additional Mitigation, Re-Assessment and Identification of Residual Effects

If the initial impact assessment identifies any significant impacts (i.e. those marked Major or Moderate in Table 3.10), additional mitigation is normally required to either eliminate or reduce effects to a non-significant level.

Effects are re-assessed following the inclusion of any further mitigation and residual effects are identified. If robust mitigation is available then it is likely that any residual effects will be reduced to a non-significant level. However, in some cases no further appropriate, effective mitigation can be identified and significant residual effects can remain.

4. Noise Propagation Modelling

4.1 Introduction

During a seismic survey, an array of airguns is used as the main acoustic source to provide imagery of the seabed and subsurface characteristics. The airgun is an anthropogenic sound source which increases the ambient noise level in the area of activity. However, sound is also used by marine fauna, especially marine mammals, to communicate, navigate, detect prey and predators, etc. Consequently, a significant change of the acoustic environment could result in considerable impacts on marine mammals.

In accordance with the 2013 Code requirements, a dedicated noise propagation modelling study was completed in order to predict the expected received levels and impact ranges on marine mammals from both a 600 cu in and 4,160 cu in airgun array:

"Where activities are planned in Areas of Ecological Importance or Marine Mammal Sanctuaries, sound transmission loss modelling will be incorporated into the MMIA methodology and ground-truthed during the course of the survey by appropriate means. Such modelling will indicate predicted sound levels within the various mitigation zones and potential impacts on species present. If sound levels are predicted to exceed either 171 dB re 1 µPa²s (SEL) at distances corresponding to the relevant mitigation zones for Species of Concern or 186 dB re 1 µPa²s at 200 m (SEL), consideration will be given to either extending the radius of the mitigation zone or limiting acoustic source power accordingly."

Details of the modelling undertaken for this MMIA are provided below, including provision of results. The full noise propagation modelling report can be found in Appendix B.

In order to meet 2013 Code requirements, validate impact ranges predicted, and assess the suitability of the mitigation area, underwater acoustic ground-truthing will be conducted during the course of the survey. The mitigation impact range prediction will be ground-truthed using measurements obtained from the vessel seismic streamer, which allows the determination of received acoustic level over the length of the streamer. This information will be used to predict the mitigation radii of the seismic airgun arrays based on local field condition, in order to validate the propagation modelling and to assess the suitability of the mitigation measure proposed.

4.2 Noise Propagation

Sound results from the propagation of a mechanical disturbance in a compressible medium, which are associated fluctuations in pressure and density due to particle motion. Water is denser and less compressible than air; therefore the sound waves propagate faster in water than in air. Sound speed on average in water is ~1521 m/s while in air ~344 m/s, and attenuation is generally less.

The source level (SL) can be given by the addition of the received level (RL) and propagation or transmission loss (TL) by SL=RL+TL.

TL is the term used to describe the reduction of the sound level as a function of distance from an acoustic source, and will be dependent on the environmental characteristics of a specific area. The mechanisms by which the sound intensity reduces are primarily geometrical spreading, sound absorption in the water, and losses into the seabed or other boundaries. The accurate estimation of the TL requires a precise model for the transmission of the sound and its interaction with the seabed and sea surface.

4.3 Noise Modelling Method

The noise propagation study has employed the Range dependent Acoustic Model (Collins, 1993) which is based on the parabolic equation solution to the wave equation, and is part of AcTUP V2.2L (Maggi and Duncan, 2002). Parabolic equation models are an efficient class of models for low-frequency problems in range-dependent environments. The RAM variants which have been utilised in the current study were RAMGeo and RAMSGEO. RAMSGEO accounts for the shear properties of the sediments and was utilised to determine the impact range estimations. RAMGeo implements a stratified seabed model in which multiple bottom layers run parallel to the bathymetry and was used to create the 360M noise model maps (found in Appendix B).

The accuracy of the propagation model is limited by the quality and resolution of the available environmental data, such as: bathymetry data, sound speed profiles in the water column and geo-acoustic profiles of the ocean sub-bottom.

The acoustic propagation model was run along 360 transects radially from the three locations chosen (Figure 4.1). Each transect covers a range of 10 to 600 km from the noise source in order to determine the area at which the noise dissipates to the ambient levels. For marine mammal impact range estimations, predictions based on 8 radial transects (N, NE, E, SE, S, SW, W, NW) were modelled at 10 km from the source.

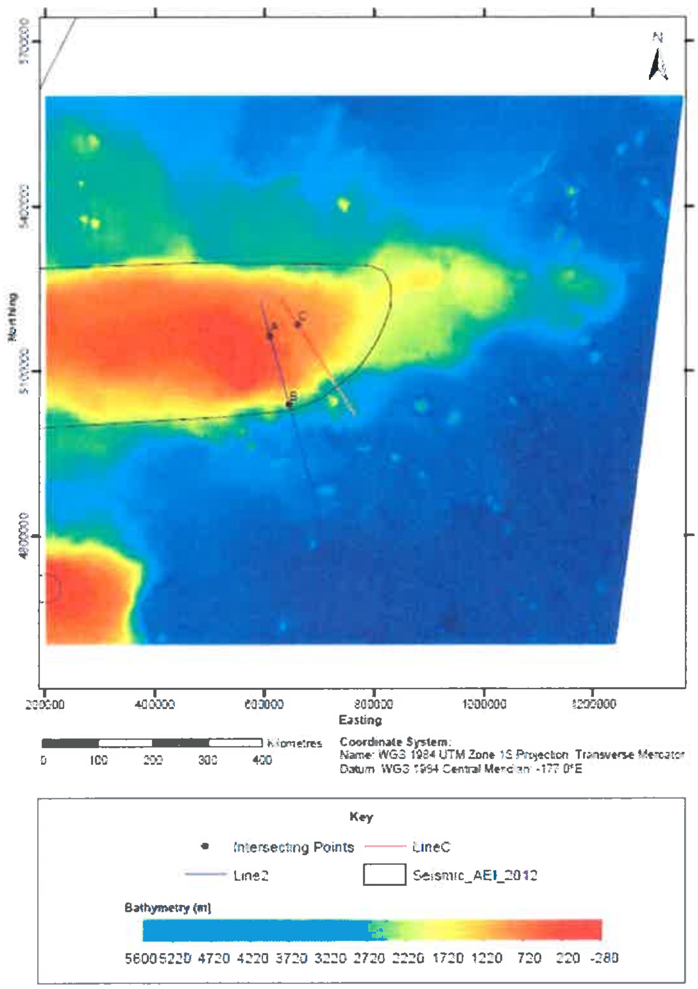


Figure 4.1 Bathymetry of the survey area including survey lines OBS2 and C on the Chatham Rise with the points (A, B, C) chosen for propagation modelling

The sound speed profile was calculated from ambient water column properties. Oceanographic data was provided by the client and used to construct the sound speed profile for the Chatham Rise. The nearest grid to the modelled locations was used in the analysis. Location A and C had an average sound speed of 1490 m/s and a mean temperature of 8.66° C. Location B had an overall sound speed of 1510 m/s and a mean temperature of 7.5° C. As for geoacoustic parameters, a calcarenite seabed with five layers (Duncan *et al.*, 2013) was assumed to run the model.

4.4 Modelling Results and Impact Assessment

Due to the flat bathymetry characteristics within a 10 km radius for all three locations, the TL results were very similar across the different transects, and consequently the received levels as well.

Transmission loss was computed in 1/3 octave bands from 20 Hz to 1 kHz, this frequency range contains the large majority of acoustic energy radiated by a seismic airgun array. Figure 4.2 displays the noise propagation at 20, 50, 80, 125, 250, 500 Hz over the bathymetry for different water-depths. Modelling for both airgun arrays at all three locations was performed and the results are presented in Appendix B. Here, the results from the highest sound source at the shallowest location are shown.

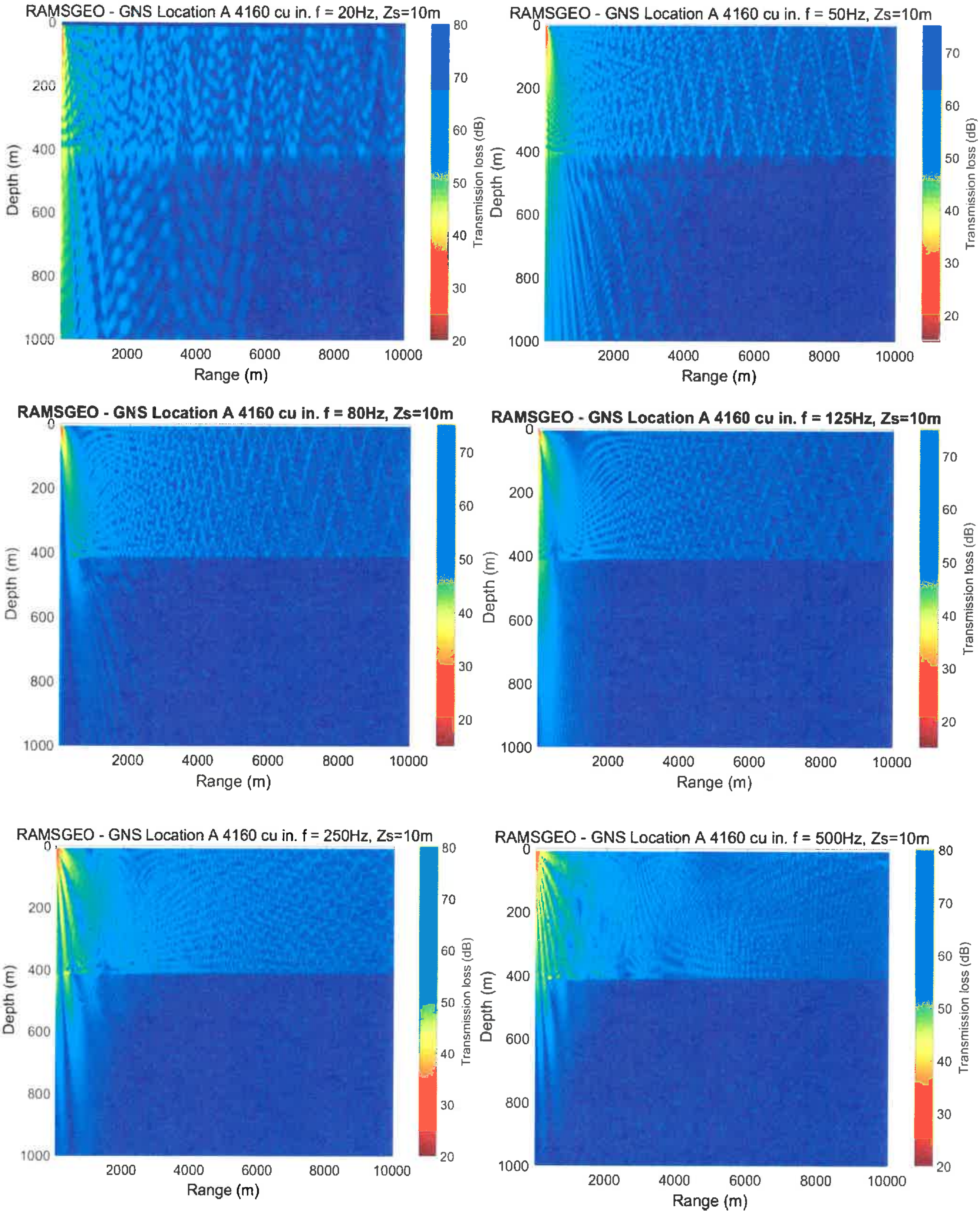


Figure 4.2 Predicted TL over bathymetry for 4,160 cu in array at Location A

In order to predict the received levels at each distance, the TL calculated for each centre 1/3 octave frequency band was subtracted from the source level. Un-weighted Sound Exposure Levels (SEL) for pulse duration of 0.05 seconds, zero-to-peak Sound Pressure Level (SPL).

In order to provide supporting information for the mitigation plan for the area, in accordance with the 2013 Code requirements, estimations of injury and behavioural disturbance ranges were conducted.

The criteria in the 2013 Code are based on M-weighted values (Southall *et al.* 2007) for pinnipeds in the water. In order to present a more comprehensive study in this report the impact range estimation also covered the cetacean groups (low, medium, and high frequency) based on Southall *et al.* (2007).

The Southall *et al.* (2007) criteria are a dual-criteria approach based on zero-to-peak SPL and energy (SEL). In this method the signal was weighted relative to hearing abilities of the species group and the M-weighted SEL were calculated.

Figure 4.3 presents an example of M-weighted SEL and zero-to-peak SPL as a function of range regarding the injury and behavioural threshold values, respectively, by Southall *et al.* (2007). This figure shows the worst case scenario of the eight transects modelled for this location.

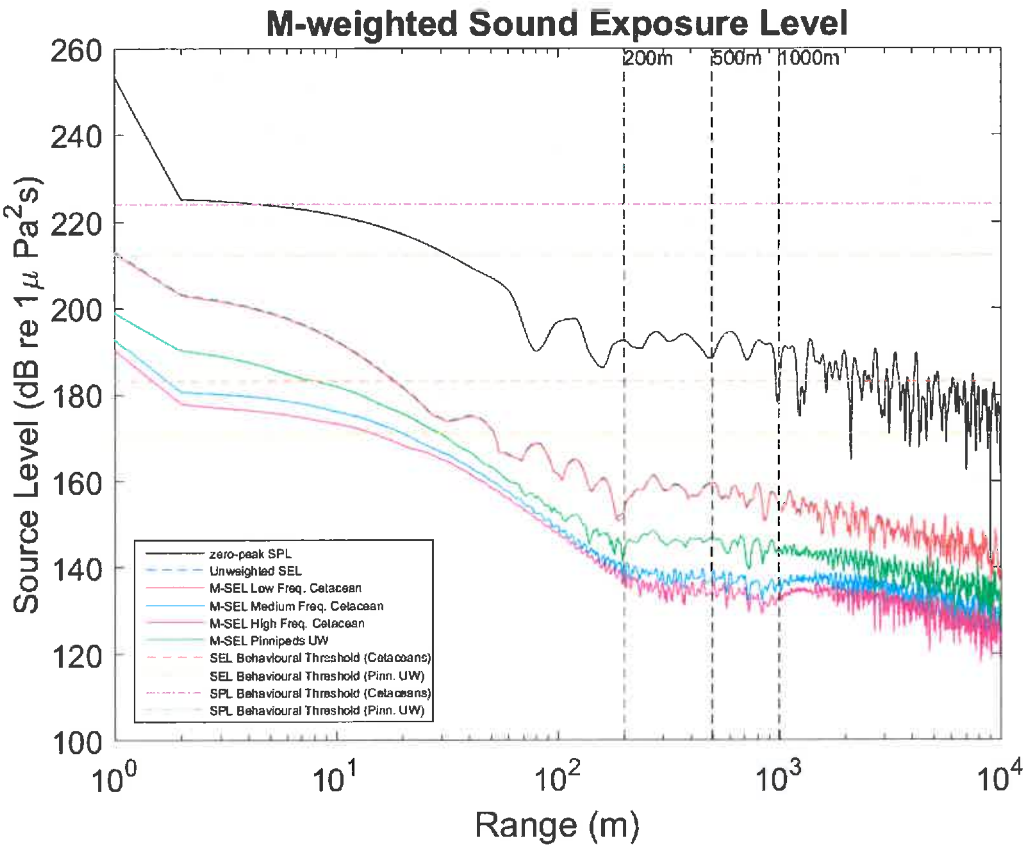


Figure 4.3 M-weighting SEL and zero-to-peak SPL as function of range regarding the injury and behavioural threshold values for 4,160 cu in. array at Location A

Using the TL model results and the impact criteria for marine mammals outlined in Southall *et al.* (2007), injury and behavioural threshold values for marine mammals have been estimated. Table 4.1 and 4.2 summarise the impact ranges predicted based on the criteria mentioned above at the Chatham Rise site. The worst case scenario of each location is reported for injury thresholds and behavioural thresholds, respectively. Note that 0 m indicates that no behavioural response or injury will be expected, even at 0 m from the source as the predicted source levels were estimated below the M-weighting thresholds.

Table 4.1 Injury threshold values for marine mammals based on Southall *et al.* (2007) criteria (single pulses)

Species	Injury Threshold Values (single pulse)					
	600 cu in array			4,160 cu in array		
	Modelled Location					
	A	B	C	A	B	C
SEL Low Frequency Cetacean (m)	0	0	0	6	6	19
SEL Med Frequency Cetacean (m)	0	0	0	0	0	0
SEL High Frequency Cetacean (m)	0	0	0	0	0	0
SEL Pinniped under water (m)	5	5	5	5	5	8

Table 4.2 Behavioural threshold values for marine mammals based on Southall *et al.* (2007) criteria (single pulses)

Species	Behavioural Threshold Values (single pulse)					
	600 cu in array			4,160 cu in array		
	Modelled Location					
	A	B	C	A	B	C
SEL Low Frequency Cetacean (m)	33	14	26	22	19	162
SEL Med Frequency Cetacean (m)	0	0	0	3	2	5
SEL High Frequency Cetacean (m)	1	1	1	0	0	3
SEL Pinniped under water (m)	45	39	48	30	29	55

As can be observed above, based on the peak noise criteria by Southall *et al.* (2007) injury in cetaceans is only likely to occur within 6 m of the 4160 cu in airgun array source, and in pinnipeds within 8 m. Behavioural disturbance based on peak levels is likely to occur within 162 m of the 4160 cu in airgun array source in cetaceans and within 55 m in pinnipeds. Injury in cetaceans is unlikely to occur at any distance from the 600 cu in array source. Behavioural disturbance in cetaceans is likely to occur within 33 m of the 600 cu in array source. Injury and behavioural disturbance is likely to occur within 5 m and 48 m for pinnipeds, respectively.

As a result, the sound levels during the survey will not exceed 171 dB re 1 μPa^2s (SEL) at distances corresponding to the relevant mitigation zones for Species of Concern nor the 186 dB re 1 μPa^2s at 200 m (SEL). Consequently, there is no need to either suggest an extension of the radius of the mitigation zone or limit the acoustic source power.

4.5 Conclusions

The impact ranges were predicted based on the source characteristics and physical parameters given by the client and applied to a propagation model. The TL results were therefore applied to the source levels, modelled in Gundalf, and the received levels were computed for each transect.

Due to the flat bathymetry characteristics within a 10 km radius for all three locations, the TL results were very similar across the different transects, and consequently the received levels as well.

In accordance with the 2013 Code an impact assessment was carried out in order to predict if the sound levels would exceed either 171 dB re 1 μPa^2s (SEL) at distances corresponding to the relevant mitigation zones for Species of Concern or 186 dB re 1 μPa^2s at 200 m (SEL).

Both sound levels mentioned in the Code are based on the threshold criteria values for injury and behavioural disturbance for pinnipeds according Southall *et al.* (2007) however it was decided to extend the assessment also for low, medium and high frequency cetacean groups.

Based on the M-weighted noise criteria by Southall *et al.* (2007) injury in cetaceans is only likely to occur within 6 m of the airgun array source, and in pinnipeds within 8 m, while behavioural disturbance is only likely to occur within 162 m and 55 m, for cetaceans and pinnipeds respectively.

As a result, the sound levels during the survey will not exceed 171 dB re 1 μPa^2s (SEL) at distances corresponding to the relevant mitigation zones for Species of Concern nor the 186 dB re 1 μPa^2s at 200 m (SEL). Consequently, there is no need to either suggest an extension of the radius of the mitigation zone or limit the acoustic source power.

5. Baseline and Evaluation of Receptors

This section sets out the environmental characteristics and the potential ZoI of the survey operations. Only those parts of the environment which are relevant to this MMIA are described - this is not a full, detailed characterisation of the marine environment, its physical-chemical properties, the attendant flora and fauna, or the socio-economic conditions pertaining to the survey area of the Chatham Rise.

5.1 Zone of Influence

The ZoI is stated as the potential area subject to the seismic survey influence on marine mammals. In any impact assessment, the ZoI should be defined according to the source characteristic of the proposed activity. The seismic sound source is characterised by being a moving point source, as the vessel travels along predetermined survey lines. Consequently, the ZoI in this assessment will be relative to the movement of the source, not a fixed area for the duration of the entire seismic survey.

The noise prediction modelling (see Section 4), demonstrated that both injury and behavioural disturbance from the proposed acoustic source - an airgun array of 4,160 and 600 cu in is only likely to occur within a maximum of 8 and 162 m respectively of the airgun array source for cetaceans and pinnipeds, considering a single pulse.

However, for multiple pulses the cumulative sound exposure level during the survey period will increase the impact range of behavioural disturbance and the zero-to-peak sound pressure level (SPL) should be considered according to Southall, *et al.* (2007). The extension of the behavioural impact range due to multiple pulses is more difficult to estimate and it is related to the airgun source capacity and the shot point interval. Furthermore, given that the acoustic source i.e. survey vessel will be constantly moving position, it is not possible to consider cumulative sounds exposure levels from a fixed point.

Various studies suggest different levels of seismic noise impact upon different species and populations. Drawing a clear conclusion on the size of the ZoI is therefore very difficult especially when different airgun array sizes and different habitat properties are taken into account. Moreover, ranges of different impacts vary greatly, with injury occurring in very close proximity to the acoustic source while masking or behavioural reactions can be recorded much further away. For example, there are some opportunistic observations of behavioural changes of sperm whales and blue whales as a response to some airgun activities at great distances from the source (Bowles *et al.*, 1994; McDonald *et al.*, 1995). Goold's (1996) study on the reactions of common dolphins (*Delphinus delphinus*) to a 2,120 cu in gun array showed that dolphins exhibit avoidance reactions within 2 km from the survey vessel. These findings are in line with the study of McCauley (1994) who suggested that most marine mammals avoid seismic vessels within 1- 3 km range (i.e. when received impulse levels reach 160 - 170 dB re 1 μPa^2).

Considering the size of the operational area (approximately 1,580 km x 1,000 km), it is almost certain that this area will encompass ranges for all significant impacts including injury and behavioural reactions for the marine mammal species (see Section 4), as well as other impacts which have the potential to extend much further away (i.e. masking for baleen whale species Siebert *et al.*, 2014). Therefore, the ZoI for the present MMIA has been set to encompass the entire operational area (see Figure 2.2). In addition, the chosen area should account for any cumulative sound exposure levels.

5.2 The Social and Cultural Environment

The Chatham Island archipelago is a particularly important area for Moriori and iwi of Wharekauri organisations and is home to New Zealand's most remote communities. Approximately 600 people inhabit two of the 11 islands that make up 'the Chathams', including a high proportion of Māori inhabitants (most likely ancestral Moriori and Māori descendants), making up 56% of the overall population (Figure 5.1). The Chatham Island territory is the smallest of the 67 districts in New Zealand and its overall occupation makes up less than one percent of New Zealand's total population (Statistics, New Zealand 2013). The Chatham Island economy is largely reliant on farming, conservation, tourism and fishing.

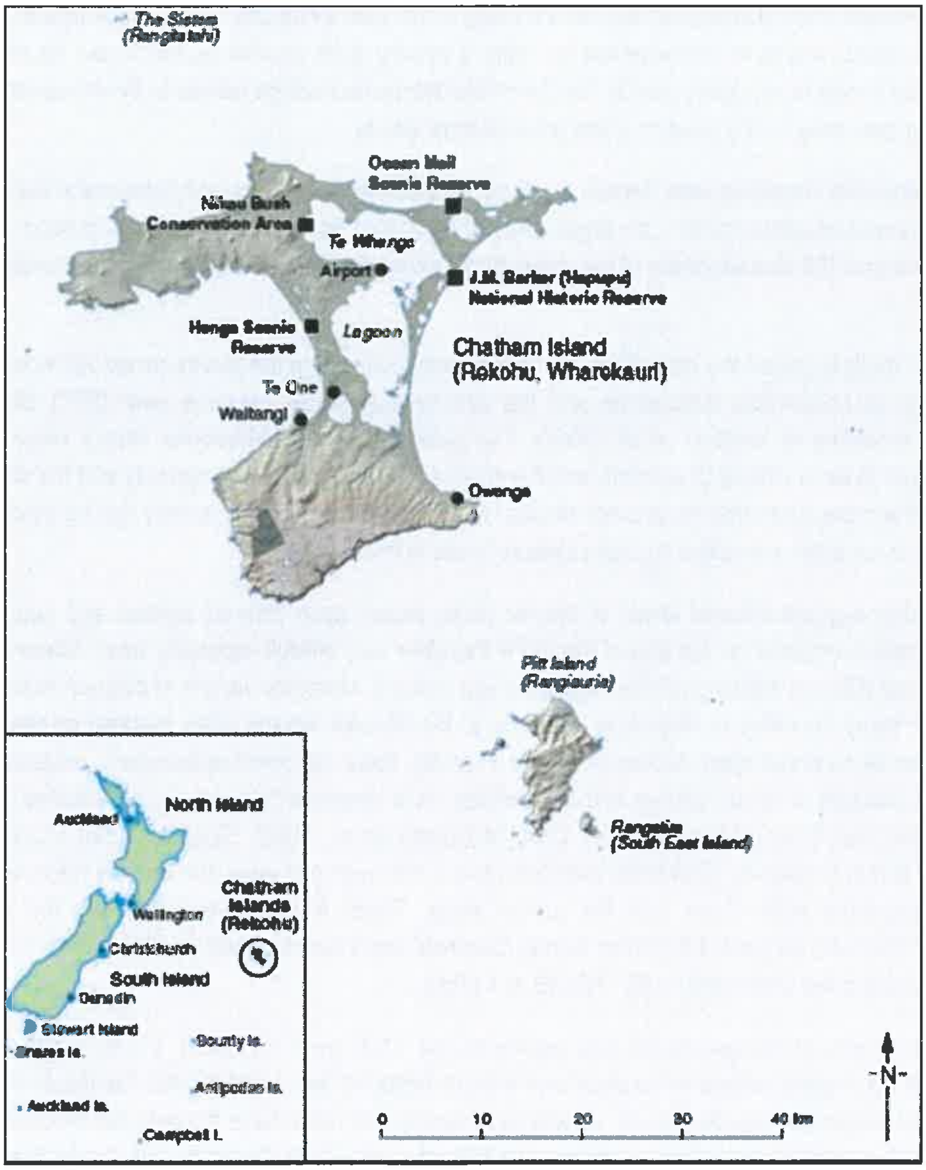


Figure 5.1 Map of the Chatham Islands and the main settlements

The ancestral fishing rights of the Māori allow the indigenous people of the Chatham Islands to have fishing quotas. The Kaimoana Customary Fishing Regulations 1998 are in place for the Chatham Islands. These regulations allow the Moriori descendants and Māori to manage their non-commercial fishing in a way that suits their local practices without having an effect on the fishing rights of others. Fisheries are an important aspect of life to the Māori and considered a main food source. Mātaitai reserves are designed to develop policies to help recognise use and management practices of Māori in the exercise of non-commercial fishing rights. The predominant species fished off the Chatham Islands are crayfish, blue cod, hapuka and paua, with the spiny red rock lobster, butterfish and kina given the largest customary allowances (MPI, 2015).

5.3 The Wider Anthropogenic Environment

Several human activities occur in the area surrounding the survey site. The dominant activities are fishing and shipping. Details of the existing anthropogenic activities in and around the survey area are provided below.

5.3.1 Fisheries

Alongside customary fisheries, there are two other important types of fisheries in New Zealand: commercial and recreational.

There are approximately 130 species targeted commercially in the New Zealand EEZ and 70% of fish caught in fisheries is taken by deepwater fisheries. Deepwater fishing occurs out to the 200 nm limit of New Zealand's EEZ. Fisheries beyond the EEZ are managed by the Ministry's International Fisheries Management Team. Commercial fishing is regulated through quotas established by the Quota Management System (QMS) for each Fisheries Management Area (FMA) (Figure 5.2), which is monitored by the Ministry for Primary Industries (MPI). The survey area is partially located in the Chatham Rise FMA (MPI, 2015) and partially within the extended continental shelf beyond the EEZ.

Trawling is generally the main fishing method used in New Zealand to catch fish (Figure 5.3). A Benthic Protected Area (East Chatham Rise BPA) was established on the north east side of the Chatham Rise in 2007, which subsequently banned any future trawling in the area. Figure 5.4 shows trawling effort between 1990 and 2008: although sections of the Chatham Rise have been heavily trawled, the main fishing method for the area has always been longline fishing. Overall, longline fishing has resulted in 99 tonnes of fish being caught out of 165.6 tonnes in the past 10 years, with trawling contributing 64 tonnes of fish being caught during this time (O'Driscoll, 2014). Most commercial fishing catches were species such as ling (*Genypterus blacodes*) (36.9%), hoki (*Macruronus novaezelandiae*) (21.3%), spiny dogfish (*Squalus acanthias*) (15.4%), javelinfish (*Coelorinchus australis*) (6.7%) and sea perch (*Helicolenus spp*) (5.2%) (O'Driscoll, 2014). Catches between 1994 and 2004 within the revised consent area, contributed to less than 0.5% of the catch of those species from the associated Quota Management Area (QMA).

Table 5.1 Annual commercial allowances for commercially viable species in the Chatham Rise region (source: MPI, 2015b)

Species	Method of fishing	Quota (kg)
Ling	Longline	4,200,000
Hoki	Bottom trawling	150,000,000
Spiny Dogfish	Bottom trawling, longline and bycactch	1,626,000
Sea perch	Bottom trawling, longline and bycactch	910,00
Orange roughy	Bottom trawling	5,000,000
Scampi	Bottom trawling	120,000

The Chatham Rise is a valuable commercial fishery and in addition to the species highlighted in O'Driscoll (2014)'s literature, it is an equally important area for orange roughy and scampi. The orange roughy is a deep sea species which historically has been shown to be both easily overfished and slow to recover (Clark, 2001). Catch limits and strict quota (current restrictions mean only 4.5% or less of the adult population can be harvested) mean that this species is now a viable commercial option with the seamounts around the Chatham Rise being inhabited by a significantly sized population (Clark, 1999). Scampi support a large fishery in New Zealand with the main areas for scampi harvesting being the Auckland Island shelf, the Bay of Plenty, the Wairarapa coast and the Chatham Rise (Smith, 1999). The area is also the main residence of adult eastern hoki and a major area for both juvenile western and juvenile eastern hoki (O'Driscoll, 2014).

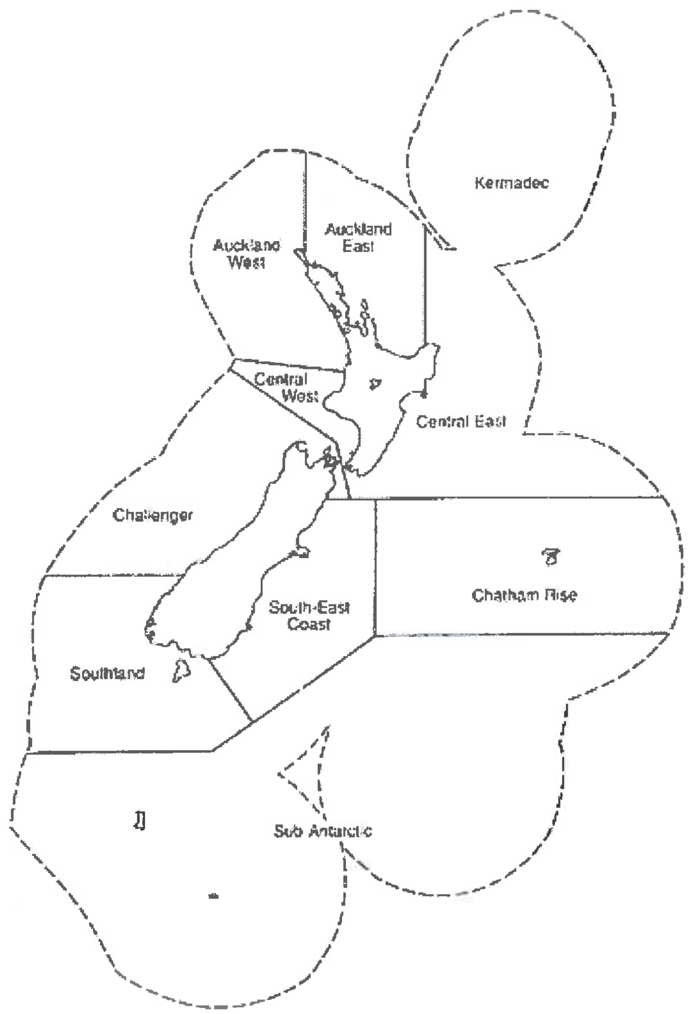


Figure 5.2 Fisheries management areas of New Zealand (*source:* Shotten, 2001)

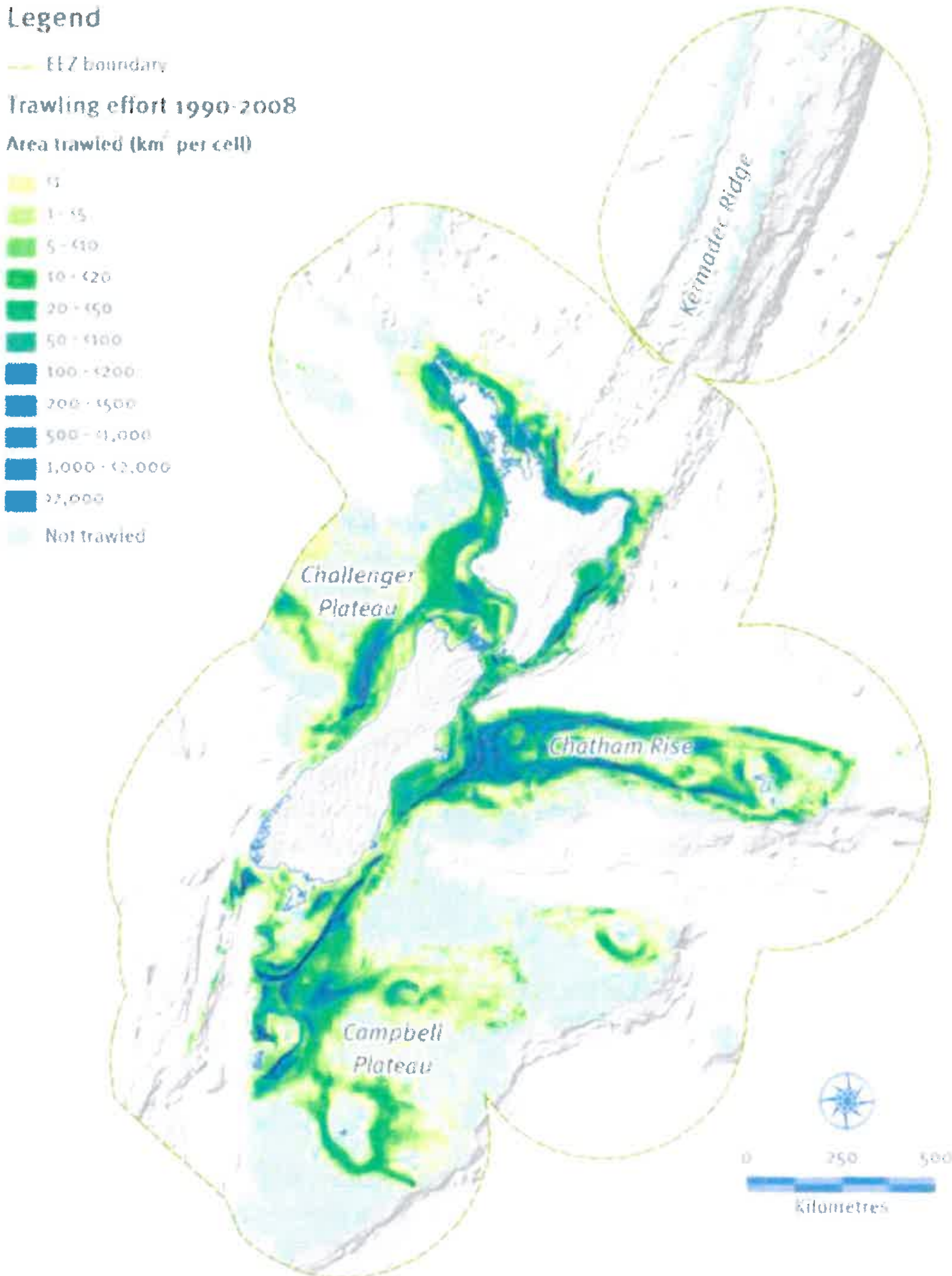


Figure 5.3 General spatial pattern of trawl fishing activity based on data set 1990-2008 (source: Ministry for the Environment, 2010)

Recreational fishing targets several species across the Chatham Rise region, however these activities are expected to occur in the inshore waters. These fisheries are regulated through different means compared to commercial fisheries and are not part of the QMS. The regulations that are in place include minimum size and catch limits in addition to specific rules for several species of finfish, two species of rock lobster (*Jasus edwardsii* and *Sagmariasus verreauxi*) and several other rules for shellfish.

The Chatham Island Inshore Fisheries (CIF) Plan encompasses the inshore and inland waters of the Chatham Islands. Fishing is incredibly valuable to the Chatham Island economy and furthermore its fisheries are a significant contributor to the overall fish exports from New Zealand (MPI, 2015).

5.3.2 Shipping

Marine traffic in the survey area is mainly due to commercial fishery and mining activities. The main shipping lanes are between the major fishing bases and vessels transiting through the areas to ports in New Zealand. The survey area is distant from the coastal commercial shipping lanes that connect major ports in mainland New Zealand. There are no predefined shipping lanes between New Zealand and the Chatham Islands but some low scale, variable commercial traffic through the Chatham Rise area can be expected.

5.3.3 Phosphate Mining

Despite New Zealand Petroleum and Minerals (NZPAM) granting a 20 year permit for the extraction of phosphate nodules from an area of 820 km^2 of the Chatham Rise, the phosphate mining will not go ahead since the marine licence for the project has been rejected due to significant and permanent adverse effects on the benthic environment of the Chatham Rise. The extraction of phosphate from the area was predicted to result in a reduced carbon footprint from the New Zealand fertiliser industry but it was deemed that significant environmental impact could not be mitigated by any set of conditions or adaptive management.

5.3.4 Other Considerations

Other uses of the marine environment in the Chatham Rise region tend to be much more coastal, such as tourism activities including sailing tours. There is also lots of non-commercial fishing activity around the Chatham Islands. Despite the presence of cetaceans in the area, there is currently no whale or dolphin-watching tours organised. Taking in consideration the location of the survey area, it is predicted that these activities are of less of a concern.

5.4 The Physical Environment

Due to the potential for seismic sound to be affected by the physical properties of the waters encompassing the Chatham Rise, a description of the physical characteristics of the seabed and overlying waters are provided in the following sub-sections.

5.4.1 Bathymetry

The Chatham Rise is a broad ridge which extends 1,400 km east from central New Zealand (McKnight & Probert, 1997). The western boundary is formed by the Mernoo Gap, a 500 m depression which separates the Chatham Rise from the New Zealand continental shelf. The Rise plateaus at 200 - 400 m in depth to the west before it reaches the Chatham Islands, which are situated c.800 km east of the New Zealand mainland (Trewick, 2000). East of the Chatham Islands the topography gradually descends to depths of approximately 3,000 m in the east (Thompson, 1991). The Rise is terminated abruptly on the north side, where the seafloor descends steeply into the Hikurangi Trench; in comparison the southern slopes are much gentler (Boskalis, 2013). The bottom topography is characterised by smooth, gently sloping profiles with the occasional jagged profile of up to 10 m of relief. Large scale bathymetric mapping shows the Chatham Rise to be a smooth topped plateau when in reality there are multiple local reliefs and banks (Mitchell & Cullen, 1984). Aside from the aforementioned Mernoo Gap, the Veryan and Reserve Banks can be found in the western margin, with the smaller Matheson Bank being located closer to the Chatham Islands. Sea mounts are a prominent feature, and the Graveyard seamount complex, located on the northern slopes of the Chatham Rise consists of 28 seamounts, the largest of which rises from a depth of 1,100 m to a peak at 750 m below the surface. Pockmarked topography characterises the southern margin of the Chatham Rise, west of the Urry Knolls, presumably reflecting the exhalation of natural gas and collapse of the overlying sediment into depressions created by this loss (Collins *et al.*, 2011). The intricate topography is primarily driven by both volcanism and submarine slides (Herzer, 1975; Collins *et al.*, 2011).

5.4.2 Circulation and Currents

New Zealand lies in the path of eastward flowing currents which are driven by winds blowing across the South Pacific Ocean. Both the south-east trade winds to the north and the 'roaring forties' winds to the south drive water along the equator. The predominant current affecting the Chatham Rise is the subtropical convergence (STC), which is a circumglobal front where subtropical and subantarctic waters meet - in this case they meet along the coast before heading out across the Rise in an easterly direction (Heath, 1983) (Figure 5.4).

There are two separate inputs of subtropical waters along the subtropical convergence. Subtropical water is transported south along the east coast of the north island by the East Cape Current (ECC), as well as from the Southland Current (STW) (although this current is lower in temperature and salinity) in to the convergence zone. The STW is also prone to fluctuations (driven by local winds) which subsequently can impact on the STC (Chiswell, 1996). In comparison, the ECC (as an extension of the East Auckland Current) is barely influenced by local winds (Stanton *et al.*, 1997). The subantarctic waters are from the Subantarctic Front which follows the south-eastern section of the Campbell Plateau (Heath, 1981); once past this flank the front joins the convergence at around 170° W.

The STC follows the southern tip of New Zealand's South Island, before following the coast north, where it runs along the eastern continental shelf, before inputs from exterior currents force the flow over the Chatham Rise. This section of the STC forms a narrow band (~150 km) held in position by the shallow bathymetry of the Chatham Rise (Sutton, 2001). Elsewhere the STC is a broad (400 - 500 km), homogeneous front, formed by distinctive tides and the meeting of two fronts with separate chemical and physical properties (Sutton, 2001; Butler *et al.*, 1992).

5.4.3 Water Density (Temperature and Salinity)

The temperature subsections across the Chatham Rise are typical of the STC. The thermocline varies north and south of the Rise depending on the water inputs (Chiswell, 2002). Near the crest of the Chatham Rise the STC is a steeply, sloped isotherm. The isotherm to the north of the Rise is driven by the Wairarapa Eddy (generally centred near 41°S (Roemmich and Sutton, 1998)), which subsequently appears to be present due to the topographic lay out of the Chatham Rise. This eddy stops southward flow and instead forces the flow eastward, forming a bounding current to the STC (Chiswell, 2002; Beattie *et al.*, 2014). There is also evidence of seasonal variation, especially in the surface waters during both spring and autumn.

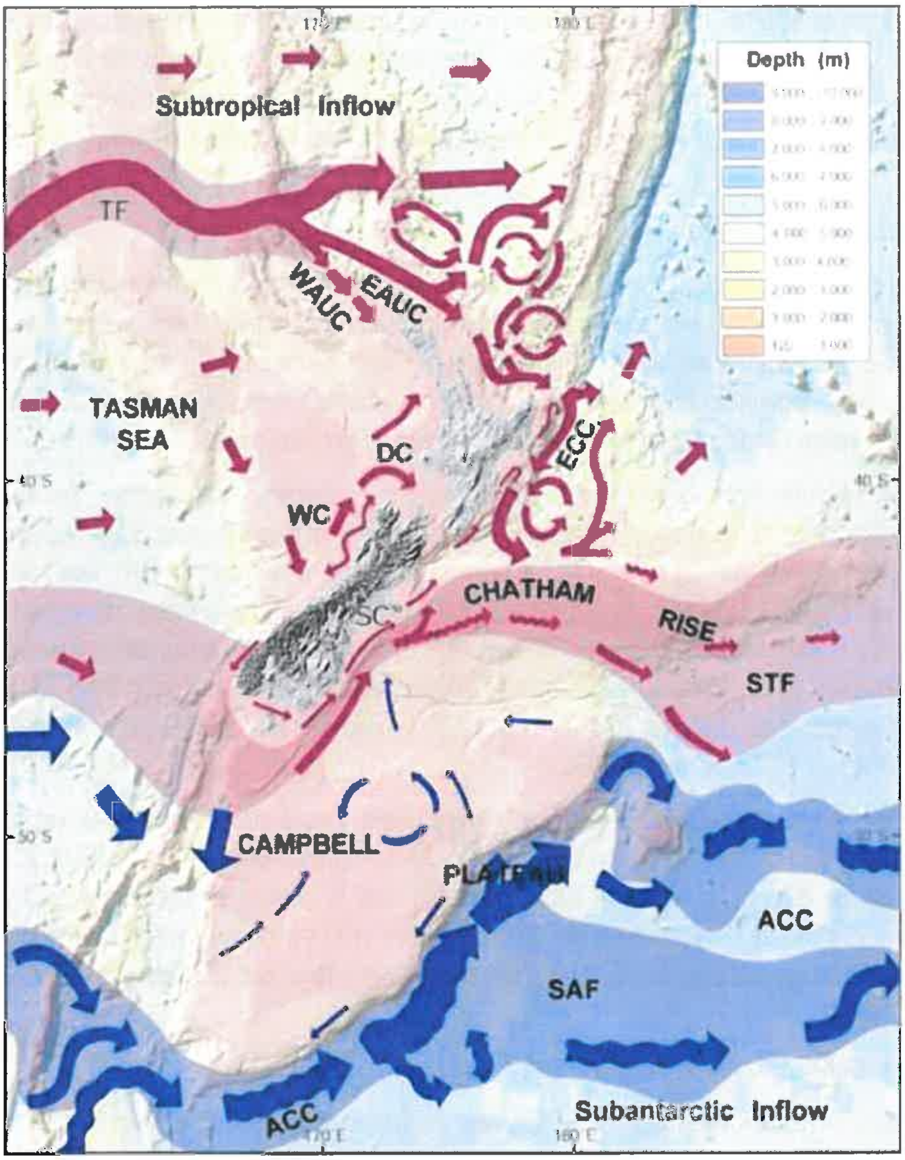


Figure 5.4 New Zealand currents and water masses (source: Te Ara, 2015)

5.4.4 Seabed Sediments

The northern margins of the Chatham Slope Basin are characterised as early Cretaceous bedrock (Figure 5.5). Sediment particle size analysis by McKnight & Probert (1997) showed that the composition is mainly comprised of muddy sands; with mean weights from 10 stations collected during north-south transects across the Chatham Rise being separated in to: clay 8%, silt 20%, sand 68% and gravel 4%. Nodder *et al.* (2011) took seabed samples around the Chatham Rise and also found high mud contents (50 - 70%, less than 63 μm, silt and clay), especially on the western and south-central parts. The seabed around the Chatham Islands and near the Mernoo Bank has much higher levels of sand and gravel. Seamounts, knolls, pinnacles and other seamount-like features are prominent and widely distributed features of the Chatham Rise environment, these seamounts possess a large amount of stony coral habitat (Clark & Rowden, 2009).

Phytopigments reflect the most labile part of the organic material accumulating in sediments, and levels have been found to be highest across the western part of the Chatham Rise (Nodder *et al.*, 2011). Additionally, as the crest of the Chatham Rise is characterised by low sedimentation rates due to prevailing currents and high productivity, it is favourable for phosphorite nodule formation. The Chatham Rise phosphorite deposit occurs as a surficial or subsurface uncemented gravel of hard sub-angular to sub-rounded "nodules", enclosed in a matrix of unconsolidated, sandy mud (Cullen, 1987). On certain areas on the Chatham Rise, the nodule layer is up to 0.7m thick (Cullen, 1987). Overall organic matter only makes up a small part of the sediment composition, generally varying between 1 - 5% of the total weight, with a trend for higher values in the north and west of the area. The sedimentation on and around the Chatham Rise is influenced by the water movements and can explain some of the variability between stations/transects (Heath, 1983).

Figure 5.5 The sediment basins around New Zealand (source: GNS, 2015)

5.5 Designated Marine Conservation Sites

There are over 40 legally protected marine reserves in New Zealand managed by the DOC (Fig 5.6). These provide the highest level of marine protection and cover 7.06% of the territorial sea. The marine reserves have been established to protect representative marine habitats and communities for science and education, and to provide a safe haven for marine life to live and breed. In addition, all of the animals, plants and seabed within the reserves are legally protected under the Marine Reserves Act 1971 which states:

- No fishing, netting, spearing, taking or killing marine life including seaweeds. All methods of fishing from the shore or at sea are prohibited within the reserve area.
- No activities that pollute, disturb or damage marine life or the seabed.
- No removal of any natural material from the marine reserve.

New Zealand has a total of six marine mammal sanctuaries (MMS) and one Whale Sanctuary (as part of Hikurangi Marine Reserve). MMS are established throughout New Zealand waters to create a permanent refuge for marine mammals. The sanctuaries prohibit activities known to harm particular marine mammal species. Activities such as fishing, tourism, mining and energy exploration are also strictly controlled within these areas to protect endemic species. The Kaikoura Whale Sanctuary which extends up to 56 km offshore has increased restrictions on seismic activity. Through the Marine Mammals Protection Act 1978, the DOC is responsible for administering and managing marine mammal sanctuaries.

There are no MMS in the vicinity of the survey area. The closest MMS is the Banks Peninsula sanctuary dedicated to the protection of the endangered Hector's dolphin. This MMS stretches 389.31 km between the Rakaia River to the mouth of the Waipara River covering an area of approximately 413,000 ha, extending 12 nm out to sea from the coast. This MMS is very distant to the survey area (Figure 5.7).

The boundaries of the proposed survey area, and the established ZoI, do not overlap with any MMS or marine reserves and it is therefore predicted that these protected sites (and any marine mammal populations present within these during the survey period) are not going to be directly affected by the proposed activity.

There are 17 Benthic Protection Areas (BPA) within New Zealand's EEZ covering 1.2 million km^2 of seabed (approximately 32% of the EEZ), established to protect the seabed habitats (Figure 5.8). Bottom trawling and shellfish dredging are forbidden within these areas. The operational area overlaps with three BPAs with several survey lines passing through the Arrow Plateau BPA (Figure 5.9). However, there are no restrictions on seismic surveys and research in these protected areas. AWI with GNS Science's assistance will however consult with DOC on potential dredge sites in these BPAs.

The DOC has identified a number of Areas of Ecological Importance (AEI) (Figure 5.10) for marine mammals based on information from the sightings and stranding database. Within these sensitive, ecologically important areas, seismic surveys should not be planned especially during key times for SoC such as breeding, calving, resting, feeding and migrating, or in confined areas. When it is demonstrated that conducting surveys within these areas is unavoidable and necessary, further mitigation measures might be required to minimise potential impact. These are assessed during the appropriate MMIA process. Furthermore, in these instances sound TL modelling is a component of the MMIA, as shown in Section 4 of this document. The results of this modelling give an indication of the relative distances from the acoustic source over which behavioural modifications and injury could be expected (see Section 4). Ground-truthing of the sound transmission loss modelling must also take place during the survey, to verify the accuracy of the model.

It should be noted that the proposed survey area is partially situated within an AEI thus all potential impacts on marine mammals will be robustly assessed and the results of the sound transmission loss modelling will be taken into account together with all requirements of the 2013 Code.

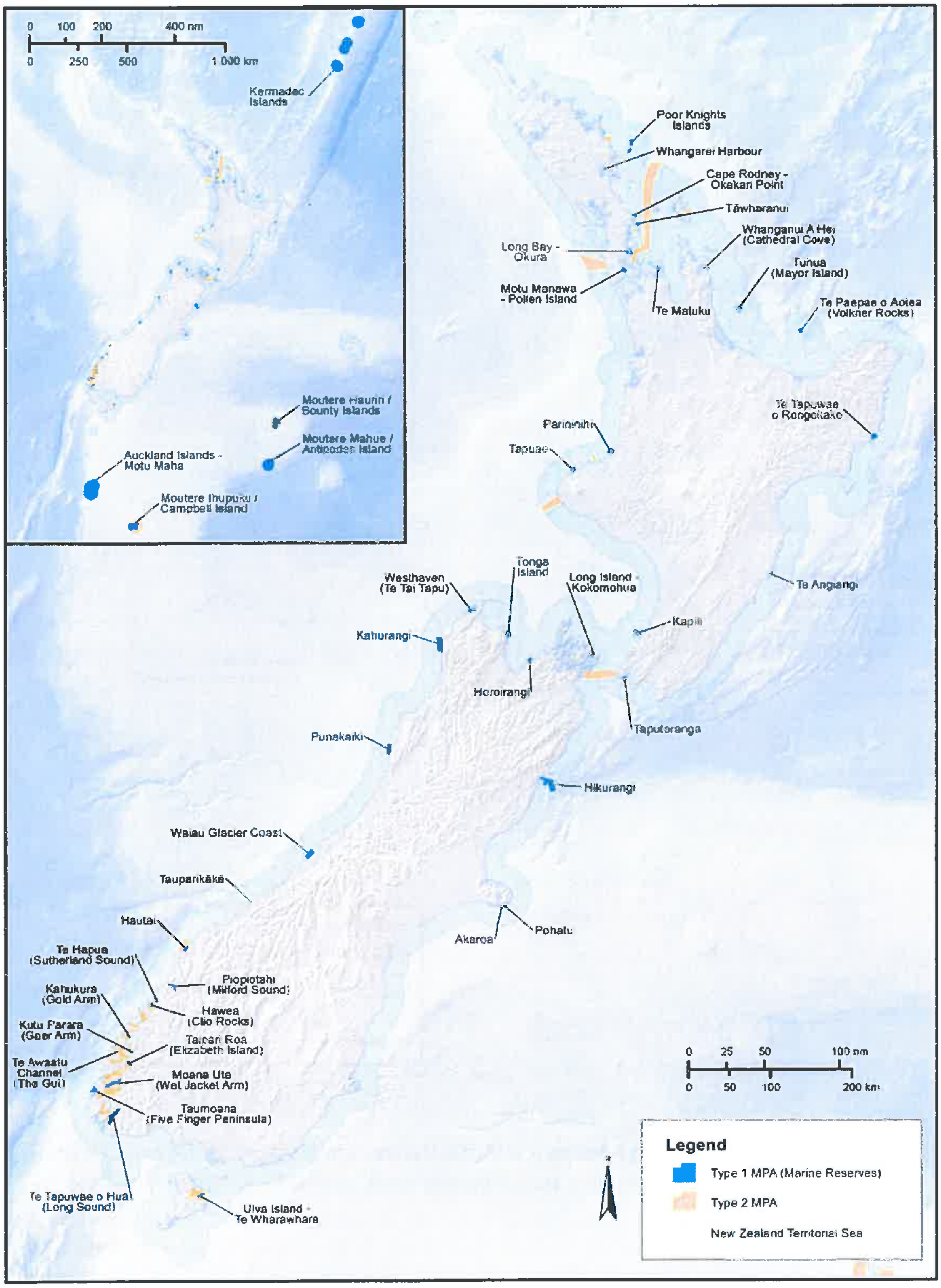


Figure 5.6 New Zealand Marine Protected Areas (note - the proposed survey area is not marked as it is outside of the map frame) (source: DOC, 2015f)

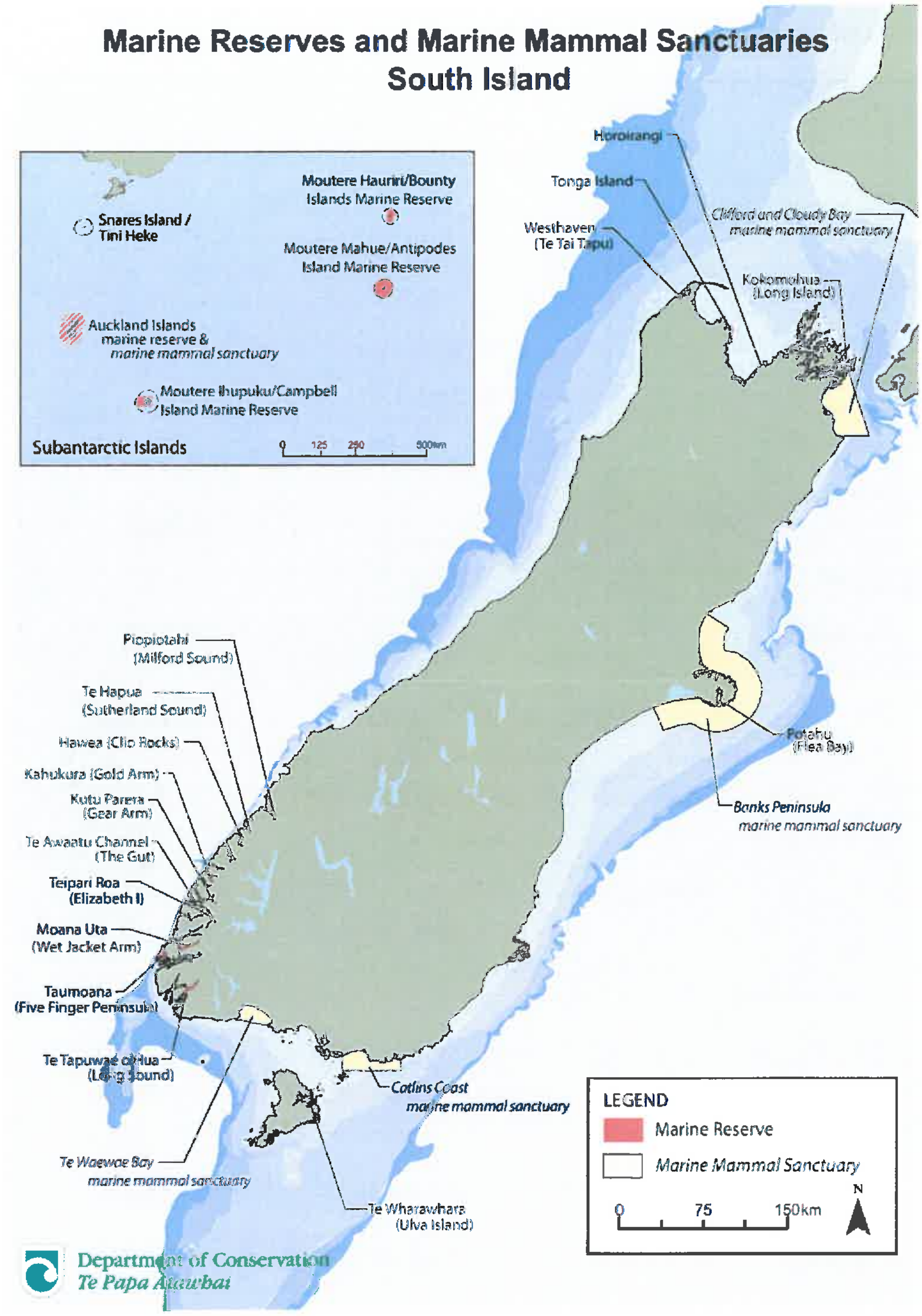


Figure 5.7 South Island Marine Reserves and Marine Mammal Sanctuaries (note - the proposed survey area is not marked as it is outside of the map frame) (source: DOC, 2015g)

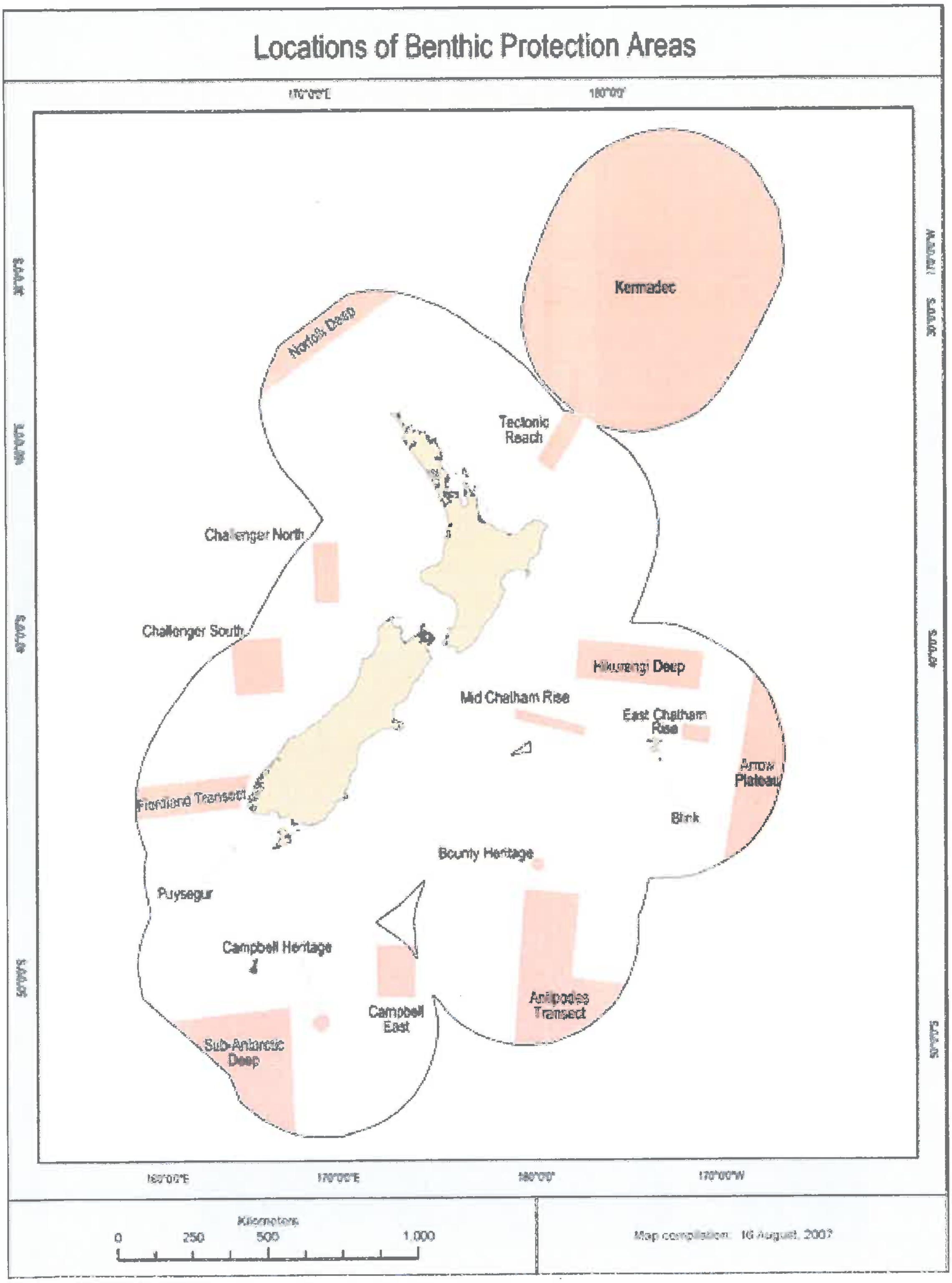
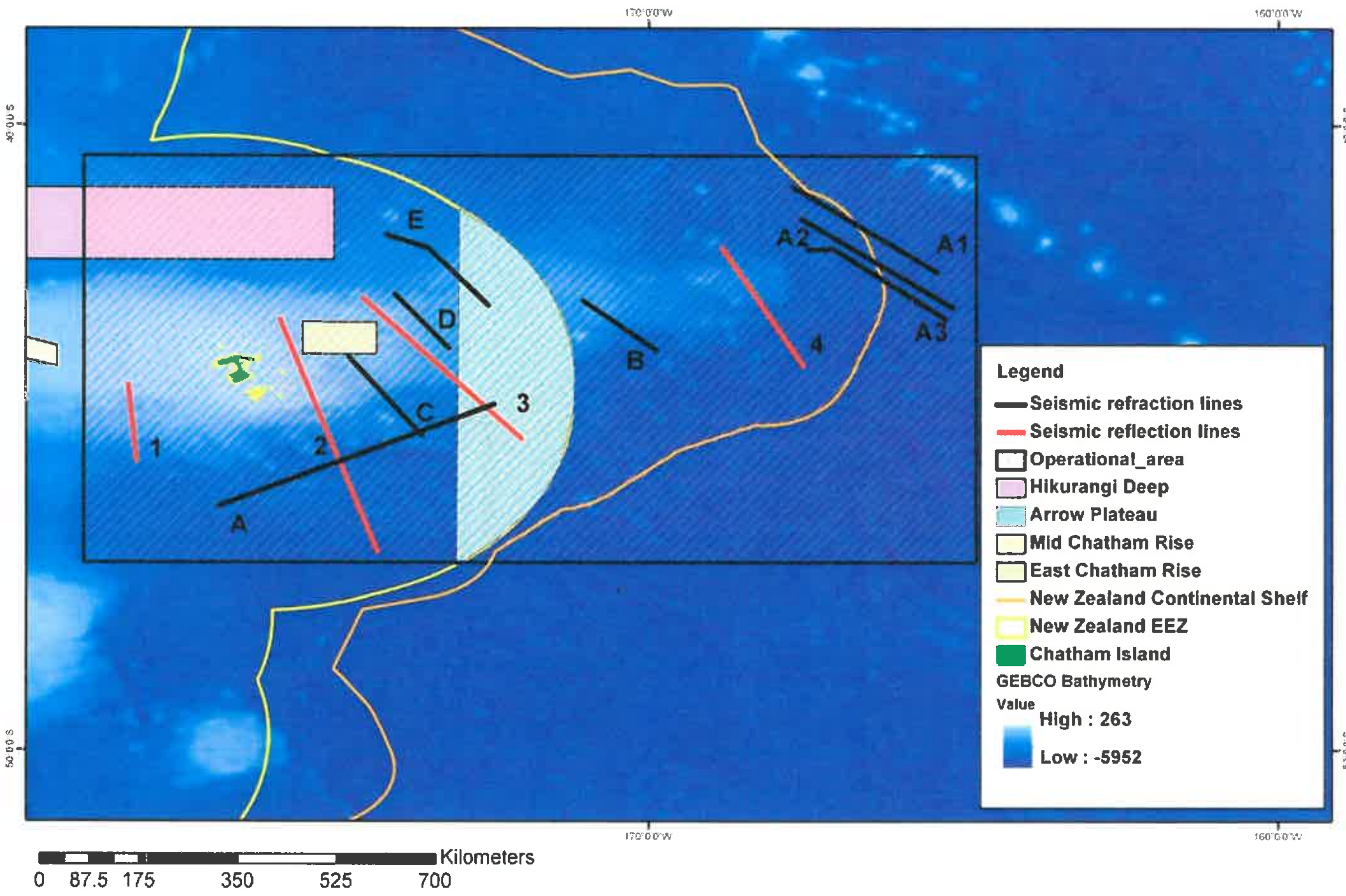


Figure 5.8 Location of Benthic Protection Areas (source: Ministry of Primary Industries, NZ)



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bathymetric Source General Bathymetric Chart of teh Ocean (GEBCO) Digital Editions 2003 published by OIC IHO and BODC Depths are indicative and shoulsd not be used for navigation

Figure 5.9 Location of Benthic Protection Areas in relation to seismic survey lines and operational area

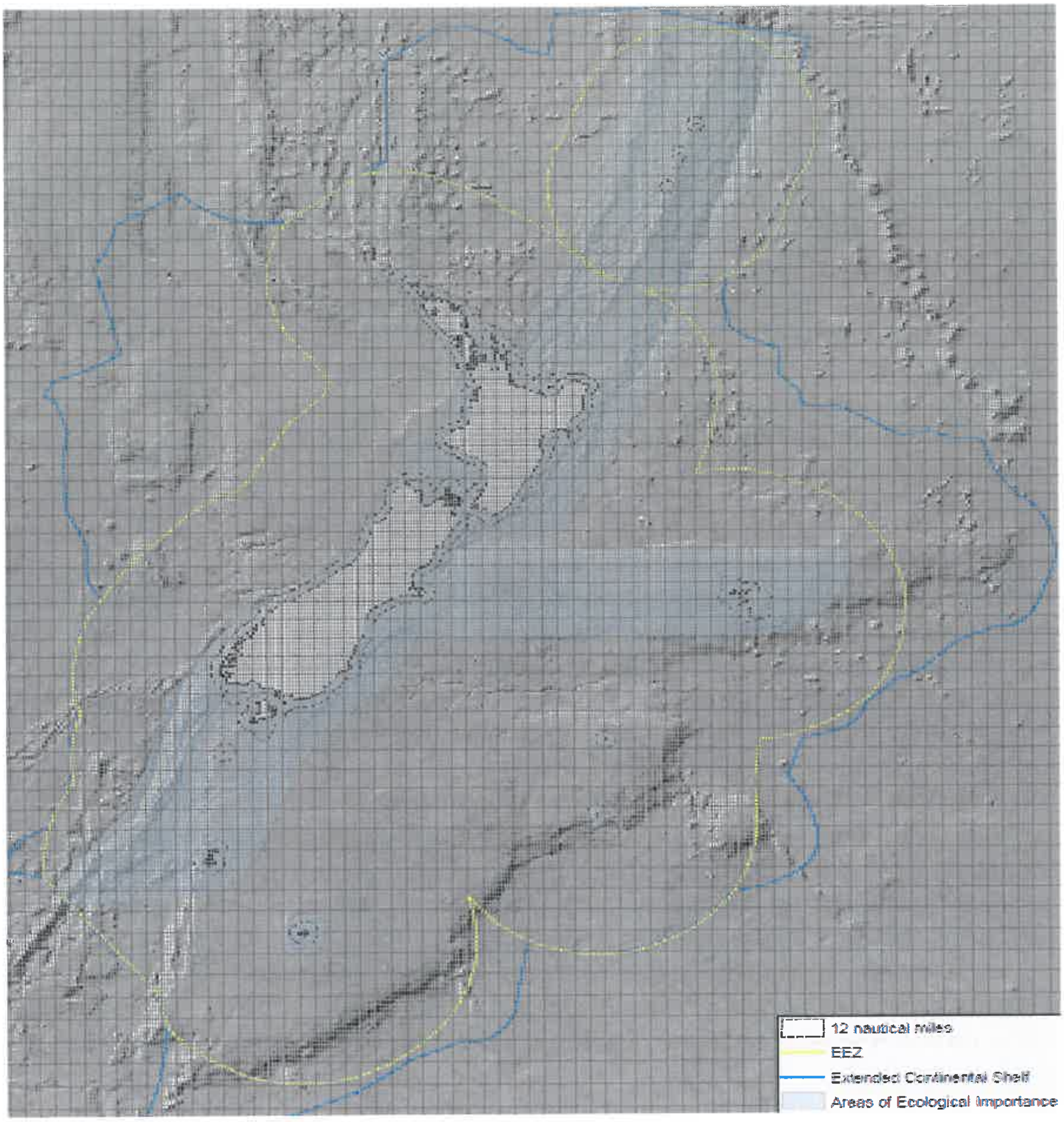

Figure 5.10 Areas of Ecological Importance for marine mammals (source: DOC, 2015h)

5.6 The Biological Environment

Under the New Zealand Marine Environmental Classification (NZMEC) system, the Chatham Rise is listed primarily as a Class 63 habitat while deep surrounding habitats are listed as Class 47, both under the 'Oceanic, shelf and subtropical front environment':

- **Class 63:** "is extensive on the continental shelf including much of the Challenger Plateau and the Chatham Rise. Water are of moderate depth (mean = 754 m) and have moderate annual radiation and moderate wintertime sea surface temperature (SST). Average *chlorophyll a* concentrations are also very moderate. Characteristic fish species (29 sites) include orange roughy, Johnson's cod, Baxter's lantern dogfish, hoki, smooth oreo and javelin fish. The most commonly represented benthic invertebrate families (14 sites) are *Carditidae, Pectinidae, Dentaliidae, Veneridaem Cardiidae, Serpulidae* and *Limidae*" (Snelder *et al.*, 2005).

- **Class 47:** "occurs extensively in deep waters (mean = 2998 m) over a latitudinal range from around 37-47° S. Average *chlorophyll a* concentrations are moderately low. Characteristic fish species (24 sites) include smooth oreo, Baxter's lantern dogfish, the rattail *Macrousus carinatus*, Johnson's cod and orange roughy" (Snelder *et al.*, 2005).

Primary production over the Chatham Rise is higher than to the north and south of the Rise (Hadfield *et al.*, 2007). The phytoplankton assemblages around the Chatham Rise during both winter and spring include a number of common species found around New Zealand. During both seasons, 13 common diatom taxa have been recorded including *Lauderia annulata, Stephanophyxis* spp., *Thalassiosira* spp., *Chaetoceros* spp., *Nitszchia/Pseudo-nitzschia* spp. and *Hemiaulus* sp. In winter there is a greater diversity of dinoflagellates taxa than in spring and a number of nanoflagellate taxa are common during both seasons (Chang & Gall, 1998). The Chatham Rise supports large blooms of phytoplankton during spring and summer due to vertical mixing between the sub tropical and sub Antarctic currents that occur over the Rise.

The macro-benthic fauna on the Chatham Rise is reasonably well known and comprises a fairly normal quota of mobile epifaunal and infaunal species (Dawson, 1984). A study by McKnight and Probert (1997) described three main epibenthic communities on the Chatham Rise: the shallowest characterised mainly by crustaceans, and two deeper water communities, mainly characterised by echinoderms. The first community is found within predominantly sandy sediments on the crest and shallower flanks of the Chatham Rise between 237 and 606 m. Species within this community include a number of crustaceans such as squat lobsters (*Munida gracilis, Phylladiorhynchus pusillis*), Sabre prawn (*Camplyonotus rathbunae*), *Pontophilus acutirostris* and *Acutiserolis bromleyana*; echinoderms such as *Amphiura lanceolata* (Ophiuroidea), and a number of bivalve species (*Cuspidaria fairchildi, Euciroa galathea*). The second community is associated with muddy sediments at 462 – 1, 693 m and includes holothurians (*Ypsilothuria bitentaculata, Pentadactyla longidentis*) echinoidea (*Brissopsis oldhami*) and ophiuroideans (*Amphiophiura ornata*). The third community, found on muddy sediments at 799 – 2, 039 m is characterised by ophiuroideans (*Ophiomusium lymani*), Asteroidea (*Porcellanaster ceruleus*), echinoidea (*Gracilechinus multidentatus*) and gastropods (*Aeneator recens*). Dense beds of sponges also exist on the Chatham Rise, and these sponge beds may increase the overall diversity, abundance and productivity of a range of species that associate with them (Morrison, 2009). The presence of *Acesta* spp., the giant limid bivalve, has been recorded on the Chatham Rise area, this species has not been found anywhere else within the New Zealand region.

Over 1,000 species of fish have been recorded in New Zealand waters (Fishbase, 2015). Of these, around 130 are targeted commercially with quotas and management schemes in place for 97 species. The benthic waters are important fisheries for hoki (*Macruronus novaezelandiae*), ling (*Molva molva*), oreo dory (*Allocyttus niger*), orange roughy (*Hoplostethus atlanticus*) and silver warehou (*Seriolella punctata*) (MPI, 2015). As well as being an important fishery, the benthic waters are also the location of multiple chains of seamounts. Seamounts and other deep sea habitats associated with various bathymetric features are generally home to a diverse range of highly specialised, endemic species (Koslow *et al.*, 2000). On the Chatham Rise, the dominant species of fish varies with depth. At 200 - 350 m bottom depth, the dominant species include hoki, dark ghost shark (*Hydrolagus novaezelandiae*), sliver warehou and spiny dogfish. Hoki, Bollons' rattail, ling and javelinfish dominate in both the 350 - 550 m and 550 - 800 m zones. Species richness is highest on the north rise in 550 - 800 m depth (Bull *et al.*, 2001). The seamounts on Chatham Rise provide habitat for one of the most overfished species in New Zealand, the orange roughy. The Chatham Rise also supports other deep water fisheries, including oreo dories and blue grenadier.

5.7 Marine Mammals

New Zealand has an abundance of marine mammals with 41 species of cetacean and nine species of pinniped known to inhabit New Zealand waters (Suisted & Neale, 2004). Of these species, eight are classified as either *Threatened* or *At Risk*, while the majority of marine mammals are classified as *Migrants* or *Vagrants* under the New Zealand Threat Classification List (DOC, 2009).

Due to the complex bathymetry of the Chatham Rise which changes quickly from depths of 200 - 400 m to >2,000 m and the nature of the subtropical convergence, coupled with the continental shelf breaks, the waters surrounding the survey area are highly productive and prime habitat for a range of cetacean species (Heath, 1985; Probert *et al.*, 1997). The available literature shows that at least 25 species of cetacean use the waters around the Chatham Rise as both a general feeding area and as a migratory corridor (Table 5.2). At present, the New Zealand fur seal (*Arctocephalus forsteri*) is the only species of pinniped to be recorded around the Chatham Rise with any regularity, although New Zealand sea lion (*Phocarctos hookeri*), leopard seal (*Hydrurga leptonyx*), southern elephant seal (*Mirounga leonina*) and subantarctic fur seal (*Arctocephalus tropicalis*) are occasional visitors (DOC, 2015e).

The majority of marine mammal species that have been encountered around the Chatham Rise are currently recognised as SoC (Table 5.2) by the New Zealand DOC. This status is assigned to the species deemed to be most sensitive to acoustic disturbance.

Table 5.2 Marine mammals recorded in the Chatham Rise region

Species Group	Common Name	Scientific Name	NZ Threat Classification	Species of Concern
Baleen whales	**Humpback whale**	*Megaptera novaeangliae*	Migrant	Yes
	Blue whale sp.	*Balaenoptera musculus*	Migrant	Yes
	Antarctic minke whale	*Balaenoptera bonaerensis*	Migrant	Yes
	Fin whale	*Balaenoptera physalus*	Migrant	Yes
	Sei whale	*Balaenoptera borealis*	Migrant	Yes
	Southern right whale	*Eubalaena australis*	Nationally Endangered	Yes
	Pygmy right whale	*Caperea marginata*	Data Deficient	Yes
	Sperm whale	*Physeter macrocephalus*	Migrant	Yes
	Pygmy sperm whale	*Kogia breviceps*	Data Deficient	Yes
	Killer whale	*Orcinus orca*	Nationally Critical[1]	Yes

[1] Nationally Critical status is assigned to Type A killer whales which are New Zealand residents. Other types also occur in New Zealand waters and are considered Vagrant.

Toothed whales and dolphins	**False killer whale**	*Pseudorca crassidens*	Not Threatened	Yes
	Long-finned pilot whale	*Globicephala melas*	Not Threatened	Yes
	Short-beaked common dolphin	*Delphinus delphis*	Not Threatened	No
	Bottlenose dolphin	*Tursiops truncatus*	Nationally Endangered	Yes
	Dusky dolphin	*Lagenorhynchus obscurus*	Not Threatened	No
	Risso's dolphin	*Grampus griseus*	Vagrant	No
	Hourglass dolphin	*Lagenorhynchus cruciger*	Vagrant	No
	Southern right whale Dolphin	*Lissodelphis peronii*	Not Threatened	Yes
	Andrew's beaked whale	*Mesoplodon bowdoini*	Data Deficient	Yes
	Arnoux's beaked whale	*Berardius arnuxii*	Vagrant	Yes
	Cuvier's beaked whale	*Ziphius cavirostris*	Data Deficient	Yes
	Gray's beaked whale	*Mesoplodon grayi*	Data Deficient	Yes
	Shepherd's beaked whale	*Tasmacetus shepherdi*	Data Deficient	Yes
	Southern bottlenose whale	*Hyperoodon planifrons*	Data Deficient	Yes
	Spade-toothed beaked whale	*Mesoplodon traversii*	Data Deficient	Yes
	Strap-toothed beaked whale	*Mesoplodon layardii*	Data Deficient	Yes
	Hector's beaked whale	*Mesoplodon hectori*	Data Deficient	Yes
Seals	**New Zealand fur seal**	*Arctocephalus forsteri*	Not Threatened	No

The available literature has been consulted to assess the likeliness of the presence of each species in the project area during the proposed survey period (February - March) (Table 5.3). Based on the stranding records (1840 - 2015), at least 19 species have been found stranded on the Chatham Islands indicating a high diversity of species in the area (Figure 5.11). The live sightings data for the area is pretty scarce, but the DOC sighting database indicates presence of at least six different species around the Chatham Islands.

Overall, the most common odontocete species seem to be the sperm whale and long-finned pilot whale. Sperm whales were seen to be present throughout the year, except for winter, while pilot whales show no seasonal patterns (Torres *et al.*, 2013). It is also worth noting that the nationally critically endangered killer whale has been occasionally recorded in the waters surrounding the Chatham Rise, although there appears to be no seasonality with these sightings (Torres *et al.*, 2013). Furthermore, the three most commonly seen *Delphinidae* species in

New Zealand - dusky dolphin, common dolphin and bottlenose dolphin - periodically strand on the Chatham Islands, indicating their presence in the area.

Two species of baleen whales migrate across the Chatham Rise on their way to/from feeding grounds in Antarctica. Although the migratory path of humpback whales takes them across the Chatham Rise (Bott, 2013; Constantine, pers.comm.) the migratory period (May - August and September - December) does not overlap with the proposed survey timings. Southern right whales also have a strong migratory cycle and Richards (2002) has hypothesized that the historical route taken by this species would follow a clockwise pattern around the Chatham Rise passing through from/to their breeding grounds. Also, it is believed that southern right whales congregate along the southern edge of the Chatham Rise during summer and autumn to forage along the Subtropical Front that converges in this area (Torres *et al.*, 2013).

Deep canyons and trenches that occur along the outer edge of the Chatham Rise are ideal habitat for beaked whales (Wimmer, 2003). Little is known about this elusive group of cetaceans, with the majority of information acquired through stranding records and opportunistic sightings (Brabyn, 1991; Torres *et al.*, 2013). At least eight different species of beaked whales have been found stranded on the Chatham Islands indicating their significant presence in the deep waters surrounding the Chatham Rise (Brabyn, 1991; Pitman *et al.*, 2006; DOC, 2015b).

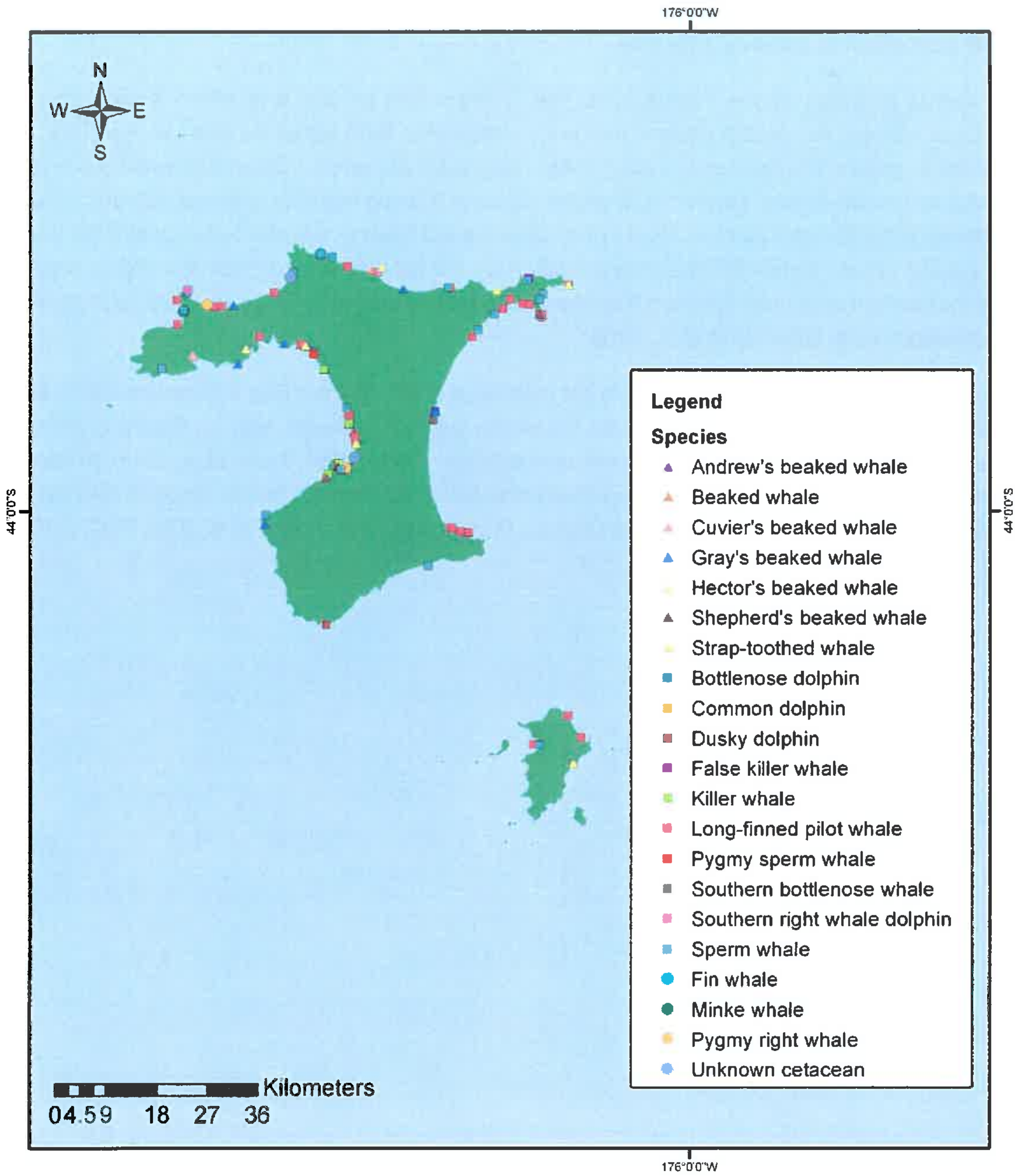

Figure 5.11 Map indicating stranding locations and species on the Chatham Islands (source: Department of Conservation, NZ)

Table 5.3 The likelihood of species presence in the survey area during February and March

Common name	Local distribution	Likelihood of being seen in the survey area
Humpback whale	Humpback whales follow the eastern coastline of New Zealand as they head to their northern breeding grounds. This migration typically occurs between May and August (Gibbs & Childerhouse, 2000). Recent research also revealed that they pass near the Chatham Islands on their way to Antractic feeding grounds during the southern migratory period between September and December (Constantine, pers.comm.). Therefore due to the timing of the survey (February - March) it is unlikely that they will be seen during either their northerly or southerly migratory periods.	Unlikely
Blue whale sp.	Blue whales occur in New Zealand waters either by passing through on annual migrations or using the waters as foraging grounds i.e. South Taranki Bight (Torres *et al.*, 2013). Antarctic (or true) blue whales migrate to the Antarctic oceans during summer months but their distribution outside of this period is largely unknown. Pygmy blue whales do not migrate south to Antarctica to feed but stay in more northern waters. There is one record of a live blue whale sighting east of Chatham Rise in January 2013 (DOC, 2015a). Besides this, there is no other evidence of blue whale presence in the area at the time of the survey hence their sightings are considered to be less likely.	Less likely
Antarctic minke whale	Antarctic minke whales have a broad distribution. They are primarily an oceanic species, sighted beyond the continental shelf break (Perrin *et al.*, 2002). It is generally considered that they are most abundant south of 60° S during summer occurring in greatest densities near the ice edge. Their migration patterns are poorly known (Reilly, 2008a) but they have been sighted previously near the survey area (Torres *et al.*, 2013) and one stranding event has been recorded on Chatham Island (DOC, 2015b). Therefore they could potentially be sighted in the survey area when they leave summer feeding grounds in Antarctica.	Likely

Fin whale	The southern hemisphere fin whales spend the summer months mostly in middle latitudes, mainly between 40° and 60° S (Reilly *et al.*, 2013a). Their main migration period is between May and December when they show preferences for deeper offshore, oceanic waters (Shirhai & Cox, 2002). Two stranding events have been recorded on the Chatham Islands (DOC, 2015b) in the months of January and February. Given the location of the proposed survey, which overlaps with their broad summer distribution, there is a chance they could occur within the deeper, offshore part of the survey site however the survey will take place outside their main migration period when their densities around New Zealand seem to be the highest (McDonald, 2006).	Less likely
Sei whale	Sei whales are primarily recorded in deeper, offshore waters during their seasonal migration. Sei whales migrate south to Antarctic feeding grounds around May - July and although they travel between New Zealand and the Chatham Islands (Hutching, 2012), their migration period does not coincide with the timing of this survey. Their summer (January - February) distribution is mainly in the zone 40 - 50° S (Reilly *et al.*, 2008b) so they could potentially be sighted during the survey.	Likely
Southern right whale	Southern right whales have been found to congregate along the southern edge of the Chatham Rise during summer and autumn to forage along the Subtropical Front that converges in this area (Torres *et al.*, 2013). Additionally, historical whaling records suggest the Chatham Rise was their traditional feeding ground (Townsend, 1935) and although the population is now small, it is still likely that this species will be seen during the survey.	Likely
Pygmy right whale	Rarely sighted cetacean inhabiting offshore waters of the southern hemisphere. The bulk of recorded sightings are from south Australia, Tasmania and New Zealand (Matsuoka *et al.*, 2005; Gill *et al.*, 2008). Believed to breed in the waters around New Zealand, but distribution records are sparse. Two stranding events have been recorded on the Chatham Island in the month of January and August (DOC, 2015b). Given their preferences for offshore waters, this species might be encountered in the deeper, offshore part of the survey area.	Likely
Sperm whale	The northern and southern slopes of the Chatham Rise are optimal habitat for sperm whale prey hence they are frequently recorded in this area throughout the year (Torres *et al.*, 2013). There are also multiple records of this species standing on the Islands as well as sightings off the Chatham Rise (DOC, 2015a, 2015b). Therefore they are likely to be seen during the survey.	Likely

Pygmy sperm whale	Due to the high number of strandings reported in New Zealand (Baker, 1972; Brabyn, 1991), pygmy sperm whales are considered abundant in the waters offshore of the east coast of the North Island (DOC, 2009). It is believed that this species breeds in New Zealand waters (DOC, 2009) and general distribution range includes waters around the Chatham Islands (IUCN, 2015).	Likely
Killer whale	According to Visser (2000) there could be three sub-populations of resident killer whales in New Zealand with the Antarctic type also visiting New Zealand waters (Visser, 1999). Their distribution range includes the Chatham Rise (NABIS, 2015) and they have been previously recorded in the area (Torres *et al.*, 2013; DOC, 2015a). Therefore there is a good likelihood that killer whales will be seen during the survey.	Likely
False killer whale	False killer whales are often found in oceanic waters and sometimes near oceanic islands (Baird *et al.*, 2010) such as the Chatham Islands. They might also be calving in New Zealand waters (DOC, 2009). Multiple stranding events have been recorded on the islands (DOC, 2015b). Therefore it is likely that this species will be present in the survey area.	Likely
Long-finned pilot whale	Their preferred habitat of steep oceanographic features, slopes and areas of high topographic relief are characteristic of the survey area. Additionally there have been a number of strandings and sightings of long-finned pilot whales recorded around the Chatham Islands (DOC, 2015a, 2015b), indicating their presence in this area. Therefore it is likely that long-finned pilot whales will be present.	Likely
Short-beaked common dolphin	This species is one of the most abundant around New Zealand. Their distribution range encompasses most of the North Island, South Island, as well as Stewart Island and Chatham Island coastlines (NABIS, 2015). A number of sightings of common dolphin have been recorded over the Chatham Rise region and around the Chatham Islands (Torres *et al.*, 2013) and additionally a number of strandings have been reported on the Chatham Islands, indicating their presence in the area. Also, during the austral autumn and winter (March to September) they tend to go further offshore (Neumann, 2001), therefore it is likely they will be present within the survey area.	Likely
Bottlenose dolphin	Bottlenose dolphins, most likely the offshore ecotype, have been previously observed in the waters over the Chatham Rise region (Torres *et al.*, 2013; DOC, 2015a). Therefore they could be observed during the survey.	Likely

Dusky dolphin	Although they are most frequently sighted along the east coast of the South Island, sightings have been recorded around the Chatham Islands and a number of strandings have also been reported in this area (DOC, 2015a, 2015b). Their distribution range is thought to include the Chatham Islands (NABIS, 2015).	Likely
Risso's dolphin	There are very few records of sightings or strandings of Risso's dolphin in New Zealand. However, they might be seen in the survey area in parts that match their general habitat preferences of deep water (400-1,000 m) with steep bottom topography (Jefferson *et al.*, 1993).	Less likely
Hourglass dolphin	Hourglass dolphins are distributed in a circumpolar pattern in the higher latitudes of the southern ocean with their range reaching the ice-edge in the south (Hammond *et al.*, 2008). Very few records exist in New Zealand waters, however one individual stranded on Banks Peninsula in 2010 (Luscombe, 2010). Therefore they are less likely to be sighted in the survey area.	Less likely
Southern right whale dolphin	Southern right whale dolphins are typically found in cool temperate to subantarctic waters of the Southern Hemisphere, mostly between 30 and 65° S (Hammond *et al.*, 2012). They prefer to dwell in deep offshore waters but can occasionally be seen nearshore where deep water approaches the coast. They have been previously recorded on the east coast of the South Island in large numbers (DOC, 2009) therefore they could potentially be seen in the survey area.	Less likely
Andrew's beaked whale	The majority of strandings recorded for this species occurred in New Zealand (Baker, 2001), which suggests this area has the highest concentration of Andrew's beaked whales. Several stranding events have been previously recorded on the Chatham Islands (DOC, 2015b). They inhabit deep waters and feed primarily on cephalopods (Taylor *et al.*, 2008a). Andrew's beaked whales are likely to be present during the survey due to seabed topography of the survey area.	Likely
Arnoux's beaked whale	Arnoux's beaked whales are most commonly sighted in the Tasman Sea, Cook Strait and South Island with some on the North Island (Brabyn, 1991). They tend to prefer areas with steep-bottomed slopes beyond the continental shelf edge (Taylor *et al.*, 2008b). As these features are present in the survey area, Arnoux's beaked whales may be present however previous sightings of this species in this area are limited.	Less likely
Cuvier's beaked whale	Both sightings and strandings are known to occur around the South Island of New Zealand and the Chatham Islands (Taylor *et al.*, 2008c). Cuvier's beaked whales are likely to be encountered during the survey due to the seabed topography of the survey area.	Likely

Gray's beaked whale	Many strandings of this species have been recorded in New Zealand including the Chatham Islands. There is also a suggested hot spot for sightings east of New Zealand, between the South Island and the Chatham Islands (Dalebout *et al.*, 2004). Additionally, they are usually found in deep water near the edge of the continental shelf (Taylor *et al.*, 2008d) therefore they are likely to be observed during the survey.	Likely
Shepherd's beaked whale	Shepherd's beaked whales are primarily known from stranding data, most of which has been recorded in New Zealand (including Chatham Islands). It is assumed that they have circumpolar distributing inhabiting offshore cold temperate waters of the Southern Hemisphere (Taylor *et al.*, 2008e). They are thought to feed on deep water species and are likely to be present due to the seabed topography of the survey area.	Likely
Southern bottlenose whale	They inhabit deep waters south of 30°S but primarily between 57°S and 70°S (Jefferson *et al.*, 1993; Taylor *et al.*, 2008f).They are found in Antarctic waters during the summer when this species is most frequently seen within about 100 km of the Antarctic ice edge (Carwardine, 1995). There is a suggestion that they show strong seasonality, moving northward out of the Antarctic in late summer (Van Waerebeek *et al.*, 2004). The survey area seems to be outside of their main summer range, however there is still a possibility to encounter animals that are moving northwards in later summer.	Less likely
Spade-toothed whale	This is a poorly known species with only a handful of strandings recorded including one on the Chatham Islands (Taylor *et al.*, 2008g). Spade-toothed whales may be present in the survey area but data to support this is very limited.	Likely
Strap-toothed whale	It is the most common species of *Mesoplodon* in the southern hemisphere with reported strandings in New Zealand and on the Chatham Islands (DOC, 2015b). Their distribution range includes the region of the Chatham Rise (Taylor *et al.*, 2008h).They are known to inhabit deep waters similar to the one found in the survey area. Therefore they are likely to be present in the survey area while the survey is being conducted.	Likely
Hector's beaked whale	Hector's beaked whale is considered a southern hemisphere, cool temperate species (Taylor *et al.*, 2008i). It has been speculated that the species has a continuous distribution in the Atlantic and Indian oceans at least from South America to New Zealand. It is presumed to inhabit deep offshore waters and feed on squid, similar to other beaked whale species. There is a stranding record from the Chatham Island (DOC, 2015b) hence it is a possibility of encountering this species during the survey.	Likely

New Zealand fur seal	They have numerous breeding colonies on the Chatham Islands and the coast of South Island, and will often forage up to 200 km beyond the continental slope. Therefore they are likely to be seen during the survey.	Likely

5.7.1 Baleen Whales (*Mysticetes*)

There are ten species of baleen whale which have been recorded in the waters around New Zealand. Of these, four are classified as Endangered by the IUCN (IUCN, 2015); these are the sei, blue, fin and humpback whale (Oceania subpopulations). However, two further species are listed on the New Zealand Threat Classification list: the Bryde's whale, which is Nationally Critical, and the southern right whale which is Nationally Endangered.

Every year, most of these species undertake extensive migrations to and from their feeding/breeding grounds. Their spring migration takes them from the Pacific islands to the Antarctic Ocean to feed, returning to the Pacific islands to breed during the autumn/winter (May - July) migration (DOC, 2007). The majority of baleen whales are observed in offshore waters (Torres, 2012) except southern right whales which tend to come close inshore to mate and calve during winter and spring. The Chatham Rise region has previously been shown to be part of the migration corridor for a range of baleen whale species and six of the ten species of baleen whale have been recorded in this region. Further information on individual species is provided below.

Humpback whale *(Megaptera novaeangliae)*

Humpback whales are a migrant species in New Zealand and are sighted along the coast on both stages of their migration (Rasmussen *et al.*, 2007). In the summer months, each individual feeds on 390 – 840 kg of krill and small schooling fish per day (Reilly *et al.*, 2004). To reach this total they employ a diverse range of feeding techniques which include lunging, stunning prey with flippers and forming "bubble-nets" (Fleming & Jackson, 2011). Once they have acquired sufficient fat reserves they leave the Antarctic waters and then head north towards their calving grounds in the subtropical south Pacific (Garrigue *et al.*, 2007; Constantine *et al.*, 2007).

The migration corridor that the humpback whales follow on their northern migration travels past the east coast of the South Island and then either past the east coast of the North Island or through the Cook Strait and north along the west coast of the North Island. There are a rising number of individuals who pass through the Cook Strait (Bott, 2013). The northern leg of the journey takes place between May and August, whilst the return journey occurs between September and December (Gibbs & Childerhouse, 2000). The southwards migration takes the humpback predominantly past the west coast of both the North and South Islands, before they disperse back into their Antarctic feeding grounds (Dawbin, 1956). However recent research has shown that some whales do pass close to the Chatham Islands and along the Eastern Chatham Rise during their southwards migration (Constantine, pers.comm.) (Figure 5.12).

Commercial whaling operations limited the number of humpback whales in the southern hemisphere from 120,000 animals to around 15,000 individuals today (Suisted & Neale, 2004). The remaining population is split into separate stocks for easier management: New Zealand waters host migrants residing in the southwest Pacific stock (Group V) category (Suisted & Neale, 2004). Recent research indicates that humpback whales migrating through New Zealand waters form part of the eastern Australia breeding stock (Franklin *et al.*, 2014) and the New Caledonia/Tonga breeding population (Constantine *et al.*, 2007). Franklin *et al.* (2014) indicates that humpback whales migrating through the Cook Strait show site-fidelity to eastern Australia, while whales re-sighted in Caledonia and Tonga migrate north along the eastern coast of the North Island (Constantine *et al.*, 2007). The South Pacific Whale Research Consortium (SPWRC) (2008) provided a preliminary estimate of the Oceania breeding population of 3,827 for 1999 - 2004. While Noad *et al.* (2006) estimated the eastern Australia population as 7,090 individuals for 2004. The IUCN has the Oceania subpopulation recorded as Endangered (IUCN, 2015).

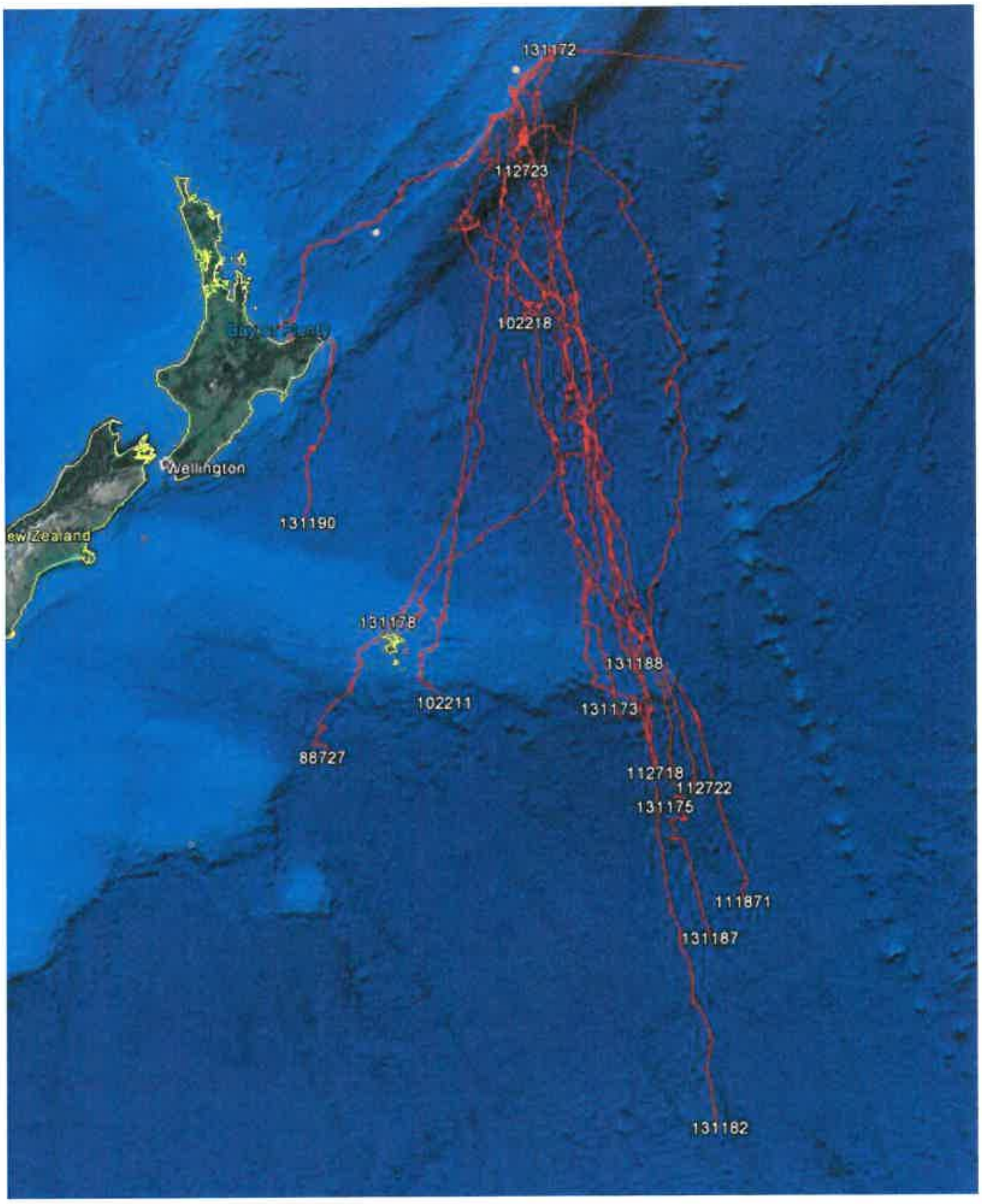

Figure 5.12 Map indicating the migratory path of 15 tagged humpback whales from Raoul Island to Antarctica (source: R. Constantine)

Blue whale sp. *(Balaenoptera musculus sp.)*

Blue whale presence and abundance has been reported in New Zealand (Torres, 2013; Miller *et al.*, 2013), and two subspecies are confirmed to occur: the Antarctic blue whale (*Balaenoptera musculus intermedia*) and the pygmy blue whale (*Balaenoptera musculus brevicauda*). Furthermore, there is evidence suggesting the presence of a separate New Zealand type (McDonald, 2006; Miller *et al.*, 2014; Olson *et al.*, 2013). Seasonal patterns and habitat use have not been established however, partly because of the difficulty separating the different subspecies of blue whale in the field (Branch *et al.*, 2007; Torres, 2013; Olson *et al.*, 2013). The diagnostic features that separate the subspecies are minimal and so genetic or acoustic data is the only practical way to distinguish individuals at a subspecies level (Conway, 2006; Samaran *et al.*, 2010).

Blue whale presence in New Zealand waters has usually been linked to migration between the summer feeding grounds in the Antarctic and equatorial waters where they spend the winter, but recent studies have shown the existence of feeding grounds in the South Taranaki Bight (Torres, 2013). Blue whales have been recorded occasionally in the west region of the Chatham Rise, close to the South Island coastline (Torres *et al.*, 2013).

Currently, the blue whale is classified as a migrant under the New Zealand Threat Classification System, which means they are not awarded the same level of conservation protection as other large baleen whales that use the coastal waters around New Zealand, such as the southern right whale. With regards to their IUCN status, the Antarctic blue whale is classified as Critically Endangered and the pygmy blue whale as Data Deficient (IUCN, 2015).

Antarctic minke whale (*Balaenoptera bonaerensis*)

Antarctic minke whales have a circumpolar distribution throughout the southern hemisphere, where they generally occur at lower latitudes and are more abundant than the sympatric dwarf minke whale. In summer they are abundant south of 60° S (Reilly *et al.*, 2008a) where they predominantly feed on Euphausiids (Perrin *et al.*, 2002). In the Austral winter they are found in their breeding grounds between 10° S - 30° S (Siebert *et al.*, 2014), although an unknown proportion of the population remains in Antarctic waters during the winter (Mead & Brownell Jr., 2005). Their migration patterns are poorly known (Reilly *et al.*, 2008a) but they have been previously recorded near the survey area. Namely, Torres *et al.* (2013) recorded four sightings during spring, summer and winter over the Chatham Rise and Chatham Islands coast.

The overall population size of the Antarctic minke whale is difficult to distinguish. Up until the 1990s, only a single species of minke whale (the northern minke whale (*Balaenoptera acutorostrata*)) was recognised, so analysing historical distribution records to a species level is troublesome (Reilly *et al.*, 2008a). The most recent abundance estimates come from three circumantarctic surveys estimating the population size to be 574,000 (Bravington & Hedley, 2012).

In the field it is difficult to identify the diagnostic features that separate Antarctic minke whale and the sympatric dwarf minke whale, leading to a large number of 'unidentified' individuals (Acevedo *et al.*, 2011). It is therefore unsurprising that the IUCN has them categorised as Data Deficient (IUCN, 2015).

Fin whale (*Balaenoptera physalus*)

Fin whales have a global distribution, with two genetically isolated populations recognised in each hemisphere (Aguilar, 2002). They are currently recognized as an Endangered species by the IUCN (IUCN, 2015). Fin whales are typically found in deep offshore, oceanic waters (Shirihai & Cox, 2002), and they undertake extensive migrations between summer feeding and winter breeding grounds (Aguilar, 2002). Their summer distribution in the southern hemisphere is associated with the mid-latitudes between 40° S and 60° S (Reilly *et al.*, 2013a). Their winter distribution is less well known, although is likely to reach southern Africa and South America (Reilly *et al.*, 2013b). New Zealand is one of the aggregation areas for fin whales in the southern hemisphere but they favour offshore waters (Gambell, 1985). They have a seasonal presence in New Zealand waters, travelling through during their migration, and tending to remain at or beyond the continental shelf edge (McDonald, 2006). McDonald (2006) recorded acoustic activity of whales in northern New Zealand and found that fin whales had a peak calling density between May and December, coinciding with their migration. Fin whale diet does overlap with that of blue whales (Aguilar, 2002), and it is possible that fin whales use the area as a foraging ground similar to blue whales.

Sei whale (*Balaenoptera borealis*)

Sei whales are distributed throughout the southern hemisphere with their summer distribution predominantly between 40° S and 50° S (Myashita *et al.*, 1996). Known wintering grounds include areas off South America and southern Africa (Horwood, 2002). They follow a seasonal migration of tropical/sub-tropical latitudes in winter and sub-polar latitudes in summer (Reilly *et al.*, 2008b) with suggestions that some animals pass between New Zealand and the Chatham Islands (Hutching, 2012). Sei whales have been recorded in New Zealand, primarily in deeper, offshore waters (Shirihai & Cox, 2002; Horwood, 2002) with one sighting recorded around the Chatham Islands during the summer months (Torres *et al.*, 2013). Important areas in New Zealand for this species, similar to the other baleen whales, include the waters off Kaikoura, Cook Strait and off the west coast of South Island during migration (mainly May - July and November – December). There is overlap with the diet of fin and blue whales (Horwood, 2002), therefore it is possible that this species could use the same areas as a foraging ground. Sei whales are listed as Endangered by the IUCN (2015).

Southern right whale (*Eubalaena australis*)

This species is a native migrant to New Zealand and has a circumpolar distribution typically between 20° S and 55° S (DOC, 2015k). The IWC (2001) recognises seven winter calving grounds in the South Pacific/Indian Ocean basin including New Zealand mainland/Kermadec and New Zealand subantarctic. During the breeding season (May to September), they are recorded mostly in the waters around the subantarctic Auckland and Campbell Islands but are occasionally sighted around mainland New Zealand (DOC, 2015k). Recently they have been shown to be expanding their breeding range with recent sightings in Fjordland, Te Waewae Bay, in Otago and Wellington harbours and along the Kapiti Coast (Torres *et al.*, 2013). Outside of the winter calving season, southern right whales remain in offshore waters to forage. Their summer feeding grounds are not known with certainty but are thought to be linked to the distribution of their prey species (NOAA, 2012). Historical whaling records suggest summer feeding grounds off the Chatham Rise (Townsend, 1935). Figure 5.13 shows expected distribution of this species in New Zealand (NABIS, 2015).

Seasonal predictions of southern right whale distribution in the New Zealand region, based on habitat models of historical whaling data, include the Chatham Rise area (Torres *et al.*, 2011). It is thought that they do congregate along the southern edge of the Chatham Rise during summer and autumn, where they forage on copepod prey that aggregate here as a function of the Subtropical Front (Torres *et al.*, 2013). One sighting of southern right whale was recorded by Torres *et al.* (2013) in the Chatham Rise area. The lack of sightings could be due to the fact that the population size is small and therefore sightings are rare and also no dedicated survey effort has been conducted in the area.

The southern right whale is listed as Least Concern by IUCN (2015) as the species has shown evidence of a strong recovery (Reilly *et al.*, 2013b), although some breeding populations are still quite small. Despite 65 years of protection, southern right whales in New Zealand waters still number less than 5% of their historical abundance (Patenaude, 2003) and hence are considered nationally endangered.

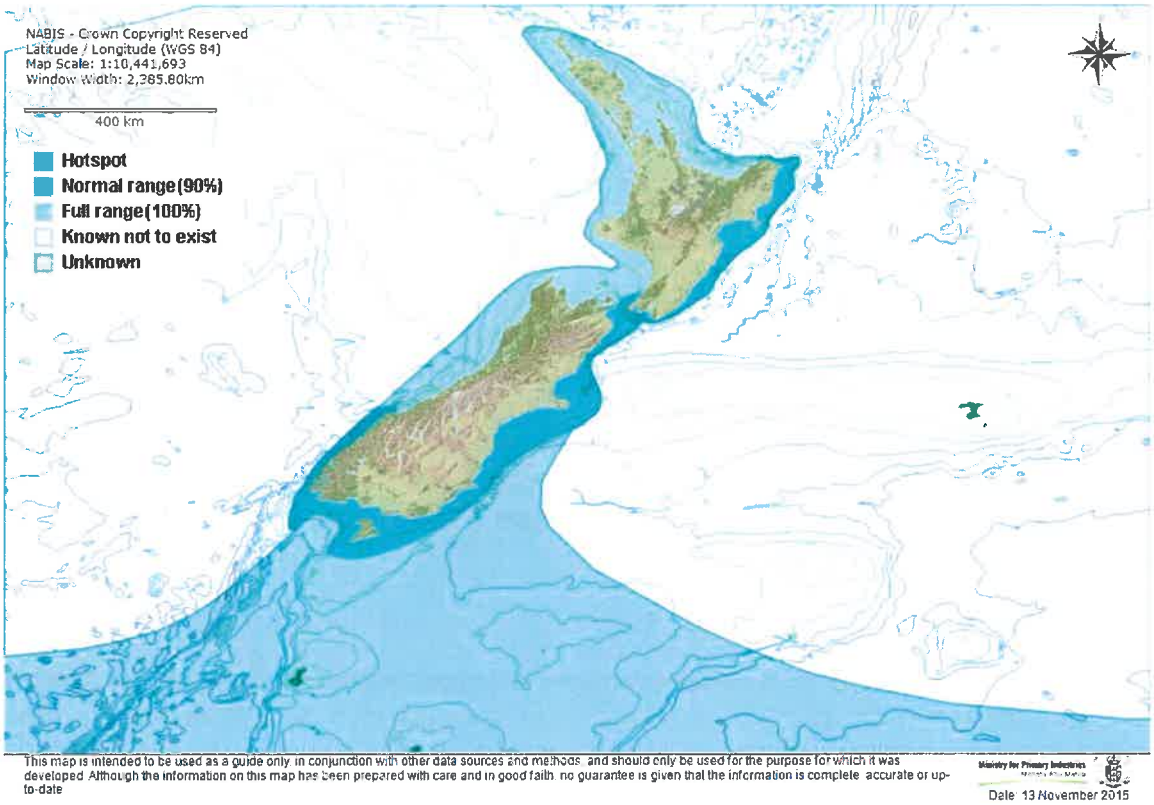

Figure 5.13 Southern right whale distribution in New Zealand waters (source: NABIS, 2015)

Pygmy right whale (*Caperea marginata*)

The pygmy right whale is the smallest of the baleen whales (Kemper, 2002). The majority of research associated with pygmy right whales is aiming to decipher their phylogenetic routes and place them into a broader evolutionary context, as they are thought to be the sole surviving species of an extinct clade of whales (the *Cetotheres*) (Fordyce & Marx, 2012). These whales inhabit offshore water of the southern hemisphere having probably a circumpolar distribution in temperate waters between 30° S and 55° S (Hoffmann and Best 2005). Of the limited sightings most have occurred in South Australia, Tasmania and New Zealand (Matsuoka *et al.*, 2005; Gill *et al.*, 2008). A single sighting of 80 pygmy right whales accounting for nearly half the live records of this species (Matsuoka *et al.*, 1996) while a group of 14 individuals was sighted at 46° S southeast of New Zealand Matsuoka *et al.*, 2005). Also two stranding records exist for the Chatham Islands (DOC, 2015b). At a national, regional and international level the species remains 'Data Deficient' (Reilly *et al.*, 2008c).

5.7.2 Toothed Whales and Dolphins (*Odontocetes*)

Over 20 species of odontocetes have been recorded in the waters of New Zealand, five of which are considered resident: the short-beaked common dolphin, bottlenose dolphin, dusky dolphin, killer whale and Hector's dolphin, including a sub-species of the Hector's dolphin known as Maui dolphins. The majority of these species have been recorded in the waters of the Chatham Rise and Chatham Islands.

Sperm whale *(Physeter macrocephalus)*

Sperm whales are a cosmopolitan species usually encountered in deep waters near the continental shelf break or near deep canyons as these habitats are productive for foraging on squid (Torres, 2012). They can dive for over an hour and during those deep dives they heavily rely on acoustic senses to navigate, communicate and target prey (Whitehead, 2002). Sperm whales have distinct distributions depending on the sexes. Females prefer waters over 1000 m, over 15°C at latitudes between 40°N and S (except in the North Pacific where their range has been recorded to 50°N). Young male sperm whales remain with the females in tropical and sub-tropical waters until they are 4 - 21 years when they then migrate to higher latitudes. Males gradually become more solitary, with the largest males inhabiting highest latitudes (Whitehead, 2002).

Sperm whales have been documented year round on the Chatham Rise (Berzin, 1971; Gaskin, 1973). They are known to concentrate in deep water habitats near steep continental shelves (Berzin, 1971; Clarke, 1996) such as the northern and southern slopes of the Chatham Rise. Additionally the Chatham Rise has a steep temperature gradient as the Subtropical Front flows along the southern edge acting as a boundary between warm (sub-tropical) and cold (sub-Antarctic) water masses, creating optimal habitat conditions for their main prey, cephalopods (Berzin, 1971). Seasonal predictive maps created by Torres *et al.* (2011) indicate the relatively high presence of sperm whales over the Chatham Rise in all seasons except winter. A comparison of two datasets of marine mammal sightings between 1981 and 2007 within the Chatham Rise area showed that sperm whales were one of the most frequently recorded species (Torres *et al.*, 2013) and although there was a peak of sightings during the summer months, they were seen all year round. Furthermore, this species seems to be the one most common species found stranded on the Chatham Islands (DOC, 2015b).

Sperm whales are classified as Vulnerable by the IUCN and are listed as a SoC under the 2013 Code, although they are not regarded as a threatened species in New Zealand (Suisted & Neale, 2004). The sperm whale was historically one of the most heavily exploited species, resulting in population of only around 100,000 at present (Taylor *et al.*, 2008j).

Pygmy sperm whale (*Kogia breviceps*)

Pygmy sperm whales are known to inhabit tropical waters where it is deep, particularly near to the continental slope (Jefferson, 1993; McAlpine, 2002). They are considered Data Deficient by both the IUCN (2015) and New Zealand (Baker *et al.*, 2010). They primarily feed on deep sea cephalopods and occasionally on fish and crustaceans (Jefferson, 1993, Beatson *et al.*, 2007). As an inconspicuous species when surfacing, pygmy sperm whale distribution is poorly known in New Zealand (Suisted and Neale, 2004) with no specific knowledge of their temporal and spatial distribution. Due to the high number of strandings reported in New Zealand (Baker, 1972; Brabyn, 1991), pygmy sperm whales are considered abundant in the waters offshore of the east coast of the North Island (DOC, 2009). It is believed that this species breeds in New Zealand waters (DOC, 2009) and general distribution range includes waters around the Chatham Islands (IUCN, 2015).

Killer whale (*Orcinus orca*)

The killer whale occurs in almost every marine region in both hemispheres, and appears to be most common in near shore, cold temperate to sub-polar regions (Culik, 2011). Studies indicate there are several types of killer whale, with up to five forms reported in the southern hemisphere and five in the northern hemisphere (NOAA Fisheries Service, 2013). Recent genetic studies indicate there may be more than one species of killer whale (Morin *et al.*, 2010). Killer whales are classified as Data Deficient by the IUCN (IUCN, 2015) and Type A killer whales are considered a Nationally Critically Threatened species in New Zealand as this resident population is relatively small consisting of approximately 120 individuals (Suisted & Neale, 2004; Visser, 2000). Type A killer whales are a globally common form however there are indications that there may be three sub-populations based on geographic distribution in New Zealand (North Island only, South Island only and North & South-Island subpopulations) (Visser 2000). In addition there is evidence that Antarctic type killer whales also visit New Zealand waters (Visser, 1999) while type B, C and D individuals have also been recorded (all considered vagrant) in New Zealand waters (Baker *et al.*, 2010). Prey type consists of four main types: rays, sharks, fish and cetaceans, although other prey types including birds and cephalopods are occasionally taken (Visser, 2007).

Due to their flexible foraging strategies and diverse diet, the habitat use patterns can vary between shallow to middle water depths (< 500 m) and benthic and pelagic habitats. It is thought that killer whales may use the Chatham Islands area during the summer months to take advantage of feeding opportunities due to the fur seal breeding season (Torres *et al.*, 2013). A comparison of datasets of cetacean sightings between 1985 and 2003 showed that killer whales were recorded 12 times in the Chatham Rise area and the sightings were spread throughout the year (Torres *et al.*, 2013). Figure 5.14 shows the expected distribution of the species around the waters of New Zealand.

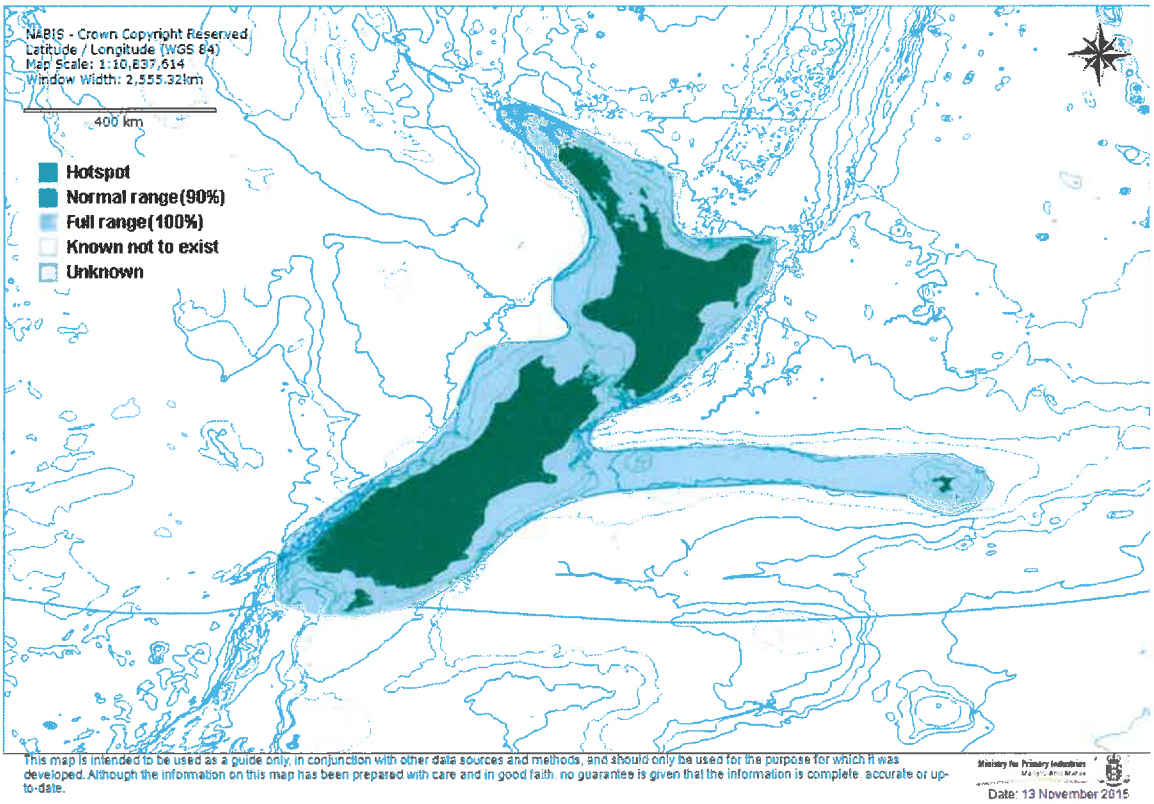

Figure 5.14 Killer whale distribution in New Zealand waters (source: NABIS, 2015)

False killer whale (*Pseudorca crassidens*)

False killer whales dwell in warm-temperate to tropical waters between 50° N and 50° S, usually in deep offshore areas (Jefferson, 1993). Despite their distribution being predominantly oceanic, they are known to approach close to shore at oceanic islands (Baird *et al.*, 2010) and to occasionally venture into shallow inshore water. They are gregarious by nature, travel in relatively large groups (20 - 100 individuals) and are known to form strong social bonds (Baird *et al.*, 2008). They feed primarily on cephalopods which suggests a presence in deep areas. There are also records of attacking small delphinids (Jefferson *et al.*, 1993; Perrin *et al.*, 2002). Being predominantly an oceanic species, their spatial and temporal distributions are poorly known in New Zealand waters. However it has been reported that false killer whales probably calve in New Zealand (DOC, 2009). The occurrence of strandings along the New Zealand coasts, including several on the Chatham Islands, implies a presence in the surrounding waters. A study by Torres *et al.* (2013), found one record of a sighting of false killer whales on the slopes of the Chatham Rise.

Under the IUCN Red List, they are classified as Data Deficient (IUCN, 2015) and in New Zealand they are regarded as Not Threatened (Baker *et al.*, 2010).

Long-finned pilot whale *(Globicephala melas)*

Long-finned pilot whales occur in temperate and sub-polar regions, in oceanic and coastal waters with their distribution reaching as far south in the southern hemisphere as 68° S (Taylor *et al.*, 2008k). Around New Zealand, long-finned pilot whale distribution ranges from Great Barrier Island in the north to the Antarctic Convergence in the south (Rice, 1998). Long-finned pilot whales primarily forage on cephalopods (Beatson *et al.*, 2007), but occasionally feed on small fish (Jefferson *et al.*, 1993). Foraging takes place mostly at night, when dives may last for 18 minutes or more and reach depths of over 800 m (Carwardine, 1995; Heide-Jørgensen *et al.*, 2002). They are mostly nomadic and their movements are considered to be related to the distribution of squid, their preferred prey. This species is also known to calve in New Zealand waters (DOC, 2009). Initial analysis indicates a strong preference for waters above 17 ° C and depths over 100 m (Torres, 2012).

Common habitats of pilot whales are shelf breaks, slope waters and areas of high topographic relief, which are all common features of the Chatham Rise region. In a study by Torres *et al.* (2013), pilot whale sightings were recorded in the waters of the Chatham Rise and Chatham Islands 26 times between 1981 and 2007. Therefore pilot whales are one of the most frequent species seen in this area. Additionally there have been a large number of strandings of pilot whales around New Zealand. Over 25 years, from 1976 – 2000, there have been 29 strandings on the Chatham Islands, including a number of mass strandings (O'Callaghan *et al.*, 2001).

The species is listed as Data Deficient by the IUCN (2015) and as Not Threatened in New Zealand (Baker *et al.*, 2010).

Short-beaked common dolphin (*Delphinus delphis*)

Short-beaked common dolphins are widely distributed in warm temperate and tropical waters of the Atlantic and Pacific Oceans (Culik, 2011). Regarding their distribution in New Zealand, they occur around most of the North Island with an apparently more limited distribution around the South Island (Stockin & Orams, 2009) (Figure 5.15). However their distribution has been found to encompass most of the North Island, South Island, as well as Stewart Island and Chatham Island coastlines (NABIS, 2015). Neumann (2001) reported a seasonal offshore shift in short-beaked common dolphins in New Zealand waters which appears to be correlated with sea surface temperature. During autumn/winter short-beaked common dolphins move further offshore (Neumann, 2001) and tend to be found in larger groups. This is thought to be the result of nutrient upwelling leading to increased prey availability (Stockin *et al.*, 2008).

A number of sightings of common dolphin have been recorded over the Chatham Rise region and around the Chatham Islands (Torres *et al.*, 2013) and additionally a number of strandings have been reported on the Chatham Islands, indicating their presence in the area.

The species is classified as Least Threatened on the IUCN Red List (IUCN, 2015) and Not Threatened in New Zealand (Baker *et al.*, 2010), and in fact the short-beaked common dolphin is one of the most abundant species in New Zealand waters (Baker, 1972; Cawthorn, 2011).

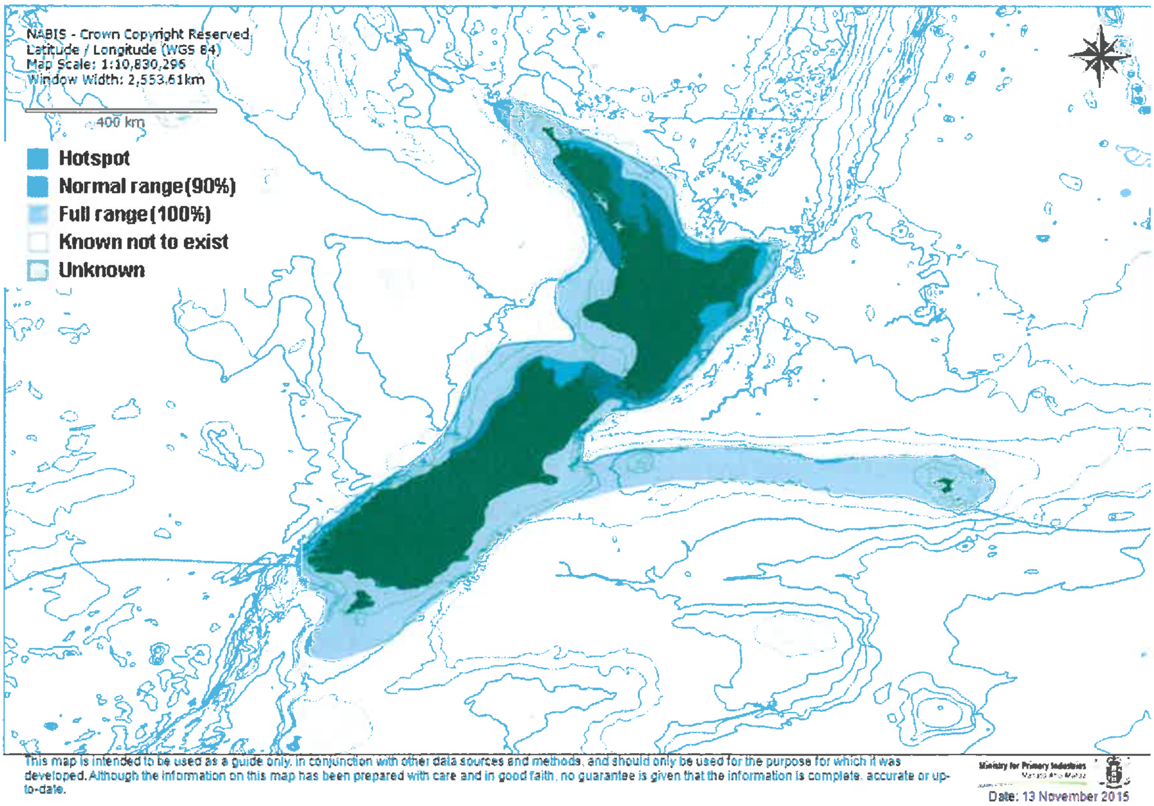

Figure 5.15 Common dolphin distribution in New Zealand waters (source: NABIS, 2015)

Bottlenose dolphin (*Tursiops truncatus*)

Bottlenose dolphins are found primarily in coastal and inshore temperate and tropical waters worldwide, even though there are also offshore, pelagic populations (Culik, 2011). There are three main coastal populations of bottlenose dolphins around New Zealand (Baker *et al.*, 2010) with recent analysis indicating little gene flow between them (Tezanos-Pinto *et al.*, 2009). These populations are regarded as range restricted (Torres *et al.*, 2013). Bottlenose dolphins are listed as Least Concern by the IUCN (2015), although they are listed as a Nationally Endangered species in New Zealand due to low abundance and concerns over potential declines of coastal populations (Suisted & Neale, 2004; Baker *et al.*, 2010). An offshore population is observed more widely but less frequently around New Zealand. This population is considered a separate sub-species even though it is not taxonomically distinct from inshore populations (Tezanos-Pinto *et al.*, 2009). Figure 5.16 shows their expected distribution around the waters of New Zealand.

Bottlenose dolphins have been observed in the Chatham Rise region and it has been suggested that these sightings were of the offshore ecotype (Torres *et al.*, 2013). This ecotype is not considered range restricted but very little is known of their distribution or ecology. They tend to feed in shallower areas of the water column (< 500 m) on small to mid-sized fish and squid associated with the mixed scattering layer (Torres *et al.*, 2013).

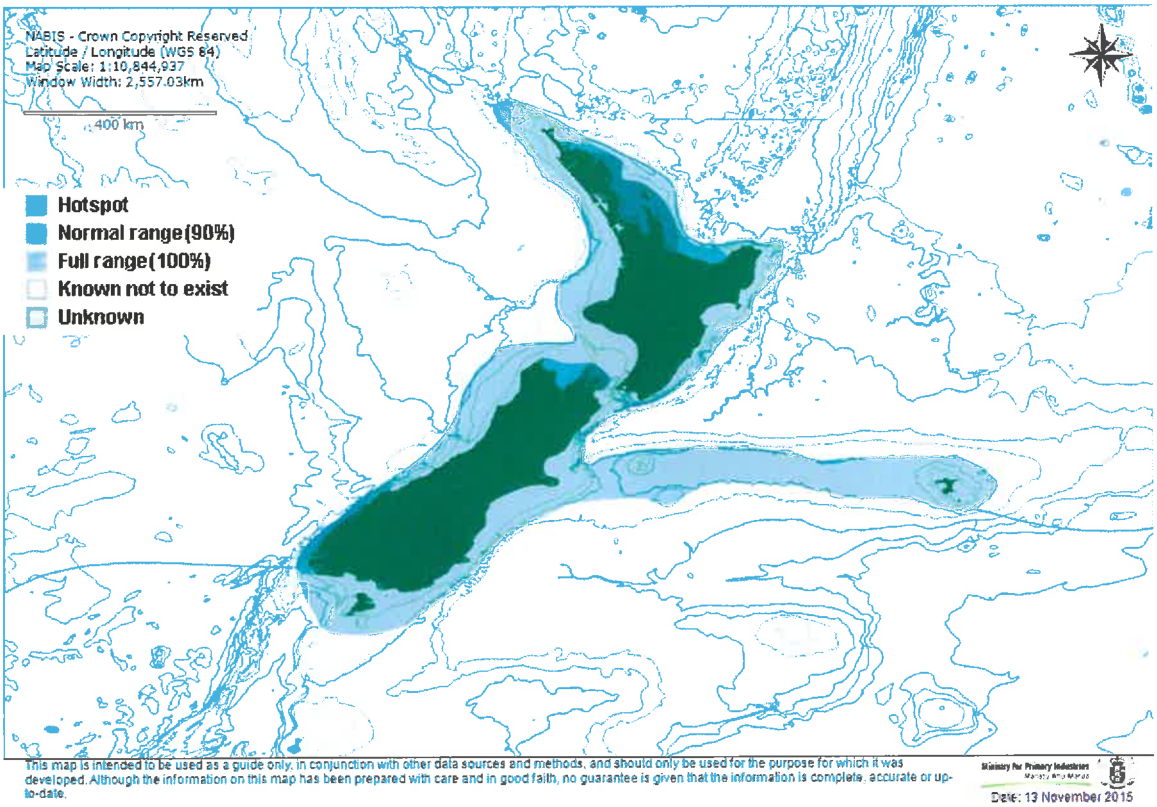

Figure 5.16 Bottlenose dolphin distribution in New Zealand waters (source: NABIS, 2015)

Dusky dolphin (*Lagenorhynchus obscurus*)

Dusky dolphins have a widespread distribution in the southern hemisphere including waters of New Zealand as far south as Campbell Island (NABIS, 2015). Hotspots for these dolphins occur in the waters surrounding Dunedin, Kaikoura and the Marlborough Sounds. Their diet consists of anchovies, hake, squid and a variety of other small fish species. Calving occurs from November to mid-January (DOC, 2015c). Due to their coastal nature, populations of dusky dolphins around the world are discontinuous and reproductively isolated. However, large scale migrations are known to occur in New Zealand and inshore-offshore movements are made both diurnally and seasonally with dolphins moving further offshore in winter (DOC, 2015c). Their predicted range is thought to include the coastline of the Chatham Islands (Figure 5.17), which has been confirmed with the numerous records of stranding (DOC, 2015b) and sighting data (Torres *et al.*, 2013).

Dusky dolphins are classified as Data Deficient by the IUCN and are regarded as Not Threatened in New Zealand (Baker *et al.*, 2010).

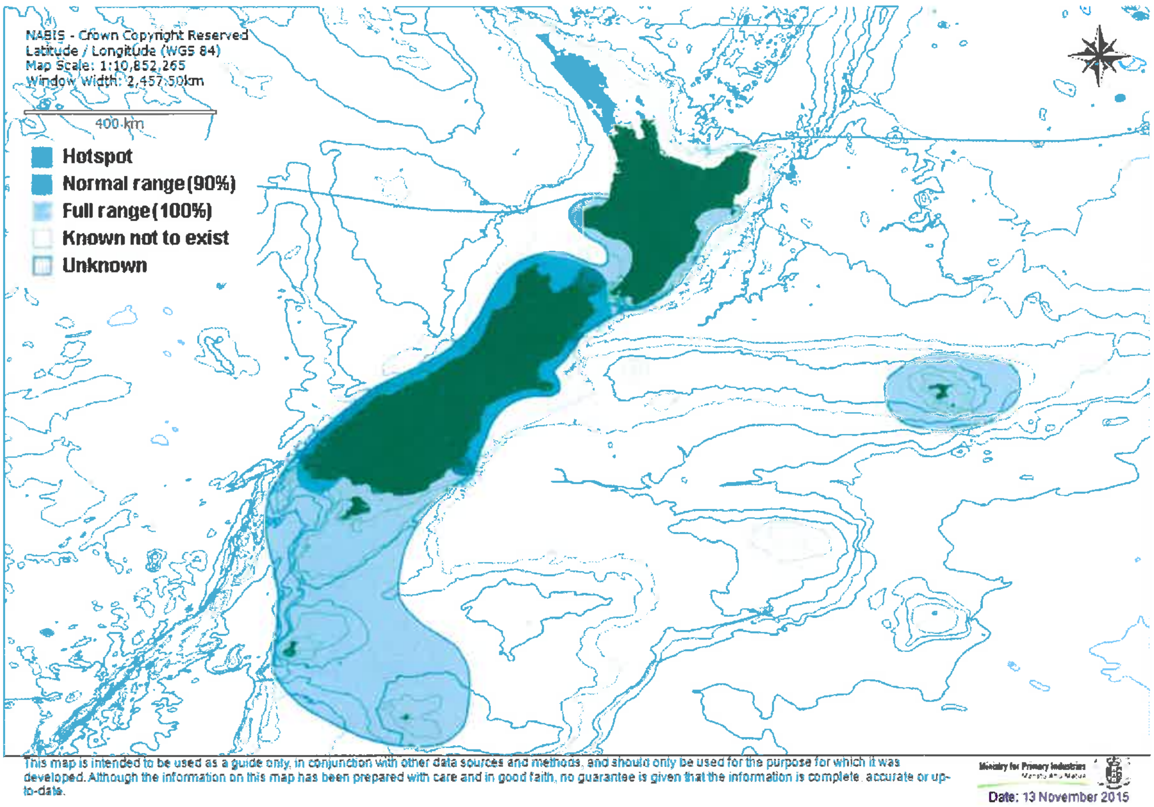

Figure 5.17 Dusky dolphin distribution in New Zealand waters (source: NABIS, 2015)

Risso's dolphin *(Grampus griseus)*

Risso's dolphins inhabit deep (400 - 1,000 m) oceanic and continental slope waters (Jefferson *et al.*, 1993) and are generally concentrated around areas with steep bottom topography (Kruse *et al.*, 1991). They show preference for habitats characterised with subsurface seamounts and escarpments where they feed on vertically migrant and mesopelagic cephalopods. There are very few reports concerning Risso's dolphins (*Grampus griseus*) in New Zealand waters. Although their general distribution encompasses the waters around New Zealand, including the Chatham Islands (IUCN, 2015), they are considered vagrant in New Zealand and not listed as a SoC within the 2013 Code. Risso's dolphins are considered Least Concern by the IUCN (2015).

Hourglass dolphin

Hourglass dolphins are distributed in a circumpolar pattern in the higher latitudes of the southern oceans (Goodall, 1997). Their range extends to the ice-edges in the south but not much is known about their northern limits, however there are indications that they can be found as far as 33° S. They are normally sighted in offshore waters and most sightings occur around the Antarctic Convergence, between South America and Macguaire Island (Hammond *et al.*, 2008). In 2010, a single stranding of an individual hourglass dolphin occurred on the Banks Peninsula, on the South Island of New Zealand (Luscombe, 2010). This was the first record in New Zealand for over 150 years. The species is listed as of Least Concern by IUCN (IUCN, 2015).

Southern right whale dolphin (*Lissodelphis peronii*)

Southern right whale dolphins are restricted to the cold temperate climate of subantarctic waters mostly between 30° S and 65° S (Hammond *et al.*, 2012). This is mainly an oceanic species and will only be found in coastal areas when deep waters approach the coast, as they feed on squid and deep-sea fish such as lanternfish (Baker, 1972; Jefferson *et al.*, 1993). On the east coast of the South Island, there has been recent regular sightings of tens to hundreds individuals (DOC, 2009) showing that they do inhabit New Zealand waters. The southern right whale dolphin is listed as Data Deficient by the IUCN.

Andrew's beaked whale (*Mesoplodon bowdoini*)

Andrews' beaked whale is known only from 35 stranding records between 32° S and 55° S. Most of these have come from the South Pacific and Indian Oceans, with well over half coming from New Zealand (Baker, 2001). Based on the concentration of stranding records in this area (Baker, 2001), the waters around New Zealand may represent an area of concentration for the species. Furthermore, an analysis of the stranding records showed the presence of foetuses between May and September and juveniles between May and June, which could indicate timing for a breeding season in New Zealand waters (Baker, 2001). It is suggested that the species has a circumpolar distribution in the southern hemisphere; however, there is a gap in the known distribution between the Chatham Islands, east of New Zealand and the west coast of South America. Essentially nothing is known of the biology of this species and information on their behaviour and ecology has been inferred from stranding records. They are assumed to inhabit deep, offshore waters and feed on cephalopods as with other beaked whale species. It is classified as Data Deficient in New Zealand and by the IUCN (IUCN, 2015) and are recognised as a SoC.

Arnoux's beaked whale (*Berardius arnuxii*)

Arnoux's beaked whales are circumpolar in the southern hemisphere, from the Antarctic continent and ice edge north to about 34° S in the southern Pacific. The overwhelming majority of strandings have been around New Zealand waters (Jefferson *et al.*, 1993), with multiple strandings in the Firth of Thames and Wellington region (Brabyn, 1991). They seem to be relatively abundant in the Cook Strait, at least during summer (Taylor *et al.*, 2008b). The northernmost records are strandings from Brazil, Argentina, South Africa and Australia; however, nowhere within their range are they very well known or considered common (Paterson & Parker, 1994; Taylor *et al.*, 2008b). They have been classified as Vagrant within New Zealand waters (Baker *et al.*, 2010) and are a SoC. The IUCN has classified the species as Data Deficient (IUCN, 2015).

It is assumed that the diet of Arnoux's beaked whale is similar to that of Baird's beaked whale, its northern hemisphere relative, consisting of deepwater squid, and possibly crustaceans and echinoderms (i.e. sea urchins and starfish) found on the sea floor (Taylor *et al.*, 2008b; Jefferson *et al.*, 1993). Consequently, they are considered accomplished deep divers, foraging on the sea-bed at depths of between 1,000 m and 3,000 m. They are an oceanic species and are seldom seen over continental shelves, but are common in deep oceanic waters, particularly close to regions carrying higher prey densities, such as sea mounts and submarine escarpments (Jefferson *et al.*, 1993). Although this species is generally encountered in groups of six to ten individuals, reports of congregations of as many as 80 have also been recorded.

Cuvier's beaked whale (*Ziphius cavirostris*)

This is the most cosmopolitan of any beaked whale species, and is therefore arguably the best known of the beaked whale species. They inhabit all oceans of both hemispheres, in cold, temperate and tropical waters, with the exception of shallow waters and very high-latitude polar regions (Taylor *et al.*, 2008c). Their distribution range includes New Zealand, as evidenced by both sightings and strandings being known to occur especially around the South Island. Several strandings have been recorded on the Chatham Islands too (DOC, 2015b). The IUCN has classified this species as Least Concern (IUCN, 2015), however the DOC have listed this species as Data Deficient in New Zealand waters (Baker *et al.*, 2010) and as a SoC.

Although few stomach contents have been examined, Cuvier's beaked whales appear to feed mostly on deep sea squid, but also sometimes take fish and some crustaceans (Santos *et al.*, 2001). A preference for deep pelagic waters greater than 1,000 m deep on the continental slope, as well as around steep underwater geological features such as seamounts and submarine canyons has been suggested (Heyning, 1989). Cuvier's beaked whales tend to occur in small groups (one to six whales) that can include several females, immature whales and often only one adult male. Abundant rake scars suggest that males are involved in regular fights, presumably for access to females (Carwardine, 1995). The average dive cycle comprises long (40 - 90 minute) and deep (600 - 2000 m) foraging dives, followed by a series of shorter and shallower dives (Tyack *et al.*, 2006). Cuvier's beaked whales currently hold the record for the longest and deepest dive of any marine mammal (1992 m depth, lasting 137.5 minutes) (Schorr *et al.* 2014).

Gray's beaked whale (*Mesoplodon grayi*)

Gray's beaked whale is a cool, temperate species found in the southern hemisphere and appears to be circum-Antarctic in occurrence (Macleod & D'Amico, 2006). Most records are south of 30° S in Antarctic and sub-Antarctic waters, and in summer months they appear near the Antarctic Peninsula and along the shores of the continent as well as occasionally in the sea ice (Taylor *et al.*, 2008d). Many of the stranding records are from New Zealand, southern Australia, South Africa and South America. In New Zealand, the area between the South Island and the Chatham Islands has been considered a "hot spot" for sightings of this species (Dalebout *et al.*, 2004). Mass strandings of Gray's beaked whale are the second most common after pilot whales, with 14 recorded in New Zealand, one of which involved 25 whales which stranded on the Chatham Islands in 1874 - 75 (Brabyn, 1991). The stranding records for the Chatham Islands alone revealed 29 stranding events with average group size of 3.5 animals (DOC, 2015b). Gray's beaked whale primarily occurs in deep waters beyond the edge of the continental shelf. Some sightings have been made in very shallow water, usually of animals in poor health which are likely to strand (Dalebout *et al.*, 2004). The presence of many mature females with calves during summer strandings in Australia suggests that Gray's beaked whales may use waters over the continental shelf for breeding and calving purposes (Dalebout *et al.*, 2004; Shirihai & Jarrett, 2006). The occurrence of early foetuses in May, near-term foetuses in September, and mothers with calves in January - February indicates summer breeding in the New Zealand region (Van Waerebeek *et al.*, 2004).

While this species is rarely seen at sea due to their oceanic distribution, deep diving ability, elusive behaviour, and possible low abundance, the limited number of sightings suggests it may be more conspicuous at the surface than other beaked whales (Dalebout *et al.*, 2004). It seems to be more active and, unlike other beaked whales, Gray's beaked whale is very gregarious and, as noted above, has a tendency to strand in large groups (Carwardine, 1995). Examination of stomach contents from stranded beaked whales indicates that these animals feed primarily on deep-water cephalopods (Shirihai & Jarrett, 2006). The IUCN have listed this species as Data Deficient, as has the New Zealand Threat Classification (IUCN, 2015; Baker *et al.*, 2010).

Shepherd's beaked whale (*Tasmacetus shepherdi*)

Shepherd's beaked whale is known from a few dozen strandings, all of which are south of 30° S, around New Zealand, southern Australia, the Juan Fernandez Islands, and Tristan de Cunha (Mead, 2009; Van Waerebeek *et al.*, 2004). The majority of strandings have occurred in New Zealand (including the Chatham Islands), but it is presumed that they have a circumpolar distribution in cold temperate waters of the southern hemisphere. It is possible that the species may be more widespread than records suggest, since it was not likely to have been accurately identified at sea until its recent re-description (Pitman *et al.*, 2006). The few confirmed, live sightings have been south of Tasmania and in oceanic waters of the South Atlantic (Pitman *et al.*, 2006). Shepherd's beaked whales are known to feed on several species of fish (primarily eelpouts), as well as squid and crabs, possibly near the bottom in deep waters (Taylor *et al.*, 2008e). Both the New Zealand Threat Classification system and IUCN have listed this species as Data Deficient (IUCN, 2015; Baker *et al.*, 2010).

Southern bottlenose whale (*Hyperoodon planifrons*)

Southern bottlenose whales have a circumpolar distribution in the southern hemisphere, south of around 30° S (Jefferson *et al.*, 1993), and most sightings are between approximately 57° S to 70° S (Taylor *et al.*, 2008f). Sightings off Durban (South Africa) show strong seasonality, suggesting a general movement northward out of the Antarctic in late summer (Van Waerebeek *et al.*, 2004). They are found in Antarctic waters during the summer when this species is most frequently seen within about 100 km of the Antarctic ice edge, where it appears to be relatively common (Carwardine, 1995). Like northern bottlenose whales, they are probably a deep diving species, though they do not tend to travel much horizontal distance while submerged (Carwardine, 1995). It may remain at the surface for 10 minutes or more, blowing every 30 to 40 seconds and when swimming fast, especially under stress, it may raise its head clear of the water on surfacing. It can stay underwater for at least an hour, but typical dive times are much shorter (Carwardine, 1995). They are commonly observed in pods of 10 or fewer, although groups of more than 25 individuals have been noted (Bastida & Rodríguez, 2003). Whilst the IUCN have listed this species as Least Concern, the New Zealand Threat Classification system has classified it as Data Deficient (IUCN, 2015; Baker *et al.*, 2010).

Spade-toothed beaked whale (*Mesoplodon traversii*)

This is considered to be the world's rarest whale based on the scarcity of the records and the total absence of previous sightings. Until recently the only information on this species came from specimens collected at three locations: a single mandible collected from the Chatham Islands in 1872, and two skulls collected from White Island in the 1950s and Robinson Crusoe Island, Chile in 1986. More recently, two spade-toothed beaked whales were found stranded on New Zealand's Opape Beach, North Island in December 2010 which provided more information on their morphology (Thompson *et al.*, 2012). It has been suggested that the species probably has a South Pacific and possibly even circum-Antarctic species distribution (Jefferson *et al.*, 2008). Its true distribution will remain unknown until more records are found (Taylor *et al.*, 2008g). It is listed as Data Deficient by both the IUCN and New Zealand threat classification (IUCN, 2015; Baker *et al.*, 2010).

Strap-Toothed Beaked Whale (*Mesoplodon layardii*)

The strap-toothed whale is the most commonly reported *Mesoplodon sp.* in the southern hemisphere. There have been over 150 strandings and sightings recorded, with most sightings relating to animals in deep water, beyond the continental shelf. The species' distribution appears to be continuous throughout the cold and temperate waters of the southern hemisphere, mostly between 35° S and 60° S which includes the region of the Chatham Rise. Evidence related to the seasonality of strandings seems to suggest that this species may migrate (Taylor *et al.*, 2008h). The presence of sub-Antarctic squid species in strandings around South Africa and New Zealand further supports a northward migration in late summer/autumn (Sekiguchi *et al.*, 1996). There is also some evidence of sexual segregation in distribution (Taylor *et al.*, 2008h). Both the IUCN and the New Zealand Threat Classification have listed this species as Data Deficient (IUCN, 2015; Baker *et al.*, 2010).

Hector's beaked whale (*Mesoplodon hectori*)

Hector's beaked whale is considered a southern hemisphere, cool temperate species. Records are mostly strandings and come from South America, South Africa, southern Australia, and both the north and south islands of New Zealand (Rice, 1998). There is also a stranding record from the Chatham Islands (DOC, 2015b). It has been speculated that the species has a continuous distribution in the Atlantic and Indian Oceans, at least from South America to New Zealand. Although there are no current records from the central and eastern Pacific Ocean, their range may prove to be circumpolar (Taylor *et al.,* 2008i). Due to the lack of sightings, very little is known about this species. It is presumed to inhabit deep offshore waters and feed on squid similarly to other beaked whale species. The New Zealand Threat Classification has listed this species as Data Deficient, as has the IUCN classification (IUCN, 2015; Baker *et al.,* 2010).

5.7.3 Pinnipeds

There are nine species of pinniped which have been recorded in the waters of New Zealand (Baker *et al*., 2010). Only one, the New Zealand sea lion (*Phocarctos hookeri*), is classified as Vulnerable by the IUCN (2015).The New Zealand sea lion, along with the southern elephant seal (*Mirounga leonine*), is also registered as Nationally Critical on the New Zealand Threat Classification List (Baker *et al*., 2010). Of the remaining species of pinniped recorded in New Zealand waters, seven are considered either Migrants or Vagrants (Baker *et al*., 2010).

The most likely pinniped species to be recorded in the survey area is the New Zealand fur seal, which breeds on the Chatham Islands. A further four species of seals - the New Zealand sea lion, leopard seal, southern elephant seal and subantarctic fur seal - have been recorded in the area but are considered rare or occasional visitors (DOC, 2015e). Although the Chatham Islands were once part of their distribution, New Zealand sea lions are now unlikely to occur in the survey area, as their range is mostly restricted to the Campbell Islands, Auckland Islands, Stewart Island and the southern tip of mainland New Zealand (Childerhouse & Gales, 1998; Harcourt 2001). Leopard seals are generally found along the edge of the pack ice in Antarctic waters, however they do travel great distances and small concentrations can be found annually on the South Island and Subantarctic islands (Harcourt, 2001). In New Zealand waters, there is a small population of southern elephant seal however the 250 - 260 individuals are generally range restricted to the Campbell and Antipodes Islands (McMahon *et al.,* 2005). Subantarctic fur seals are occasionally recorded on the Antipodes and Snares Islands, with a single record occurring on the south island (Taylor, 1990), they are therefore unlikely to be recorded in the survey area.

New Zealand fur seal (*Arctocephalus forsteri*)

New Zealand fur seals are the most common seal in New Zealand waters, classified as Data Deficient by the IUCN and not regarded as a threatened species in New Zealand (Baker *et al*., 2010) as the population is large, consisting of approximately 55,000 individuals (Suisted & Neale, 2004). New Zealand fur seals forage on fish, cephalopods such as squid and octopus, and crustaceans including krill (Willis *et al*., 2008; Boren, 2010). New Zealand fur seals will forage up to 200 km beyond the continental slope, often diving as deep as 200 m with most dives lasting 1 or 2 minutes (Davis, 2012). Research indicates foraging habitat and behaviour separation between adult male, female and juvenile seals (Page *et al*., 2005; 2006). Males tend to dive deeper and longer than females and also utilise waters over the continental shelf (Page *et al*., 2005). In addition, while little seasonal differences in behaviour have been recorded in males, females and juveniles forage closer to colonies in summer months over the continental shelf, moving further offshore during winter and demonstrating seasonal differences in dive characteristics (Mattlin *et al*., 1998; Page *et al*., 2006; Harcourt *et al*., 2002). Males arrive at the breeding colonies first from late October - November, establishing territories. The females follow in late November when they give birth and nurture the pups until July or August (Davis, 2012). New Zealand fur seals are widely distributed around both islands, as well as the Chatham Islands, with a number of breeding and haul-out sites known around the country (Figure 5.18).

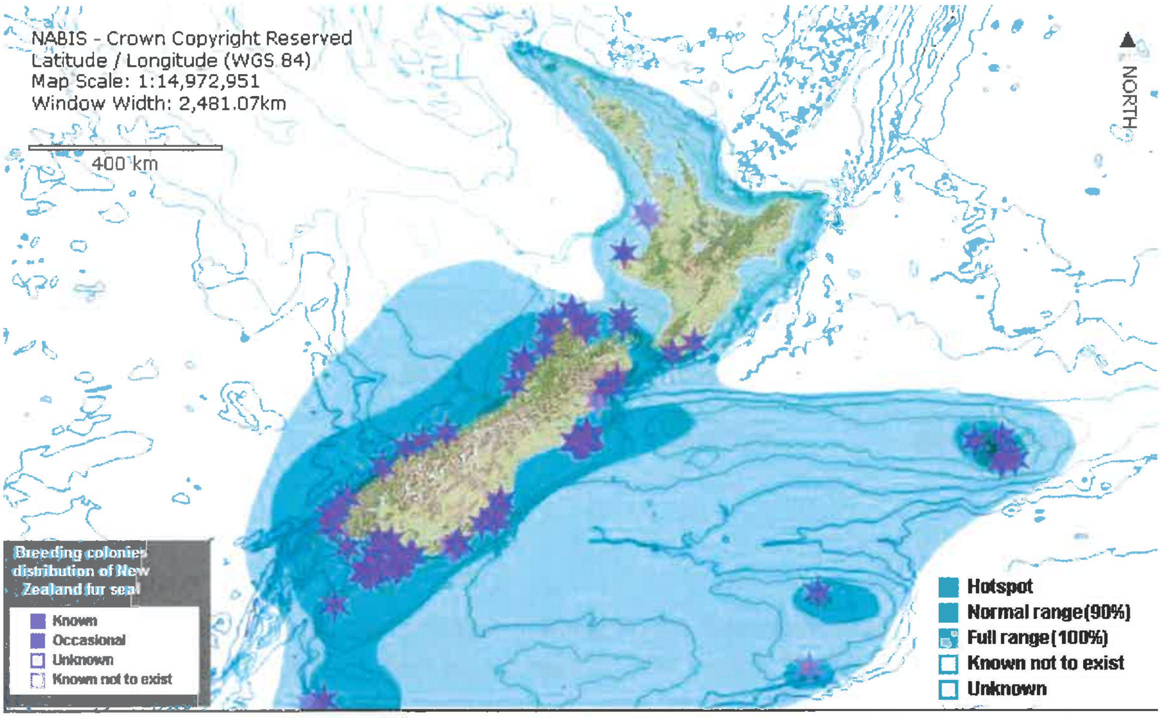

Figure 5.18 New Zealand fur seal distribution in New Zealand waters (source: NABIS, 2015)

5.8 Other Marine Mega Fauna

5.8.1 Sea Turtles

Five species of sea turtle have been recorded in the waters around New Zealand: loggerhead (*Caretta caretta*), olive ridley (*Lepidochelys olivacea*), hawksbill (*Eretmochelys imbricata*), green (*Chelonia mydas*) and leatherback turtle (*Dermochelys coriacea*) (Gill, 1997). Species that are classified as Migrant include the green and the leatherback turtle; all remaining species are regarded as Vagrant. The leatherback and olive ridley turtle are classified as Vulnerable, the green and loggerhead turtle are regarded as Endangered and the hawksbill turtle is listed as Critically Endangered by the IUCN (2015) (Table 5.4).

Though poorly understood, the abundance of turtles tends to be greater in waters to the north of the North Island. The leatherback and green turtle are the only two species that are seen with any regularity (DOC, 2015d). The green turtle has only been recorded south of the North Island on three occasions (once in the Cook Strait, once in Tasman Bay and once off the South Island itself), whilst the leatherback turtle is routinely recorded further south and has been previously recorded around the Chatham Islands (Gill, 1997).

Table 5.4 Records of marine turtles in New Zealand waters (DOC, 2015d; IUCN, 2015).

Loggerhead turtle	*Caretta caretta*	Endangered	DOC records (dead or alive)
Olive ridley turtle	*Lepidochelys olivacea*	Vulnerable	12
Hawksbill turtle	*Eretmochelys imbricata*	Critically Endangered	46
Green turtle	*Chelonia mydas*	Endangered	73
Leatherback turtle	*Dermochelys coriacea*	Vulnerable	129
Loggerhead turtle	*Caretta caretta*	Endangered	47

5.8.2 Sharks and Rays

Around 112 species of sharks, skates, rays and chimaeras have been recorded in the waters surrounding New Zealand (New Zealand Ministry of Fisheries, 2008). Of these species there is a high level of endemism, with 13 shark species, 18 skates and ray species and three chimaeras being endemic to New Zealand waters (New Zealand Ministry of Fisheries, 2008). Great white sharks (*Carcharodon carcharias*) are fully protected within New Zealand waters under the Wildlife Act (1953) in addition to the oceanic whitetip shark (*Carcharhinus longimanus*), basking shark (*Cetorhinus maximus*), deepwater nurse shark (*Odontaspis ferox*), whale shark (*Rhincodon typus*), giant manta ray (*Manta birostris*), spinetail devil ray (*Mobula japonica*), giant grouper (*Epinephelus lanceolatus*) and spotted black grouper (*Epinephelus daemelii*) (McMillian *et al.*, 2011).

New Zealand is one of the world's hotspots for great white sharks and the New Zealand Threat Classification System lists great white sharks as in Gradual Decline (Baker *et al.*, 2010). They are also listed as Vulnerable by the IUCN (2015). Satellite tagging has shown that great white sharks aggregate around Stewart Island and the Chatham Islands (most likely these areas are feeding grounds due to the large population of prey in the form of New Zealand fur seals), but undertake seasonal long distance migrations to subtropical and tropical parts of the southwest Pacific, departing New Zealand over an extended period between February and September (DOC, 2015i). Given this, there is a small likelihood that some remaining and late migrating great white sharks will be present in the survey area at the time of the survey.

5.8.3 Seabirds

New Zealand has a huge diversity of seabirds, with 86 species currently recorded. This is made up of albatrosses (Diomedeidae), cormorants and shags (Phalacrocoracidae), fulmars, petrels, prions, shearwaters (Procellariidae), terns (Sternidae), gulls (Laridae), penguins (Spheniscidae) and skuas (Stercorariidae) (Biswell, 2007). Of these species, 33 (38%) are endemic and breed nowhere else in the world (Biswell, 2007; Croxall *et al.*, 2012). New Zealand also has the highest number of species of conservation concern, with 38 species (44%) listed as threatened on the IUCN Red List (Croxall *et al.*, 2012).

The Chatham Islands are an important breeding ground for many species of seabird and a number of endemic and rare species breed on these islands. Many of these species are under threat due to the fishing industry, introduced predators and chick harvesting. Common species found around the Chatham Islands include albatrosses, mollymawks, prions, skuas, sooty shearwaters, storm petrels and little blue penguins (DOC, 2015j). Endemic species include the Chatham Island tāiko, Chatham Island oystercatcher, Chatham petrel, Northern

Royal albatross (although there is also a small colony at Taiaroa Head, Dunedin), Chatham Island shag and Pitt Island shag.

The Chatham Island tāiko is extremely rare, listed as Critically Endangered by the IUCN, and one of New Zealand's most endangered species with a population estimated at 150 birds and only 15 breeding pairs. The population of the Chatham petrel is also listed as Endangered by the IUCN and the population is estimated to be around 1, 000 with 100 - 130 breeding pairs being actively managed since 1999 to increase productivity (DOC, 2015j).

Albatrosses, shearwaters and petrel species are pelagic and wide-ranging therefore they are likely to be recorded in the survey area. Many of these species use areas such as the Chatham Rise to forage as it is an area of high productivity.

A number of more coastal species may also be found in the survey area or during transit, including, blue penguin, southern black-backed gull, red-billed gull, brown skua, white-fronted tern, Chatham Island shag and Pitt Island shag (Aikman & Miskelly, 2004). Although the majority of these species feed in coastal habitats, some may travel offshore to feed.

The list of seabird species most likely to occur in the project area is given in Table 5.5.

Table 5.5 Seabird species most likely to occur in the project area and their conservation status (IUCN, 2015; Aikman & Miskelly, 2004)

Common Name	Scientific Name	IUCN Classification	New Zealand Threat Classification	Presence of a Breeding Colony Nearby Project Area
Northern Royal albatross	*Diomedea sanfordi*	Endangered	Nationally vulnerable	Yes
Antipodean (wandering) albatross	*Diomedea [exuland] antipodensis*	Vulnerable	Range restricted	Yes
White-capped mollymawk	*Thalassarche [cauta] steadi*	Near threatened	Range restricted	Yes
Salvin's mollymawk	*Thalassarche salvini*	Vulnerable	Range restricted	Yes
Chatham mollymawk	*Thalassarche eremita*	Vulnerable	Serious decline	Yes
Indian Yellow-nosed mollymawk	*Thalassarche [chlororhynchos] carteri*	Endangered	Coloniser	No
Pacific mollymawk	*Thalassarche* undescribed sp.	Near threatened	Range restricted	No
Sooty shearwater	*Puffinus griseus*	Near threatened	Gradual decline	Yes
Subantarctic little shearwater	*Puffinus assimilis elegans*	Least concern	Range restricted	Yes

Southern diving petrel	*Pelecanoides urinatrix chathamensis*	Unknown	Not threatened	Yes
Snares cape pigeon	*Daption capense austral*	Unknown	Range restricted	Yes
Northern giant petrel	*Macronectes halli*	Least concern	Not threatened	Yes
Fairy prion	*Pachyptila turtur*	Least concern	Not threatened	Yes
Chatham Island fulmar prion	*Pachyptila crassirostris pyramidalis*	Unknown	Range restricted	Yes
Broad-billed prion	*Pachyptila vittata*	Least concern	Not threatened	Yes
Chatham petrel	*Pterodroma axillaris*	Endangered	Nationally endangered	Yes
Black-winged petrel	*Pterodroma nigripennis*	Least concern	Not threatened	Yes
Chatham Island tāiko	*Pterodroma magentae*	Critically endangered	Nationally critical	Yes
Grey-backed storm petrel	*Oceanites nereis*	Least concern	Not threatened	Yes
White-faced storm petrel	*Pelagodroma marina maoriana*	Not assessed	Not threatened	Yes
Chatham Island blue penguin	*Eudyptula minor chathamensis*	Not assessed	Range restricted	Yes
Brown skua	*Catharacta skua lonnbergi*	Not assessed	Sparse	Yes
Southern black-backed gull	*Larus dominicanus*	Least concern	Not threatened	Yes
Red-billed gull	*Larus novaehollandiae scopulinus*	Not assessed	Not threatened	Yes
White-fronted tern	*Sterna striata*	Least concern	Gradual decline	Yes
Chatham Island shag	*Leucocarbo onslowi*	Critically endangered	Range restricted	Yes
Pitt Island shag	*Stictocarbo featherstoni*	Endangered	Range restricted	Yes

5.9 Valuation of Receptors

Using the methodology set out in Section 3.5, each identified marine mammal species potentially present within the ZoI (i.e. status assigned as Likely or Less Likely in Table 5.3) has been valued according to its conservation status and potential abundance within the ZoI. The results of this exercise are presented in Table 5.6.

Table 5.6 Receptor valuation

Species	Conservation Status (Cs)		Abundance Score (As)		Receptor Value	
	Conservation Status	Score	Abundance within ZoI	Score	Value $(\frac{Cs+As}{20})$	Valuation
Baleen whales						
Blue whale sp.	IUCN Endangered	8	Not present in Nat. or Int. important numbers- Increasing	1	0.45	Medium
Antarctic minke whale	IUCN Data Deficient	7	Not present in Nat. or Int. important numbers - Unknown	3	0.5	Medium
Fin whale	IUCN Endangered	8	Not present in Nat. or Int. important numbers - Unknown	3	0.55	Medium
Sei whale	IUCN Endangered	8	Not present in Nat. or Int. important numbers - Unknown	3	0.55	Medium
Southern right whale[2]	Nationally Endangered	8	Present in Nat. important numbers - Increasing	5	0.65	High
Pygmy right whale	IUCN Data Deficient	7	Not present in Nat. or Int. important numbers - Unknown	3	0.5	Medium
Toothed whales and dolphins						

[2] Given the small size of the New Zealand population and their status, any number of these whales anywhere within New Zealand waters can be considered as Nationally important.

Sperm whale	IUCN Vulnerable	6	Not present in Nat. or Int. important numbers - Unknown	3	0.45	Medium
Pygmy sperm whale	IUCN Data Deficient	7	Not present in Nat. or Int. important numbers - Unknown	3	0.5	Medium
Killer whale[3]	Nationally Critical	10	Not present in Nat. or Int. important numbers - Unknown	3	0.65	High
False killer whale	IUCN Data Deficient	7	Not present in Nat. or Int. important numbers - Unknown	3	0.5	Medium
Long-finned pilot whale	IUCN Data Deficient	7	Not present in Nat. or Int. important numbers - Unknown	3	0.5	Medium
Short-beaked common dolphin	IUCN Least Concern	2	Not present in Nat. or Int. important numbers - Unknown	3	0.25	Low
Bottlenose dolphin[4]	Nationally Endangered	8	Not present in Nat. or Int. important numbers - Unknown	3	0.55	Medium
Dusky dolphin	IUCN Data Deficient	7	Not present in Nat. or Int. important numbers - Unknown	3	0.5	Medium
Risso's dolphin	IUCN Least Concern	2	Not present in Nat. or Int. important numbers - Unknown	3	0.25	Low

[3] Killer whale type A is listed as Nationally Critical, while offshore types B, C and D are listed as Vagrant (Baker *et al.*, 2010). Type A is considered the more regular type around New Zealand and it is estimated that the population totals 117 individuals (95% CI 64-167) (Visser, 2000). Types B, C and D are known to occur in the Southern Hemisphere around the Antarctic, and some evidence suggests occurrence in New Zealand waters (Baker *et al.*, 2010). Recent research indicates the presence of these offshore ecotypes around Chatham Islands in February (Lauriano and Panigada, 2015). However it is still unknown which type is more likely to be encountered in the survey area hence the more precautionary status is assigned.

[4] The Nationally Endangered status of bottlenose dolphins in New Zealand is due to the population's restricted habitat, total abundance and evident decline in two coastal populations (Baker *et al.*, 2010). The size and trend of offshore bottlenose dolphins (which are likely to be present in the survey area) is unknown, however they are not regarded as taxonomically distinct from inshore populations, therefore they are assigned the same status.

Hourglass dolphin	IUCN Least Concern	2	Not present in Nat. or Int. important numbers - Unknown	3	0.25	Low
Southern right whale dolphin	IUCN Data Deficient	7	Not present in Nat. or Int. important numbers - Unknown	3	0.5	Medium
Andrew's beaked whale	IUCN Data Deficient	7	Not present in Nat. or Int. important numbers - Unknown[5]	3	0.5	Medium
Arnoux's beaked whale	IUCN Data Deficient	7	Not present in Nat. or Int. important numbers - Unknown	3	0.5	Medium
Cuvier's beaked whale	IUCN Least Concern	2	Not present in Nat. or Int. important numbers - Unknown	3	0.25	Low
Gray's beaked whale	IUCN Data Deficient	7	Not present in Nat. or Int. important numbers - Unknown	3	0.5	Medium
Shepherd's beaked whale	IUCN Data Deficient	7	Not present in Nat. or Int. important numbers - Unknown	3	0.5	Medium
Southern bottlenose whale	IUCN Least Concern	2	Not present in Nat. or Int. important numbers - Unknown	3	0.25	Low
Spade-toothed beaked whale	IUCN Data Deficient	7	Not present in Nat. or Int. important numbers - Unknown	3	0.5	Medium
Strap-toothed beaked whale	IUCN Data Deficient	7	Not present in Nat. or Int. important numbers - Unknown	3	0.5	Medium
Hector's beaked whale	IUCN Data Deficient	7	Not present in Nat. or Int. important numbers - Unknown	3	0.5	Medium

[5] Given the large paucity in the knowledge of exact distribution and abundance of beaked whales, there is a difficulty in assigning an abundance score to these species. Therefore all of them have been scored 'Not present in Nationally or Internationally important numbers' due to the great unknowns related to their abundance and habitat ranges in general.

Pinnipeds						
New Zealand fur seal	IUCN Least Concern	2	Not present in Nat. or Int. important numbers- Increasing	1	0.1	Negligible

The majority of beaked whale species are valued as 'medium' with the exception of Cuvier's beaked whale and the southern bottlenose whale, which are valued as 'low.' This is due to their IUCN status of 'Least Concern' which gives them a lower conservation status score than the IUCN status of 'Data Deficient' assigned to other species within this group. However, due to similar ecology among these species and the effects of underwater noise, a precautionary score of 'medium' will be used for all beaked whale species in the assessment of potential effects within this document.

6. Inbuilt Mitigation

6.1 The 2013 Code

The inbuilt mitigation designed into this survey work is mainly derived from the 2013 Code which sets out the requirements for marine mammal mitigation for Level 1 surveys, as described below.

6.1.1 Observers

At least two Qualified MMOs and two Qualified PAM Operators are required on-board the survey vessel at all times. At all times while the acoustic source is in the water, at least one qualified MMO (during all daylight hours) and at least one qualified PAM Operator must be on watch. Observations at any other time during the survey when practical and possible are encouraged.

Observers will be responsible for recording and reporting (in detail) all marine mammal sightings or detections, sighting conditions, seismic source operations and variations from the standard practices of the Code. In the case of any variations from the Code, the observer will report such instances within 24 hours (rather than immediately as stated by the Code) to the Director-General of DOC.

The operator will provide a display screen showing acoustic source operations – this 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.

6.1.2 PAM

If operating in an area where calves are anticipated to be present or have been visually observed during the survey, then vocalisations detected by PAM are assumed to be produced from a cow/calf pair and as such the most stringent mitigation zones will be applied unless a sighting by the MMO can confirm otherwise. Furthermore, any ultra-high frequency cetacean vocalizations (30 – 180 kHz) will require an immediate shut down or delay (as per procedures described below) unless the MMO can confirm that the species detected falls under the 'other marine mammal' category.

The standard provisions of the 2013 Code prescribe the following measures in case of PAMS malfunction:

If the PAMS malfunctions or becomes damaged, operations may continue for 20 minutes in the absence of PAM whilst diagnosing the issue. If the diagnosis indicates that the PAM equipment must be repaired to solve the problem, operations may continue for an additional two 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 two hours;
- Two MMOs maintain a 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 PAMS;
- Operations with an active source, but without an active PAMS, do not exceed a cumulative total of four hours in any 24-hour period.

However, if PAMS cannot be repaired whilst on sea, DOC will be consulted and advice on proceeding with the survey but without active PAMS will be sought.

6.1.3 Soft Starts

Soft starts are required whenever the acoustic source is to be activated, with the exception of certain tests (see below) and breaks in firing that are less than 10 minutes in duration immediately following normal operations at full power. In the case of the latter, the acoustic source may start at full power provided the qualified observers have not detected marine mammals in the relevant mitigation zones (as per Section 4.2.4 of the 2013 Code). Soft starts should gradually increase the acoustic source power output, starting with the lowest capacity gun, over a minimum of 20 minutes and should not exceed 40 minutes in duration. On completion of the soft start, operations should be planned so that the survey line starts shortly after. Soft starts give any mobile marine mammals in the area time to move away from the source before full power is reached.

6.1.4 Pre-start Procedures

The acoustic source can only be activated once the vessel is within the specified operational area (see Section 2, above). Operations can then commence with a soft start provided the following:

DAY TIME

- At least one MMO has made continuous 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 have been observed in the respective mitigation zone for at least 30 minutes.

- A qualified PAM Operator has conducted acoustic monitoring for at least 30 minutes before activation of the acoustic source and no vocalising cetaceans have been detected in the respective mitigation zones.

NIGHT TIME / POOR SIGHTING CONDITIONS

- A qualified PAM Operator has conducted acoustic monitoring for at least 30 minutes before activation of the acoustic source and no vocalising cetaceans haven been detected in the respective mitigation zones.

ADDITIONAL REQUIREMENTS FOR START UP IN A NEW LOCATION IN POOR SIGHTING CONDITIONS

Additional requirements apply when arriving at a new location in the survey programme for the first time. In such instances, the initial acoustic source activation must not be undertaken at night or during poor sighting conditions unless MMOs have undertaken observations within 20 nm of the planned start up position for at least the last two hours of good sighting conditions preceding proposed operations and no marine mammals have been detected.

If there have been fewer than two hours of good sighting conditions preceding proposed operations within 20 nm of the planned start up position, the source can be activated if:

- PAM monitoring has been conducted for two hours immediately preceding proposed operations;

- Two MMOs have conducted visual monitoring in the last two hours immediately preceding proposed operations;

- No SoC have been detected visually or acoustically in the relevant mitigation zones in the two hours immediately preceding proposed operations;

- No other marine mammals have been detected visually or acoustically in the relevant mitigation zones in the 30 minutes immediately preceding proposed operations;
- No fur seals have been detected visually or acoustically in the relevant mitigation zones in the 10 minutes immediately preceding proposed operations.

6.1.5 Delays and Shutdowns

Qualified observers have the authority to shut down (for Species of Concern) or delay seismic operations if a marine mammal is detected in the following mitigation zones:

a) *1500 m for Species of Concern[6] with calves*

b) *1000 m for Species of Concern*

c) *200 m for any other marine mammal.*

Operations can only start or re-commence once the marine mammal has been observed leaving the respective mitigation zone or, despite continuous observations, a period of 30 minutes has passed since the last detection within the mitigation zone. In the case of New Zealand fur seals, operations may commence if 10 minutes has passed since the last detection within 200 m of the source or the individual or group has been observed leaving the 200 m mitigation zone.

6.1.6 Seismic Source Tests

All tests require soft starts, with the exception of tests below a total volume of 150 cu in. In this instance, tests can commence without a soft start provided the relevant pre-start observations have been made. For all other tests, the soft start must not exceed the rate of a normal soft start and it should be up to 20 minute in duration. Tests can commence provided the qualified observer has confirmed no marine mammals are present in the relevant mitigation zones. Acoustic source tests cannot be used for mitigation purposes, or to avoid the implementation of soft start procedures.

6.1.7 Vessel Speed Restrictions

Although not part of the 2013 Code requirements, the survey vessel *R/V Sonne* will be restricted to a normal surveying speed of between 3.5 knots (6.5 km/h) and 5.5 knots (10 km/h), with cruising to/from the survey location restricted to 12 knots (22 km/h), which falls below the most dangerous levels of speeds that cause vessel strikes (Laist *et al.*, 2001; Jensen & Silber, 2003; Vanderlaan & Taggart, 2007). These restrictions will act as a significant mitigation measure in relation to reducing the risk of vessel strikes, especially for larger whale species.

There are 36 marine mammal species listed as Species of Concern (SoC) in Schedule 2 of the 2013 Code, as those species particularly sensitive to seismic activities.

7. Assessment of Potential Effects

There are a number of potential effects on marine mammals from the survey operations and these are outlined in Table 7.1. The following sub-sections assess each potential effect against the species identified in Table 5.3.

Table 7.1 Scope of the assessment

Source	Pathway	How the Receptor Could Potentially be Affected	Receptors
Increased vessel activity	Collision	Injury / Mortality	Mainly baleen whales
	Physical presence of vessel and associated noise	Disturbance to ecologically important behaviours (foraging, resting, nursing, breeding) Displacement from habitat	All marine mammal species
Seismic survey	Noise	Physiological (non-auditory and auditory injury and mortality) Perceptual (masking of vocalisations) Behavioural changes Indirect (effects on prey)	All marine mammal species

As explained in Sections 3.7 and 3.8, each impact will be assessed by assigning appropriate *impact severity* (0 - 4) (Table 3.7) and *proportion of population affected* (0 - 4) (Table 3.8) scores. This in turn will help determine the impact magnitude (0 - 1 *negligible*; 2 - 4 *low*; 5 - 9 *medium*; and 10 - 16 *high*). Finally, the determination of impact significance involves the interaction of the receptor value together with the assessment of the overall magnitude (Table 3.10).

7.1. Vessel Collision Risk

Given the presence of a research vessel in the area, the potential for collisions with marine mammals, notably larger whale species, must be evaluated.

Large vessels might collide with large whales and cause fatalities or injuries – a report by Jensen and Silber (2003) found that 68% of reported ship strikes on large whales resulted in fatality, whereas 16.4% resulted in non-fatal injury. Of 11 cetacean species known to be hit by vessels, fin whales are struck most frequently, while right whales (*Eubalaena glacialis* and *Eubalaena australis*), humpback whales, sperm whales, and grey whales (*Eschrichtius robustus*) are hit commonly. The most lethal or severe injuries are caused by ships 80 m or longer and those travelling 14 knots or faster (Laist *et al.*, 2001). According to Vanderlaan and Taggart (2007), the probability of a fatality to a whale is less that 5% for vessels travelling at a speed of 4 - 4.5 knots (Figure 7.1).

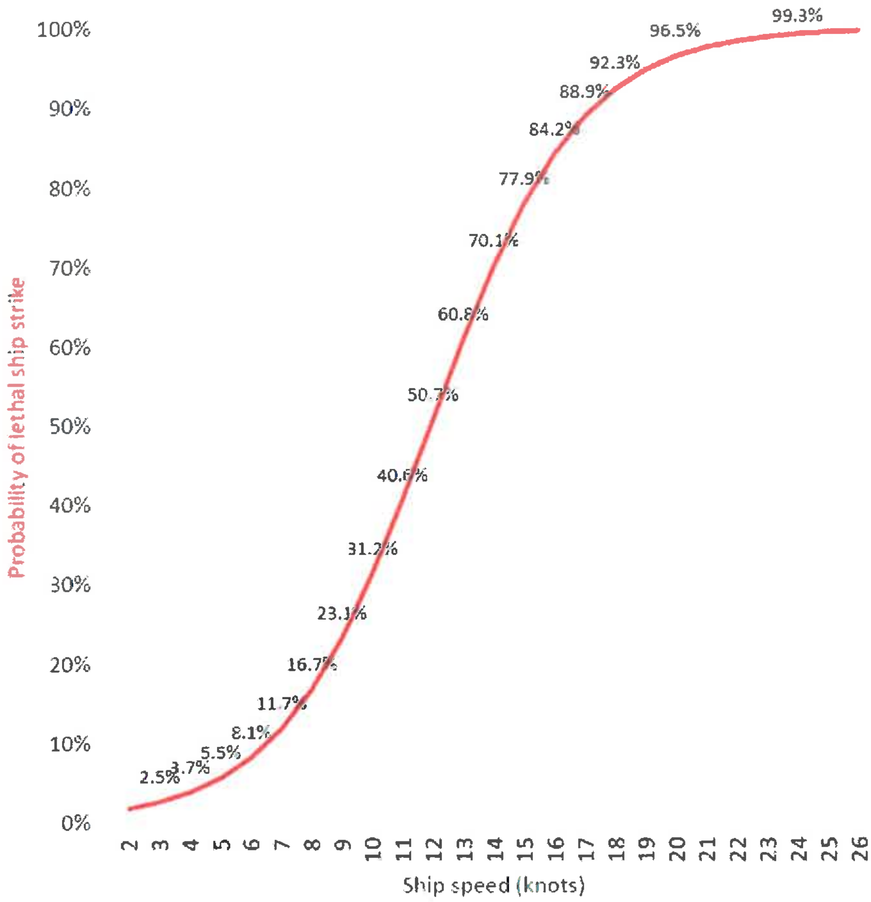

Figure 7.1 Probability of a collision between a whale and a vessel travelling at various speeds resulting in lethal strike. Calculated using equations in Vanderlaan and Taggart (2007)

There are other factors that can influence the chances of collision, such as the age and gender of animals, distraction by feeding or mating activities, habituation to vessels (or otherwise failing to sense and react to vessel approach) and congregation in feeding or breeding areas (in which case, the risk may be density dependent) (Dolman *et al.*, 2006). Additionally, certain areas and regions are considered hotspots for vessel collisions. Namely, 90% of incidents occur in either the continental shelf or slope region (Laist *et al.*, 2001).

Out of the 11 collision risk species (Jensen & Silber, 2003), five baleen whales (blue, fin, sei, southern right and minke whale sp.) and two odontocetes (sperm and killer whale) are likely to occur around the Chatham Rise.

As per the 2013 Code requirement, at least one MMO will be on watch during transit times and during operational activity whilst on site and therefore will be able to report on any marine mammals present in the immediate vicinity of the vessel that could pose a collision risk.

As vessel speed appears to be the most significant factor for vessel strikes, the speed restrictions set out in Section 6 (normal surveying speed of between 3.5 knots and 5.5 knots and cruising to/from the survey location restricted to 12 knots) will act as effective inbuilt mitigation.

Table 7.2 sets out the results of the impact assessment taking into account the inbuilt mitigation identified.

Table 7.2 Collision risk assessment

Species	Receptor Value	Impact Magnitude		Impact Magnitude	Impact Significance
		Severity	PoPA		
Baleen Whales					
Blue whale sp.	Medium	4	1	Low	Minor
Antarctic minke whale	Medium	4	1	Low	Minor
Fin whale	Medium	4	1	Low	Minor
Sei whale	Medium	4	1	Low	Minor
Southern right whale	High	4	1	Low	Minor
Pygmy right whale	Medium	4	1	Low	Minor
Toothed whales and dolphins					
Sperm whale	Medium	4	1	Low	Minor
Pigmy sperm whale	Medium	3	0	Negligible	Not significant
Killer whale	High	4	1	Low	Minor
False killer whale	Medium	3	0	Negligible	Not significant
Long-finned pilot whale	Medium	3	0	Negligible	Not significant
Short-beaked common dolphin	Low	3	0	Negligible	Not significant
Bottlenose dolphin	Medium	3	0	Negligible	Not significant
Dusky dolphin	Medium	3	0	Negligible	Not significant
Risso's dolphin	Low	3	0	Negligible	Not significant
Hourglass dolphin	Low	3	0	Negligible	Not significant
Southern right whale dolphin	Medium	3	0	Negligible	Not significant
Beaked whale sp.	Medium	3	0	Negligible	Not significant
Seals					
New Zealand fur seal	Negligible	2	0	Negligible	Not significant

Due to the nature of the impact and their vulnerability, the associated impact severity score for baleen whales as a group is considered *high (4)*. There are no known breeding, calving or feeding grounds in the area in which high numbers of baleen whales would congregate, while migratory periods will mostly be avoided due to the timing of the survey. The exception is the southern right whale which seems to be present along the southern edge of the Chatham Rise during summer and autumn to forage (Torres *et al.*, 2013). However, their densities appear not to be as high as those around the Campbell and Auckland Islands, where they congregate close to the shore in large numbers to breed. Therefore, they are assigned the same *proportion of population affected* score as other baleen whales. Overall, it is expected this impact will be limited to very low numbers of individuals present in the area at the time of the survey (proportion of population affected score *very low (1)*).

The associated severity score for the majority of toothed whales and dolphins is considered *medium* (3). This is due to the fact that these animals are less likely to suffer injury or fatality due to ship strikes in comparison to baleen whales. The exceptions are sperm whales and killer whales, which are the only odontocetes listed as collision risk species according to Jensen & Silber (2003), hence their associated severity score is *high (4)*. Considering that odontocetes as a species group are less likely to be affected by vessel collision risk, the associated proportion of population affected score is *barely perceptible (0)* except for killer whales and sperm whales which scored very *low (1)*.

As such, the overall magnitude of this impact is considered to be *low* for baleen whales and *negligible* to *low* for odontocetes, resulting in an impact significance which varies from *minor* to *not significant* between the two species groups.

Seals tend to be impacted the least by vessel collisions hence their associated severity score is considered *low (2)* and the proportion of the population affected as *barely perceptible (0)*. Therefore, the expected impact significance for New Zealand fur seals is considered *not significant*.

No significant effects are predicted and no additional mitigation is either identified or required in relation to collision risk, however additional measures will be utilised as best practice (see Section 8).

7.2 Physical Disturbance Due to the Presence of Vessels

The presence of a vessel and its associated activity together with the noise produced could potentially disturb marine mammals whilst they are engaged in ecologically important behaviours (foraging, resting, nursing or breeding) or cause a displacement from their habitat if such disturbance is persistent and long term. Previous studies suggest a certain level of impact mostly in terms of short-term behavioural reactions. For example, short-term behavioural changes of bottlenose dolphins in Doubtful Sound, New Zealand have been recorded due to vessel presence (Lusseau, 2006). During these interactions, dolphins tended to move horizontally and vertically to avoid vessels whilst their movement becomes more erratic. A study by Williams *et al.* (2006) investigated the activities of northern resident killer whales in the presence and absence of vessels. They found that when vessels were nearby, killer whales reduced their time spent feeding and socialising. Moreover, a multi-year study on humpback whales showed that whales change their behaviour in the presence of cruise ships. The typical reactions of whales to the presence of vessels (up to 4 km away) included avoidance by diving underwater or swimming away, reducing their surface time, and changing their breathing rates (Baker & Herman, 1989). The reaction of animals depends on many factors including the behavioural state of animals, type of vessel and vessel activity (Lusseau, 2006). In addition, the bathymetry of the location in which the animals encounter vessels must be considered, as this will affect the propagation of noise from the vessel, and therefore alter the sound levels encountered by the animals.

Table 7.3 sets out the result of the impact assessment for physical disturbance.

Table 7.3 Physical disturbance assessment

Species	Receptor Value	Impact Magnitude		Impact Magnitude	Impact Significance
		Severity	PoPA		
Baleen Whales					
Blue whale sp.	Medium	1	1	Negligible	Not significant
Antarctic minke whale	Medium	1	1	Negligible	Not significant
Fin whale	Medium	1	1	Negligible	Not significant
Sei whale	Medium	1	1	Negligible	Not significant
Southern right whale	High	1	1	Negligible	Not significant
Pygmy right whale	Medium	1	1	Negligible	Not significant
Toothed whales and dolphins					
Sperm whale	Medium	2	1	Low	Minor
Pigmy sperm whale	Medium	2	1	Low	Minor
Killer whale	High	1	1	Negligible	Not significant
False killer whale	Medium	1	1	Negligible	Not significant
Long-finned pilot whale	Medium	2	1	Low	Minor
Short-beaked common dolphin	Low	1	1	Negligible	Not significant
Bottlenose dolphin	Medium	1	1	Negligible	Not significant
Dusky dolphin	Medium	1	1	Negligible	Not significant
Risso's dolphin	Low	1	1	Negligible	Not significant
Hourglass dolphin	Low	1	1	Negligible	Not significant
Southern right whale dolphin	Medium	1	1	Negligible	Not significant
Beaked whale sp.	Medium	2	1	Low	Minor
Seals					
New Zealand fur seal	Negligible	1	1	Negligible	Not significant

Taking into the consideration the characteristics of the survey (i.e. occurring in open waters; the vessel travelling within a large survey site and not spending significant amount of time at one location; only one survey vessel being present in the survey area), the associated impact severity score for the majority of species is considered to be *negligible (1)* given that expected impacts will be only temporal with no lasting avoidance of the survey area. Also, there are no records that the survey area is located in the immediate vicinity of any important resting, breeding or nursing grounds for the majority of species, therefore if any temporal displacement did occur, it would not result in changes to a key life stage. However, the Chatham Rise might be an important foraging ground for certain species whose feeding habits are associated with specific topography features in the area (i.e. southern right whale, sperm whale, pygmy sperm whale, long-finned pilot whale and beaked whales). These species might be more impacted by avoidance of the area than those species whose feeding habits are mainly concentrated in the water column (e.g. oceanic dolphins), and this could potentially result in short term changes in foraging efficiency (i.e. impact severity score *low (2)*).

Given the temporary and short-term nature of the activity occurring in open waters, it is expected that physical disturbance will be limited to very low numbers of individuals present in the imminent vicinity of the survey vessel (proportion of population affected score is therefore *very low (1)*). As such, the overall magnitude of this impact is considered to be *negligible* to *low* while the impact significance is *not significant* to *minor*.

Considering the results of this assessment, no significant effects are predicted and no additional mitigation is either identified or required in relation to physical disturbance due to presence of the vessel.

7.3 Seismic Sound Effects

There is the potential for negative impacts from underwater noise as the frequencies at which marine mammals detect and produce sounds overlap with those of the seismic source (Figure 7.2). Such impacts can be direct and indirect depending on the acoustic characteristics of the source (i.e. noise level, duration, duty cycle, rise time and spectrum), the medium (bathymetry and hydro- and geo-acoustics parameters of the environment) and the receiver (age, size, behavioural state, auditory capabilities) (Erbe, 2012).

In general, the impacts of underwater noise produced by a seismic sound source on marine life can be:

- Physiological:
    - non-auditory – damage to body tissues and induction of gas and fat embolisms
    - damage to the auditory system, permanent hearing threshold shift (PTS) and temporary hearing threshold shift (TTS) resulting in hearing loss
- Perceptual: masking of communication with con-specifics[7], masking of other biologically important sounds used for navigation, finding prey, etc.
- Behavioural: interruption of normal behaviours such as feeding, breeding and nursing, behaviour modification, adaptive shifting of vocalisation intensity/frequency, and displacement from an area (short or long term)
- Indirect: disturbance or reduction in prey species.

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[7] Con-specific: two or more individual organisms, populations or taxa that belong to the same species.

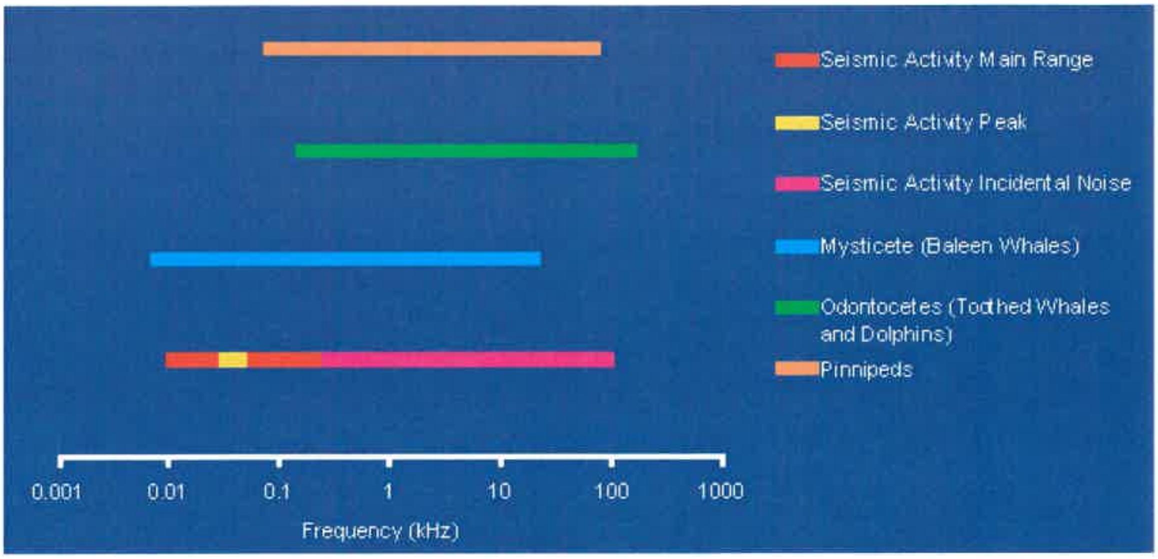

Figure 7.2 Auditory frequencies used by marine mammals and main frequency range of seismic activity based on Götz *et al.* (2009) and Southall *et al.* (2007)

Baleen whales are considered particularly vulnerable to seismic sound as their hearing frequency range (7 Hz to 22 kHz) overlaps greatly with those frequencies used for seismic surveys (10 to 120 Hz) (Figure 7.2). However, other marine mammals can be affected as well, given the fact that seismic surveys can produce incidental noise of up to 22 kHz (Goold & Fish, 1998).

It should be noted that the primary objectives of the 2013 Code aim to minimise disturbance to marine mammals and to minimise noise in the marine environment arising from seismic survey activities. All the mitigation measures outlined in the Code serve these primary objectives and these are included in the inbuilt mitigation (see Section 6).

7.3.1 Physiological Impacts

High levels of underwater sound can impact marine life as it could cause physical damage to tissues and organs (in particular gas-filled organs) and cavitations (bubble formation) (Erbe, 2012). Any mortality or direct physical injury from the noise and vibrations generated by a particular sound source is associated with very high peak pressure or impulse levels. Typically, these effects are associated with blasting activities or in the immediate vicinity of an acoustic source. It has been observed that at high exposure levels, such as those typical of underwater explosive activities or offshore impact pile-driving activities, fatality may occur in species of fish and marine mammals where the incidental peak to peak sound level exceeds 240 dB re 1 µPa. The likelihood of fatality increases with levels above 240 dB re 1 µPa, and as the time period of the exposure increases. Similarly, physical injury has been seen to occur where peak to peak levels exceed 220 dB re 1µPa (Hill, 1978; Goertner, 1982; Richardson *et al.*, 1995; Hastings & Popper, 2005).

Permanent and temporary injury as a result of acoustic exposure can occur in the form of hearing loss when the source level is of sufficient energy. This occurs when loud noises affect the hearing sensitivity of an individual either permanently (known as permanent threshold shift, PTS) or temporarily (temporary threshold shift, TTS; Richardson *et al.*, 1995).

A direct injury as a result of seismic surveys is only likely at very close range to an acoustic source of very high sound intensity. The acoustic modelling results suggest that injuring is only likely within maximum 8 m from the larger airgun source (i.e. 4,160 cu in). But considering the inbuilt mitigation measures which specify large mitigation zones that will be monitored for the presence of marine mammals throughout the duration of the survey covering both day and night periods the potential for any serious physiological impact during the proposed survey can be considered highly unlikely. Furthermore, the joint effort of MMOs and PAM Operators will ensure that the mitigation zones are monitored effectively for the presence of any SoC. If any are identified within the appropriate mitigation zones, immediate shut down of the active acoustic source will be initiated. Also, implementation of soft start procedures will ensure that any marine mammals not recorded during pre-start observation are warned about the presence of the acoustic source before it reaches its maximum power.

Due to marine mammal sensitivity to underwater noise and their protected status, a severity score of *2 (low)* is assigned for the majority of species. However, a higher score of *3 (medium)* is assigned to deep diving species (beaked whales and sperm whales) due to the higher number of recorded strandings associated with underwater noise. Marine mammals are highly mobile and will most likely avoid acoustic sources causing them discomfort before they get within the range at which physiological damage might occur (Gordon *et al.*, 2003). Taking that fact into account together with the inbuilt mitigation measures, the associated score for the proportion of the population affected is assigned as *very low (1).* Overall, impact magnitude is then *low* and impact significance either *minor* or *not significant*..

Table 7.4 sets out the result of the impact assessment for physiological impacts of the sound source.

Table 7.4 Non-auditory and auditory injury and mortality assessment

Species	Receptor Value	Impact Magnitude		Impact Magnitude	Impact Significance
		Severity	PoPA		
Baleen Whales					
Blue whale sp.	Medium	2	1	Low	Minor
Antarctic minke whale	Medium	2	1	Low	Minor
Fin whale	Medium	2	1	Low	Minor
Sei whale	Medium	2	1	Low	Minor
Southern right whale	High	2	1	Low	Minor
Pygmy right whale	Medium	2	1	Low	Minor
Toothed whales and dolphins					
Sperm whale	Medium	3	1	Low	Minor
Pigmy sperm whale	Medium	3	1	Low	Minor
Killer whale	High	2	1	Low	Minor
False killer whale	Medium	2	1	Low	Minor
Long-finned pilot whale	Medium	2	1	Low	Minor
Short-beaked common dolphin	Low	2	1	Low	Not significant
Bottlenose dolphin	Medium	2	1	Low	Minor
Dusky dolphin	Medium	2	1	Low	Minor
Risso's dolphin	Low	2	1	Low	Not significant
Hourglass dolphin	Low	2	1	Low	Not significant
Southern right whale dolphin	Medium	2	1	Low	Minor
Beaked whale sp.	Medium	3	1	Low	Minor
Seals					
New Zealand fur seal	Negligible	2	1	Low	Not significant

7.3.2 Perceptual (Masking of Vocalisations)

Marine mammals rely on sound as their primary sense for a variety of biologically significant functions. Increased levels of background noise can interfere with an individual's ability to detect relevant sounds by masking communication and echolocation signals as well as environmental sounds produced by prey species (David, 2006). Some species will respond to masking by ceasing vocalisation (Bowles *et al.*, 1994), whilst others may alter the intensity, length or frequency of their vocalisation (Di Iorio & Clark, 2010). Consequently, this can have implications for marine mammals' communication, navigation and foraging activities.

The greatest potential for masking of acoustic signals occurs in species that produce and perceive low frequency sounds, such as the baleen whales, seals and sea lions (Wright, 2008). Baleen whales in particular are thought to be sensitive to frequencies as low as 10 Hz, with their vocalizations typically occurring in the 10 – 300 Hz frequency range (Richardson *et al.*, 1995). Acoustic masking may occur over large areas particularly in those species that communicate in the lowest frequency ranges (i.e. blue and fin whales). Indeed, a recent study of Siebert *et al.* (2014) has revealed that airgun noise can lead to significant loss in communication ability for blue whales and fin whales up to 2,000 km from the source depending strongly on the frequency content of the vocalisation. The potential for masking at higher frequencies (1 to 25 kHz) exists when the vessel is in close proximity to the animal (Wright, 2008). In these circumstances, other marine mammals, including dolphins and porpoises may also experience masking to some degree.

Table 7.5 shows the frequency range of vocalisations produced by marine mammals that could occur in the survey area. Since frequencies used for communication in odontocetes are in the lower frequency range in comparison to those used for echolocation, these are more likely to be masked by seismic noise. Therefore animals' communication and social behaviour would be more affected than the foraging activities associated with echolocation signals.

Table 7.5 Frequencies of acoustic signals produced by marine mammals that are likely to be encountered in the survey area

Species	Communication Frequency range (kHz)	Echolocation Frequency range (kHz)	References
Blue whale sp.	0.016 - 0.2	N/A	McDonald, 2006; Samaran *et al.*, 2010; Manser, 2005
Antarctic minke whale	0.06 - 0.85	N/A	Gedamke *et al.*, 2001, Rankin & Barlow, 2005
Fin whale	0.016 - 0.044	N/A	Richardson *et al.*, 1995; Nieukirk *et al.*, 2004
Sei whale	0.1 – 3.5	N/A	Richardson *et al.*, 1995; McDonald *et al.*, 2005; Rankin & Barlow, 2007
Southern right whale	0.035 - 3	N/A	Parks & Tyack, 2007; Webster, 2014; Hofmeyr-Juritz, 2010
Killer whale	1.5 - 18	45 - 80	Richardson *et al.*, 1995; Howorth, 2003; Wellard *et al.*, 2015; Deecke *et al.*, 2005; Morisaka & Connor, 2007

False killer whale	2.7 – 10	Peaked frequencies: 45.7 – 110	Au *et al.*, 1995; Oswald *et al.*, 2003; Weir *et al.*, 2013; Morisaka & Connor, 2007
Long-finned pilot whale	1 - 8	Peaked frequencies: 34 - 94	Richardson *et al.*, 1995; Nemiroff & Whitehead, 2009; Eskesen *et al.*, 2011
Short-beaked common dolphin	3.56 - 23.51	71.8 - 128.8	Richardson *et al.*, 1995; Ansmann *et al.*, 2007; Morisaka & Connor, 2007
Bottlenose dolphin	0.2 - 24	34.5 - 131.9	Lôpez & Shirai, 2009; Morisaka & Connor, 2007
Risso's dolphin	4 - 22	Peaked frequencies: 80 – 100	Howorth, 2003; Corkeron & Van Parijs, 2001; Morisaka & Connor, 2007
Dusky dolphin	8.15 - 13.22	30 - 130	Au & Wursig, 2004; Vaughn-Hirshorn *et al.*, 2012; Yin, 1999; Morisaka & Connor, 2007
Hourglass dolphin	Data deficient	Peak frequency: 126	Kyhn *et al.*, 2009
Pygmy sperm whale	N/A	60 - 200 (Peak frequencies 45 - 117)	Marten, 2000; Ridgway & Carder, 2001; Madsen *et al.*, 2004a
Sperm whale	0.05 - 32	0.05 - 32	Howorth, 2003; Barlow & Taylor, 2005; Morrisey *et al.*, 2006
Arnoux's beaked whale	1 – 8.5	3 - 11	Rogers & Brown, 1999; Macleod & D'Amico, 2006
Cuvier's beaked whale	8 - 12	13 - 45	Johnson *et al.*, 2004; Macleod & D'Amico, 2006
New Zealand fur seal	0.5 - 2.6	N/A	Page *et al.*, 2002

Seismic airguns are characterised by emitting high intensity and low frequency noise. Most of the energy produced by a seismic array is under 200 Hz in frequency with a broad peak around 20 to 120 Hz (Breitzke *et al.*, 2008). Based on this, the main seismic frequency range heavily overlaps with frequencies used by baleen whales that are likely to occur in the survey area, while there is also a certain degree of overlap between the whole seismic frequency range (including incidental frequencies) and odontocetes, sperm whale and bottlenose dolphins in particular (Figure 7.3). Sperm whales are the largest odontocetes and are thought to have better low frequency hearing than smaller odontocetes (Ketten, 1992), so it is likely that sperm whales are more vulnerable to disturbance from seismic surveys. Madsen *et al.* (2006) quantified the airgun pulses recorded on sperm whales and concluded that, despite the presence of high frequency energy in some airgun pulses, the low duty cycle of airgun noise suggests that the pulses are not likely to pose a significant masking problem for sperm whale acoustic communication or echolocation (Madsen *et al.*, 2006; Mate *et al.*, 1994). New Zealand fur seals might also be affected to a certain extent given a partial overlap with their hearing frequency and the main seismic activity frequency range.

Overall, the potential for a masking effect is higher in deeper areas and for communication ranges using frequency bands below 100 Hz. Airguns can mask the communications of marine mammals up to 2,000 km, but that applies to species using the upper water column (0 - 200 m) (Siebert *et al.*, 2014).

Considering available literature, the impacts of possible masking will mostly affect vocalisations of baleen whale species, sperm whales, bottlenose dolphins and, to some extent, New Zealand fur seals. It is expected that the impact will be only short term considering that marine mammals are likely to exhibit avoidance behaviour, moving away from the zone within which their communication will be influenced (Gordon *et al.*, 2003). Therefore the associated impact severity for the mentioned species is *low (2)*, whilst it is *negligible (1)* for all other species.

Baleen whales communicate over great distances thus the impact of masking their sound will affect a higher proportion of the population (the proportion of the population affected is *medium (3)*). The odontocete species will be less impacted therefore their score is proportionally lower (*low (2)* for sperm whales and bottlenose dolphins and *very low (1)* for other species). The New Zealand fur seal score followed the same logic as that for the sperm whales and bottlenose dolphins.

As outlined in Table 7.6, the overall impact significance is considered to be either *minor* or *not significant*, meaning that the impacts of masking are not expected to significantly impair ecologically important behaviours of the majority of marine mammals in the survey area.

However, it appears that southern right whales will be more impacted by masking given their '*moderate*' impact significance score. This is due to their '*high*' receptor value based on their highly protected status in New Zealand. Despite this score, we could consider that the overall impact of masking on this species will be very similar as for other baleen whale species. This takes into account the fact that southern right whales do not congregate around the Chatham Rise in high numbers or for social purposes (i.e. breeding or nursing) when communication calls are prevalent. It is believed that they potentially use the wider area of the Chatham Rise as a foraging ground (Torres *et al.*, 2013), hence maintaining a group cohesion might not be of a paramount importance. Nonetheless, additional mitigation will be considered for this species and further measures outlined in the Section 8.

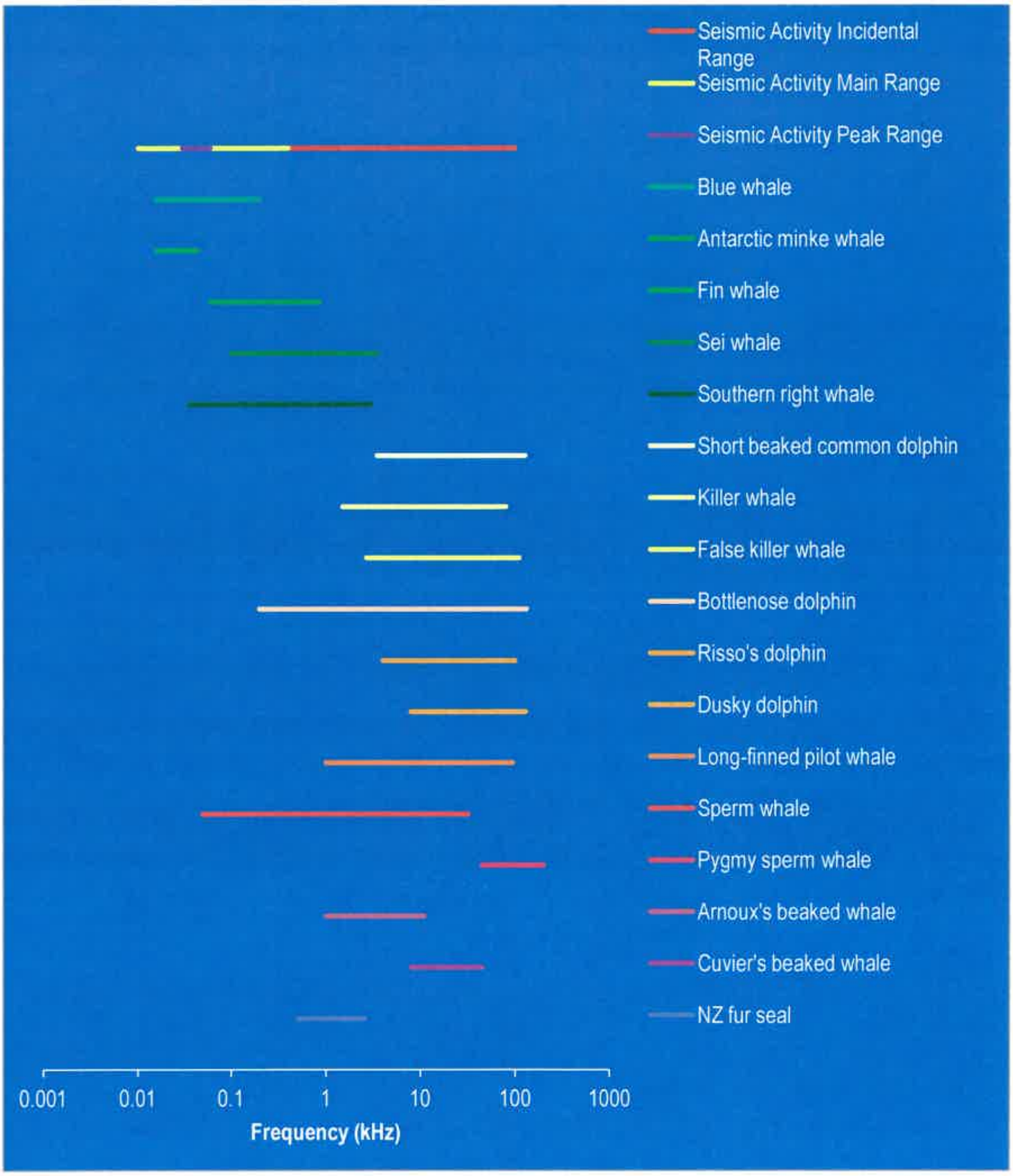

Figure 7.3 Frequency ranges of marine mammals likely to occur in the survey area and their overlap with the seismic survey frequency range

Table 7.6 Masking assessment

Species	Receptor Value	Impact Magnitude		Impact Magnitude	Impact Significance
		Severity	PoPA		
Baleen Whales					
Blue whale sp.	Medium	2	3	Medium	Minor
Antarctic minke whale	Medium	2	3	Medium	Minor
Fin whale	Medium	2	3	Medium	Minor
Sei whale	Medium	2	3	Medium	Minor
Southern right whale	High	2	3	Medium	Moderate
Pygmy right whale	Medium	2	3	Medium	Minor
Toothed whales and dolphins					
Sperm whale	Medium	2	2	Low	Minor
Pigmy sperm whale	Medium	1	1	Negligible	Not significant
Killer whale	High	1	1	Negligible	Not significant
False killer whale	Medium	1	1	Negligible	Not significant
Long-finned pilot whale	Medium	1	1	Negligible	Not significant
Short-beaked common dolphin	Low	1	1	Negligible	Not significant
Bottlenose dolphin	Medium	2	2	Low	Minor
Dusky dolphin	Medium	1	1	Negligible	Not significant
Risso's dolphin	Low	1	1	Negligible	Not significant
Hourglass dolphin	Low	1	1	Negligible	Not significant
Southern right whale dolphin	Medium	1	1	Negligible	Not significant
Beaked whale sp.	Medium	1	1	Negligible	Not significant
Seals					
New Zealand fur seal	Negligible	2	2	Low	Not significant

7.3.3 Behavioural Disturbance

The greatest amount of information available on the responses of marine mammals to sound from seismic surveys concerns behavioural responses. The available literature on this subject is also the most varied and highlights the lack of consensus among the scientific community on the occurrence, scale and significance of such effects (Götz *et al.,* 2009). Sounds at received levels above 120 dB re 1 µPa are believed to cause behavioural changes in 50% of all marine mammals (Richardson *et al.,* 1995).

Behavioural responses of marine mammals to underwater noise are dependent on a wide variety of factors, for example hearing sensitivity, historical exposure to similar noises and behaviour at the time of exposure. Sound can impact behaviour such as dive patterns, travelling distances or feeding behaviour. Responses such as avoidance or attraction behaviour could cause a disruption to normal functioning. When assessing this impact, many factors need to be considered including the hearing ability of the species as well as the context in which the species is exposed to the acoustic source. Ultimately, the extent of the impact will depend on the context in which the animal experiences the sound as well as the physical characteristics of the sound (Götz & Janik, 2011).

Existing studies have shown that many cetaceans exhibit different degrees of behavioural responses to seismic surveys (Stone & Tasker, 2006). One study on short-beaked common dolphins found populations to be temporarily disturbed (Goold, 1996), while another has found a reduction in cetacean diversity, mainly amongst members of the Delphinidae[8] family during an intense seismic survey (Parente & De Araujo, 2005). During seismic operations, killer whales have been shown to remain significantly further away from the source when the airguns are operating and show localised spatial avoidance (Stone & Tasker, 2006). However, no reduction in the sighting rate was found in response to operating airguns. Mate *et al.* (1994) reported sperm whale density in a preferred area of the Gulf of Mexico decreased to approximately one third of pre-survey levels for the two days after a seismic survey had started and decreased further to zero by the fifth day of surveying. In contrast to these reports, observations have been made that suggest sperm whales show little response and are not excluded from habitats by seismic surveys (Gordon *et al*., 2003). A more recent study of Thompson *et al.* (2003) has revealed that harbour porpoises get temporarily displaced when exposed to a 470 cu in acoustic source array. Their results revealed that such responses are short-lived lasting only a few hours and that the level of response declined throughout the 10-day survey period not leading to the long-term displacement of animals.

Many baleen whale species including blue, sei, minke, humpback and fin whales have shown behavioural changes in response to sound from seismic surveys (Malme *et al*., 1985; McCauley *et al.,* 2003; Gordon *et al.*, 2003). Male humpback whales appear to show either tolerant or attraction behaviour to seismic sources, while females show avoidance behaviour (McCauley *et al*., 1998; 1999; 2000). A group of 250 fin whales were reported to cease vocalising across an area of 10,000 square nautical miles coincident with a seismic survey (Clark & Gagnon, 2006).

The available studies on seals' reactions to seismic sound are even more contradictory. At one end of the spectrum there is avoidance behaviour, alteration of dive profiles, cession of foraging, moving away from the acoustic source (Thompson, 2000; Thompson *et al*., 1998), tighter grouping patterns between individuals, spending more time with their heads raised from the water, and staring at the airguns (Bain & Williams, 2006; Richardson, 2002). On the other hand, there is considerable tolerance towards novel underwater sounds especially in the presence of high food concentrations (Richardson, 2002; Reeves *et al*., 1996) and only mild localised avoidance to airguns demonstrated by arctic seals (primarily ringed seals, *Pusa hispida*), suggesting a degree of tolerance to the seismic noise produced (Harris *et al.,* 2001).

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[8] Family *Delphinidae* includes oceanic dolphins

The inbuilt mitigation measures outlined in the 2013 Code will probably have the greatest influence on reducing behavioural disturbance, since they are primarily designed to minimise acoustic disturbance to marine mammals from seismic operations. Considering the stringent requirements of the 2013 Code, specifically the use of soft starts, delays and shutdown of operations and the large mitigation zones, the effects of this impact will be greatly reduced. The results of the acoustic modelling for this survey suggest that behavioural disturbance can occur within maximum of 162 m from the larger acoustic source i.e. 4,160 cu in (see Section 4). However, taking into account the available literature which suggests a certain degree of behavioural disturbance even at large distances, the precautionary severity score *low* (2) has been assigned. It is expected that a small proportion of the population (*very low (1)*) in the immediate vicinity of the acoustic source will be directly affected for all except deep diving species who spend the majority of their time below the sea surface, and inhabit certain areas with specific seabed features. Such species are less likely to transit from the impact area and therefore a bigger proportion of the population will be affected (*low (2)*). Taking all this into account, the expected overall impact significance of behavioural disturbance will be *minor* or *not significant* (Table 7.7).

Table 7.7 Behavioral disturbance assessment

Species	Receptor Value	Impact Magnitude		Impact Magnitude	Impact Significance
		Severity	PoPA		
Baleen Whales					
Blue whale sp.	Medium	2	1	Low	Minor
Antarctic minke whale	Medium	2	1	Low	Minor
Fin whale	Medium	2	1	Low	Minor
Sei whale	Medium	2	1	Low	Minor
Southern right whale	High	2	1	Low	Minor
Pygmy right whale	Medium	2	1	Low	Minor
Toothed whales and dolphins					
Sperm whale	Medium	2	2	Low	Minor
Pigmy sperm whale	Medium	2	2	Low	Minor
Killer whale	High	2	1	Low	Minor
False killer whale	Medium	2	1	Low	Minor
Long-finned pilot whale	Medium	2	1	Low	Minor
Short-beaked common dolphin	Low	2	1	Low	Not significant
Bottlenose dolphin	Medium	2	1	Low	Minor
Dusky dolphin	Medium	2	1	Low	Minor
Risso's dolphin	Low	2	1	Low	Not significant
Hourglass dolphin	Low	2	1	Low	Not significant
Southern right whale dolphin	Medium	2	1	Low	Minor
Beaked whale sp.	Medium	2	2	Low	Minor
Seals					
New Zealand fur seal	Negligible	2	1	Low	Not significant

7.3.4 Indirect Effects on Prey Species

Although less research has been conducted on the responses of fish/invertebrate species to seismic sound, there is the potential that sound could cause disturbance, displacement or reduction in the presence of marine mammal prey species. Seismic surveys may therefore indirectly affect marine mammals in the area by changing the accessibility of their prey species.

A few studies have indicated that there may be such a connection. An observed lack of foraging dives reported for sperm whales exposed to seismic surveys could have been a result of prey displacement (Weilgart, 2007). Miller *et al.* (2006) also suggested that the observed foraging behaviour of sperm whales during seismic surveys might have been related to behavioural reactions of the sperm whale prey to airgun sound. These conclusions are supported by large scale changes in behaviour among fish populations exposed to seismic surveys (Götz *et al.*, 2009). Indeed, a study by Fewtrell and McCauley (2012) on captive marine fish and squid found that with increasing airgun noise (SEL between 120 and 184 dB re 1 $\mu Pa^2.s$), fish responded by moving to the bottom of the water column and swimming faster in more tightly cohesive groups. Also, a significant increase in alarm responses were observed in fish and squid exposed to airgun noise exceeding 147-151 dB re µPa SEL. Furthermore, studies by Engås *et al.* (1996) and Løkkeborg and Soldal (1993) have indicated probable declines in the catch rates for both cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus)* (between 45 and 70%) in the vicinity of an airgun array. Fish catches were affected at distances of nearly 25 nm and catch rates did not recover within five days of operations ending. A similar study showed a 52% decline in catches in a rockfish fishery exposed to a single airgun array (Skalski *et al.,* 1992). The exact reasons for such declines are presumed to be a result of changes in the swimming depth of fish or of shoaling behaviour in response to the airgun sound (Wardle, 2001). On the contrary, a study of Pena *et al.* (2013) did not find any changes in the behaviour of feeding herring schools. The authors observed no changes in fish swimming speed, swimming direction and school size that could be attributed to the seismic noise produced by an approaching vessel from a distance of 27 to 2 km over a 6-hour period. The lack of response was interpreted as a combination of a strong motivation for feeding, a lack of suddenness of the airgun stimulus and an increased level of tolerance to the seismic noise during the exposure period. Similarly, Miller and Cripps (2013) did not find any significant effects of the seismic surveys on the overall abundance and species richness of coral reef fish species. This contrasting evidence suggests that fish response to sound stimuli depends on the internal state and the behavioural activity as well as the character of the sounds exposure, and that there is not necessarily a direct link between sound exposure and fish reactions (Pena *et al.*, 2013).

Besides behavioural reactions, seismic surveys can have auditory impacts on fish and squid and there is evidence of physical injury among captive fish exposed to seismic noise at close range (McCauley *et al.*, 2000). A study on three species of fish examined threshold shifts caused by exposure to an operating 730 cu in airgun array (Popper *et al.*, 2005). The results showed varying degrees of threshold shift with recovery within 24 hours of exposure. André *et al.* (2011) examined the effects of low frequency sound exposure in four cephalopod species and found massive trauma in their acoustic structures.

It is very important to take into consideration the nature of a particular survey (i.e. noise exposure) when assessing the extent of the impact. In this particular case, the survey will not consist of a fine grid of closely spaced transect lines focusing on one area for long periods of time, as is usually the case for marine petroleum investigations. Instead, this survey will consist of widely spaced seismic lines within a large area focusing on different topographic features of interest. Therefore, the vessel will move through the area causing only temporary, short-lived impacts in one place at a time. In addition to this, the largest part of the survey will occur in deep waters where expected impacts are minimal (Parry & Gason, 2006).

Any impacts observed on fish species will in turn result in short term changes in the foraging efficiency of marine mammals. The severity of this impact is considered to be *low (2)* affecting only animals foraging in close vicinity of the acoustic source (i.e. the proportion of population affected will be *very low (1)*). This assessment resulted in *low* impact magnitude and overall *minor* to *not significant* impact significance for the marine mammal species being considered (Table 7.8).

Table 7.8 Indirect impact on prey species assessment

Species	Receptor Value	Impact Magnitude		Impact Magnitude	Impact Significance
		Severity	PoPA		
Baleen Whales					
Blue whale sp.	Medium	2	1	Low	Minor
Antarctic minke whale	Medium	2	1	Low	Minor
Fin whale	Medium	2	1	Low	Minor
Sei whale	Medium	2	1	Low	Minor
Southern right whale	High	2	1	Low	Minor
Pygmy right whale	Medium	2	1	Low	Minor
Toothed whales and dolphins					
Sperm whale	Medium	2	1	Low	Minor
Pigmy sperm whale	Medium	2	1	Low	Minor
Killer whale	High	2	1	Low	Minor
False killer whale	Medium	2	1	Low	Minor
Long-finned pilot whale	Medium	2	1	Low	Minor
Short-beaked common dolphin	Low	2	1	Low	Not significant
Bottlenose dolphin	Medium	2	1	Low	Minor
Dusky dolphin	Medium	2	1	Low	Minor
Risso's dolphin	Low	2	1	Low	Not significant
Horglass dolphin	Low	2	1	Low	Not significant
Southern right whale dolphin	Medium	2	1	Low	Minor
Beaked whale sp.	Medium	2	1	Low	Minor
Seals					
New Zealand fur seal	Negligible	2	1	Low	Not significant

8. Additional Mitigation

This MMIA has identified that the majority of the predicted effects of the survey are either non-significant or of minor significance, with the exception of masking which has moderate impact significance for southern right whales.

With the absence of moderate or major significant effects for the majority of species, no further mitigation is strictly required in order to protect these marine mammal populations from the potential effects of the survey. However, using GENZL's practical experience of undertaking marine mammal mitigation work the following additional mitigation will be incorporated into the survey to further reduce risk and assist in reporting to the Director-General of DOC:

- Two qualified MMOs will be on watch during all pre-start observations during daylight hours and any other key times (heath and safety permitting).
- To avoid any risk of collision with baleen whales during transit, at least one MMO is to be on watch during transits or at any times of increased vessel speed (i.e. above usual survey speed). If any baleen whales are sighted in the vicinity ahead of the vessel and if judged by the MMO that the animal/s is/are not responsive (i.e. during times of resting, feeding, socialising), the vessel's course will be altered to avoid collision with the animal/s.
- Immediate notification of the Director-General of DOC if SoC are encountered in unusually high numbers during the survey.
- Immediate notification of the Director-General of DOC if any SoC, identified as unlikely to be present in the survey area (especially baleen whales) is encountered during the survey.

In regards to southern right whales and the potential for masking of their biologically important calls, additional mitigation will be implemented: the mitigation zone for this species will be extended to 2 km if there are more than two sightings within a 24-hour period. The extended mitigation will last for 24 hours from the second and any other consecutive sighting within that period.

Finally, the majority of the measures and standards outlined in the 2013 Code will be followed even though they are not mandatory for the proposed survey (see Section 6). Hence both inbuilt and additional mitigation measures will be put in place for the duration of the survey.

9. In-Combination and Cumulative Effects

9.1 In-Combination Effects

Synergistic effects from the survey on individual receptors (e.g. collision risk + noise risk) may cause effects that, when combined, produce an increase (and possibly significant) in adverse effects.

The results of the assessment show mostly non-significant and minor levels of risk when assessed in isolation (with the exception of masking for southern right whales). When all potential project specific effects are viewed in-combination, the highest overall risk relates to largely baleen whales and deep-diving species (sperm whales and beaked whales) due to their higher sensitivity to underwater noise and overlap between their hearing ranges and main frequency ranges of seismic surveys. However, given the high level of mitigation proposed (inbuilt plus additional) it is not considered that the in-combination effects are more than minor for these species and no further mitigation is required.

9.2 Cumulative Effects

Cumulative effects can occur when other offshore projects or developments are conducted at the same time as this survey, providing a synergistic (incremental) change on receptors either through overlap in their respective ZoIs, extending the time period for disturbance to occur, or other similar mechanisms.

No other seismic surveys (e.g. for oil and gas exploration) are planned to coincide in the Chatham Rise region, therefore no overlap of the ZoI is expected. However, some seismic surveys might occur in the wider area off the east coast of the South Island (more than 500 km away from Chatham Island). There are two proposed large-scale, multi-basin surveys planned to take place during the summer season of 2015/16. Their exact timing and whether they will actually go ahead remains unknown at this point (DOC, per. comm.).

Other marine users might be present in the area such as fishing vessels and other non-seismic vessel which could potentially increase the risk of collision and physical disturbance. However, taking into account the nature of the proposed survey, the size of the survey area and the fact that other vessels will be most likely transiting through the survey area, the overlap in their activities and locations will be minimal. Therefore the associated cumulative risks are considered to be short-lived and insignificant.

It is therefore reasonably concluded that at the time of writing, there is no additional risk of cumulative effects occurring which would elevate the risks identified previously in this report to significant levels.

10. Monitoring and Reporting

For the duration of the survey, two MMOs and two PAM Operators will be present onboard the survey vessel. At least one MMO will be on watch during daylight hours while the acoustic source is in the water in the operational area and during transits to port. Both MMOs will be on watch during pre-start observations during daylight hours (health and safety permitting). MMOs with experience in PAM, when not required for visual observation, are allowed to undertake acoustic monitoring and allow the PAM Operator to have a refreshment break and time off for meals. A direct line of communication will be maintained between the MMOs and PAM Operators during those times.

Acoustic monitoring will be undertaken 24 hours per day, allowing coverage of the hours of darkness and poor visibility. One PAM Operator will be on watch at all times while the acoustic source is in the water in the operational area. If PAM equipment gets damaged or any problems occur with the system, operations may continue in the absence of PAM for 20 minutes whilst diagnosing the issue. If the diagnosis indicates that the PAM equipment must be repaired to solve the problem, operations may continue for an additional two 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 two 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 PAMS;
- Operations with an active source, but without an active PAMS, do not exceed a cumulative total of four hours in any 24 hour period.

The maximum duration of each observer's shift will be 12 hours in any 24 hour period, including time needed for reporting requirements.

Any on-duty observer has the authority to implement the mitigation measures outlined in the MMIA.

If any crew member onboard the survey vessel observes a marine mammal, he/she will promptly inform the MMO on duty who will then try to identify the animal/s and determine the distance from the acoustic source. When it is not possible to confirm the sighting, the crew member who reported the observation will provide as much information as possible for the MMO to complete the relevant recording forms. If the animal/s observed were within the relevant mitigation zone, it will be up to the MMO to decide whether to implement any mitigation measures. Observations reported by crew members will be clearly differentiated within the recording forms.

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

The recording and reporting will be done according to the requirements outlined in the 2013 Code.

All sightings/detections of marine mammals during the survey period will be recorded, including those beyond the mitigation zone and/or those during transit, in the standardised recording sheets. In addition to marine mammals, all sightings of other marine mega fauna such sea turtles and sharks will be recorded too. Whilst collecting data, a clear differentiation should be made between data derived from:

- MMO and PAM Operators
- Qualified and trained observers
- Watches conducted during survey operations (ON survey) or at any other times (OFF survey).

This raw data will be submitted by the Qualified observers, directly to the Director-General, at the earliest opportunity but no longer than 14 days after the completion of the survey. The 2013 Code requires interim data to be submitted following each crew rotation, however no crew changes are planned for this survey, so data will be submitted to DOC once operations are completed.

In addition to this, the Director-General is to be informed immediately when SoC are encountered in unusually high numbers. A decision whether any of the sightings or species encounters qualify for this requirement will be upon the professional judgement of the Qualified MMO onboard.

Furthermore, the Director-General should be notified about any variations from the standard provisions of the Code of Conduct and additional measures outlined in the MMIA within a 24-hour period. Such communication should be pursued via telephone. The first point of contact should be Ian Angus (Manager, Marine Species and Threats) +64 4 471 3081 (office) or (mobile).

A final trip report will be submitted to the Director-General at the earliest opportunity but no later than 60 days after completion of the survey. Both MMO and PAM Operators will be jointly responsible for recording observation data and compiling a final trip report.

This report should include:

- 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 vessel used
- Specifications of the seismic source array and PAM array
- Position, date, start/end of survey, GPS track logs of vessel movements
- Total time of seismic source operation (hours and minutes), indicating the respective durations of full-power operation, soft starts and acoustic source testing, and power levels employed, plus at least one random soft start sample during the survey
- 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, behaviour/activity and response of the marine mammal group (plotted in relation to vessel throughout detection)
- confirmed identification 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 variations from the standard provisions of the Code.

Data will be recorded in a standardised format, see: http://www.doc.govt.nz/notifications.

11. Research

Data collection for research purposes is a vital part of the 2013 Code and one if its main objectives. Considering that there is only limited data coming from live animal sightings around the Chatham Islands, all data collected during this survey will contribute to filling the knowledge gap on their presence in the area at this particular time of the year. In order to contribute to the scientific community, all effort will be given to publish this data in appropriate peer-reviewed journals.

Data on other marine mega fauna (sea turtles and sharks) will also be collected while MMOs with experience in seabird surveying will, where possible, collect incidental data on seabirds.

A whole chapter in the final survey report will be dedicated to any first record species sightings and acoustic detections, evidence of the extent of species' distribution ranges, and unusual sightings of species that were assessed as not likely to occur in the survey area during the survey.

MMOs on watch will use digital cameras to record all sightings possible. If any sightings of killer whales, southern right whales or humpback whales occur and good images are obtained, the photographs will be sent to these species' specialists in order to verify the origin (population/type) of these animals.

Overall, the data collected during this survey will be able to contribute to the knowledge on marine mammal presence/distribution around the Chatham Rise and associated deep waters, as well as the behavioural responses of marine mammals to this type of acoustic source.

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12. Appendices

Appendix A Consultation

Contact List for MMIA Consultation

Iwi/Trusts (2)

Name of Organisation	Contact person	Contact details	Date of correspondence	Comments received
Hokotehi Moriori Trust	– General Manager	Postal Address: PO BOX 188, Chatham Is / Rekohu 8942 Phone: 03 305 0450 / 0800 MORIORI Fax: 03 305 0454 Email: office@kopinga.co.nz Website: http://www.moriori.co.nz	04/11/2015	No comments received
Ngāti Mutunga O Wharekauri Iwi Trust	– chair Administrator Secretary	Postal Address: PO BOX 50, Waitangi, Chatham Islands 8942 Phone: 033050500 Fax: 033050566 Email: iwitrust@nmow.co.nz Website: http://www.nmow.co.nz	04/11/2015	No comments received

Local Councils and Government (3)

Name of Organisation	Contact person	Contact details	Date of correspondence	Comments received
Chatham Islands Council	n/a	Postal Address: 9 Tuku Road, Waitangi, PO Box 24, Chatham Islands 8942 Phone: (03) 305-0033 or 305-0034 Email: info@cic.govt.nz	04/11/2015	No comments received
DOC	Dave Lundquist - Technical Advisor, Marine	dlundquist@doc.govt.nz DDI: +64 4 471 3204 VPN 8204	Previous meetings between clients and DOC on 20/08/2014 and	Information provided on other surveys in the area, as

	Species and Threats Connie Norgate – manager Chatham Island office	cnorgate@doc.govt.nz DDI: +64 3 305 0098 | | VPN: 5548	12/08/2015 Consultation email sent by GENZL: 04/11/2015	well as information on sightings and strandings in the area. Awaiting to hear from Connie Norgate.
Environmental Protection Authority	Natasha O'Reilly Advisor, EEZ	General number: +64 4 916 2426 rminfo@epa.govt.nz	Previous meetings between clients and EPA on 12/08/2015 Consultation email sent by GENZL: 04/11/2015	No comments received.

Other NGOs and Institutions (7)

Name of Organisation	Contact person	Contact details	Date of correspondence	Comments received
NZ Whale and Dolphin Trust	n/a	General number: +64 27 447 4418 info@whaledolphintrust.org.nz	04/11/2015	No comments received
Project Jonah, NZ	General Manager	General number: (09) 302 3106	04/11/2015	No comments received
WWF NZ	n/a	General number: (04) 499 2930 info@wwf.org.nz	04/11/2015	No comments received
University of Otago	Professor Professor dr.	Office: 310 Castle Street, room 211A Phone: Email: Email: Phone	04/11/2015	No comments received
University of	Dr	School of Biological Sciences,	04/11/2015	No

Auckland	– Senior Lecturer	University of Auckland, Private Bag 92019, Auckland, New Zealand. Phone: Fax: +64 (0)9 373-7417 Email:		comments received
Coastal Marine Research Group (Massey University)	Prof – Co-director Dr. – Co-director (maternity leave, to contact her replacement)	Coastal-Marine Research Group Room 5.11 Building 5, Gate 4 Albany Campus Massey University Tel: Email:	04/11/2015	No comments received
NIWA	Dr - Principal Scientist - Fisheries	Postal Address: 41 Market Place Viaduct Harbour Auckland Central 1010 Private Bag 99940 Newmarket, Auckland 1149 Fax: +64 7 856 0151	04/11/2015	No comments received

Fishery Groups (9)

Name of Organisation	Contact person	Contact details	Date of correspondence	Comments received
Seafood NZ	- CEO - Policy Manager		04/11/2015	No comments received

		Email: info@seafood.org.nz Phone: · Postal address: Seafood New Zealand PO Box 297 Manners Street Wellington 6140 New Zealand		
Deepwater group	Fisheries Specialist	General number: +64 4 802 1844 admin@deepwatergroup.org	04/11/2015 05/11/2015 11/11/2015 13/11/2015 16/11/2015 17/12/2015 22/12/2015 23/12/2015	replied asking for survey line coordinates. Possible overlap with important fishery habitats for scampi and orange roughy. Concerns raised on potential loss of catch rate and impact on species such as scampi. Coordinates were sent as well as some papers on the effect of seismic surveys on fish and shellfish. supplied maps of fishery sensitive areas for hoki, scampi, orange roughy, ling and oreo dory collated by the MPI. Communication channels to be established prior to the survey and final MMIA sent to
Sealord	n/a	General number: +64 9 579 1659 inquiries@sealord.com	04/11/2015	No comments received

Egmont Seafoods	Managing director		04/11/2015	No comments received
New Zealand Federation of Commercial Fishermen	President	General number: 04 802 1501	04/11/2015	No comments received
Te Ohu Kaimoana (The Maori Fisheries Trust)	Chair Deputy Chair	Te Ohu Kaimoana PO Box 3277 WELLINGTON Phone: 04 931-9500 Fax: 04 931-9518	04/11/2015	No comments received
Ngāi Tahu Seafood Limited		6 Bolt Place / PO Box 3787 Christchurch New Zealand Telephone: Email: fish@ngaitahu.iwi.nz	04/11/2015	No comments received
United Fisheries		50-58 Parkhouse Road Sockburn Christchurch 8042 New Zealand Phone: +64 3 343 0587 Fax: +64 3 348 6788 mail@unitedfisheries.co.nz	04/11/2015	
Sanford Ltd	vessel manager	Postal Address: PO Box 443 Auckland 1140 New Zealand General numbers: Tel: +64 (9) 379 4720 Fax: +64 (9) 309 1190	04/11/2015 11/11/2015	replied asking for survey line coordinates. Coordinates sent. No further comments received.

		info@sanford.co.nz		

Consultation Letter and Information Sheet Sent to Consultees

GARDLINE ENVIRONMENTAL (NEW ZEALAND) LIMITED.
HP Tower, Level 15, 171 Featherston Street,
Wellington, 6011, New Zealand

Tel: +64 (0) 4 894 8569
Fax: ++64 (0) 4 894 6598
Email: marine-wildlife@gardline.com

4th November 2015

2016 Scientific Survey - Chatham Rise (New Zealand): Gondwana breakup and Chatham Rise Structure
Alfred Wagner Institute for Polar Research (Germany) and GNS Science

Marine Mammal Impact Assessment

Dear Sir/Madam,

We write on behalf of the Alfred Wegener Institute Helmholtz-Centre for Polar and Marine Research (AWI) (Germany) and GNS Science regarding the Marine Mammal Impact Assessment (MMIA) for a scientific geophysical and geological survey, which is currently scheduled for 1st February to 22nd March 2016. The survey will cover the eastern part of the Chatham Rise, New Zealand and will be composed of seismic surveying, gravity/magnetic surveying, geothermal heat-flow measurements and hardrock dredging. During approximately 16 days of the seven week survey, seismic airguns will be utilised. The aim of the survey is to improve understanding of the processes controlling the disassembly of a supercontinent, in particular Gondwana, the structure of the Chatham Rise, as well as the nature of the continental-ocean transitional crust to the southeast of the Chatham Rise. Further information regarding the survey itself and a brief explanation of the effects of underwater noise on marine mammals are provided in the accompanying summary sheet.

Gardline Environmental (New Zealand) Ltd has been appointed to undertake an MMIA in advance of the survey. The aim of the MMIA is to determine the potential impact on local marine mammal populations. The team is currently collating data and undertaking an initial consultation of all relevant stakeholders, in accordance with the guidelines of the '2013 Code of Conduct for minimising acoustic disturbance to marine mammals from seismic survey operations', published by the New Zealand Department of Conservation.

To assist us with compiling a robust MMIA, we welcome any comments or concerns you may consider relevant to either the assessment itself (including any comments on appropriate assessment methods), or the survey. We are working to a strict schedule, and would therefore be grateful if you could respond at the first possible instance, but no later than 18th November to Maja Nimak-Wood (maja.nimak-wood@gardline.com).

Please do not hesitate to contact us with any queries you may have regarding the proposal.

Yours sincerely,

Maja Nimak-Wood
Senior Marine Mammal Scientist

2016 SCIENTIFIC GEOPHYSICAL AND GEOLOGICAL SURVEY

CHATHAM RISE (NEW ZEALAND): GONDWANA BREAKUP AND CHATHAM RISE STRUCTURE

SUMMARY SHEET

THE SURVEY

The Alfred Wegener Institute Helmholtz-Centre for Polar and Marine Research (AWI) in collaboration with the Helmholtz-Centre for Ocean Research (GEOMAR), both in Germany, and GNS Science from New Zealand will be conducting a geophysical and geological survey as part of a scientific research project. The proposed survey is currently scheduled for 1st February to 22nd March 2016. The survey will mainly cover the eastern end of the Chatham Rise, New Zealand (Figure 1) and will be composed of seismic surveying, gravity/magnetic surveying, geothermal heat-flow measurements and hardrock dredging.

The project will focus on the southeast Chatham Rise - the region of initial breakup, in the New Zealand region, of the long-lived (300 to 100 million years ago) Gondwana supercontinent. Survey data collected by AWI from Marie Byrd Land, Antarctica, will be matched to data collected from the southeast Chatham Rise to build an understanding of the reasons for the supercontinent breakup and how the gap between New Zealand and Antarctica developed. More detailed knowledge of this breakup between 110 and 85 million years ago will assist in understanding the widespread formation of basins throughout New Zealand and the southwest Pacific during this same period.

The project will also examine the structure of the Chatham Rise and how it was formed by plate tectonic subduction processes between 270 and 100 million years ago.

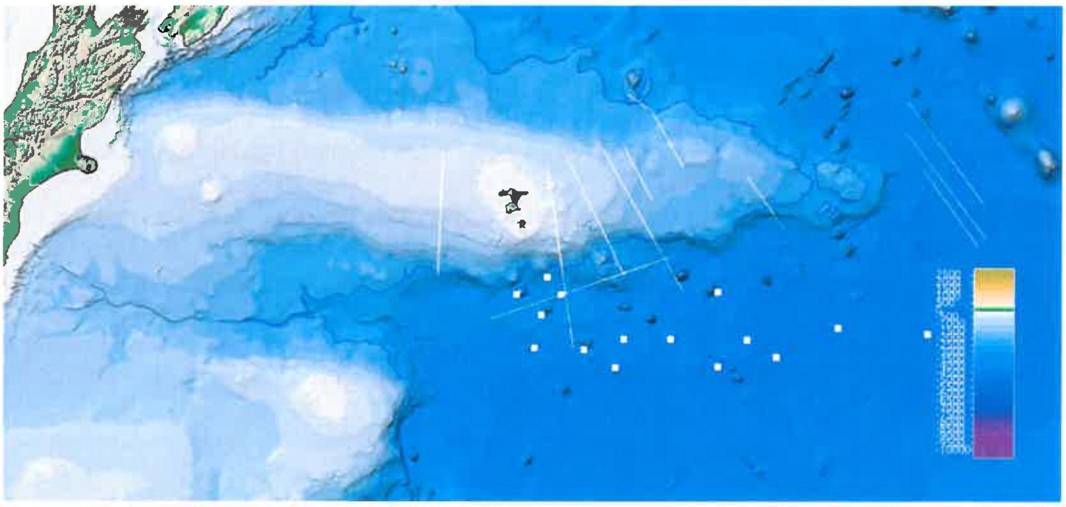

Figure 1 **Location map of the survey lines and proposed dredge sites (squares)**

During approximately 16 days of the seven week survey, seismic airguns of operational capacity of up to 4,052 cubic inches (cu.in.) will be utilised. The seismic survey will involve long, single transect, regional seismic profiles, spaced 50 - 250 km apart (Figure 1). By nature, this type of survey is different from systematic seismic surveys used for oil and gas development, where a series of parallel seismic lines, often forming a grid, are run within a particular licence block. The current survey will also measure the gravity and magnetic field along profiles, geothermal heat flow through the seafloor at certain sites, and conduct detailed mapping of the seafloor depth. Rock samples will be obtained from seamounts formed in the area of the Gondwana breakup by dragging a dredge, with a 1 x 0.4 m mouth, up part of the side of exposed seamounts.

Following data analysis in the ensuing few years post-survey, interpretation of the findings will be published and the data made publicly available.

THE 2013 CODE

The *'2013 Code of Conduct for minimising acoustic disturbance to marine mammals from seismic survey operations'* (hereafter "the 2013 Code") defines levels of seismic surveys based on the clear demarcation of acoustic source capacity.

- **Level 1 survey** – any marine seismic survey using an acoustic source with a total combined operational capacity exceeding 427 cu. in. These surveys are the most stringently controlled with the largest mitigation zones and highest number of marine mammal observers required.

Given the airgun source capacity for the current survey, the seismic activity associated with this survey has been classified as **"Level 1"** by the Department of Conservation.

The seismic survey undertaken from the foreign research vessel is exempt from mandatory provisions of the 2013 Code and Marine Mammal Impact Assessment (MMIA), however both AWI and GNS Science wish to voluntarily adopt provisions of the 2013 Code in order to protect marine mammals in the survey area.

Therefore, a MMIA will be conducted which aims to identify the potential impacts to marine mammals in the area from the seismic operations, and determine steps to avoid, remedy or mitigate any negative effects.

SEISMIC ACTIVITY AND MARINE MAMMALS

An acoustic pulse produced by an array of towed airguns creates a sound wave which allows visualisation of the structure of the seabed to considerable depths below its surface (Figure 2). Seismic exploration includes the input of sound into the marine environment, at frequencies that overlap with the auditory frequencies used by many marine mammals.

Impacts to marine mammals are likely to be species and individual specific, and rely on factors such as exposure levels and duration. In 2013, the Department of Conservation produced a robust set of guidelines for seismic contractors to minimise the impacts of operations on this important group of marine animals. These guidelines include the use of mitigation measures, such as visual and acoustic monitoring of marine mammals throughout survey operations. The mitigation measures which will be employed during the current survey are outlined below.

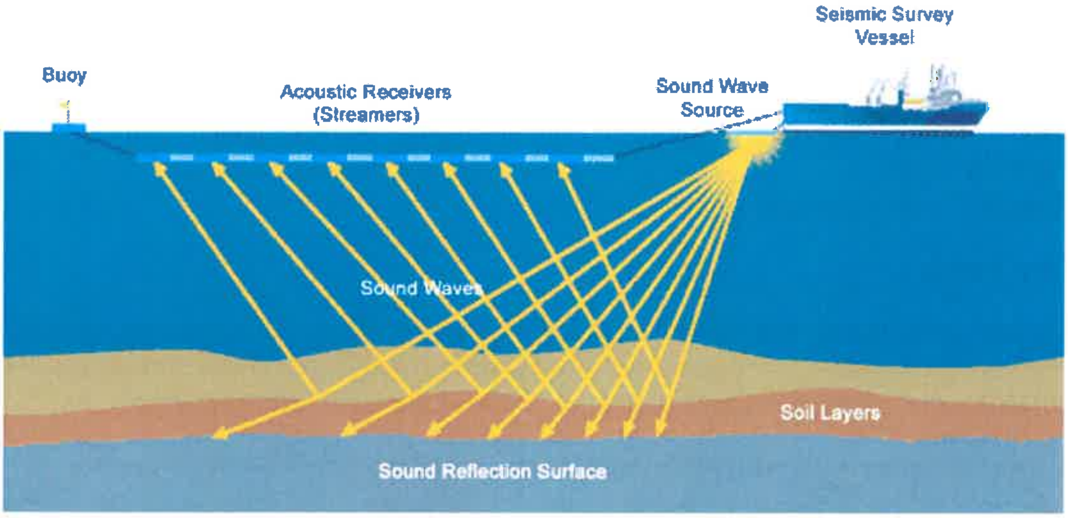

Figure 2 **Seismic survey diagram** *(source www.fishsafe.eu)*

MITIGATION APPROACHES

A minimum of two Marine Mammal Observers (MMOs) will be present for all daylight seismic activity. These MMOs will be responsible for monitoring seismic activity and ensuring that operations are carried out in a safe manner for marine mammals in the area as per the standards outlined in the 2013 Code.

In addition to visual observations, Passive Acoustic Monitoring (PAM) will be utilised during seismic surveying on a 24-hour basis, with a minimum of two PAM System operators onboard the survey vessel. PAM provides a means of monitoring for vocalising marine mammals, meaning that mitigation can be conducted in periods of low visibility, or at night-time, and when used in conjunction with visual observations, it enhances the likelihood of marine mammal detection in the survey area.

All members of the mitigation team will be sufficiently trained, experienced and accredited by the Department of Conservation.

Standard mitigation approaches detailed in the 2013 Code include conducting pre-start observations before any seismic activity commences; delaying the start of operations for marine mammals within broad mitigation zones of up to 1.5 km; increasing the power of the acoustic array gradually to allow animals to leave the area before operations reach full power (soft starts); and performing shut-downs of operations for marine mammals identified as Species of Concern by the New Zealand Government. The MMIA may recommend extra mitigation approaches as necessary on a site by site case.

More information about the mitigation approaches adopted by seismic surveys in New Zealand waters can be found on the Department of Conservation website (http://www.doc.govt.nz/conservation/marine-and-coastal/seismic-surveys-code-of-conduct/).

Written Responses Received

From: Maja Nimak-Wood
Sent: 23 December 2015 12:05
To: 'Richard Wells'
Subject: RE: Invitation for consultation

Dear Richard,

Our client agrees that it is very important to keep communication on timing of the survey lines, especially those crossing the fishing grounds. The initial timing schedule will be prepared and available early January. This schedule will be refined when at sea if weather and equipment problems cause any changes.

Proving that contact numbers/details are established by the 1st Feb (when the survey commences), this information and regular updates will be sent to you or the appropriate contact person in advance. Please specify how much in advance would you require such information?

Also, please note that this information will be communicated via notices to mariners.

Regarding the impact upon fish stocks, we do not expect any major effects but only temporal ones such as localised, short term scattering impacting only animals in the close proximity of the acoustic source. We will provide you with the final version of the MMIA once it is approved by the DOC which we expect to be by the end of January 2016.

Best wishes,

Maja

Maja Nimak-Wood, MSc, MIMarEST
Senior Marine Mammal Scientist

Gardline Environmental Limited

Endeavour House, Admiralty Road,
Great Yarmouth, Norfolk, NR30 3NG
Tel: +44 (0)1493 845600
Fax: +44 (0)1493 852106
www.gardlinemarinesciences.com

From: Maja Nimak-Wood [mailto:maja.nimak-wood@gardline.com]
Sent: Wednesday, 23 December 2015 3:40 a.m.
To:
Subject: RE: Invitation for consultation

Dear

Many thanks for the maps. I have forward them together with your email to our client and will inform you on their response regarding the communication and assessment.

Will be in touch as soon as I hear back from them.

All the best for the festive season ahead.

Merry Christmas.

Kind regards,

Maja Nimak-Wood, MSc, MIMarEST
Senior Marine Mammal Scientist

Gardline Environmental Limited

Endeavour House, Admiralty Road,
Great Yarmouth, Norfolk, NR30 3NG
Tel: +44 (0)1493 845600
Fax: +44 (0)1493 852106
www.gardlinemarinesciences.com

From.
Sent: 17 December 2015 18:34
To: Maja Nimak-Wood
Cc:
Subject: RE: Invitation for consultation

Hullo Maja,

Apologies for the tardiness in my response.

I have had Ministry for Primary Industries (Fisheries Div) collate data on our more important fishing grounds in the area proposed for survey transects.

Maps for key species – hoki, scampi, orange roughy, ling and oreo dory are attached.

Our concerns with these surveys are always related to potential loss of catch rate due to fish aggregations dispersed by noise as well as actual impact on species such as scampi.

Also navigational conflict can be a problem for both parties

It is very important to us that we have absolutely best information on confirmed timing of the survey and information on communications.

Can you please advise when this information will be available?

Also can you please provide for our reference the overall risk assessment undertaken for this work including final marine mammal assessment?

Merry Xmas!

Regards,

Fisheries Specialist

Deepwater Group Ltd
M
E
W www.deepwatergroup.org

From:
Sent: 16 November 2015 19:56
To: Maja Nimak-Wood
Subject: RE: Invitation for consultation

Hi Maja,

Thank you for the papers, I have circulated to some of my members.

Please note that the Govt dept involved (MPI) are redrawing the maps of grounds I have requested taking out the actual detail of fishing positions so that they show the area rather than actual positions thus confidentiality preserved). Once this is done I shall run them past my members then on their advise send thru to you.

Thank you for your patience.

Rgds Etc I

Regards,

Fisheries Specialist

Deepwater Group Ltd
M
E
W www.deepwatergroup.org

From: Maja Nimak-Wood
Sent: 13 November 2015 09:41
To:
Cc: Joana Torres
Subject: RE: Invitation for consultation

I have reviewed available literate and concluded that we can expect only minor impacts such as temporal displacement of fish within few hundred meters of the acoustic source. Overall, given the nature of the proposed survey which will consist of widely spaced single transect lines (not like typical petroleum surveys which focus on one specific area running a fine grid of survey lines for days/weeks), the temporal impacts of the proposed activity (only 16 days of acoustic activity in total but within a wide area so impact at one location will be limited to a day or two) as well as abundance and wide distribution of fish species, any expected impacts on fish species will be insignificant.

There is less information on impacts on scampi and crustaceans but similar effects are being expected.

Please see some papers attached. I will send few more in another email due to attachment size.

Let me know if you have any further questions.

Kind regards,

Maja

Maja Nimak-Wood
Senior Marine Mammal Scientist

Gardline Environmental Limited

Endeavour House, Admiralty Road,
Great Yarmouth, Norfolk, NR30 3NG
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Fax: +44 (0)1493 852106
www.gardlinemarinesciences.com

From:
Sent: 10 November 2015 16:32
To: Maja Nimak-Wood
Subject: RE: Invitation for consultation

Hi Maja,

I have commenced work on this immediately. I will ask our authorities (MPI) who manage fisheries to create a map based on vessel official logbooks (reconciled against VMS) to delineate areas of major fishing activity.

I am hoping this will be a rapid process.

Thanks

Regards,

Fisheries Specialist

Deepwater Group Ltd
M
E
W www.deepwatergroup.org

From: Maja Nimak-Wood [mailto:maja.nimak-wood@gardline.com]
Sent: Wednesday, 11 November 2015 12:32 a.m.
To:
Cc: Joana Torres
Subject: RE: Invitation for consultation

Dear I

Many thanks for your replay.

Our client has agreed to provide you with the line coordinates. Please see them attached. Please note that they will also be announced via 'notice to mariners' before the commencement of the survey. In addition, if you are concerned on the impact of the seismic survey to fish and scampi, we can provide you with papers that show there is no major effect on these stocks.

Also, it would be of a great help for the assessment and for the logistics of the survey if you could provide us with the locations of fishery areas (in particular those most sensitive ones), what type of fishing gear is in use at those locations and periods of intensive fishing effort.

Kind regards,

Maja Nimak-Wood
Senior Marine Mammal Scientist

Gardline Environmental Limited

Endeavour House, Admiralty Road,
Great Yarmouth, Norfolk, NR30 3NG
Tel: +44 (0)1493 845600
Fax: +44 (0)1493 852106
www.gardlinemarinesciences.com

From:
Sent: 05 November 2015 17:51
To: Maja Nimak-Wood
Subject: RE: Invitation for consultation

Hi Maja,

Can we please have the start and end position of the seismic survey snaphots.

They appear to go directly over some very important fisheries habitat for scampi and orange roughy.

Regards,

From: Maja Nimak-Wood [mailto:maja.nimak-wood@gardline.com]
Sent: Wednesday, 4 November 2015 11:42 p.m.
Subject: Invitation for consultation

Dear Sir/Madam,

On behalf of the Alfred Wegner Institute for Polar Research (Germany) and GNS Science (New Zealand), we would like to invite you to participate in the consultation and help us develop a robust Marine Mammal Impact Assessment (MMIA) for the upcoming scientific survey 'Chatham Rise : Gondwana breakup and Chatham rise structure'.

Please find consultation letter and information sheet attached.

Please do not hesitate to contact me should you have any questions.

I am looking forward to hearing back from you.

Kindest regards,

Maja Nimak-Wood
Senior Marine Mammal Scientist

Gardline Environmental Limited

Endeavour House, Admiralty Road,
Great Yarmouth, Norfolk, NR30 3NG
Tel: +44 (0)1493 845600
Fax: +44 (0)1493 852106
www.gardlinemarinesciences.com

From: Maja Nimak-Wood
Sent: 11 November 2015 09:23
To:
Cc: Joana Torres
Subject: RE: Scientific survey 2016, Chatham Rise

Dear

Many thanks for your replay.

Our client has agreed to provide you with the line coordinates. Please see them attached. Please note that they will also be announced via 'notice to mariners' before the commencement of the survey.

Kind regards,

Maja Nimak-Wood
Senior Marine Mammal Scientist

Gardline Environmental Limited

Endeavour House, Admiralty Road,
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Fax: +44 (0)1493 852106
www.gardlinemarinesciences.com

From:
Sent: 10 November 2015 02:48
To: Maja Nimak-Wood
Subject: Scientific survey 2016, Chatham Rise

Good afternoon Maja,

Could you please send me the latitude & longitude positions for the start & end of the transect lines proposed for the survey at the eastern end of the Chatham Rise.

There is only a very general indication on your information sheet

Thanks & rgds

Vessel Manager - San Discovery

SANFORD

Hall Street, North Mole, Timaru 7910, New Zealand

Private Bag 905 - Timaru 7940, New Zealand

SANFORD.CO.NZ

From: Maja Nimak-Wood [mailto:maja.nimak-wood@gardline.com]
Sent: Wednesday, 4 November 2015 10:42 p.m.
Subject: Invitation for consultation

Dear Sir/Madam,

On behalf of the Alfred Wegner Institute for Polar Research (Germany) and GNS Science (New Zealand), we would like to invite you to participate in the consultation and help us develop a robust Marine Mammal Impact Assessment (MMIA) for the upcoming scientific survey 'Chatham Rise : Gondwana breakup and Chatham rise structure'.

Please find consultation letter and information sheet attached.

Please do not hesitate to contact me should you have any questions.

I am looking forward to hearing back from you.

Kindest regards,

Maja Nimak-Wood
Senior Marine Mammal Scientist

Gardline Environmental Limited

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Appendix B Noise Prediction Modelling

Noise Propagation Modelling Report

Prepared For

Project

Marine Mammal Impact Assessment
Chatham Rise (New Zealand): Gondwana Breakup and Chatham Rise Structure

Date

12th January 2016

Published by

Gardline Environmental (New Zealand) Ltd
HP Tower, Level 15
171 Featherston Street
Wellington
6011
New Zealand

www.gardlinemarinesciences.com

Executive Summary

- This appendix has been prepared by Gardline Environmental (New Zealand) Ltd. (GENZL) under the scope of work of the Marine Mammal Impact Assessment (MMIA), for the seismic survey operations proposed for the southeast Chatham Rise, New Zealand.

- In order to address the 2013 the Department of Conservation's Code '*2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations*' requirements, noise prediction modelling was conducted to assess both the potential effects that the seismic survey would have on marine mammals and the suitability of the mitigation measures proposed.

- The impact ranges were predicted based on the source characteristics and physical parameters given by the client for two airgun arrays at three locations within the survey area. The propagation model utilised was Gardline Environmental (New Zealand) Limited's (GENZL's) 360M predictive acoustic model which was run along 360 transects radially from each of the locations chosen. For marine mammal impact range estimations predictions based on 8 radial transects (N, NE, E, SE, S, SW, W, NW) were modelled at 10 km from the source.

- The predicted impact ranges were computed for species groups based on their predicted hearing sensitivity; low frequency cetaceans, medium frequency cetaceans, high frequency cetaceans and pinnipeds in water as mentioned in Southall *et al.* (2007), for injury and behavioural disturbance.

- The results confirm that there is no need to either extend the radius of the mitigation zone or limit the acoustic source power, as the impact ranges obtained are all less than 200 m.

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List of Abbreviations

AWI	Alfred Wegner Institute
Bar-m	Bar-meter
$CaCO_3$	Calcium carbonate
cu in	Cubic inch
dB	Decibels
DOC	Department of Conservation
GENZL	Gardline Environmental (New Zealand) Limited
Hz	Hertz
kHz	Kilohertz
Km	Kilometers
m	Meters
MMIA	Marine Mammal Impact Assessment
m/s	Meters per second
N/m^2	Newton per meter squared
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OBS	Ocean bottom seismometers
Pa	Pascal
RAM	Range Dependent Acoustic Model
RL	Received Level
RMS	Root mean square
SEL	Sound Exposure Level
SoC	Species of Concern
SPL	Sound Pressure Level
TL	Transmission Loss

1. Introduction

1.1 Scope of Work

This present appendix has been prepared by Gardline Environmental (New Zealand) Ltd. (GENZL) under the scope of work of the Marine Mammal Impact Assessment (MMIA) required by the Alfred Wegner Institute Helmholtz Centre for Polar and Marine Research (AWI) and GNS Science. This report provides the results of noise propagation modelling and the assessment of underwater noise from seismic survey operations proposed for the *R.V. Sonne* research cruise SO-246 at Chatham Rise, New Zealand.

The purpose of the study is to provide supporting information for the mitigation plan for the area in accordance with Department of Conservation (DOC) *2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations* requirements, Appendix 1:

"Where activities are planned in Areas of Ecological Importance or Marine Mammal Sanctuaries, sound transmission loss modelling will be incorporated into the MMIA methodology and ground-truthed during the course of the survey by appropriate means. Such modelling will indicate predicted sound levels within the various mitigation zones and potential impacts on species present. If sound levels are predicted to exceed either 171 dB re 1 µPa²s (SEL) at distances corresponding to the relevant mitigation zones for Species of Concern or 186 dB re 1 µPa²s at 200 m (SEL), consideration will be given to either extending the radius of the mitigation zone or limiting acoustic source power accordingly."

1.2 Survey Area and Parameters

The survey site is to be located on the eastern end of the Chatham Rise, New Zealand (Figure 1.1) in an area of water-depth ranging between 200 and 3000 m.

The survey will be composed of seismic surveying, gravity/magnetic surveying, geothermal heat-flow measurements and hardrock dredging.

During approximately one third of the 51 day survey, crustal seismic reflection and seismic refraction equipment with a maximum source of 4,160 cu in and minimum source of 600 cu in will be utilised. The seismic survey will compose of long, single way, regional seismic profiles covering essential elements of crustal structure in the region of the Chatham Rise.

1.3 Report Structure

The present report will comprise the following sections:

- Introduction to the basics of underwater acoustic metrics and propagation
- Sound source description
- Underwater noise propagation modelling including parameters, assumptions and results
- Impact assessment
- Conclusions

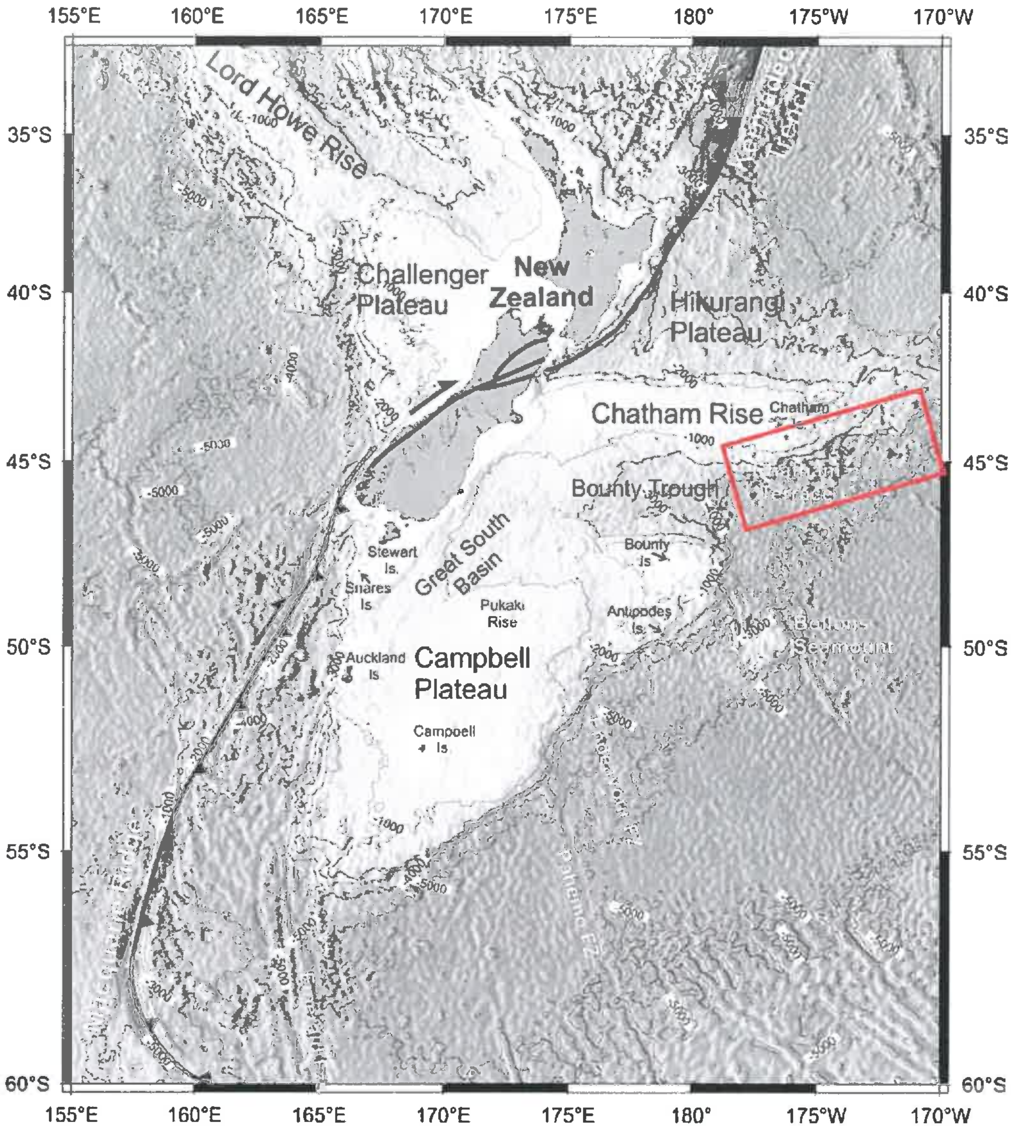

Figure 1.1 Location of the Chatham Rise survey area

2. Basics of Underwater Acoustic Metrics and Propagation

This section outlines some of the relevant concepts in underwater acoustics.

2.1 Underwater Noise Metrics

It is very important to state correct acoustic metrics in a clear and unambiguous way. There are guidance documents available (TNO, 2011; NPL, 2014) which provide a detailed review of the metrics used to measure and assess the impact of underwater noise in the marine environment. Therefore, a brief overview of these concepts is provided here rather than a comprehensive review.

Sound results from the propagation of a mechanical disturbance in a compressible medium, which are associated with fluctuations in pressure and density due to particle motion.

Water is denser and less compressible than air; therefore the sound waves propagate faster in water than in air. Sound speed in water is ~1521 m/s while in air is only ~344 m/s, and attenuation is generally less. The sound waves are thereby propagated from the sound source at the speed of sound (Au & Hastings, 2008).

2.1.1 Sound Pressure

Underwater sound can be described as a pressure wave travelling through the water. The low absorption in water (Kaye & Laby, 2004; Kinsler *et al.*, 1982) allows sound to travel large distances in the ocean, particularly low frequency sound. A number of quantities may be used to describe a sound wave, but the most common is sound pressure.

The sound pressure can be described as the difference between instantaneous total pressure and pressure that would exist in the absence of sound ("equilibrium" pressure). This quantity is in effect the quantity that is being represented when a sound pressure waveform is plotted. The unit of sound pressure is the Pascal (Pa), which is equivalent to a Newton per metre squared, or N/m^2, as defined by the International System of Units (S.I.) (BIPM, 2006).

2.1.2 Sound Levels

In acoustics, it is common to express sound levels in decibels (dB) relative to a fixed reference pressure. The fixed reference pressure used is 1 µPa for measurements made underwater, and 20 µPa for airborne acoustics.

Sound Pressure Level (RMS SPL):

The most common convention in underwater acoustics for expressing Sound Pressure Level (SPL) is a root mean square (RMS) value. The RMS value is a time-averaged pressure value, which allows the SPL to be related to the time-averaged acoustic power (the original use of the decibel notation is for expressing power ratios) (Carey, 2006).

The convention in acoustics for expressing RMS SPL is calculated by the expression:

$$SPL = 10 \log \left[\frac{P_{RMS}}{P_0} \right]^2$$

where P is the RMS sound pressure and P_0 is the reference pressure of 1 µPa.

Peak-to-peak Sound Pressure Level:

For a pulse waveform, or sound of impulsive nature, peak-to-peak sound level or zero-to-peak sound level is commonly used.

For a specific pulse, the peak-to-peak pressure, $P_{pk\text{-}pk}$, is calculated from the pressure, p, by the expression:

$$P_{pk-pk} = \max(p) - \min(p)$$

where max(p) and min(p) are the peak positive and peak negative pressures in the waveform, respectively.

Since the peak negative pressure has a negative value, the peak-to-peak pressure is equivalent to the sum of the magnitudes of the peak positive and peak negative pressures. The value is expressed as the peak-to-peak pressure level in dB re 1 μPa. This is calculated from:

$$L_{pk-pk} = 10 \log \left[\frac{P_{pk-pk}}{P_0} \right]^2$$

where P_0 is the reference pressure of 1 μPa.

Zero-to-peak Sound Pressure Level:

The maximum absolute sound pressure during a stated time interval is referred to as the zero-to-peak SPL. A peak sound pressure may arise from either a positive or negative sound pressure.

For a symmetric waveform, the zero-to-peak amplitude is half the value of the peak-to-peak amplitude. However, the waveforms typically encountered in measurements exhibit significant asymmetry, and so the zero-to-peak values are more commonly used.

$$L_{pk} = 10 \log \left[\frac{P_{pk}}{P_0} \right]^2$$

where P_{peak} maximum absolute sound pressure and P_0 is the reference pressure of 1 μPa.

Sound Exposure Level (SEL):

The Sound Exposure Level (SEL) is a measure of the pulse energy content. The SEL for a single pulse is calculated by integrating the square of the pressure waveform over the duration of the pulse. The duration of the pulse is defined as the region of the waveform containing the central 90% of the energy of the pulse. The calculation is given by:

$$E_{90} = \int_{t_5}^{t_{95}} p^2(t)\,dt$$

The value is then expressed in dB re 1 $\mu Pa^2 s$ and is calculated from:

$$SEL = 10 \log \left[\frac{E_{90}}{E_0} \right]$$

where E_0 is the reference value of 1 μPa^2s.

Note also that the definition above uses the central 90% of the energy in the pulse. This is because it is difficult to determine the precise beginning and end of the pulse when the waveform contains noise.

2.2 Underwater Acoustic Model

The basic approach to the acoustic model adopted in airborne acoustics is also valid in the underwater environment:

- a source (characterised by the Source Level)
- a sound transmission medium (which will be influenced by boundary conditions and environmental conditions)
- a receiver (characterised by the Received Level)

2.2.1 Source Level (SL)

Source Level (SL) is a metric used in underwater acoustics to describe the source output amplitude. The decibel units for this quantity may be written as dB re 1 μPa^2m. It should be noted that SL is an idealised acoustic far-field parameter and is not necessarily equal to the acoustic pressure or received level measured at a distance of 1 m from the source. It may be considered as the SPL that would exist at a range of 1 m from the acoustic centre of an equivalent simple source, which radiates the same acoustic power into the medium as the source in question.

In general, SL may be given by:

$$SL = RL + TL,$$

where RL is the Received Level in the acoustic far-field and TL is the Transmission Loss.

2.2.2 Transmission Loss

TL is the term used to describe the reduction of the sound level as a function of distance from an acoustics source. The mechanisms by which the sound intensity reduces are primarily geometrical spreading, sound absorption in the water, and losses into the seabed or other boundaries. It is normal for TL to be stated as a positive number in dB representing the loss for the total range between the reference distance (1 m for source level) and the receiver location.

The accurate estimation of the TL requires a precise model for the transmission of the sound and its interaction with the seabed and sea surface.

By the equation, the TL may be modelled separately from the source or receiver, since the TL is assumed to be independent.

Ocean acoustic propagation models may be divided into four classes, based on the technique that is used to solve the wave equation: ray-theory, normal modes, wave-number integration and parabolic equation. Each class of models employs a different set of approximations and are applicable under different circumstances.

2.2.3 Received Level (RL)

The RL is the acoustic pressure which arrives at any acoustic receptor (e.g. marine fauna or hydrophone) which is exposed to a sound. The RL can be expressed in a number of ways, for example, as a SPL (dB re 1 μPa^2) or a SEL (dB re 1 μPa^2·s). When predicting received levels from estimated source levels, the received level is determined by the following:

$$RL = SL - TL,$$

where the TL is estimated using a transmission loss model, and both SL and TL are measured in decibels.

3. Sound Source

During a seismic survey, an array of airguns is used as the main acoustic source to provide imagery of the seabed and subsurface characteristics.

The airguns are characterised by emitting high intensity and low frequency noise. Most of the energy produced by a seismic array is under the 200 Hz frequency band with a broad peak around 20 - 120 Hz (Breitzke *et al.*, 2008). The acoustic signal of airguns is characterised as being impulsive, with a short time duration of each pulse.

The current survey includes a seismic source to obtain both seismic reflection profiling data and seismic refraction surveying data (Figure 3.1). Seismic reflection profiling targets images of the crustal structure beneath the basement rock, using an airgun array and hydrophone streamer with a shot interval of 10 -15 seconds. Seismic refraction surveying includes the deployment of 30 - 40 Ocean Bottom Seismometers (OBS) placed along the line, with an airgun shot rate approximately once every minute. The signal is recorded from the hydrophone streamer (reflection) and from the OBS on the seafloor (refraction). The arrival times of the rays are then used to model the velocity of the rock layers, which is informative of their properties.

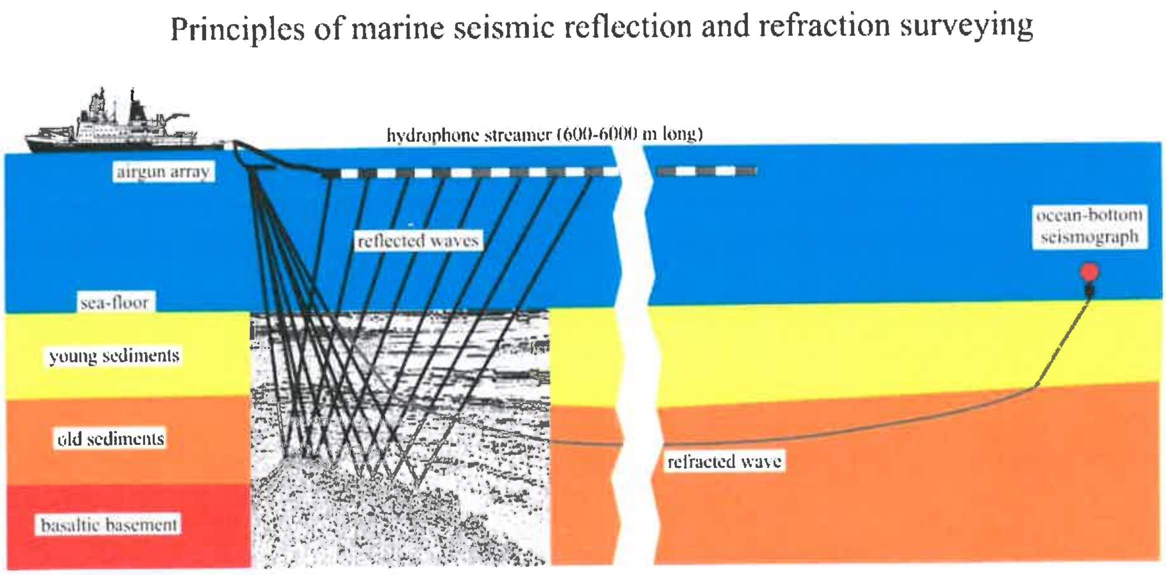

Figure 3.1 Diagram illustrating both seismic reflection and refraction survey processes (source: AWI)

3.1 Array Summary

The acoustic source to be utilised during the *R.V. Sonne* cruise SO-246 includes two different airgun configurations. The first source comprises of four clusters of 2 G-Gun type 520 (by Sercel), each with a volume of 520 cu in resulting in a total volume of 4,160 cu in Airguns are towed at 5 m water-depth for seismic reflection profiling or 10 m water-depth for seismic refraction surveying. Table 3.1 lists the statistics for the modelled array and Figure 3.2 shows the array diagram.

Table 3.1 Airgun array parameters (4,160 cu in)

Array parameter	Array value
Number of airguns	8
Total volume (cu in)	4160 (68.2 litres)
Peak to peak amplitude (bar-m)	71.4 +/- 1.26 (7.14 +/- 0.126 MPa, ~ 257 dB re 1 μPa^2 at 1 m)
Zero to peak amplitude (bar-m)	36.6 (3.66 MPa, 251 dB re 1 μPa^2 at 1 m)
RMS pressure (bar-m)	4.39 (0.439 MPa, 233 dB re 1 μPa^2 at 1 m)
Primary to bubble (peak to peak) (bar-m)	17.9 +/- 4.78
Bubble period to first peak (s.)	0.04 +/- 0.00375
Maximum spectral ripple (dB): 10.0 - 50.0 Hz.	3.44 (dB re 1 μPa^2 at 1 m)
Maximum spectral value (dB): 10.0 - 50.0 Hz.	208 (dB re 1 μPa^2 at 1 m)
Average spectral value (dB): 10.0 - 50.0 Hz.	208 (dB re 1 μPa^2 at 1 m)
Total acoustic energy (Joules)	146162.0
Total acoustic efficiency (%)	10.2

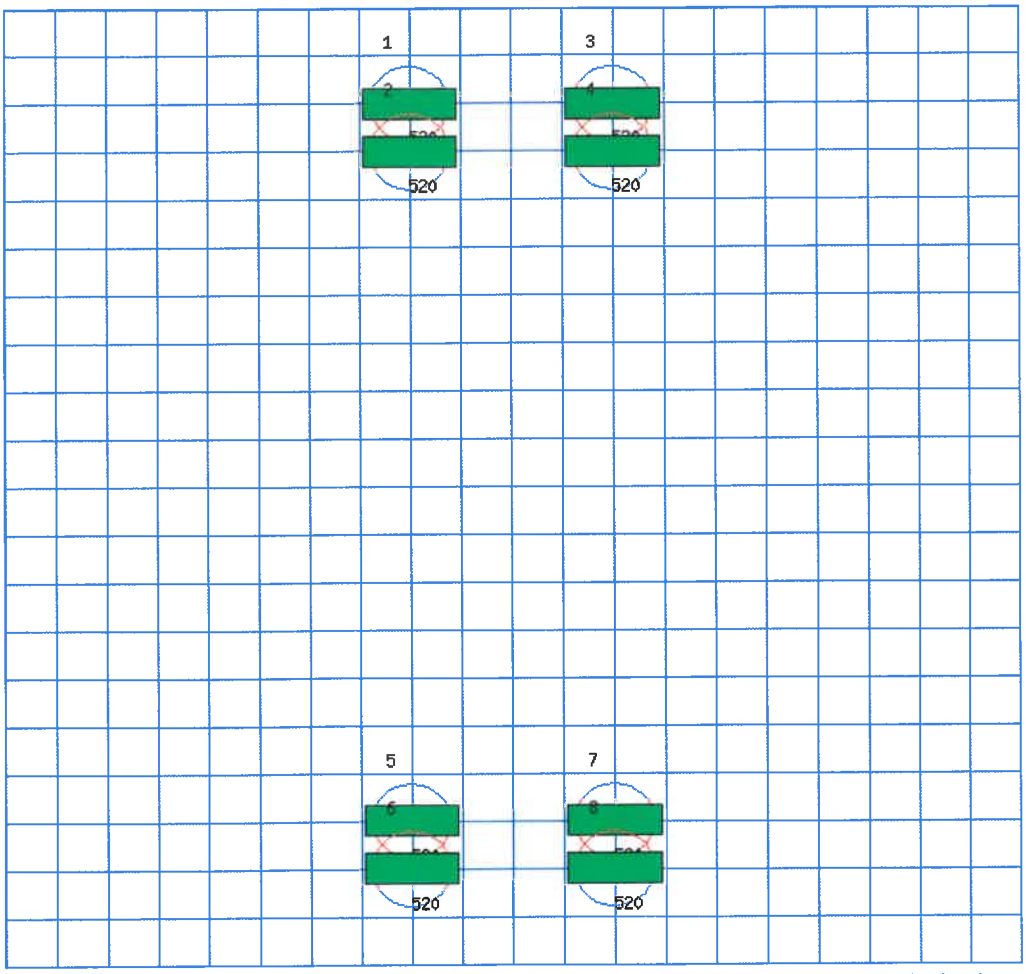

Figure 3.2 Airgun array diagram for 4,160 cu in array (green rectangles represent single airguns; the number below each airgun shows the volume(cu in); red circles denote the maximum radius reached by the bubble)

The second airgun configuration consists of two clusters of 2 GI-Gun type 150 (by Sercel), each with a volume of 150 cu in resulting in a total volume of 600 cu in towed at 2 m water-depth. Table 3.2 lists the statistics for the modelled array and Figure 3.3 shows the array diagram.

Note that GI-Guns were used in the modelling for the 600 cu in array where airguns operate in 'True GI-Mode'. Each GI-Gun fires in two stages: the generator fires creating the primary pulse and the injector produces a secondary pulse within the primary bubble 33 ms after the first pulse. The effect of such double-firing is to prevent violent collapse of the air bubble and allow the constructive summation of the bubble oscillation. As a result, the effects of secondary bubble pressure pulse is reduced, thus producing a cleaner transient signal (Figure 3.5).

Table 3.2 Airgun array parameters (600 cu in)

Array parameter	Array value
Number of airguns	4
Total volume (cu in)	600 (9.83 litres)
Peak to peak amplitude (bar-m)	24.6 +/- 1.23 (2.46 +/- 0.123 MPa, ~ 248 dB re 1 μPa² at 1 m.)
Zero to peak amplitude (bar-m)	13.5 (1.35 MPa, 243 dB re 1 μPa². at 1 m.)
RMS pressure (bar-m)	0.836 (0.0836 MPa, 218 dB re 1 μPa² at 1m.)
Primary to bubble (peak to peak)(bar-m)	8.76 +/- 13
Bubble period to first peak (s.)	0.037 +/- 0.0094
Maximum spectral ripple (dB): 10.0 - 50.0 Hz.	8.67 (dB re 1 μPa² at 1m)
Maximum spectral value (dB): 10.0 - 50.0 Hz.	188 (dB re 1 μPa² at 1m)
Average spectral value (dB): 10.0 - 50.0 Hz.	185 (dB re 1 μPa² at 1m)
Total acoustic energy (Joules)	6737.2
Total acoustic efficiency (%)	3.3

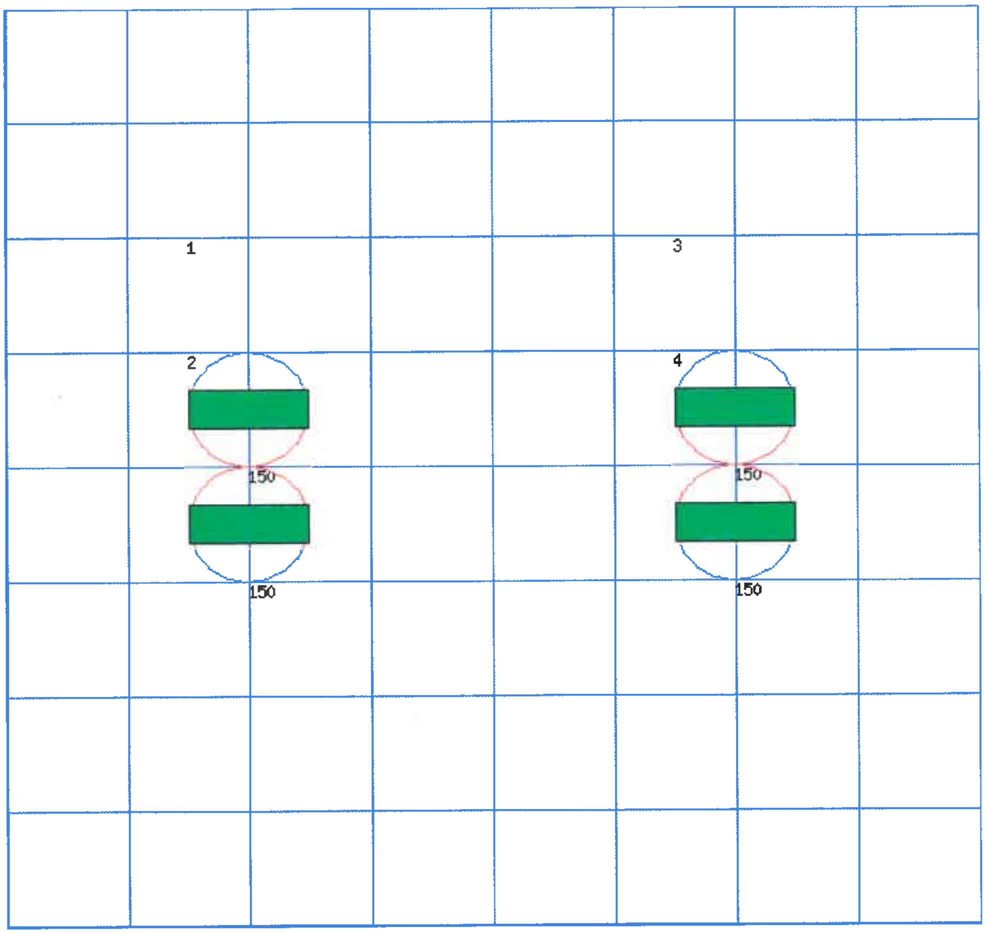

Figure 3.3 Airgun array diagram for 600 cu in array (green rectangles represent single airguns; the number below each airgun shows the volume (cu in); red circles denote the maximum radius reached by the bubble)

The airgun array source modelled results were analysed using MatLab and are presented in Figure 3.4 and Figure 3.5 for the 4,160 cu in array and 600 cu in array, respectively. Figure 3.4 indicates a zero to peak pressure of 36.6 bar-m (251 dB re 1 μPa^{2}m) and a peak to peak pressure of 71.4 bar-m (257 dB re 1 μPa^{2}m) for a tow depth of 5 m. Figure 3.5 indicates a zero to peak pressure of 13.5 bar-m (243 dB re 1 μPa^{2}m) and a peak to peak pressure of 24.6 bar-m (248 dB re 1 μPa^{2}m) for a tow depth of 2 m.

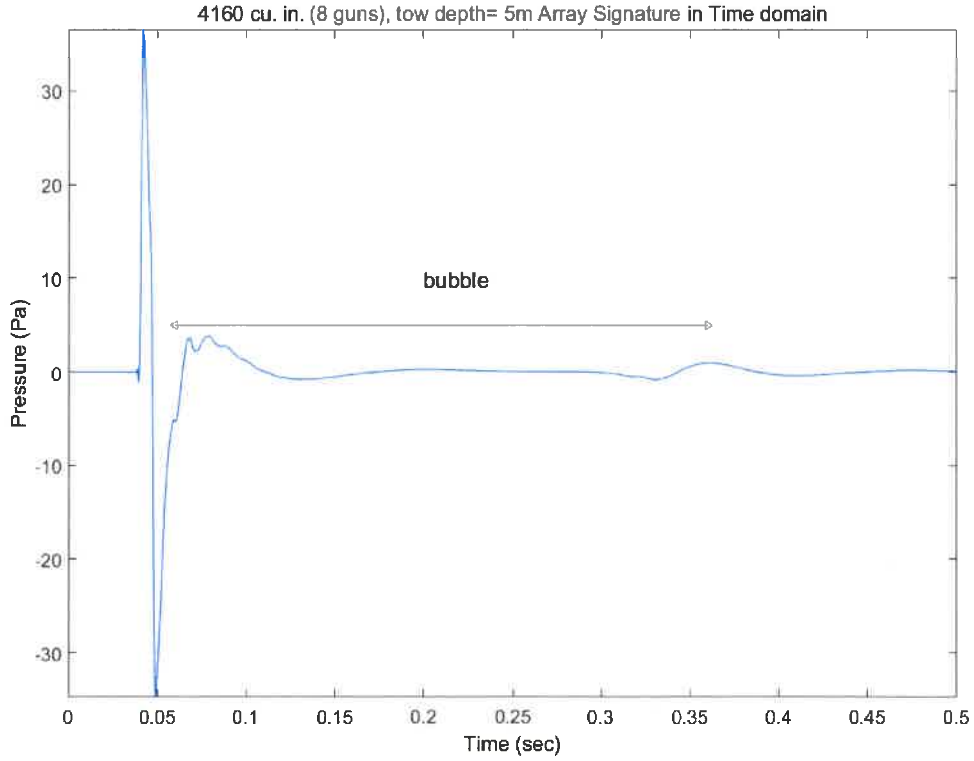

Figure 3.4 Far field signature in time domain for a 4,160 cu in airgun array reference at 1 m from the source

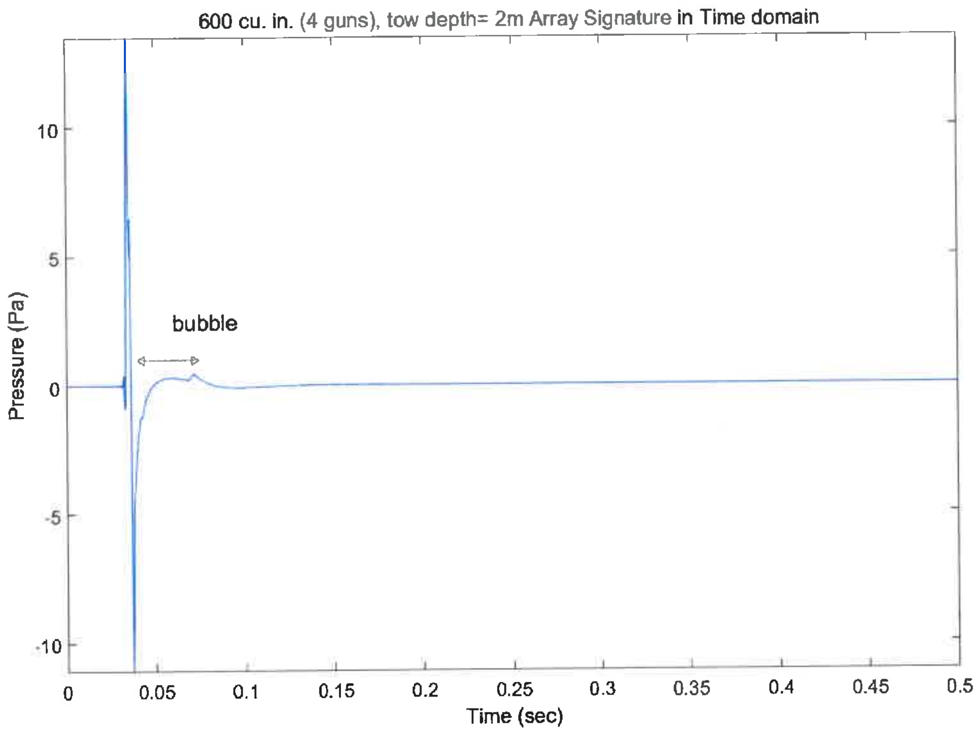

Figure 3.5 Far field signature in time domain for a 600 cu in airgun array reference at 1 m from the source

The source frequency spectrum indicates a considerable acoustic energy increase over the frequency range from 0 to 30 Hz, with a rapid decrease in amplitude above 30 Hz (Figure 3.6) for the 4,160 cu in array towed at 10 m water-depth. When towed at 5 m water-depth the 4,160 cu in array frequency spectrum shows an increase in amplitude from 10 to 50 Hz and a rapid decrease with frequency above 100 Hz (Figure 3.7). The source frequency spectrum for the 600 cu in array, towed at 2 m depth, (Figure 3.8) indicates considerable acoustic energy over the frequency range from 10 to 150 Hz and a slight decrease with frequency above 200 Hz. The measurements in all cases were only undertaken to a maximum frequency of 1,000 Hz.

It should be noted that the presented frequency spectrum is just an estimate based on Gundalf Seismic Source Modelling Software (Oakwood Computing Associates, 2015). Gundalf is configured to model far field broadband signal of an airgun configuration at a distance and it approximates the airgun source level by propagating back to the acoustic source at 1 m, using an appropriate spreading model. Gundalf does not account for near field effects which govern the propagation within close proximity of the seismic source and often disrupt the beam forming patterns of a seismic array. Thus, the actual source frequency of the array is unknown until in field measurements are made and therefore estimation using Gundalf is considered to be conservative as environmental influences are not included in the model.

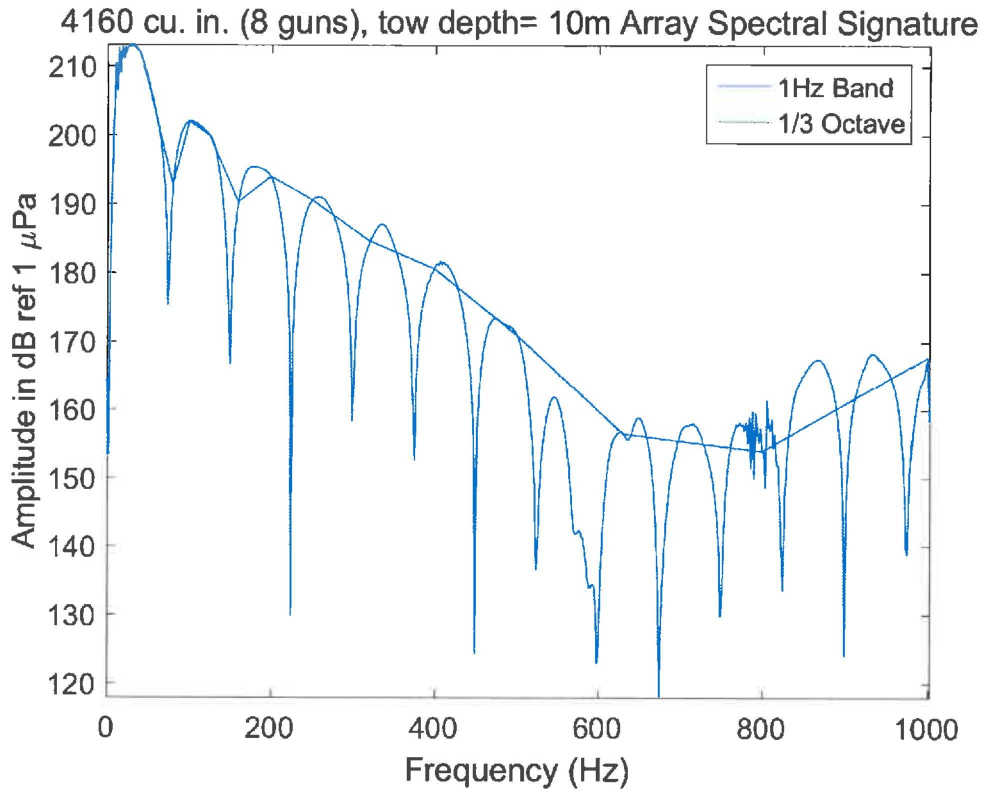

Figure 3.6 The peak noise spectrum for a 4,160 cu in airgun array with towed depth of 10 m

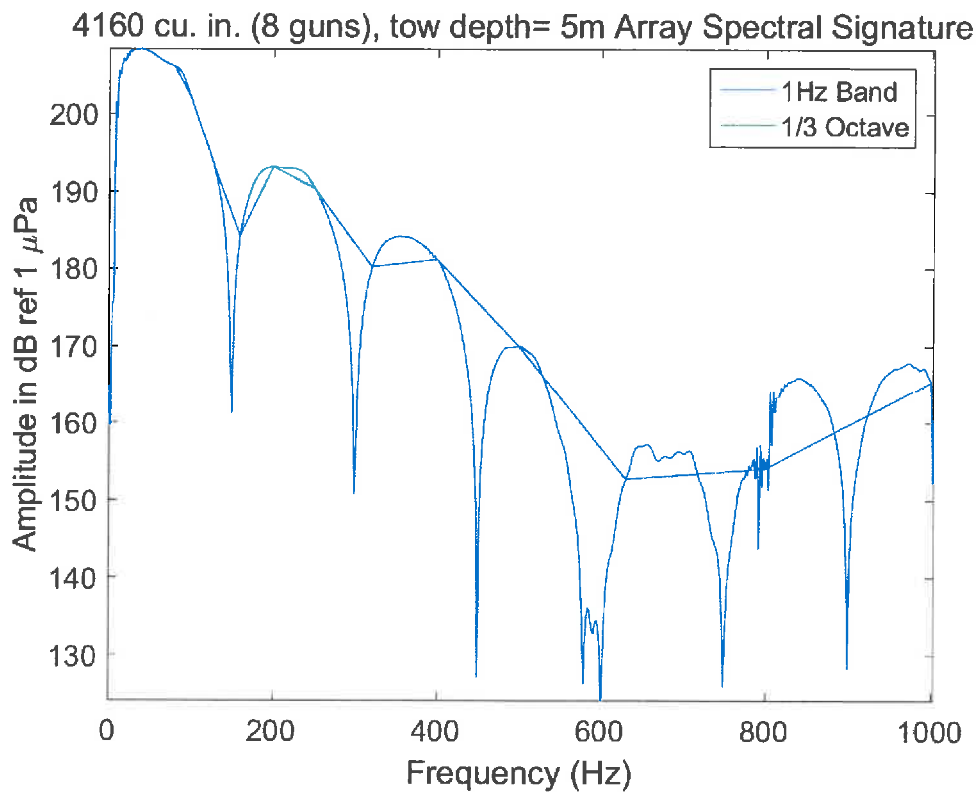

Figure 3.7 The peak noise spectrum for a 4,160 cu in airgun array with towed depth of 5 m

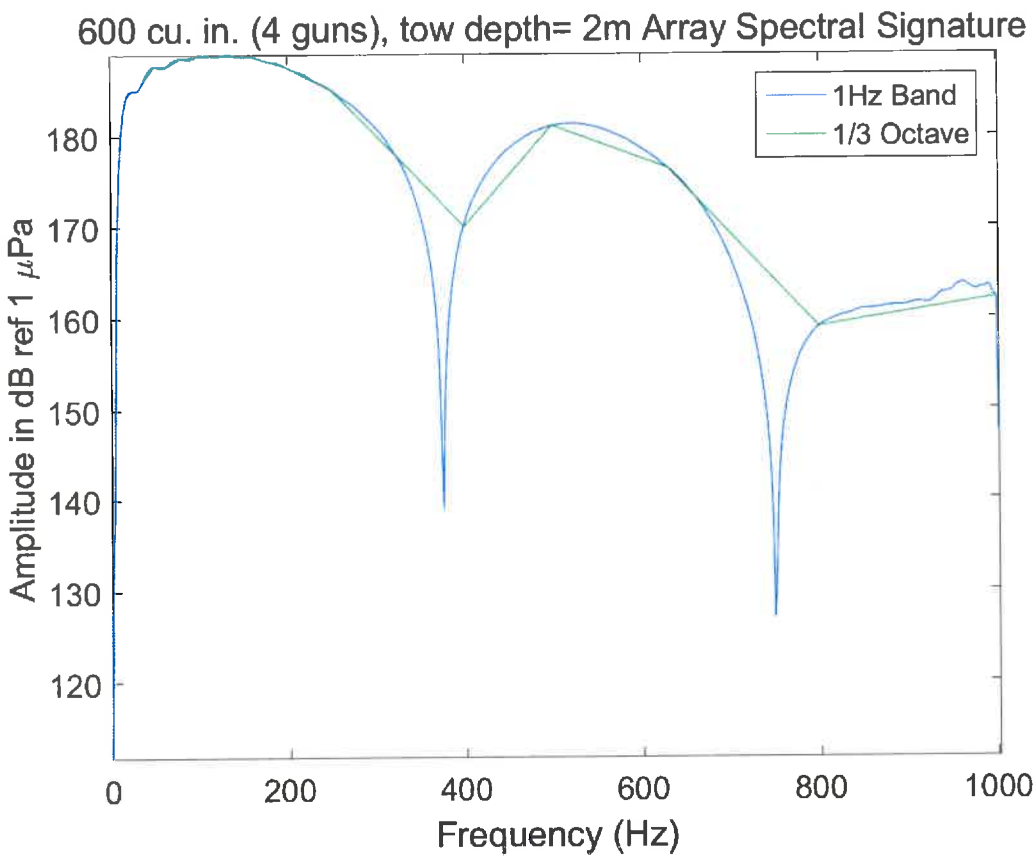

Figure 3.8 The peak noise spectrum for a 600 cu in airgun array with towed depth of 2 m

3.2 Directionality

The source level of a seismic airgun array varies considerably in both the horizontal and vertical directions, due to the complex configuration of the airguns comprising the array.

Previous studies indicates that spectral levels may be reduced as much as 6 dB in the endfire direction compared with the vertical direction (Simpkin, 2003). Similarly, broadside spectral levels can be reduced by at least the same amount compared with those in the vertical direction at frequencies up to 500 Hz and approaching 20 dB at frequencies up to 2 kHz (MacGillivray & Chapman, 2005).

However, the acoustic source modelling adopted in this study only considered far field propagation whereby noise source is assumed omnidirectional in the water column with an acoustic centre located at the specified deployment depth, thereby adopting the worse case approach. The effect of the source depth on the radiated sound power was taken into account in the source acoustic spectra for different towed depth. The model assumes a source depth of 2 m for 600 cu in array, 5 m or 10 m (4,160 cu in array) source depth. The characteristics of sound levels and spectrum are described in Section 3.

3.3 Sound Frequency Bands

The estimated spectral levels in 1/3 octave bands from 25 to 400 Hz for a 4,160 cu in airgun array towed at 10 m depth (Table 3.3), for a 4,160 cu in airgun array towed at 5 m depth (Table 3.4) and 600 cu in airgun array towed at 2 m depth (Table 3.5) are given by Gundalf.

Table 3.3 Spectral estimation for a 4,160 cu in airgun array towed at 10 m depth, based on 1/3 octave band centre frequencies

1/3 Octave Band Frequency (Hz)	Spectral Level (dB re 1 μPa²/Hz)
25	212.87
32	212.80
40	211.84
50	207.36
63	200.97
80	192.63
100	201.90
125	199.85
160	190.20
200	193.90
250	190.50
320	184.54
400	180.47

Table 3.4 Spectral estimation for a 4,160 cu in airgun array towed at 5 m depth, based on 1/3 octave band centre frequencies

1/3 Octave Band Frequency (Hz)	Spectral Level (dB re 1 $\mu Pa^2/Hz$)
25	208.03
32	208.22
40	208.38
50	207.88
63	206.94
80	206.04
100	202.08
125	194.31
160	184.24
200	193.11
250	190.39
320	180.28
400	181.19

Table 3.5 Spectral estimation for a 600 cu in airgun array towed at 2 m depth, based on 1/3 octave band centre frequencies

1/3 Octave Band Frequency (Hz)	Spectral Level (dB re 1 μPa²/Hz)
25	184.82
32	184.95
40	186.31
50	187.64
63	187.57
80	188.51
100	188.73
125	188.78
160	188.68
200	187.53
250	184.96
320	178.06
400	169.96

4. Underwater Noise Propagation Modelling

The current study has employed the Range Dependent Acoustic Model (RAM) (Collins, 1993) which is based on the parabolic equation solution to the wave equation, and part of AcTUP V2.2L (Maggi & Duncan, 2002). Parabolic equation models are an efficient class of models for low-frequency problems in range-dependent environments. The RAM variants which have been utilised in the current study were RAMSGeo and RAMGEO. RAMSGEO accounts for the shear properties of the sediments and was utilised to determine the impact range estimations. RAMGeo implements a stratified seabed model in which multiple bottom layers run parallel to the bathymetry and was used to create the 360M noise model maps (section 5.6).

The accuracy of the propagation model is limited by the quality and resolution of the available environmental data, such as:

- Bathymetry data - Accurate bathymetry data are especially important in shallow water environments (less than 200 m depth), where acoustic propagation is strongly influenced by interaction of the sound with the sea bottom and surface.
- Sound speed profiles in the water column - The sound speed is a function of temperature, salinity and depth. The sound speed profile can strongly influence long-range acoustic propagation by refracting and trapping sound energy in the water column.
- Geoacoustic profiles of the ocean sub-bottom - Geoacoustic properties of the ocean bottom materials, which include the compressional speed, shear speed, density and attenuation, influence how sound is reflected and absorbed at the seabed.

4.1 Parameters and Assumptions Considered

In order to be able to estimate the TL, a review of the existing data/parameters and assumptions were conducted as described below.

4.1.1 Bathymetry Data

The Chatham Rise is characterized by generally smooth bathymetry on the plateau with water depth varying from about 200 m to the west of the Chatham Islands and increasing to 3000 m off the slope of the rise to the east.

In order to assess the TL and acoustic impact on marine mammals from the seismic source three points in varying depths of the survey area were chosen for modelling, all points laying within the Area of Ecological Importance (Figure 4.1).

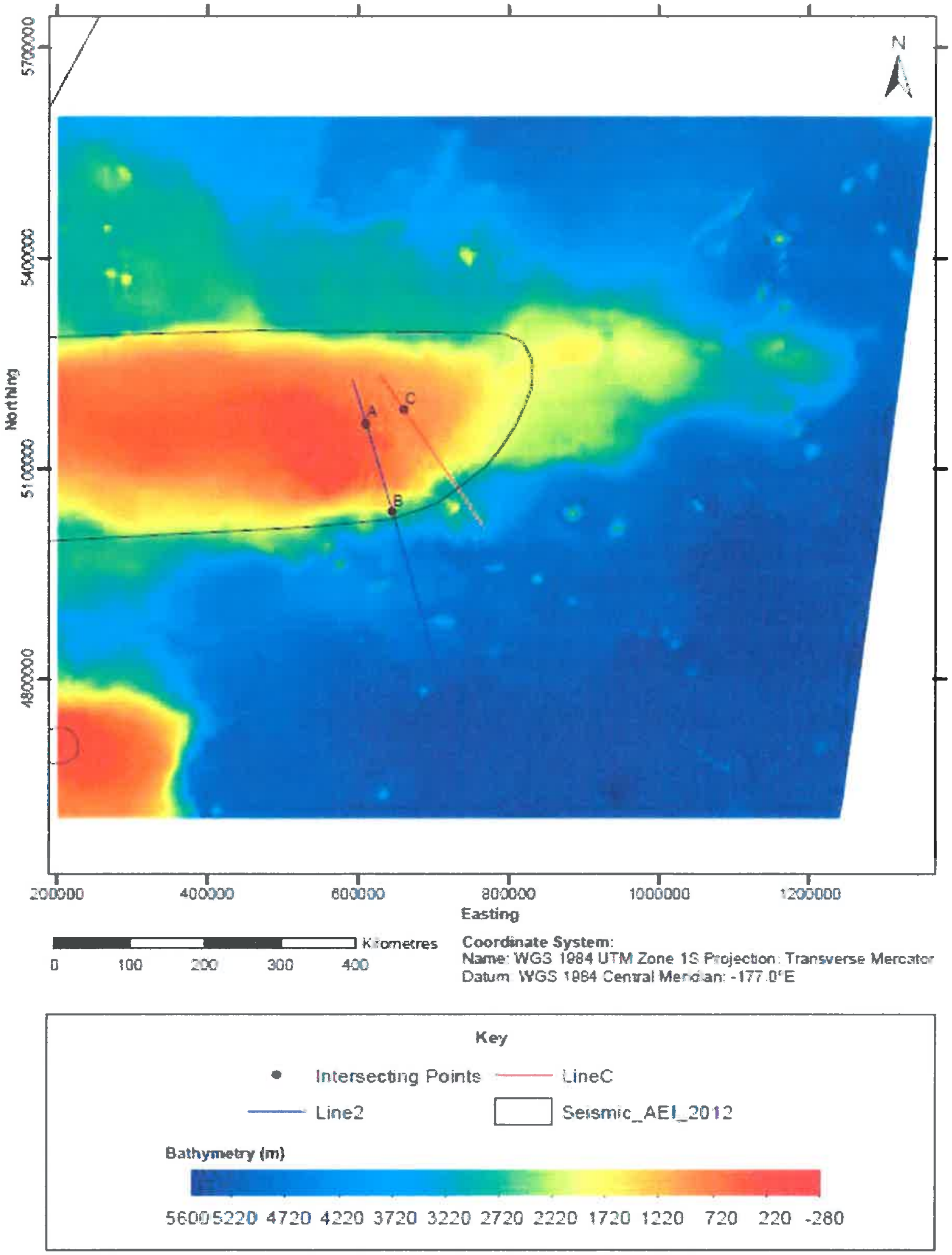

Figure 4.1 Bathymetry of the survey area including survey lines OBS2 and C on the Chatham Rise with the points (A,B,C) chosen for propagation modelling

Points along transect Line_OBS2 and Line C were extracted from the bathymetry data (Table 4.1).

Table 4.1 Locations of source modelling and their characteristics

Location	Latitude WGD84 UTM Zone 1S	Longitude WGD84 UTM Zone 1S	Depth (m)
A	43° 40' 40.702"" S	175° 37' 43.910"" W	408
B	44° 47' 53.938"" S	175° 09' 32.337"" W	2209
C	43° 29' 05.504"" S	175° 00' 25.011"" W	703

TL was computed in 1/3 octave bands from 20 Hz to 500 kHz, this frequency range contains the large majority of acoustic energy radiated by a seismic airgun array (Table 4.2).

Table 4.2 List of modelled 1/3 octave band centre frequencies, in units of Hz

Band Centre Frequency (Hz)		
20	80	320
25	100	400
32	125	500
40	160	
50	200	
63	250	

4.1.2 Sound Speed Profile

Within the Chatham Rise there is the convergence of warm, saline subtropical waters from the north and cold, fresh, sub-Antarctic waters from the south (Belkin, 1988). Thus, the thermocline on the Chatham Rise varies in the north and south, depending on the water inputs. There is also evidence of seasonal variation in the thermocline of surface waters during spring and autumn (Chiswell, 1994).

Oceanographic data was provided by the client and used to construct the sound speed profile for the Chatham Rise. The nearest grid to the modelled locations were used in the analysis. Location A and C had an average sound speed of 1,490 m/s and a mean temperature of 8.66° C (Figure 4.2). Location B had an overall sound speed of 1,510 m/s and a mean temperature of 7.5° C (Figure 4.3).

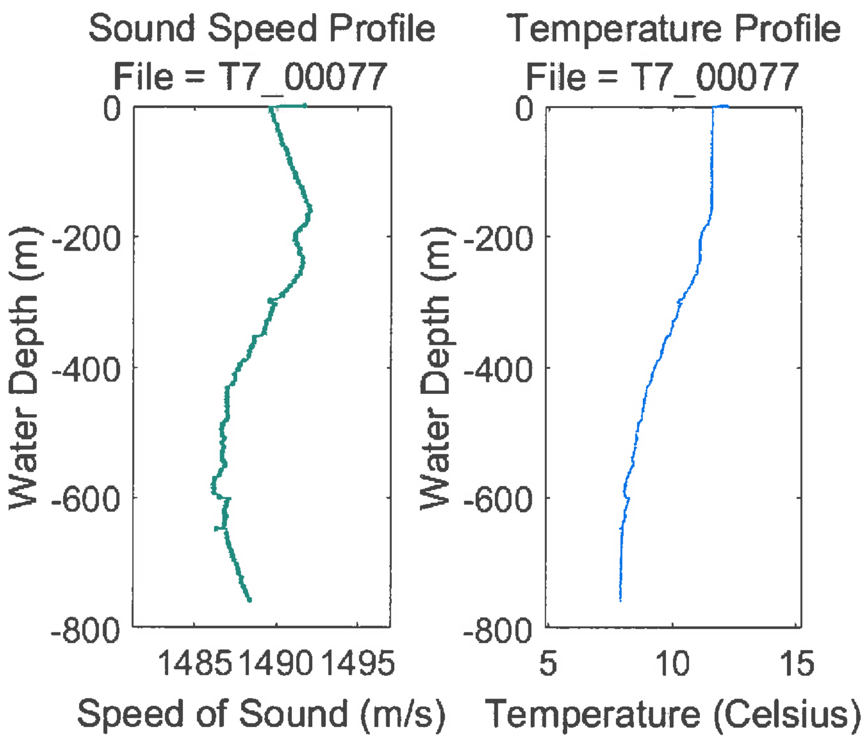

Figure 4.2 Sound speed profile and temperature profile at location A & C

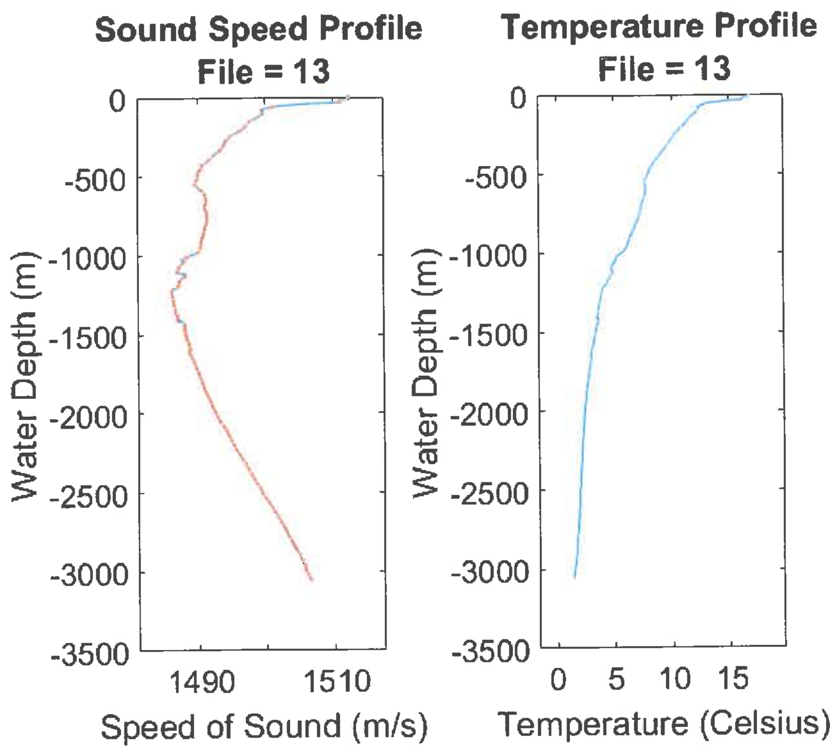

Figure 4.3 Sound speed profile and temperature profile at location B

4.1.3 Geoacoustic Parameters

The Chatham Rise is a broad ridge to the east of central New Zealand with surface sediments that are primarily sandy mud (~55 - 60% > 63 μm), however beneath less than 1 m layer of surface sediments lies Upper Eocene - Lower Oligocene chalky limestone (Nodder, 2013). Surficial sediments on the crest of the Chatham rise are typically comprised of 30 - 40% calcium carbonate (% $CaCO_3$). The greatest sand percentages (77 - 96%) are observed to the northwest of the Chatham Islands as well as on Mernoo Bank. Moderate sand percentages (20 - 34%) are seen across the western Chatham Rise, while higher mud contents are found in the south-western and north-western slopes of the rise, with less than 25% sand (Nodder *et al.*, 2011).

To run the model, a calcarenite seabed with five layers (Duncan *et al.*, 2013) was assumed (Table 4.3).

Table 4.3 Geoacoustic parameters of the seabed used for propagation modelling

Material	Density (kg/m^3)	Velocity (m/s) Comp. wave	Attenuation [dB/(kHz m)] Comp. wave	Velocity (m/s) Shear wave	Attenuation [dB/(kHz m)] Shear wave
Sandy	1800	1650	0.8	390	1.1
Well-cemented	2200	2600	0.2	1200	0.4
Slightly cemented	1900	2100	0.12	550	0.25
Semi-cemented	1900	2200	0.12	650	0.25
Basement (rock)	3000	3800	0.1	1900	0.2

4.2 Propagation Loss Modelling Results

The propagation model utilised was GENZL's 360M predictive acoustic model which is based on the Parabolic Range Dependent Modelling algorithm. The model solves the one way wave equation in 2D slices that neglect back scattered sound energy.

The acoustic propagation model was run along 360 transects radially from each of the locations noted above in Table 4.1. Each transect covers a range of 10 to 600 km from the noise source in order to determine the area at which the noise dissipates to the ambient levels.

Radial acoustic transects (N, NE, E, SE, S, SW, W, NW) from the airgun source to a range of 10km were modelled. The noise propagation between 20 – 500 Hz were investigated in order to assess the airgun array sound exposure level at the proposed mitigation zone boundaries (200 m, 1 km and 1.5 km) in accordance to the Code (2013). Impact ranges based on Southall criteria (Southall et al., 2007) were estimated for each case based on the computed TL.

A range of up to 600 km was also used to model the far field propagation of the airgun array and results were used to generate the noise map in Chatham Rise.

RAMSGEO modelling was used to approximate the TL as a function of range and depth along each modelled transect. TL was modelled at all one third octave frequency bands (Table 4.2) between 20 and 500 Hz which are considered to contain the peaks spectral energy of seismic noise. Figure 4.3 – 4.5 represents the noise propagation (at 20, 50, 80, 125, 250 and 500 Hz) over the bathymetry for different water depths.

Example of the modelled TL were extracted at a receiver depth of 50 m at the same frequencies (Figure 4.6 - 4.11) in order to illustrate the overall sound attenuation in the water column.

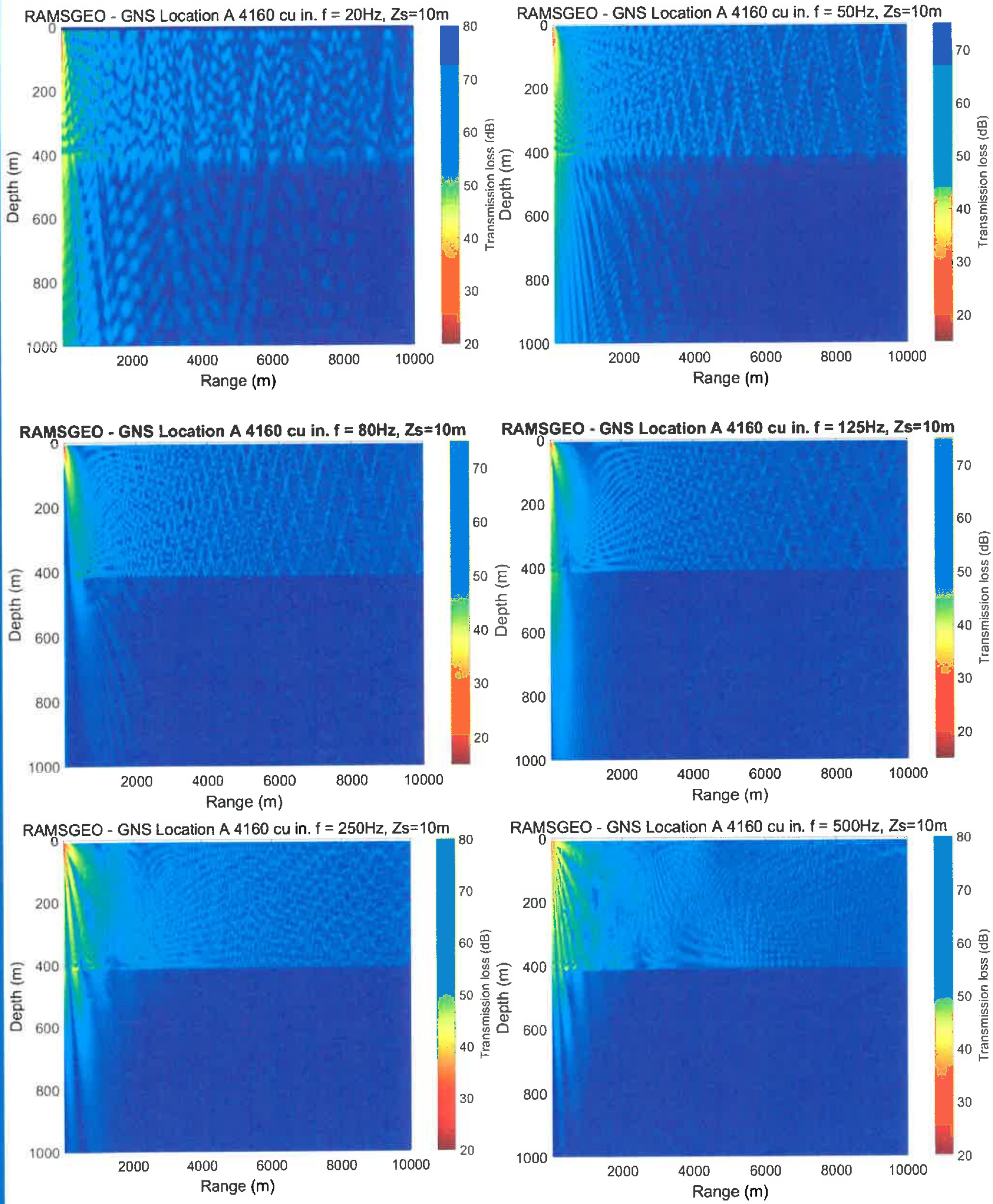

Figure 4.3 Predicted TL over bathymetry for 4,160 cu in array at Location A

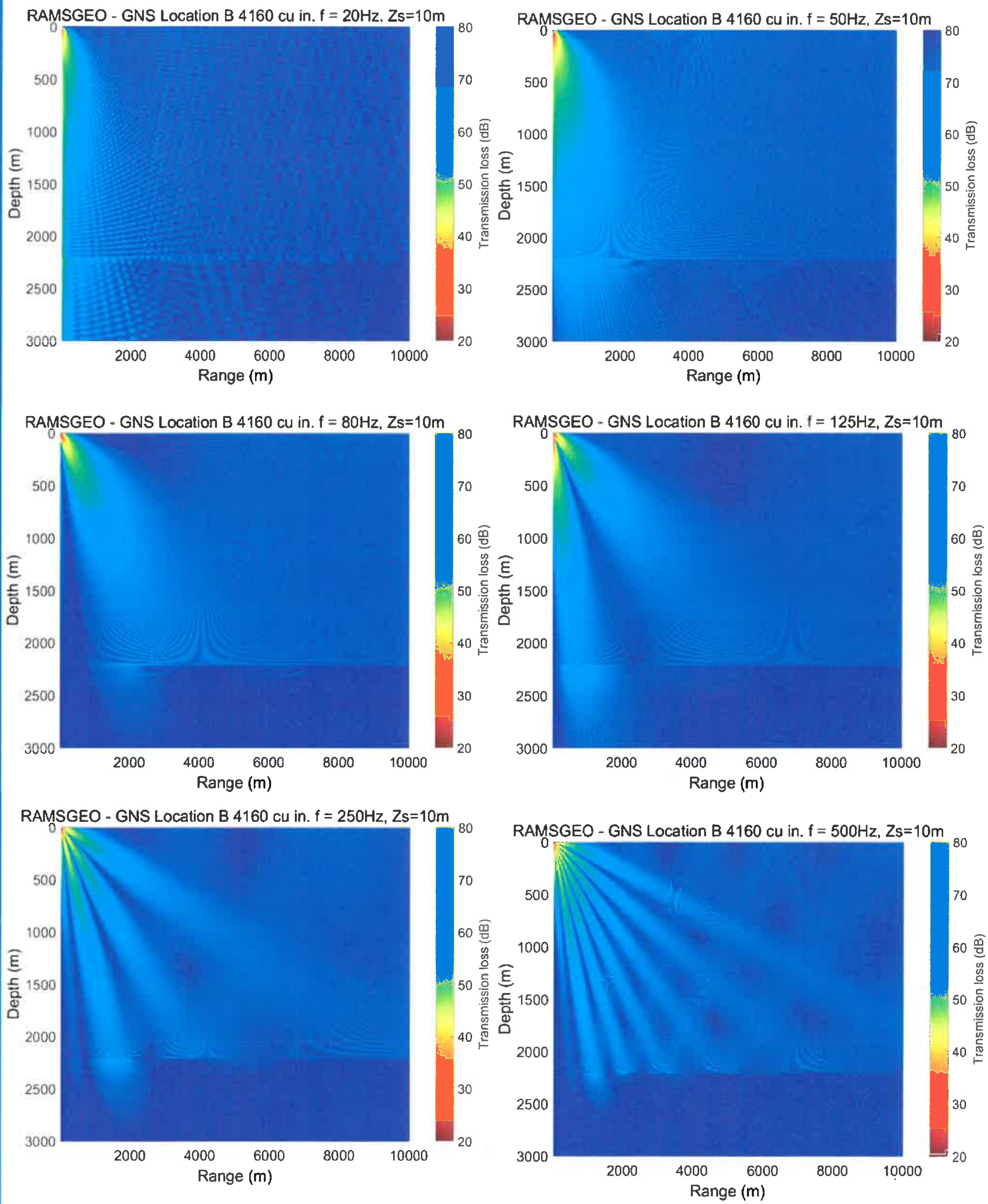

Figure 4.4 Predicted TL over bathymetry for 4,160 cu in array at Location B

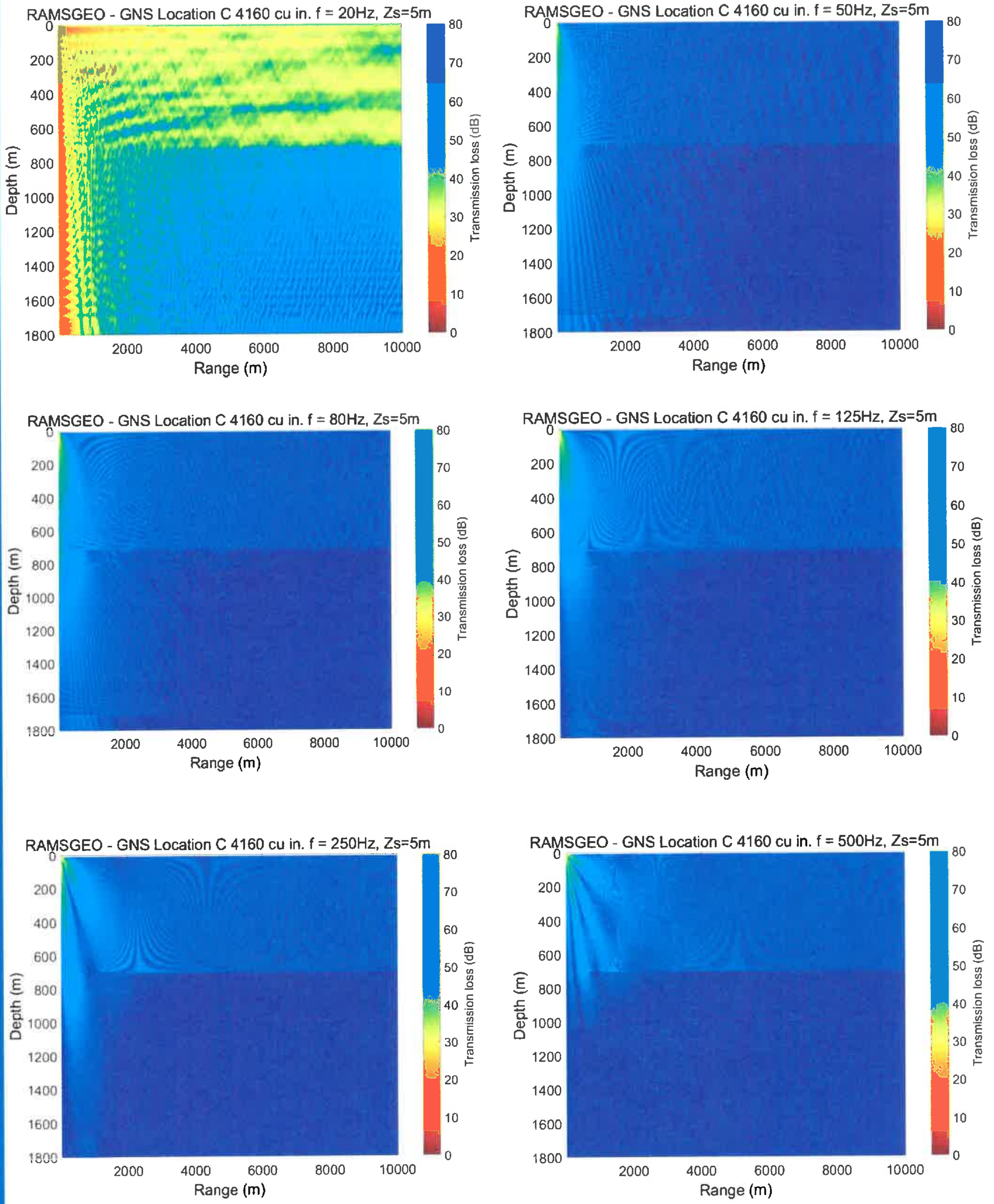

Figure 4.5 Predicted TL over bathymetry for 4,160 cu in array at Location C

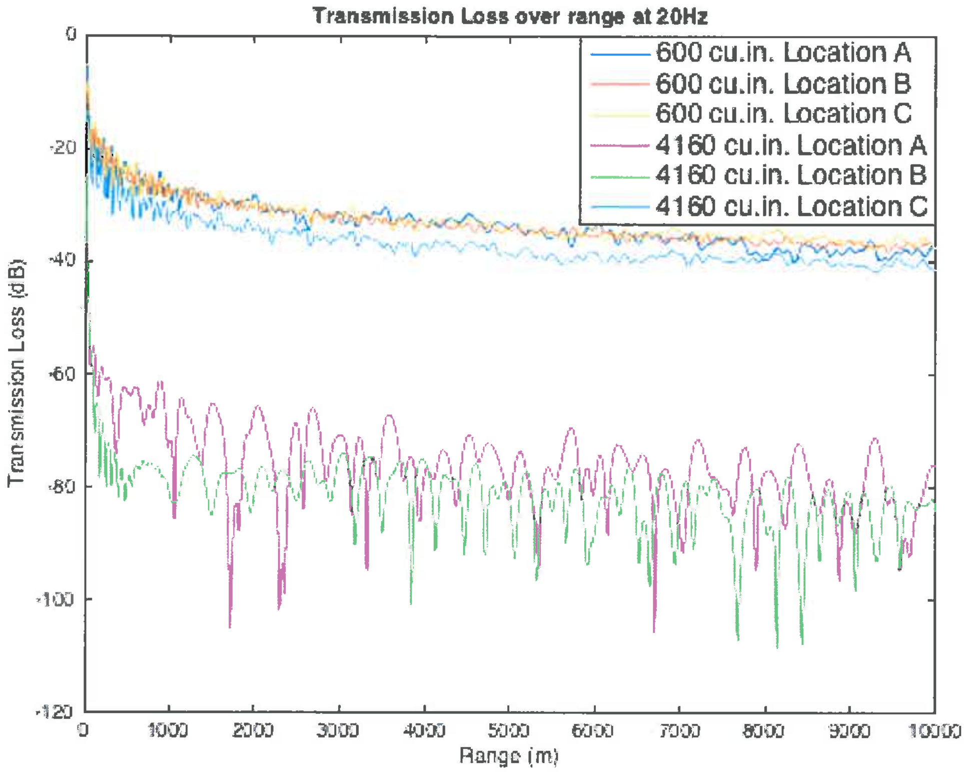

Figure 4.6 Modelled TL obtained at 20 Hz

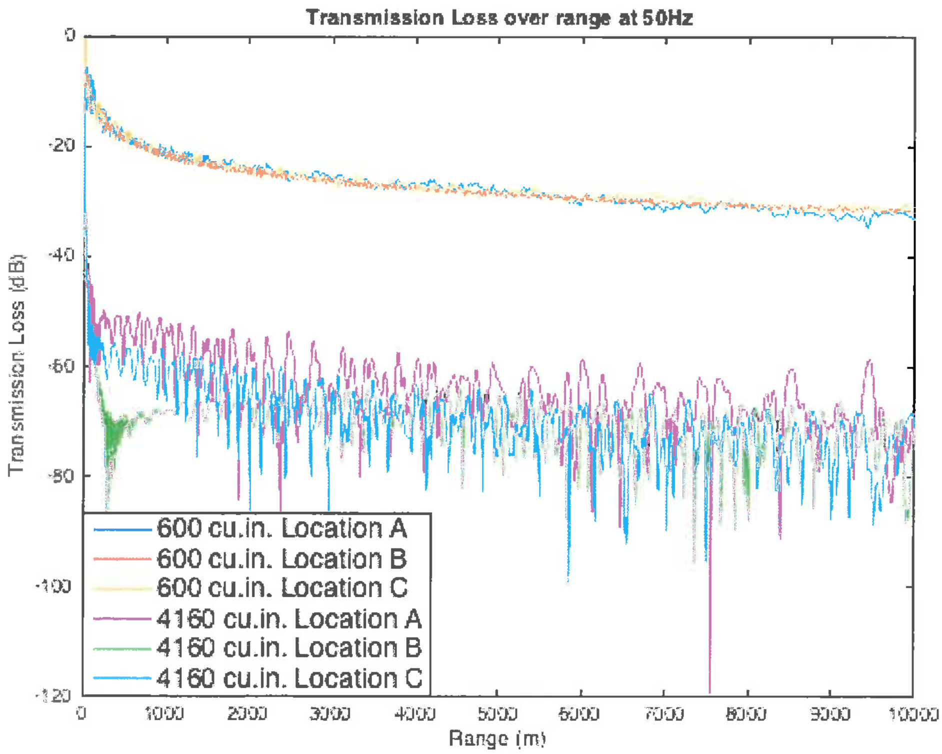

Figure 4.7 Modelled TL obtained at 50 Hz

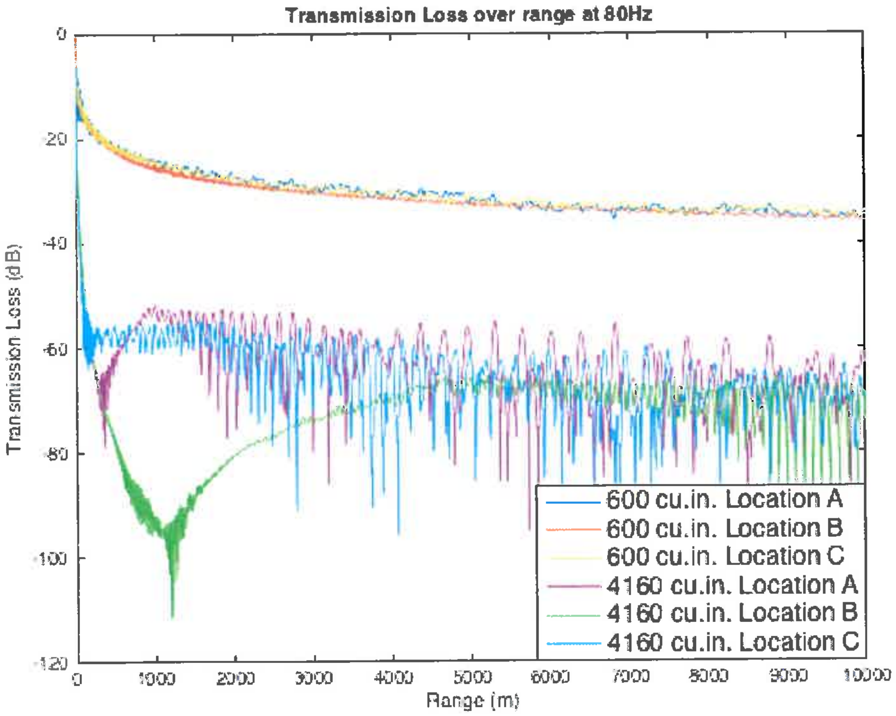

Figure 4.8 Modelled TL obtained at 80 Hz

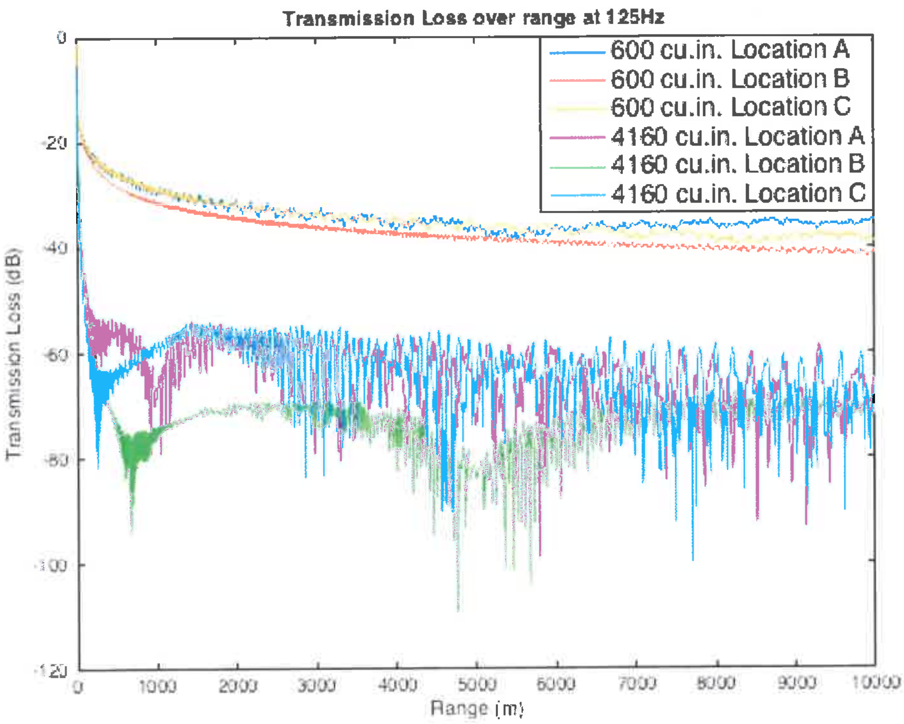

Figure 4.9 Modelled TL obtained for 125 Hz

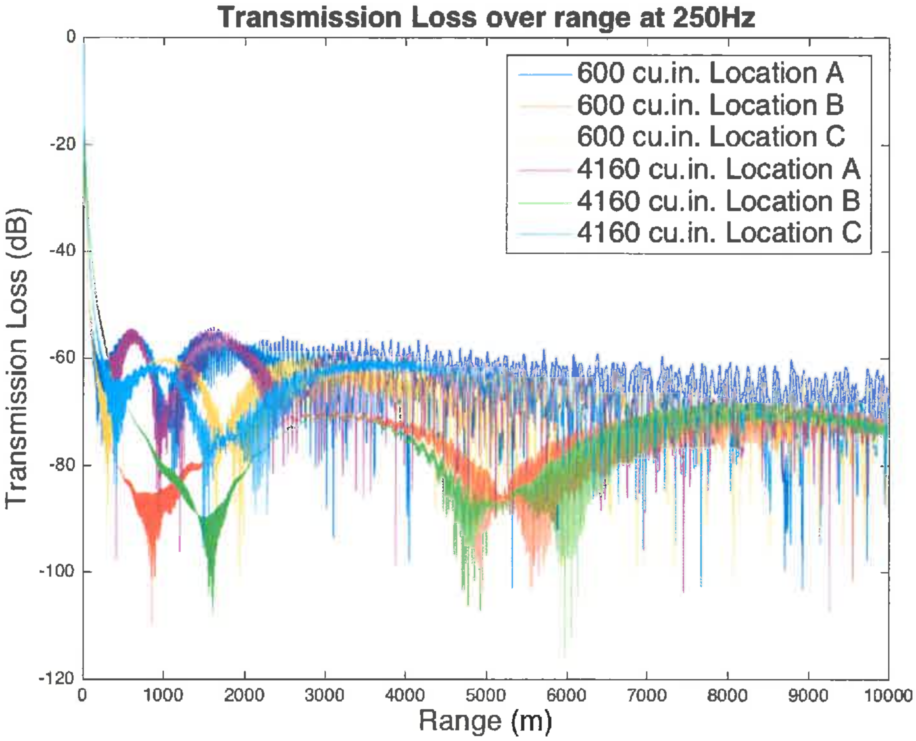

Figure 4.10 Modelled TL obtained at 250 Hz

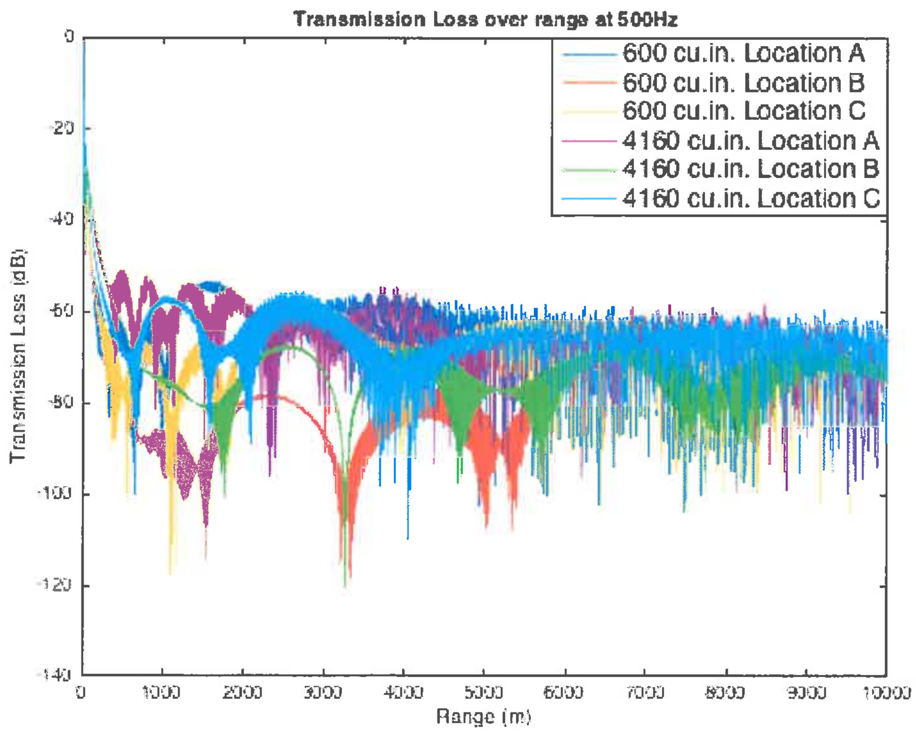

Figure 4.11 Modelled TL obtained at 500 Hz

5. Seismic Noise and Marine Animals - Impact Assessment

5.1 The Code

In order to provide supporting information for the mitigation plan for the area in accordance with the 2013 Code requirements (see Section 1.1), an estimation of instantaneous impact and behavioural disturbance ranges was conducted.

The criteria in the 2013 Code are based on M-weighted values (Southall *et al.*, 2007) for pinnipeds in water. In order to present a more comprehensive study in this report the impact range estimation also covered the cetacean groups based on Southall *et al.* (2007) and described in Section 5.2.

It should be noted that estimations are based on the best currently available methods, developed using existing data for species.

Using the TL model described in Section 4 and the impact criteria for marine mammals outlined in Section 5.2, ranges over which marine mammals may be impacted during the Chatham Rise seismic site survey have been estimated (see Section 5.5).

5.2 Marine Mammal Criteria

The US Marine Mammal Criteria Group of the National Marine Fisheries Service (NMFS) part of the National Oceanic and Atmospheric Administration (NOAA)) have proposed the 'M-weighting' model (Southall *et al.*, 2007) as part of the Marine Mammal Noise Exposure Criteria. The authors delineated five groups of marine mammals based on similarities in hearing; three for cetaceans: low, medium and high-frequency and two for pinnipeds: water and air (Southall *et al.*, 2007).

The Marine Mammal Noise Exposure Criteria was developed through the agreement of an expert committee. The criteria are peer-reviewed and now the most widely accepted exposure criteria for marine mammals.

The Southall *et al.* (2007) criteria are a dual-criteria approach based on zero-to-peak SPL and energy (SEL). In this method the signal is weighted relative to hearing abilities of species under test and the SEL are then calculated.

The likely impacts were assessed on the basis of the risk of physical injury (hearing damage) and behavioural response for a single pulse.

A summary of the criteria adopted for marine mammals in this report is given in Table 5.1.

Table 5.1 Injury and behavioural criteria according to Southall *et al.* (2007)

Criteria	Injury Threshold Values (Single Pulse)	Behavioural Threshold Values (Single Pulse)
High Frequency Cetaceans		
SEL (dB re 1 µPa^2.m^2.s)	198	183
Medium Frequency Cetaceans		
SEL (dB re 1 µPa^2.m^2.s)	198	183
Low Frequency Cetaceans		
SEL (dB re 1 µPa^2.m^2.s)	198	183
Pinnipeds in water		
SEL (dB re 1 µPa^2.m^2.s)	186	171

5.3 Un-weighted Sound Levels

The un-weighted noise has also been calculated using the 1/3 octave band propagation modelling described in Section 4. This process involves calculating the 1/3 octave band levels of source noise from the spectral levels presented in Figure 3.6 - 3.8, and then calculating the corresponding levels at range from the source by subtracting the TL in each frequency band.

To estimate the variation in zero-to-peak SPL with range, the TL has been applied to the zero-to-peak source level described in Section 3.1.

The un-weighted SEL levels assumed a pulse duration of 0.05 seconds.

5.4 M-weighted Sound Levels

In the case of SEL, the signal was first weighted relative to hearing abilities of the species under test (M-weighting). The advantage is that for signals containing multiple frequency components, measurements of energy contributions well outside the hearing band of the species will be removed from the overall exposure estimate.

M-weighting filters were developed for the five groups mentioned above based on current knowledge and interpolation of appropriate hearing data (Southall *et al.*, 2007). The 'M-weighting' filters are plotted in Figure 5.1. As outlined in Southall *et al.* (2007), M-weighting is only applied to the SEL values, and is used in this report within the instantaneous injury assessments appropriately for the relevant marine mammal functional hearing groups.

The source characteristic data provided in this study is limited to 500 Hz; however this encompasses the main source energy output for the seismic airgun array. The source data does not fully cover the frequency range required to fully implement the M-weighting scale filters proposed by Southall *et al.* (2007) (i.e. from 10 Hz to 100 kHz and greater).

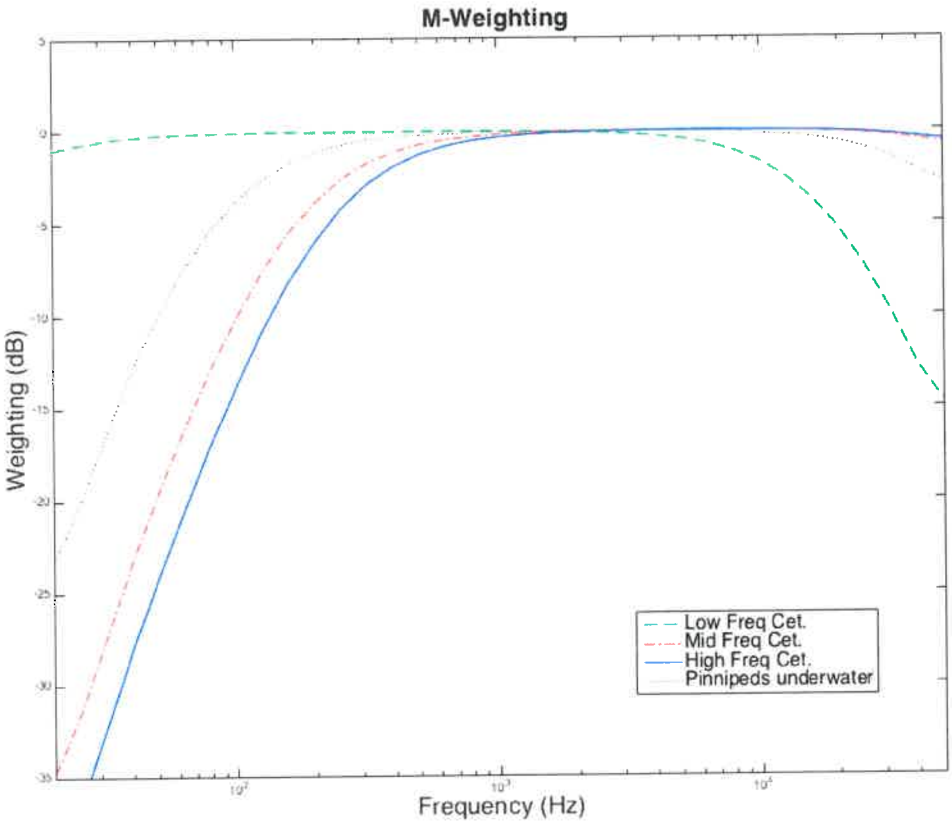

Figure 5.1 M-weighting filters for marine mammals

5.5 Impact Ranges

Figure 5.2 to Figure 5.7 present examples of M-weighted SEL and zero-to-peak SPL as a function of range regarding the injury and behavioural threshold values, respectively, by Southall *et al.* (2007). Each example only shows the worst case scenario of the 8 transects modelled for each location.

The M-weighted SEL filters were applied to the high, medium and low frequency cetaceans and for pinnipeds in water. The M-weighted SEL values vary with the dominant frequency components in the signal. As expected, the un-weighted SEL has the highest levels at each range, with M-weighted filters removing a proportion of either the high or low frequency sound energy according the characteristics of each marine mammal group.

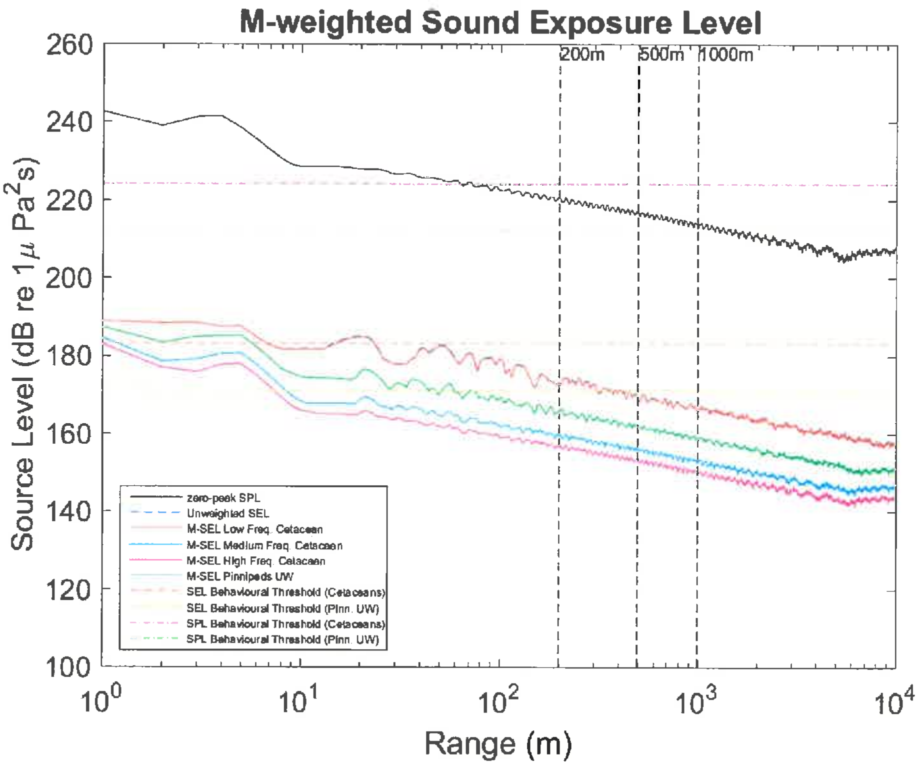

Figure 5.2 M-weighting SEL and zero-to-peak SPL as function of range regarding the injury and behavioural threshold values for 600 cu in array at Location A

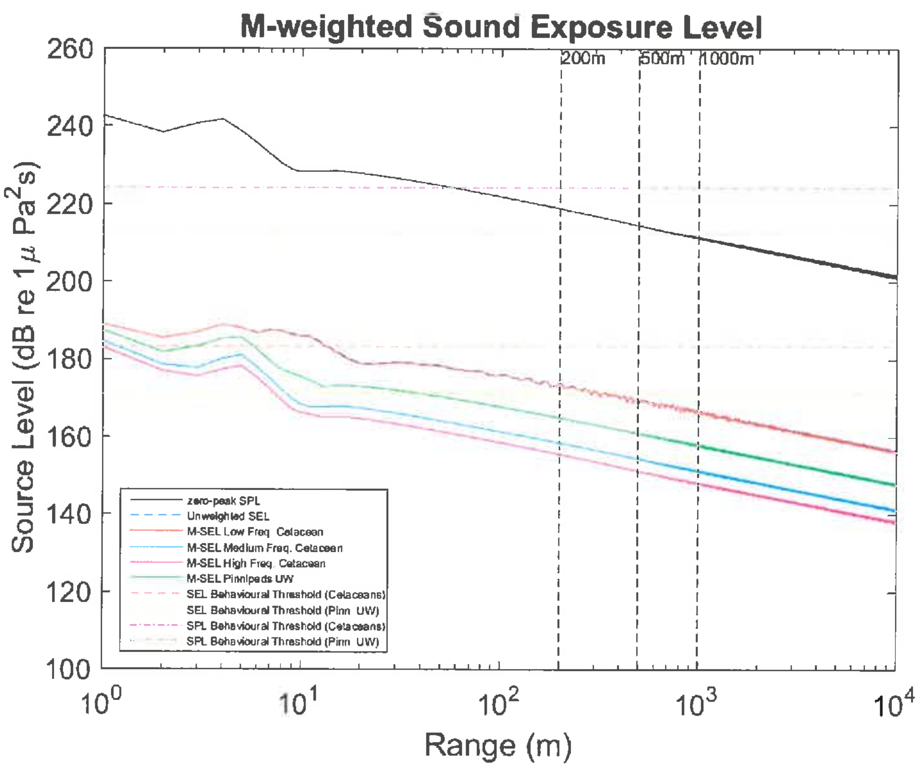

Figure 5.3 M-weighting SEL and zero-to-peak SPL as function of range regarding the injury and behavioural threshold values for 600 cu in array at Location B

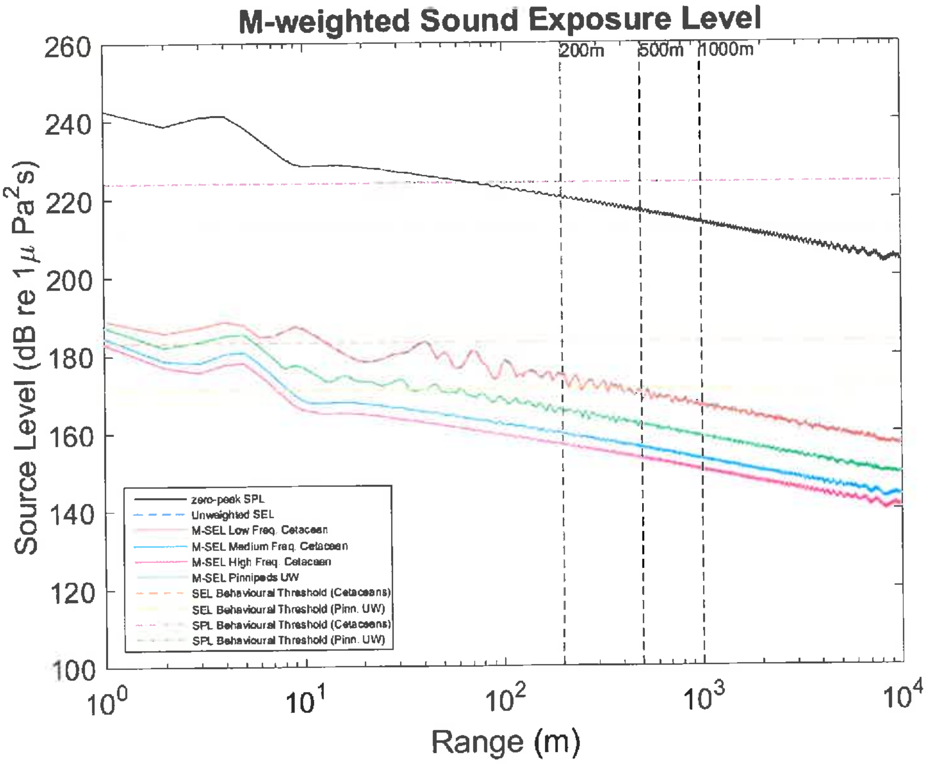

Figure 5.4 M-weighting SEL and zero-to-peak SPL as function of range regarding the injury and behavioural threshold values for 600 cu in array at Location C

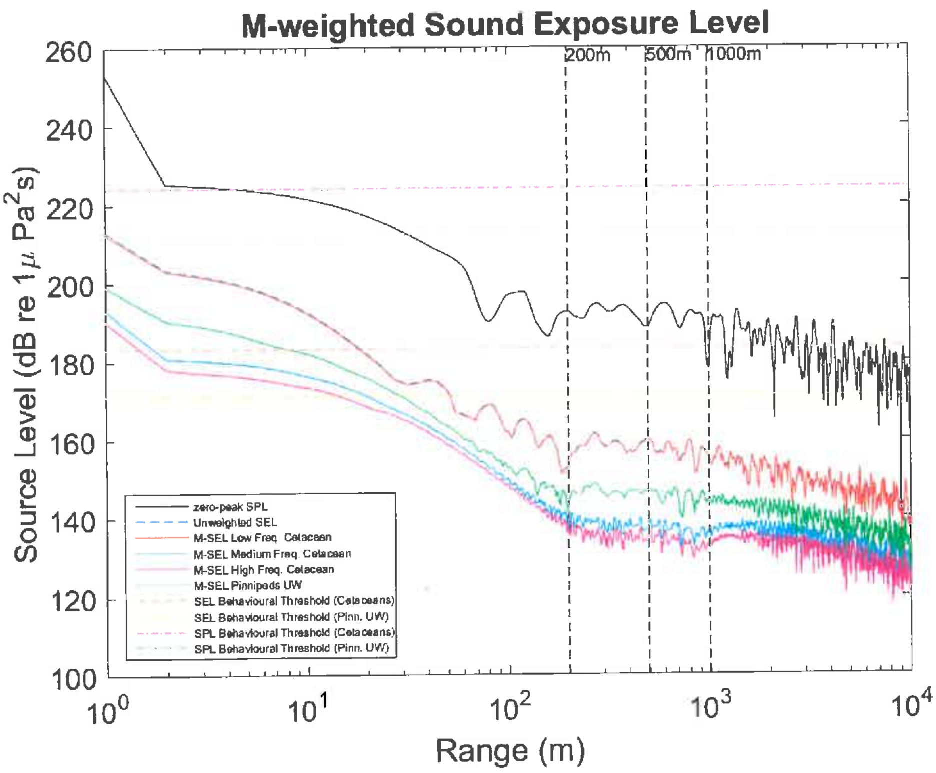

Figure 5.5 M-weighting SEL and zero-to-peak SPL as function of range regarding the injury and behavioural threshold values for 4,160 cu in array at Location A

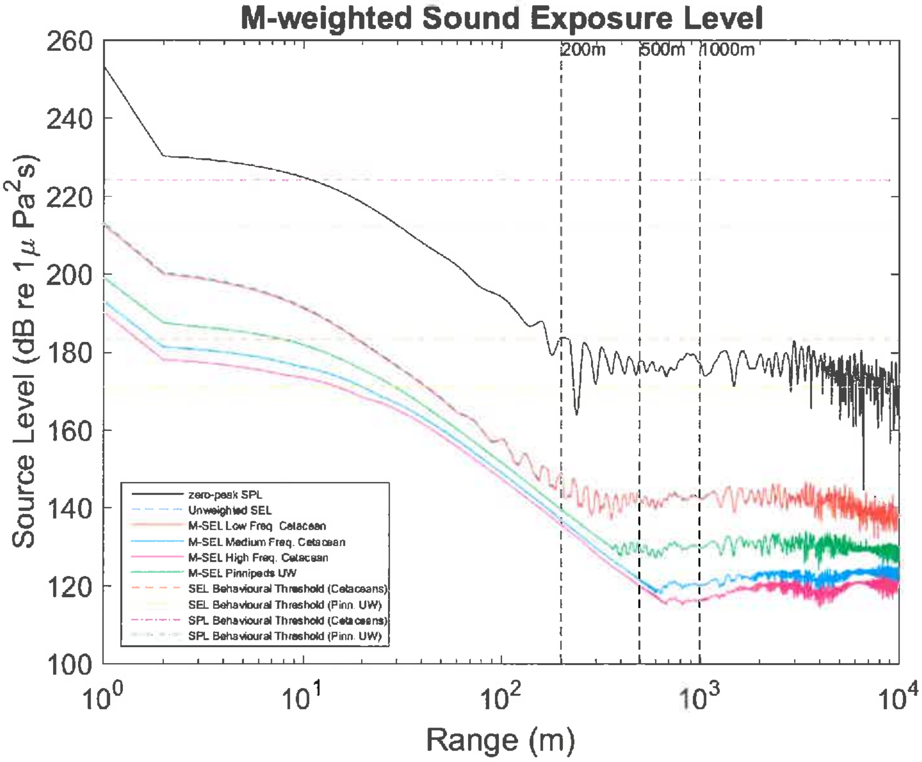

Figure 5.6 M-weighting SEL and zero-to-peak SPL as function of range regarding the injury and behavioural threshold values for 4,160 cu in array at Location B

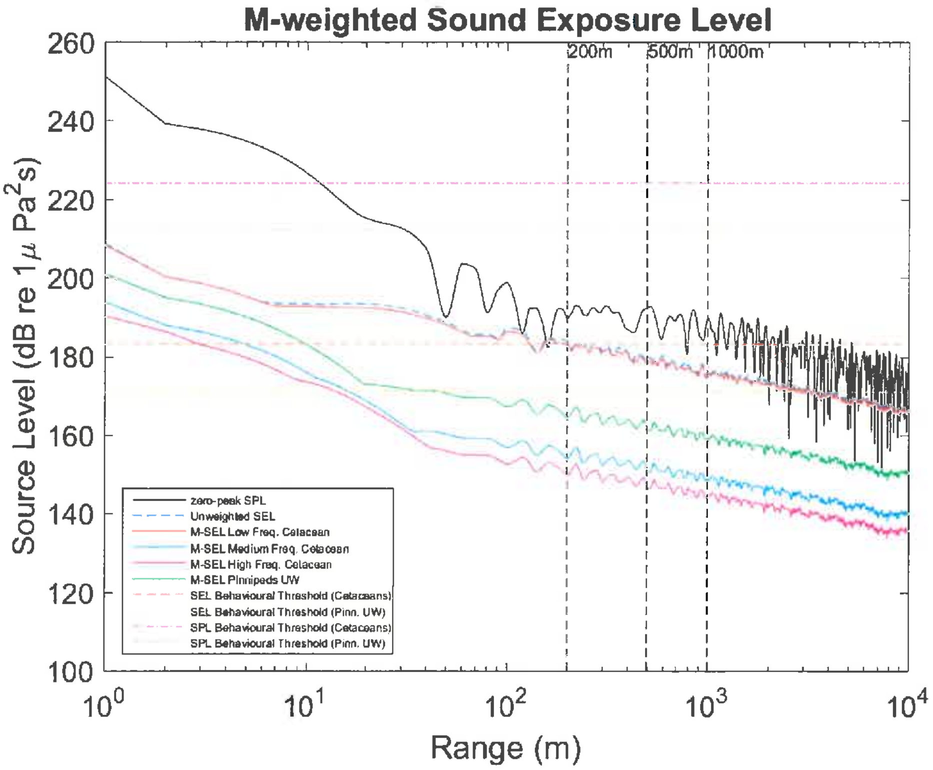

Figure 5.7 M-weighting SEL and zero-to-peak SPL as function of range regarding the injury and behavioural threshold values for 4,160 cu in array at Location C.

Table 5.2 and 5.3 summarise the impact ranges predicted based on the criteria mentioned above at the Chatham Rise site. The worst case scenario of each location is reported for injury thresholds and behavioural thresholds, respectively. Note that 0 m indicates that no behavioural response or injury will be expected, even at 0 m from the source as the predicted source levels were estimated below the M-weighting thresholds.

The predicted single pulse auditory injury and behavioural ranges for high, medium and low frequency hearing cetaceans are within the near field of the acoustic emissions from the airgun array. Based on the worst case scenario sound exposure noise criteria by Southall *et al.* (2007) injury in cetaceans is only likely to occur within 6 m of the 4,160 cu in airgun array source, and in pinnipeds within 8 m. Behavioural disturbance based on SPLs is likely to occur within 162 m of the 4,160 cu in airgun array source in low frequency cetaceans and within 55 m in pinnipeds. Injury in cetaceans is unlikely to occur at any distance from the 600 cu in array source. Behavioural disturbance in cetaceans is likely to occur within 14 m of the 600 cu in array source. Injury and behavioural disturbance is likely to occur within 5 m and 55 m for pinnipeds, respectively.

In summary, based on the worst case scenario M-weighted SEL noise criteria the injury impact ranges are only likely to occur within 6 and 8 m of the 4,160 cu in airgun array source, and behavioural impact range is likely to occur within 162 m and 55 m or the airgun array source, for cetaceans and pinnipeds respectively.

Table 5.2 Injury threshold values for marine mammals based on Southall *et al.* (2007) criteria (single pulses)

Species	Injury Impact Ranges (single pulse)					
	600 cu in array			4160 cu in array		
	Modelled Location					
	A	B	C	A	B	C
SEL Low Frequency Cetacean (m)	0	0	0	6	4	0
SEL Med Frequency Cetacean (m)	0	0	0	0	0	0
SEL High Frequency Cetacean (m)	0	0	0	0	0	0
SEL Pinniped under water (m)	5	4	5	5	4	8

Table 5.3 Behavioural impact range for marine mammals based on Southall *et al.* (2007) criteria (single pulses)

Species	Behavioural Impact Ranges (single pulse)					
	600 cu in array			4160 cu in array		
	Modelled Location					
	A	B	C	A	B	C
SEL Low Frequency Cetacean (m)	7	14	13	19	19	162
SEL Med Frequency Cetacean (m)	0	0	0	0	2	5
SEL High Frequency Cetacean (m)	1	1	1	0	0	3
SEL Pinniped under water (m)	44	39	35	30	29	55

5.6 Noise Map

As the 360M model employed in the study allows simulations with full 360° coverage, it allows an acoustic map of the underwater noise to be created in the survey area that includes the environmental information for the noise propagation.

Three locations were modelled for two seismic arrays. The results are presented in Figure 5.8 to Figure 5.13. 360M was used to predict the sound propagation of each individual one third octave band frequency (Table 4.2) for each case and the maximum SEL level were extracted from each frequency. Thus, the noise map represents the highest SEL level that is likely to occur in the water column, taking the bathymetry into consideration. Note that the absence of colour in the map indicates the noise from the seismic source dissipated below the ambient noise level.

In all cases, it can be seen that noise propagation is more efficient at shallow water locations within the Chatham Rise and received SEL level are predicted to drop considerably at the continental shelf edge. The sound level attenuates relatively slowly after the shelf edge, where the SEL level drops below 80 dB ref 1 μPa^2s to ambient level for the 600 cu in array and 100 dB ref 1 μPa^2s for the 4160 cu in array. The sound level would be expected to decrease as range increases.

It can be noted in the sound speed profile (Figure 4.2) that an acoustic sound channel is present, where sound is trapped by a combination of upward refraction within the water column and downward reflection from the sea surface. This allows for long range propagation of acoustic energy within the channel, which explains the efficient long range propagation at Location A and C.

In practice, however, acoustic energy will be lost through scattering to the surface and seabed boundaries, as the roughness of the bathymetry and surface conditions will have a direct effect on the sound propagations. Thus, the results presented in this study do not include any weather dependent factors and an average wave height of 1 m at the surface was used throughout the modelling.

It may be noted that Chatham Island formed an acoustic shadow in all cases, blocking the direct propagation path. However, this does not mean that seismic noise will not be perceived at this area, as the ocean environment is highly dynamic. The model employed in this study does not account for the horizontal refraction and scattering in the x-y plane. In order to predict the sound level in these shadow areas, a reverberant or 3D model may be used. It is expected that sound level in these areas will be lower than in the direct acoustic field due to the nature of reverberant field.

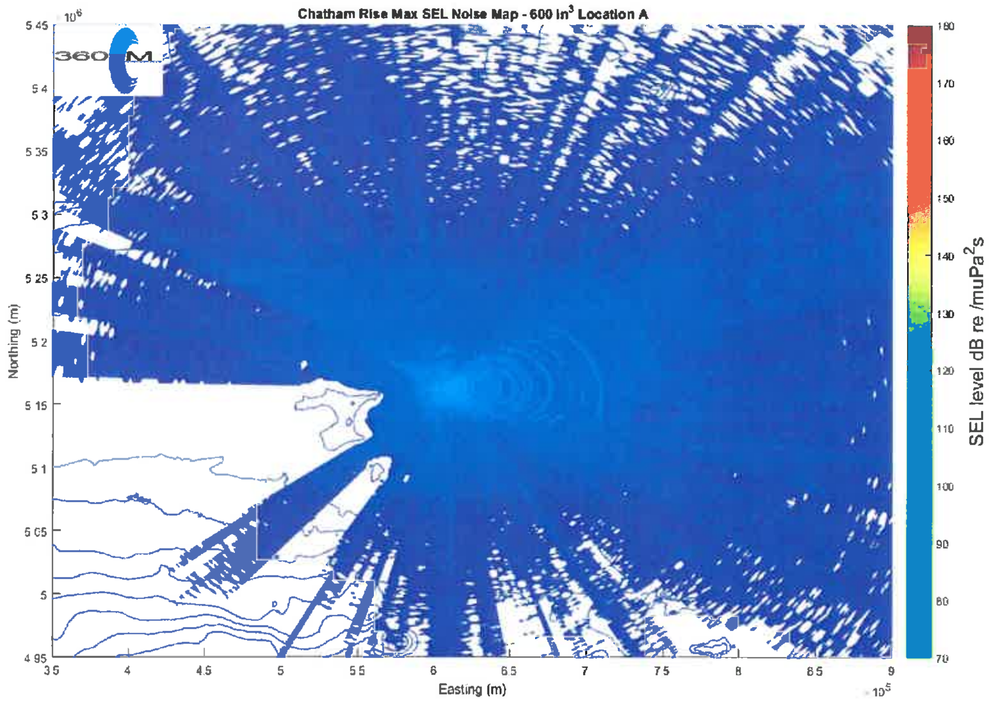

Figure 5.8 Maximum SEL dB re 1 μPa^{2}s generated by 600 cu in array at location A (Line C)

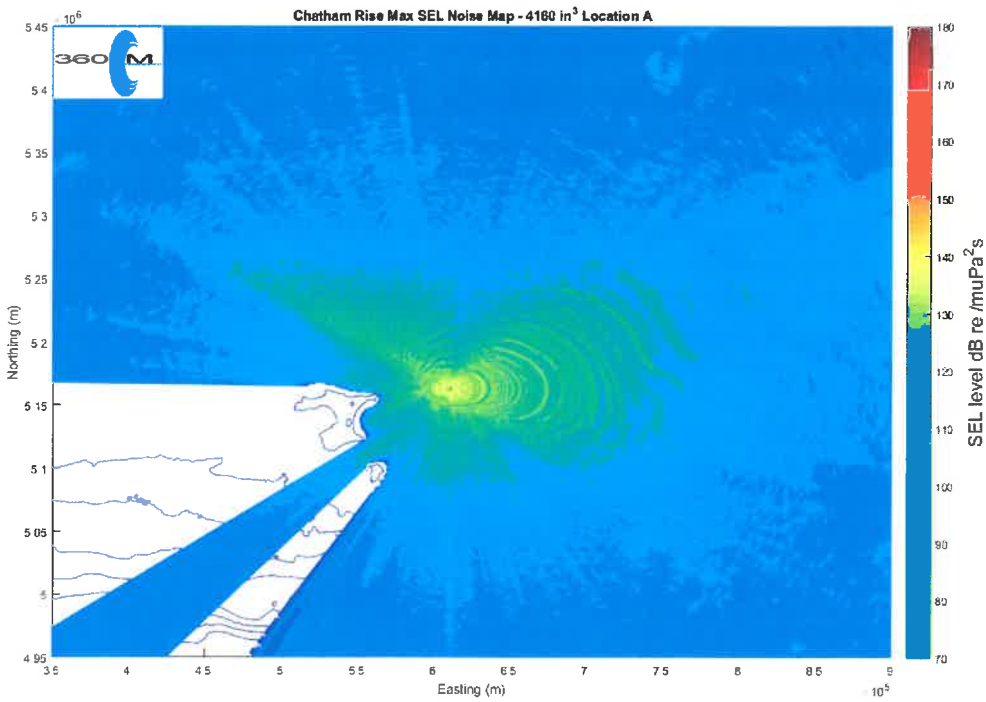

Figure 5.9 Maximum SEL dB re 1 μPa^{2}s generated by 4,160 cu in array at location A (Line C)

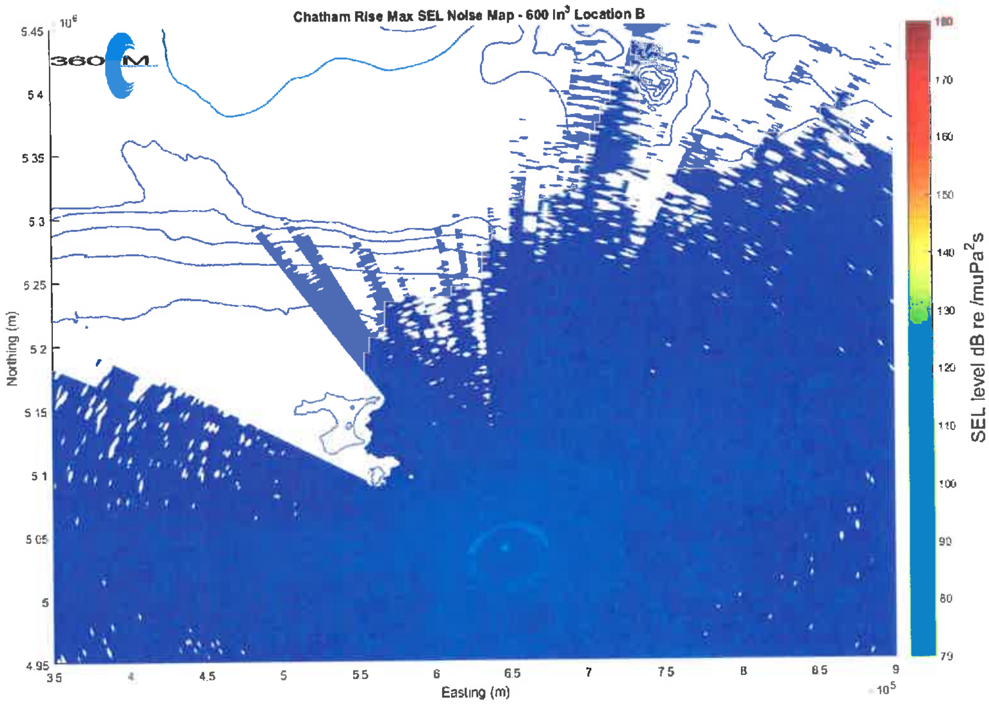

Figure 5.10 Maximum SEL dB re 1 µPa²s generated by 600 cu in array at location B (Line C)

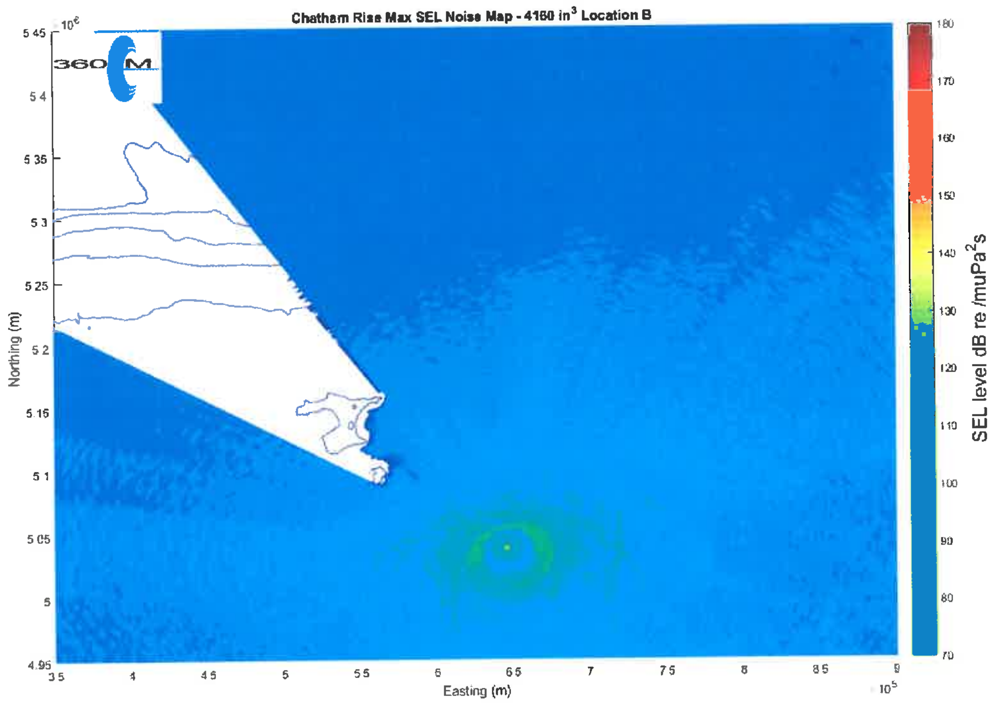

Figure 5.11 Maximum SEL dB re 1 µPa²s generated by 4,160 cu in array at location B (Line C)

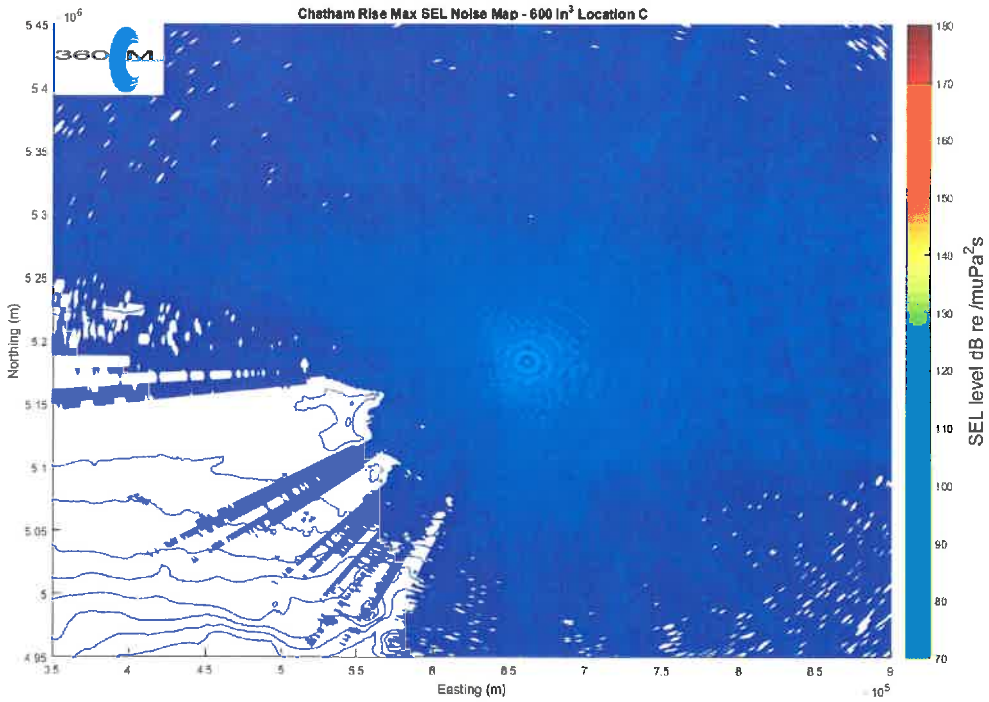

Figure 5.12 Maximum SEL dB re 1 μPa²s generated by 600 cu in array at location C (Line 2)

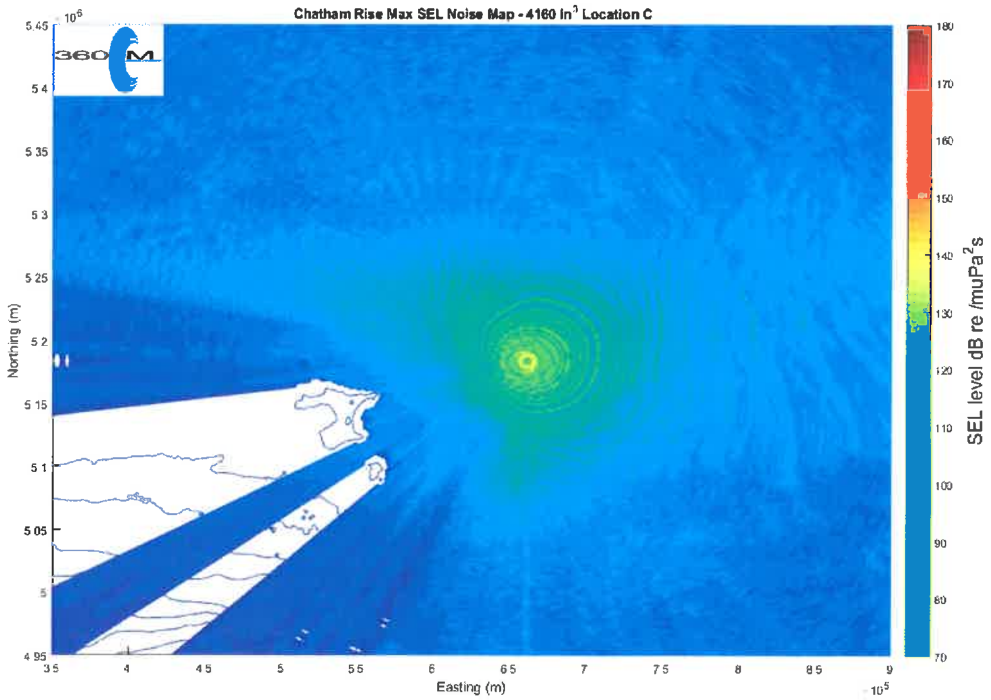

Figure 5.13 Maximum SEL dB re 1 μPa²s generated by 600 cu in array at location C (Line 2)

6. Conclusions

The current study was undertaken to model the generation and propagation of underwater noise from a 4160 cu in seismic airgun array and a 600 cu in array during a seismic survey on the Chatham Rise. Additionally, this study was conducted in order to assess the potential effects that the seismic survey would have on marine mammals in the region and the suitability of the mitigation measures proposed.

The impact ranges were predicted based on the source characteristics and physical parameters given by the client and applied to a propagation model.

Propagation models were computed for frequencies between 10 and 500 Hz, 360° radially at 10 km and 600 km radius for three locations, two located at Line 2 (408 m & 2,200 m) and one at Line C (703 m). Eight different radial transects (N, NE, E, SE, S, SW, W, NW), each with a range of 10 km assuming a source point at 5 and 10 m depth for the 4,160 cu in array and 2 m depth for the 600 cu in array, were extracted of each location and used for impact range assessment.

The TL results were therefore applied to the source levels, modelled in Gundalf, and the received levels were computed for each transect.

Due to the flat bathymetry characteristics within a 10 km radius for all three locations, the TL results were very similar across the different transects, and consequently the received levels as well.

In accordance with the 2013 Code an impact assessment was carried out in order to predict if the sound levels would exceed either 171 dB re 1 $\mu Pa^2 s$ (SEL) at distances corresponding to the relevant mitigation zones for Species of Concern (SoC) or 186 dB re 1 $\mu Pa^2 s$ at 200 m (SEL).

Both sound levels mentioned in the 2013 Code are based on the threshold criteria values for injury and behavioural disturbance for pinnipeds according Southall *et al.* (2007) however it was decided to extend the assessment also for low, medium and high frequency cetaceans groups.

Based on the M-weighted noise criteria by Southall *et al.* (2007) injury in cetaceans is only likely to occur within 6 m of the airgun array source, and in pinnipeds within 8 m, while behavioural disturbance is only likely to occur within 162 m and 55 m, for cetaceans and pinnipeds respectively.

As a result, the sound levels during the survey will not exceed 171 dB re 1 $\mu Pa^2 s$ (SEL) at distances corresponding to the relevant mitigation zones for SoC nor the 186 dB re 1 $\mu Pa^2 s$ at 200 m (SEL). Consequently, there is no need to either suggest an extension of the radius of the mitigation zone or limit the acoustic source power.

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Appendix C Marine Mammal Mitigation Plan

Prepared For

Project

Marine Mammal Mitigation Plan
2016 Scientific Geophysical and Geological Survey
Chatham Rise (New Zealand): Gondwana Breakup and Chatham Rise Structure

Date

12th January 2016

Published by

Gardline Environmental (New Zealand) Ltd
HP Tower, Level 15
171 Featherston Street
Wellington
6011
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www.gardlinemarinesciences.com

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1. Introduction

The purpose of this document is to outline the detailed mitigation procedures and protocols for the proposed scientific geophysical and geological survey[1] in order to reduce any adverse impact on marine mammals in accordance with the Department of Conservation's (DOC) *'2013 Code of Conduct for minimising acoustic disturbance to marine mammals from seismic survey operations'* (hereafter "the 2013 Code").

The Exclusion Economic Zone and Continental Shelf (Environmental Effects) Act (the EEZ Act) provides a framework for environmental management in New Zealand's EEZ and Continental Shelf. Its purpose is to promote the sustainable management of the natural resources in this area. All seismic surveys conducted in New Zealand's EEZ must comply with this Act or obtain a marine consent from the Environmental Protection Authority (EPA). The permitted activities regulations require operators to comply with the "*2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations*".

However, there are certain exemptions from permitted activity conditions, including surveys undertaken from foreign state vessels used by the foreign state for wholly-governmental purposes. That is the case with the proposed survey which will be conducted using the research vessel *R.V. Sonne* owned and operated by the German government.

Despite the exemptions in place, AWI with GNS Science's assistance wishes to voluntarily adopt provisions of the 2013 Code in order to protect marine mammals in the survey area.

During the entire duration of the survey, the 2013 Code will be adhered to and the majority of mitigation measures outlined for the Level 1 survey will be implemented with the addition of the extra measures recommended within the Marine Mammal Impact Assessment (MMIA):

- Two Qualified Marine Mammal Observers (MMOs) will be on watch during all pre-start observations during daylight hours and any other key times (heath and safety permitting).

- To avoid any risk of collision with baleen whales during transit, at least one MMO is to be on watch during transits or at any times of increased vessel speed (i.e. above usual survey speed). If any baleen whales are sighted in the vicinity ahead of the vessel and if judged by the MMO that the animal/s is/are not responsive (i.e. during times of resting, feeding, socialising), the vessel's course will be altered to avoid collision with the animal/s.

- Immediate notification of the Director-General of DOC if Species of Concern (SoC) are encountered in unusually high numbers.

- Immediate notification of the Director-General of DOC if any SoC, identified as unlikely to be present in the survey area (especially baleen whales), is encountered during the survey.

- Extension of mitigation zones to 2 km for southern right whales if there are more than two sightings in the last 24-hours. This will last for 24 hours from the second and any other consecutive sighting within that period.

However it should be noted that if, for whatever reason, the mitigation measures proposed by the MMIA become incompatible with the primary cruise objectives, e.g. both Passive Acoustic Monitoring Systems (PAMS) failing,

[1] For more details about the survey please refer to the associated MMIA document.

then the cruise leader will discuss alternative mitigation measures with DOC which enables the survey to proceed and these measures will be implemented.

2. Observers

There will be four Observers onboard throughout the survey meeting the requirements of the 2013 Code and approved by DOC. They will undertake designated roles during the survey as MMOs and PAM Operators.

As per the standards outlined in the 2013 Code, the duties of the MMO will be to:

- Give effective briefings to crew members, and establish clear lines of communication and procedures for onboard operations;
- Continually scan the water surface in all directions around the acoustic source for the 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 a Global Positioning System (GPS), sextant, reticule 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, behaviour/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;
- Record and report any instances of variation from the 2013 Code.

While undertaking the PAM Operator role, the Observer will:

- Give effective briefings to crew members, and establish clear lines of communication and procedures for onboard operations;
- Test, optimise, deploy and retrieve the hydrophone array;
- While on duty, concentrate on continually listening to received signals and/or monitoring the PAM display screens in order to detect vocalising cetaceans, except for when required to attend to PAM equipment. Undertaking work-related tasks, such as completing reporting requirements while monitoring equipment is allowed during duty watch, but PAM Operators must not be distracted by non-work activities such as listening to music or watching TV/DVDs etc.;
- Use appropriate sample analysis and filtering techniques;
- Record and report all cetacean detections, including, if discernible, the 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;
- Record and report any instances of variation from the 2013 Code.

It is acceptable for there to be one Qualified Observer and one Trained Observer in each observation role (MMO/PAM) on board. In such instances, Qualified Observers will have a mentoring capacity to a Trained Observer for the duration of the survey.

All Observers will have the appropriate training certificates and relevant experience for their designated roles. Additionally, all Observers will hold appropriate sea survival and medical certificates and will have suitable offshore Personal Protective Equipment (PPE) for their role.

Each MMO will be equipped with the following: reticule binoculars, laptop, digital camera, range finder stick, angle board, compass, recording forms, deck forms, and GPS. A sextant will be available onboard for the MMOs to use.

Acoustic monitoring will be conducted with a purpose built tow array and specialised software (PAMGUARD package). This will allow acoustic detection and monitoring for the presence of vocalising marine mammals. PAM Operators are encouraged to familiarise themselves with acoustic recordings of New Zealand species identified as likely to be in the operational area.

The operator 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 Observers in real time by providing a display screen for acoustic source operations. The Qualified Observers should be able to specify where such a screen should be located for their convenience, rather than this being determined solely by the vessel operator.

2.1 Observer Effort

For the duration of the survey, two MMOs and two PAM Operators will be present onboard the survey vessel.

At least one MMO will be on watch during daylight hours while the acoustic source is in the water in the operational area. Two MMOs will be on watch during pre-start observations during daylight hours or at any other key time where practical and possible (health and safety permitting). At least one MMO will be on watch during times of transit when no seismic data acquisition will take place. The sighting data collected during this watch will contribute to the knowledge on marine mammal distribution in the area.

The MMOs will observe from a suitable viewing platform such as the bridge or bridge wings. MMOs with experience in PAM, when not required for visual observation, are allowed to undertake acoustic monitoring and allow the PAM Operator to have refreshment breaks. A direct line of communication will be maintained between MMOs and PAM Operators during all times.

Two PAM Operators will be utilised and at least one of these will remain on watch at all times while the source is in the water. Such acoustic monitoring will cover 24 hours allowing marine mammal monitoring during hours of darkness and low visibility.

If the PAMS malfunctions or becomes damaged, operations may continue for 20 minutes in the absence of PAMS whilst diagnosing the issue. If the diagnosis indicates that the PAMS must be repaired to solve the problem, operations may continue for an additional two hours without PAMS 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 PAMS in the relevant mitigation zones in the previous two hours;

- Two MMOs maintain watch at all times during operations when PAMS is not operational;
- DOC is notified via email as soon as practicable with the time and location in which operations began without an active PAMS;
- Operations with an active source, but without an active PAMS do not exceed a cumulative total of four hours in any 24 hour period.

However, if PAMS cannot be repaired whilst on sea, DOC will be consulted and advice on proceeding with the survey but without active PAMS will be sought.

If the acoustic source is in the water but inactive, such as while waiting for bad weather conditions to pass, the 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 role onboard the vessel, such as adjusting or maintaining PAMS or other equipment, or to attend mandatory safety drills.

To avoid any risk of collision with baleen whales, at least one MMO is to be on the watch during transit or at any times of increased vessel speed (i.e. above usual survey speed). If any baleen whales are sighted in the vicinity ahead of the vessel and if judged by the MMO that the animal/s is/are not responsive (i.e. during times of resting, feeding, socialising), the vessel's course will be altered to avoid collision with the animal/s.

The maximum duration of each Observer's shift will be 12 hours in any 24 hour period including time needed for reporting requirements.

If any crew member onboard the survey vessel observes a marine mammal, he/she will promptly inform the MMO on duty who will then identify the animal/s where possible and determine the distance from the acoustic source. When it is not possible to confirm the sighting, the crew member who reported the observation will provide as much information as possible for the MMO to complete the relevant recording forms. If the animal/s observed were within the relevant mitigation zone, it will be up to the MMO to decide whether to implement any mitigation measures. Observations reported by crew members will be clearly differentiated within the recording forms.

2.2 Observer Action Protocol

Any Observer on duty has the authority to delay the start of operations or shutdown an active source according to the provisions of the 2013 Code and procedures outlined within this document.

3. PAM

During daylight hours, if any marine mammals are acoustically detected, the PAM Operator will notify the MMO/s on duty of the detection. The PAMS Operator will take appropriate mitigation action based on their determination of distance and species unless this confirmed differently by the MMO.

If operating in an area where calves are anticipated to be present or have been visually observed during the survey, then vocalisations detected by PAMS are assumed to be produced from a cow/calf pair and as such the most stringent mitigation zones will be applied unless a sighting by the MMO can confirm otherwise. Furthermore, any ultra-high frequency cetacean vocalizations (30 – 180 kHz) will require an immediate shut down or delay (as per procedures described below) unless the MMO can confirm that the species detected falls under the 'other marine mammal' category.

When MMOs are not on duty (e.g. night time) and therefore not able to confirm sightings and assist with species identification and distance, a precautionary approach will be applied when determining appropriate mitigation protocols and the PAM Operator should consider factors such as recent sighting frequency of SoC. This should be implemented especially in the case of southern right whales. Namely, if MMOs have recorded more than two southern right whale sightings during daylight hours in the preceding 24 hours, then all baleen whale acoustic detections made during night time will be considered as calls made by this species and additional mitigation measures will be applied (i.e. extension of the mitigation zone to 2 km).

Acoustic recordings and screenshots will be saved for each acoustic detection and backed up on an external hard drive.

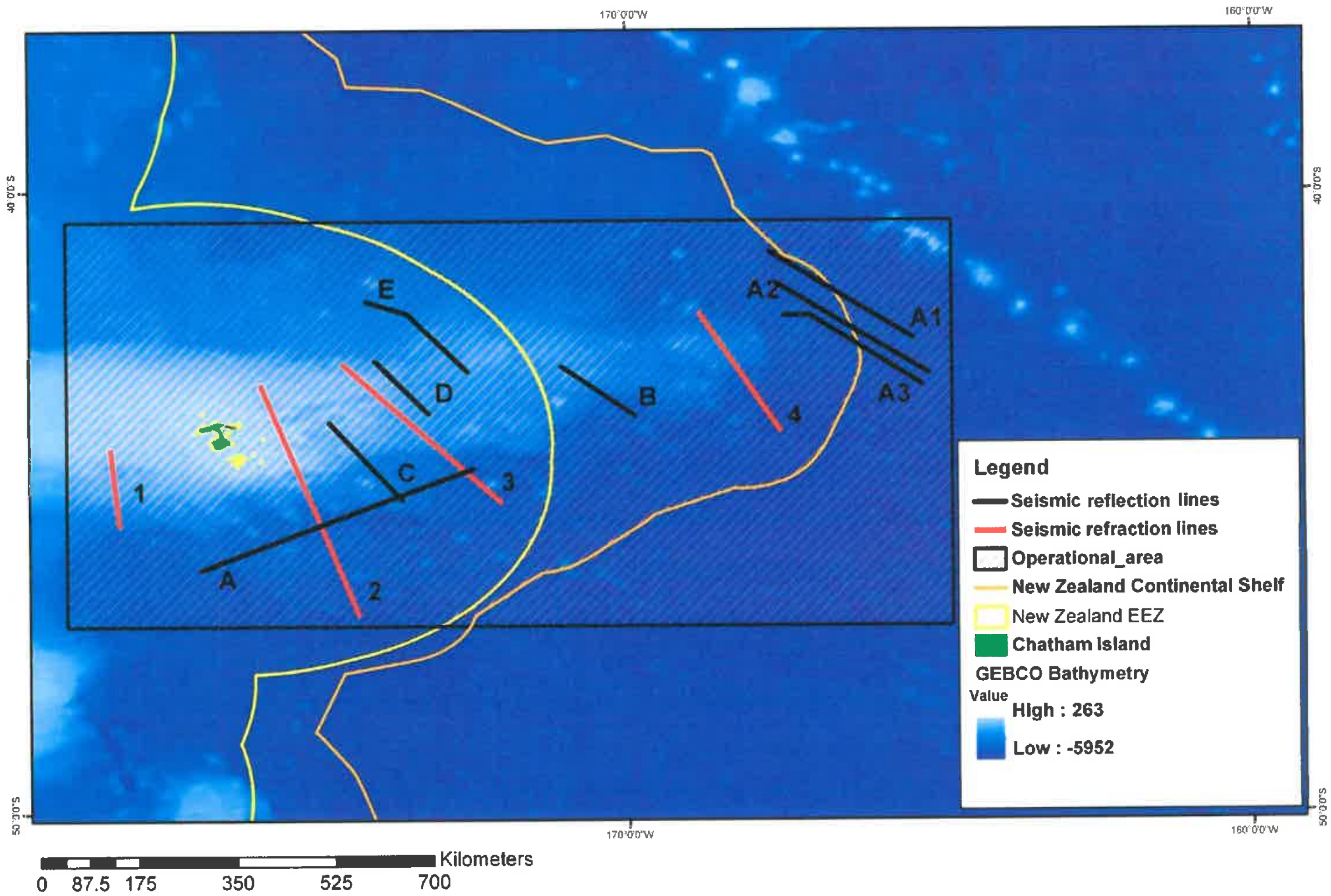
4. Operational Area

As per the requirements of the 2013 Code, an operational area will be designated outside of which the acoustic source will not be activated, including soft starts and acoustic source tests. The operational area for this survey is defined within Table 4.1 and Figure 4.1.

On duty MMOs and PAM Operators need to be aware of the vessels' location at all times in regards to the zone of operational area.

Table 4.1 Operational area coordinates for the proposed survey

Site	Latitude	Longitude	Coordinate System
Chatham Rise	- 40.5	181.0	GCS_WGS_1984
	- 40.5	195.2	
	-47.0	181.0	
	-47.0	195.2	



World EEZ Layer Copyright Claus S De Hauwere N Vanhoorne B Souza Dias, F Hernandez F and Mees, J (Flanders Marine Institute) 2014 MarineRegions org Accessed at http //marine regions org on 23/11/2015
bathymetric Source. General Bathymetric Chart of teh Ocean (GEBCO) Digital Editions 2003, published by OIC, IHO and BODC. Depths are indicative and shoulsd not be used for navigation

Figure 4.1 Map of Operational Area

5. Soft Starts

Soft starts are required whenever the acoustic source is to be activated, with the exception of certain tests (see Section 9) and breaks in firing that are less than 10 minutes in duration immediately following normal operations at full power. In the case of the latter, the acoustic source may start at full power provided the Observers have not detected marine mammals in the relevant mitigation zones (as per Section 4.2.4 of the 2013 Code). As stated in the 2013 Code, soft starts should gradually increase the acoustic source power output, starting with the lowest capacity gun, over a minimum of 20 minutes and should not exceed 40 minutes in duration. On completion of the soft start, operations should be planned so that the survey line starts shortly after. Soft starts give any marine mammals in the area time to move away from the source before full power is reached.

The maximum operational capacity of 4,160 cu in will not be exceeded during any time of the soft start.

6. Pre-start Procedures

The acoustic source can only be activated once the vessel is within the specified operational area (see Section 4) and no marine mammals have been detected in the respective mitigation zones.

Operations can then commence with a soft start provided the following:

DAY TIME

- At least one MMO has conducted continuous 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 have been observed in the respective mitigation zone for at least 30 minutes.
- A PAM Operator has conducted acoustic monitoring for at least 30 minutes before activation of the acoustic source and no vocalising cetaceans have been detected in the respective mitigation zones.

NIGHT TIME / POOR SIGHTING CONDITIONS

- A PAM Operator has conducted acoustic monitoring for at least 30 minutes before activation of the acoustic source and no vocalising cetaceans haven been detected in the respective mitigation zones.

ADDITIONAL REQUIREMENTS FOR START UP IN A NEW LOCATION IN POOR SIGHTING CONDITIONS

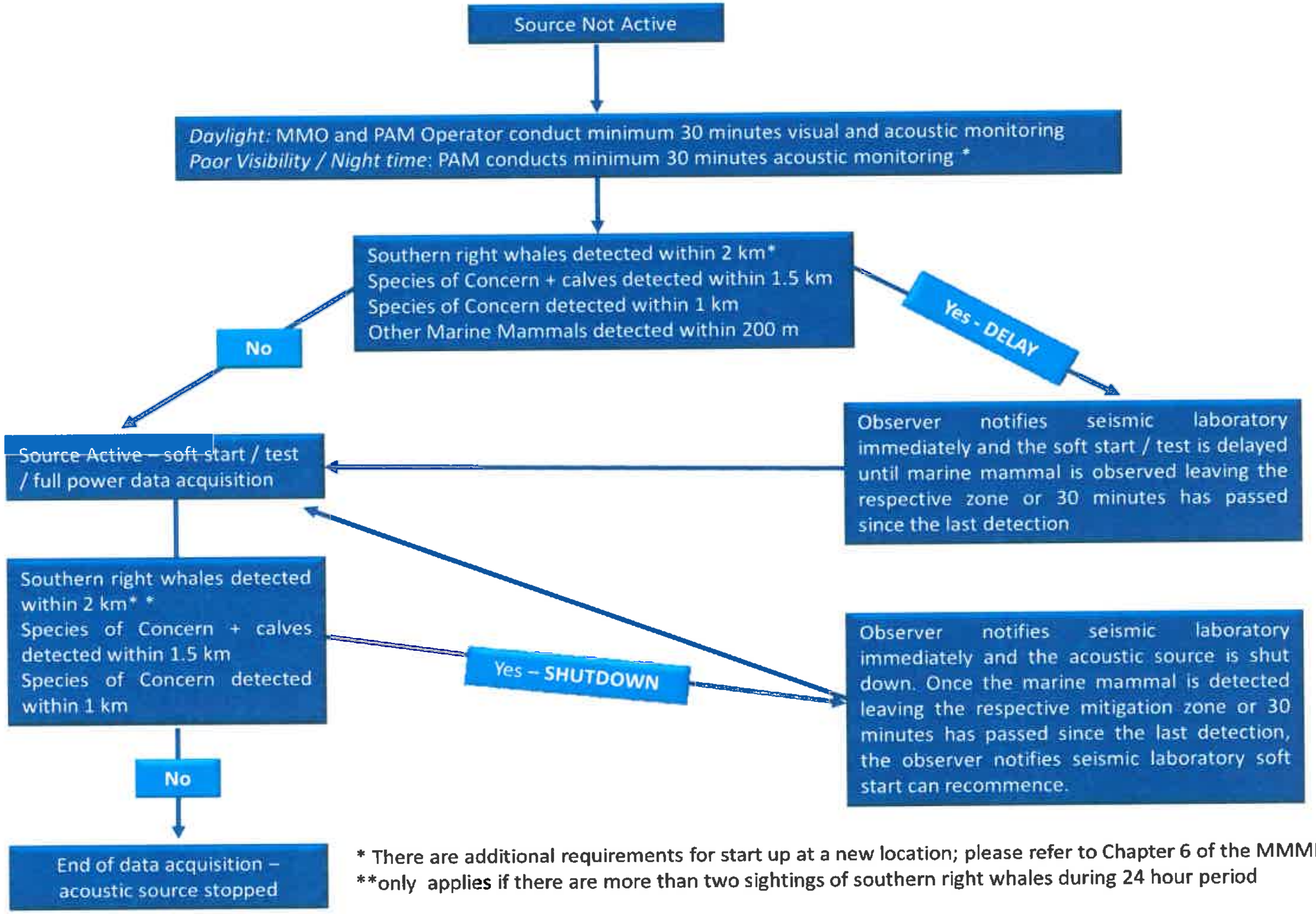
- The initial acoustic source activation must not be undertaken at night or during poor sighting conditions unless the MMOs have undertaken observations within 20 nm of the planned start up position for at least the last two hours of good sighting conditions preceding proposed operations and no marine mammals have been detected.
- If there have been fewer than two hours of good sighting conditions preceding proposed operations, (within 20 nm of the planned start up position), the source can be activated if:
    - PAM has been conducted for two hours immediately preceding proposed operations;
    - Two MMOs have conducted visual monitoring in the last two hours immediately preceding proposed operations;
    - No SoC have been detected visually or acoustically in the relevant mitigation zones in the two hours immediately preceding proposed operations;
    - No other marine mammals have been detected visually or acoustically in the relevant mitigation zones in the 30 minutes immediately preceding the proposed operations;
    - No fur seals have been detected visually in the relevant mitigation zones in the 10 minutes immediately preceding the proposed operations.

7. Delays and Shutdowns

Any Observer on watch will request to shutdown or initiate a delay in seismic operations if a marine mammal is detected in the following mitigation zones:

- *2,000 m for southern right whales with/without calves if more than two individuals are recorded within 24 hours*
- *1,500 m for Species of Concern with calves*
- *1,000 m for Species of Concern without calves*
- *200 m for any other marine mammal.*

Figure 7.1 provides a summary of the delay and shutdown process.



* There are additional requirements for start up at a new location; please refer to Chapter 6 of the MMMP

**only applies if there are more than two sightings of southern right whales during 24 hour period

Figure 7.1 Summary flow diagram of the mitigation procedures during the survey. Please note there are additional requirements for start up in a new location.

7.1 Species of Concern (SoC) with calves within a mitigation zone of 1.5 km

If, during pre-start observations or while the acoustic source is active (including soft starts), an Observer detects at least one SoC (see Section 8) with a calf within 1.5 km of the source, start up will be delayed or the source will be shutdown and not be reactivated until:

- An 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.

7.2 Species of Concern (SoC) without calves within a mitigation zone of 1 km

If, during pre-start observations or while the acoustic source is active (including soft starts), an Observer detects a SoC (see Section 8) within 1 km of the source, start up will be delayed or the source will be shut down and not reactivated until:

- A Qualified/Trained Observer confirms the animal/s has/have moved to a point that is more than 1 km from the source, or
- Despite continuous observation, 30 minutes has elapsed since the last detection of a SoC within 1 km of the source, and the mitigation zone remains clear.

7.3 Other Marine Mammals within a mitigation zone of 200 m

If, during pre-start observations prior to initiation of acoustic source soft start, an Observer detects any other marine mammal within 200 m of the source, start up will be delayed until:

- An 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.

7.4 Southern right whales with/without calves within a mitigation zone of 2 km (when there are more than two sightings during a 24-hour period)

The following procedure only applies if there are more than two southern right whale sightings within 24 hours. Otherwise, standard mitigation zones for SoC (see Section 7.1 and 7.2) will apply.

If, during pre-start observations or while the acoustic source is activated (including soft starts), an Observer detects southern right whale/s within 2 km of the source, start up will be delayed or the source will be shutdown and not be reactivated until:

- An Observer confirms the animal/s has/have moved to a point that is more than 2 km from the source, or
- Despite continuous observation, 30 minutes has elapsed since the last detection of the animal/s within 2 km 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.

8. Species of Concern

All marine mammal species are protected under the 2013 Code however certain species are designated as 'Species of Concern' (Table 8.1). These species are afforded a higher level of protection due to their conservation status or particular sensitivity to disturbance from seismic noise.

Table 8.1 The list of New Zealand SoC

Scientific name	Common name
Eubalaena australis	Southern right whale
Balaenoptera acutorostrata subsp.	Dwarf minke whale
Balaenoptera bonaerensis	Antarctic minke whale
Balaenoptera borealis	Sei whale
Balaenoptera edeni	Bryde's whale
Balaenoptera musculus	Blue whale
Balaenoptera musculus brevicauda	Pygmy blue whale
Balaenoptera physalus	Fin whale
Megaptera novaeangliae	Humpback whale
Caperea marginata	Pygmy right whale
Berardius arnuxii	Arnoux's beaked whale
Hyperoodan planifrons	Southern bottlenose whale
Mesoplodon bowdoini	Andrew's beaked whale
Mesoplodon densirostris	Blainville's beaked whale
Mesoplodon ginkgodens	Ginkgo-toothed beaked whale
Mesoplodon grayi	Gray's beaked whale
Mesoplodon hectori	Hector's beaked whale
Mesoplodon layardii	Strap-toothed whale
Mesplodon peruvianus	Pygmy beaked whale
Tasmacetusshepherdi	Shepherd's beaked whale
Ziphius cavirostris	Cuvier's beaked whale
Mesoplodon mirus	True's beaked whale
Physeter macrocephalus	Sperm whale
Kogia breviceps	Pygmy sperm whale
Kogia simus	Dwarf sperm whale
Cephalorhynchus hectori	Hector's dolphin
Cephalorhynchus hectori maui	Maui's dolphin
Orcinus orca	Killer whale
Pseudorca crassidens	False killer whale
Feresa attenuata	Pygmy killer whale
Peponocephala electra	Melon-headed whale
Tursiops truncatus	Bottlenose dolphin
Globicephala macrorhynchus	Short-finned pilot whale
Globicephala melas edwardii	Long-finned pilot whale
Lissodelphis peronii	Southern right whale dolphin
Phocarctos hookeri	New Zealand sea lion

9. Seismic Source Tests

Before each test, a pre-start observation needs to be conducted. All tests require soft starts, with the exception of tests below a total volume of 150 cu in. In this instance, tests can commence without a soft start provided the relevant pre-start observations have been made. For all other tests above 150 cu in, the soft start must not exceed the rate of a normal soft start and should be up to 20 minutes in duration. Tests can commence provided the Observer has confirmed no marine mammals are present in the relevant mitigation zones.

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

10. Line Turns

The proposed scientific survey is composed of long regional seismic lines covering essential elements of the sedimentary basins in the region of interest. There are no line turns between subsequent lines, instead the vessel will commence transit to a new location. Therefore, at the end of each seismic survey line, the acoustic source will be shut down and seismic data acquisition will cease. The source will be reactivated with a soft start according to the pre-start observation procedures prior to commencement of the next seismic survey line.

11. Communication

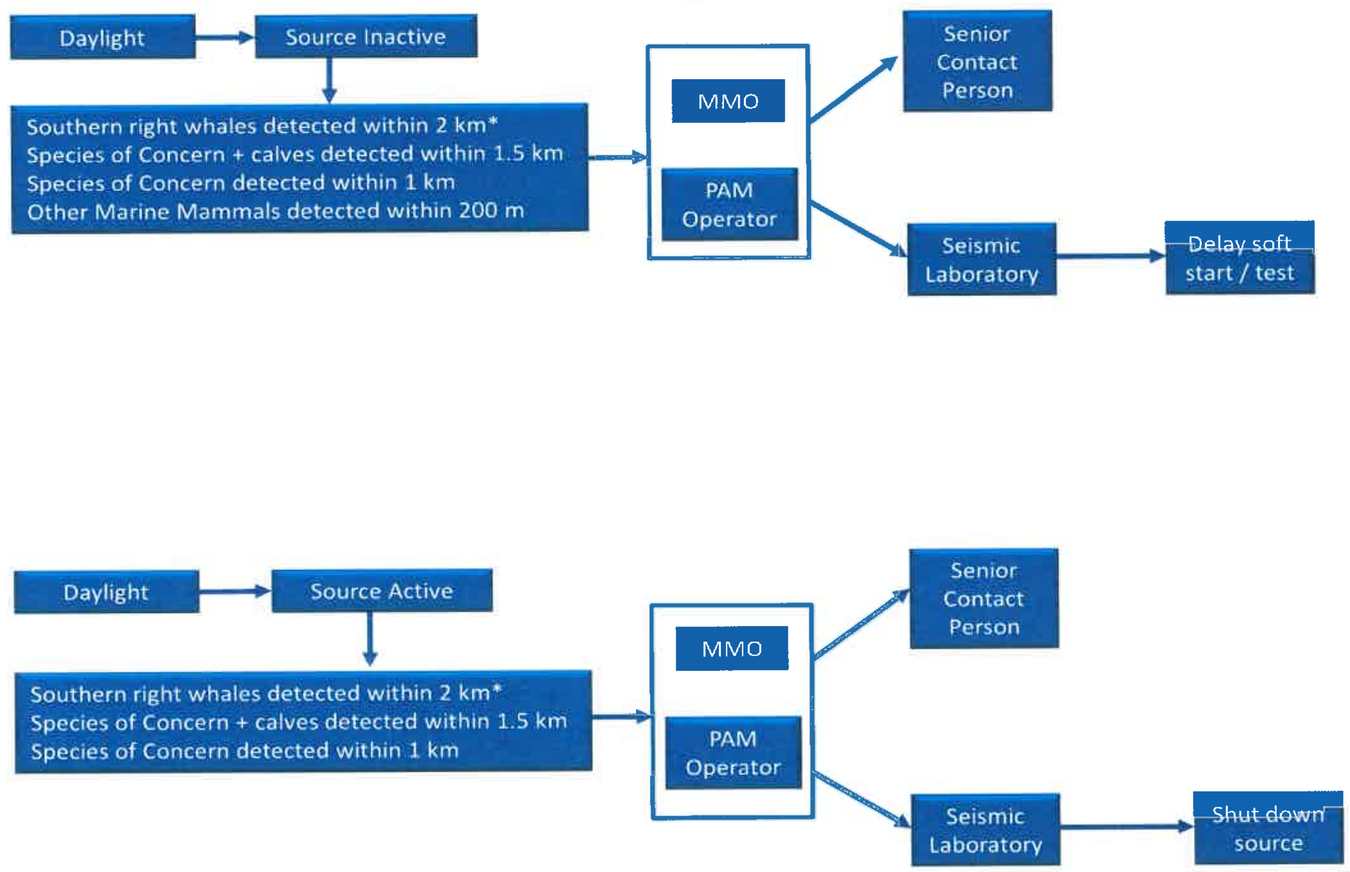
Strict communication protocols are to be followed to ensure the effectiveness of the mitigation.

11.1 Pre-job meeting

The Lead Observer will meet with the relevant onboard personnel prior to the start of the survey to discuss the mitigation protocol and its implementation. During this meeting an onboard Senior Contact Person (SCP) will be identified to whom all marine mammal sightings causing delays or shutdowns will be reported to. The same person will in turn notify the MMOs/PAM Operators on the commencement/ceasing of the acoustic source and survey plans. During this pre-job meeting, all procedures for soft starts, start-up delays and shutdowns should be defined and agreed. Figure 11.1 provides a summary of the communication procedure during daylight hours and Figure 11.2 of the procedure during the hours of darkness or poor visibility.

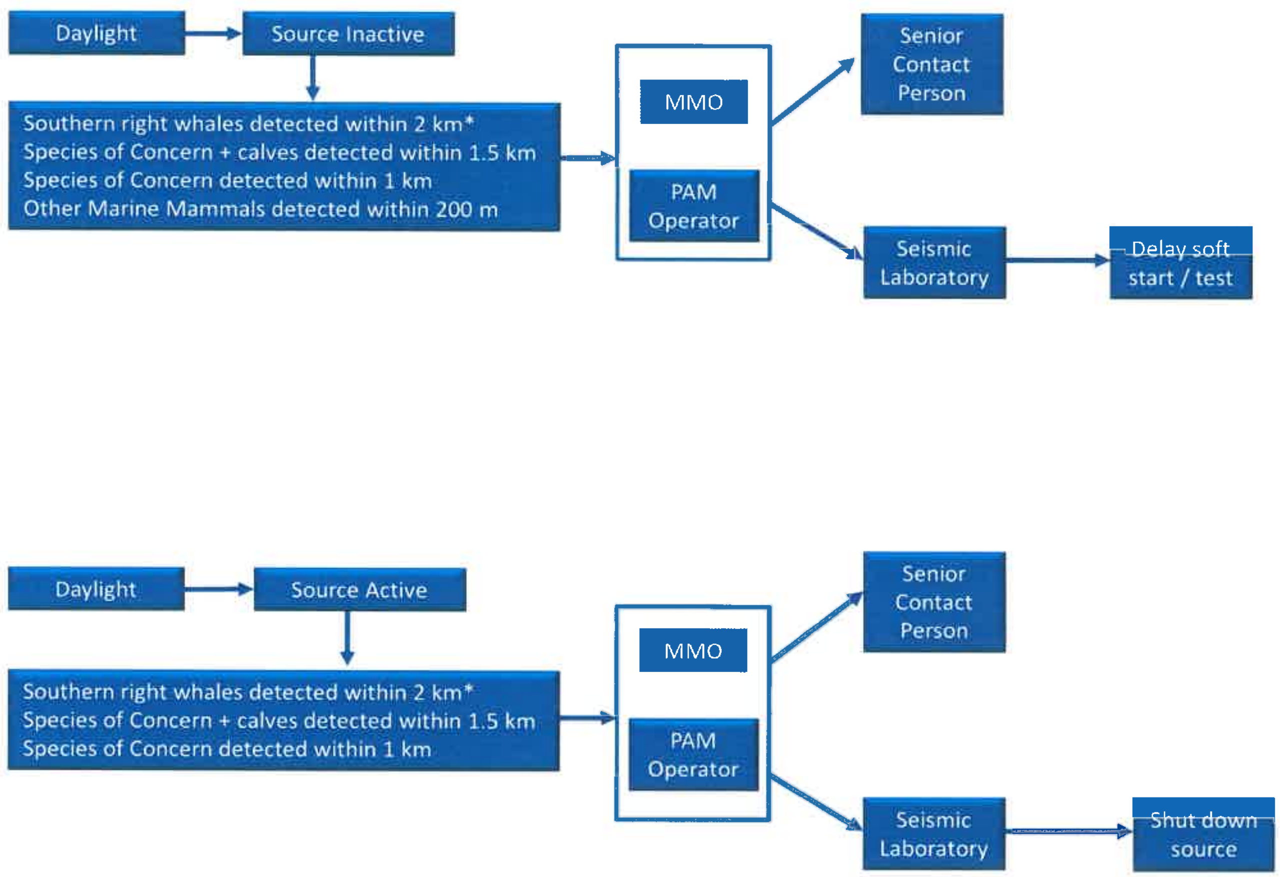
11.2 Communication with the DOC

Any urgent communication with the DOC will go though the Lead Observer and Cruise Leader by email or phone. In addition, the onshore Project Manager must be kept informed of all communications with the DOC.



* only applies if there are more than two sightings of southern right whales during 24 hour period

Figure 11.1 Summary flow diagram of the communication procedure during daylight hours



* only applies if there are more than two sightings of southern right whales in daylight hours during 24 hour period

Figure 11.2 Summary flow diagram of the communication procedure during the hours of darkness and poor visibility

12. Monitoring and Reporting

Observers will be responsible for recording and reporting (in detail) all marine mammal sightings or detections, sighting conditions, seismic source operations and any instances of the variation from the 2013 Code. In the case of variations from the 2013 Code, the Observer will report such instances to the Director-General of the DOC within 24 hours (rather than immediately as stated by the Code). Such communication should be made via telephone. The first person of contact should be Ian Angus (Manager, Marine Species and Threats) +64 4 471 3081 (office)

The recording and reporting will be done as according to the requirements outlined in the 2013 Code.

All sightings/detections of marine mammals during the survey period will be recorded, including those beyond the mitigation zone and/or those during transit, in the standardised recording sheets available from http://www.doc.govt.nz/notifications. In addition to marine mammals, all sightings of other marine mega fauna such as sea turtles and sharks will be recorded too. Whilst collecting data, a clear differentiation should be made between data derived from:

- MMO and PAM Operators;
- Qualified and trained Observers;
- Watches conducted during survey operations (ON survey) or at any other times (OFF survey).

This raw data will be submitted by the Qualified Observers, directly to the Director-General, at the earliest opportunity but no longer than 14 days after the completion of the survey.

In addition to this, the Director-General is to be informed immediately (within 24 hours) when SoC are encountered in unusually high numbers or if any SoC, identified as unlikely to be present in the survey area, is encountered during the survey within New Zealand waters. The Qualified Observers onboard will use their professional judgement to make a decision as to whether any of the sightings or species encounters qualify for this requirement.

A final trip report will be submitted by the proponent to the Director-General at the earliest opportunity but no later than 60 days after completion of the survey. Both MMOs and PAM Operators will be jointly responsible for recording observation data and compiling a final trip report.

This report will include:

- 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 vessel used;
- Specifications of the seismic source array and PAMS array position, date, start/end of survey, GPS track logs of vessel movements;
- Total duration of 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 soft start sample during the survey;

- 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, behaviour/activity and response of the marine mammal group (plotted in relation to the vessel throughout detection);
  - confirmed identification 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 of the detection, 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 variation from the 2013 Code.

13. Variations from the 2013 Code

The following will be considered as variations and the Director-General of the DOC will be informed as per Section 12 above:

- If operational capacity of the acoustic source exceeds the maximum stated volume (i.e. 4,160 cu in);
- If a request for the delay or shutdown due to the presence of marine mammals in their respective mitigation zones is not followed;
- Soft starts are shorter or longer than 20 or 40 minutes, respectively;
- The acoustic source is activated outside of the operational area;
- Acoustic source tests exceeding a total volume of 150 cu in are not conducted with an appropriate soft start;
- A break in firing of more than 10 minutes is not followed by a soft start;
- Acoustic source is activated before the MMO or PAM Operator has conducted their pre-start observation.

It is the Observers' duty to seek justifications and report reasons for any variations from the provisions of the 2013 Code.